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Chapter 15: Complex, diverse and changing agribusiness and livelihood systems in the Amazon

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Chapter 15

Complex, diverse and changing agribusiness and livelihood systems in the Amazon

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ACRONYMS AND ABBREVIATIONS

EMBRAPA	Brazilian Agricultural Research Corporation
GVP	Gross value of production
IBAMA	Brazilian Institute of the Environment
IBGE	Brazilian Institute of Geography and Statistics
ILK	Indigenous and local knowledge
INCRA	Brazilian National Institute for Agrarian Reform
INPE	Brazilian National Institute for Space Research
IPLCs	Indigenous peoples and local communities
MDA	Ministry of Agrarian Development
MPA	Ministry of Fisheries and Aquaculture
NGOs	Non-governmental Organizations
PNATER	National Policy of Technical Advisory and Extension Services for Family Agriculture and Agrarian Reform
PNPB	Brazil’s National Biodiesel Production and Use Program
PPCDAM	Brazil’s Action Plan for the Prevention and Control of Deforestation in the Legal Amazon
PROBOR	Brazilian Federal Government's National Program for the Development of Rubber
PRODES	Brazil’s Program to Calculate Deforestation in the Amazon
PRONAF	National Program for Strengthening Family Agriculture
PRONATER	National Program of Technical Advisory and Extension Services

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PT	Production trajectories
PULS	Proportion of used land to total owned land
RECA	Consortium and Densified Economic Reforestation Project**,** cooperative comprising more than 300 farming families in Rondônia, Brazil.
RIL	Reduced-impact logging
SEAF	Insurance for Family Farmers
ST&I	Science, Technology and Innovation

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KEY MESSAGES

Key agrarian production systems (crops, livestock, agroforestry, fisheries, forestry and tree plantations) are complex and vary in form and dominance across Amazonian countries. The different actors involved in both large-scale and family-based systems interact in multiple ways that vary from country to country, with important impacts on ecosystem services. These production systems are undergoing rapid change in the context of structural shifts in the economy and markets, varying policies, political contexts, accelerated urbanization, and climate change.

The trajectory of production systems in the Brazilian Amazon region over the past fifteen years, the analytical focus of this chapter, reflects both the divergent trajectories and the profoundly asymmetric treatment of smallholder and corporate production systems. Supportive pro-growth policies regarding land tenure, access to agricultural and other forms of credit and technical assistance, as well as the building of access infrastructure, have favored larger scale producers and agribusiness, especially livestock, soy cultivation and palm oil, while a large number of family producers have moved out of agriculture. Under previous governments targeted support to smallholders and for more diversified systems provided important if insufficient resources to the sector, but in recent years these programs have been downgraded and defunded. Path dependent policy, institutional supports, and market impacts favor opportunities for commercial production structures, which rely upon unequal access to resources, encourage deforestation, and unleash other environmental impacts on land and rivers that undermine environmental services and possibilities for more resilient, equitable and sustainable development pathways.

A prominent feature of Amazonian land use change has been the transfer, both legal and illegal, of public land for private use, facilitated by institutional support for research focused on agro-industrial crops, supportive credit lines, and infrastructure development. Expropriation of protected areas and lands of traditional peoples with collective histories and land claims have fueled social conflict and marginalized the region’s small producers, who grapple with erratic state policies, limited institutional support, and highly volatile markets. Expanding clandestine economies of multiple types threaten protected areas and spur forest degradation, especially affecting IPLCs whose lands may not be adequately demarcated, legally recognized and protected by government.

Increased tensions over land, and stagnant incomes, have squeezed rural families, leading to a large-scale move to cities and wage labor, but family-based agroforestry and agricultural systems have continued to persist and adapt to climate, increasing urbanization, and other challenges. Local livelihoods based on longstanding and diversified agroforestry and fisheries systems that bridge rural and urban networks remain vulnerable, despite promising examples of more sustainable production systems. The main challenge to food production and local livelihoods in Amazonia is to engage these local communities in initiatives to transition to more sustainable and diversified agriculture and resource use practices that can provide multiple sources of employment and household income, support regional development, and develop and sustain the functionality environmental services.

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ABSTRACT

Finding pathways to more sustainable agriculture and resource use from the currently unsustainable practices is among the most pressing challenges that Amazonian countries are currently facing. This chapter focuses on recent changes in the structure and types of agrarian production systems and identifies local responses to deal with the challenges and opportunities to engage in more sustainable production and extraction in Amazonia. Expansion of agribusiness enterprises now dominates in the region, enhanced by subsidies, institutional support, and other policies such as infrastructural development. These trends are associated with forest loss and degradation, pollution of waterways, and increased greenhouse gas emissions, and undermine an array of ecosystem services. The impacts of socio-economic and hydro-climatic changes on livelihoods, environments and biodiversity are very diverse and complex in each one of the Amazonian countries. An in-depth quantitative case study on the Brazilian Amazon focuses on changes among key agrarian production systems (agricultural crops, cattle raising, agroforestry, and tree plantations), through analysis of comparable agrarian census data from 1995, 2006, and 2017. The quantitative analysis is complemented by qualitative empirical discussions that provide insights into the changes and impacts of these different activities, how they are interlinked, and how they differ across Amazonian countries. The findings provide the basis for proposals in the final section of the chapter to document, test and promote adaptive, profitable, and more sustainable smallholder production and management systems in the context of increasing urbanization and climate change, to reduce deforestation and support local communities and economies.

*Keywords***:** Production trajectories, livelihoods, agriculture, cattle, agroforestry, fisheries, forest management, logging, land speculation, deforestation, climate change

GRAPHICAL ABSTRACT

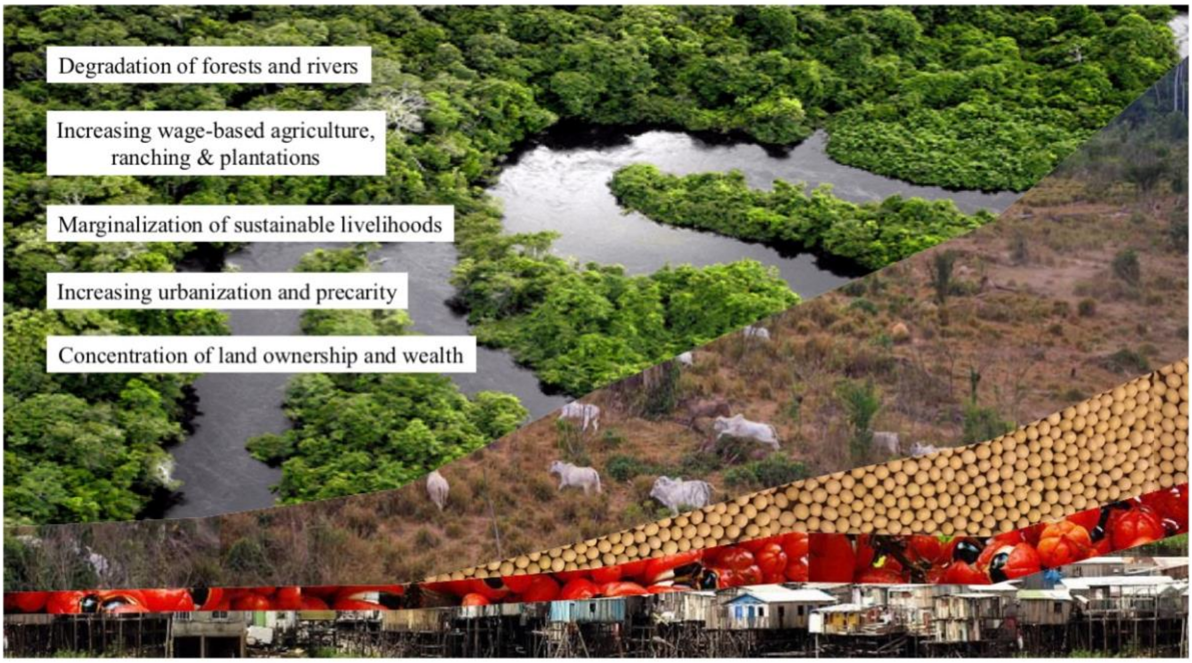

Figure 15.0: Finding pathways to more sustainable agriculture and resource use from the currently unsustainable practices is among the most pressing challenges facing Amazonian countries.

Chapter 15

1. INTRODUCTION: COMPLEX, DIVERSE AND CHANGING STRUCTURES OF PRODUCTION

Finding paths to transition agriculture and resource use from unsustainable to more sustainable practices is among the most pressing challenges that Amazonian countries are currently facing. This chapter focuses on recent rapid changes in the structure of systems of production by which specific types of actors in the Amazon region produce economic value (by combining labor, natural resources and technology in different systems). It also explores the implications of these changes for the environment and society of the region, and highlights local responses to deal with the challenges and opportunities to engage in more environmentally sustainable production and use of natural resources in the Amazon.

The discussion in this chapter is heavily weighted towards the Brazilian reality due to the rich data available, whose analysis reveals the rapid expansion of agribusiness over the past few decades in the Amazon region. Favored by pro-growth policies, the gross value of agricultural, livestock and extractive production (GVP) of the 556 municipalities that make up the Brazilian Amazon biome grew at constant 2019 prices, from US$ 5.1 billion in 1995 to US$ 16.1 billion in 2017, expanding over the two decades by a factor of three.[i] This growth was due largely to the rapid expansion of agribusiness production systems, which grew from 48% of the total GVP in 1995 to 80% in 2017. In contrast, the small farm sector collapsed from 52% to only 20% in the same time period (Figure 15.1a, Annex).

While many of these main trends hold across national borders, the chapter also points to specific distinctions in other Amazonian countries. In the territories of the different countries that share Amazonia, agro-industrial economies have been expanding rapidly in recent decades, reflected in the increased area of the soy-corn system, livestock, and palm oil. This dynamic growth, with important impacts to public lands, has been favored by pro-growth policies discussed in Chapters 14 and 17. The impact of socio-economic and hydro-climatic changes on livelihoods, environments and biodiversity are very diverse and complex in each one of the Amazonian countries, involving distinct actors within different modes and structures of production. Historically, both traditional, long-term and recently-arrived large-scale farmers and smallholders have interacted with one another and with the highly diverse,

[i] All values in US$ were corrected to 2019 prices and converted into US$ by the exchange rate of 12-31- 2019: R$ 4.0307/US$.

complex natural environment of the Amazon, mediated by different institutions and alternative technical resources as discussed in Chapter 14, thus shaping a plural, multifaceted reality.

This chapter's in-depth quantitative case study in the Brazilian Amazon focuses on changes among key agrarian production systems (agriculture, cattle raising, agroforestry, tree plantations), through analysis of agrarian census data from 1995, 2006, and 2017. It demonstrates the dynamic growth of agribusiness, which also entailed large-scale appropriation of about 13 million hectares of public land: from 86 million in the 1995 agricultural census to 99 million in 2017. Appropriated lands were transformed into pastures and agricultural areas in increasing proportions: in 1995, 37 million ha (43,0% of total owned land); and by 2017, 57.8 million ha (58.5%). (Figure 15.2a, Annex). This structural land use shift resulted in deforestation of 20.8 million hectares between 1995 and 2017. The process also resulted in critical reductions in labor demand (from 2.3 million workers in 1995, the number of jobs decreased to 1.7 million in 2017) and a massive out-migration of people from agrarian employment to jobs in infrastructure, extractive industries, and Amazon towns and cities.

The quantitative analysis of these changes in the Brazilian Amazon is complemented by qualitative empirical discussions that provide more in-depth insights into the changes and impacts of these different activities, and how they differ across Amazonian countries. The findings provide the basis for proposals, in the final section of the chapter, to document, test and promote adaptive, profitable and more sustainable production and management systems in the context of urbanization and climate change.[ii] The chapter ends with a series of recommendations and suggestions to transition to more sustainable production and resource use that can facilitate Amazonian countries achieving the Sustainable Development Goals (SDGs, see Chapter 26).

1.1. Production Systems and Trajectories in the Brazilian Amazon

The Brazilian Institute of Geography and Statistics (IBGE) published versions of the Agricultural and Livestock Censuses of 1995, 2006 and 2017 that included separate sets of

[ii] Although the chapter discusses the importance and relevance of local knowledge systems, it does not provide an analysis of the agriculture, husbandry, extractive, or other types of production by Indigenous groups; insights into these activities can be found in Chapters 10 and 25.

information about "family farming" and "non-family farming landholdings," as defined below. The availability of this unique data series for the Amazon region permits rigorous analysis of changes over time among most of the key sectors of the agrarian economy.[iii] Non-family landholdings are agribusiness establishments with a predominance of wage labor and with larger land plots; hence, they are medium and large-farms and rural companies. We refer to the first type of establishments as "smallholder" or "family-based," and the second type as "agribusiness" or "wage-based." The use of the term "family-based" regards the predominance of the *labor* involved, not necessarily *ownership,* as many large-scale agribusiness companies and ranching enterprises in the Amazon might be *family-owned,* but operated as a large-scale agribusiness enterprise relying predominantly on wage labor.[iv]

Within these two broad categories, the census data permit the comparison of six key types of actors and productive structures based on the social relations of production, three of them mainly "family-based" and three others "wage-based agribusiness" (Figure 15.1). The productive structures are further identified within each of the two broad categories as "agroforestry," "crops," "plantations," and "livestock" according to the activity that has a greater share in the value of total production and a greater importance in net income and investments than other types of crops and activities (following Costa, 2009b, 2021).

[iii] Brazil's agricultural censuses are the only source of data that cover the whole agrarian sector in the Amazon region (and for Brazil as a whole). Using internationally-established rules of data collection for such instruments, they provide the basis for Brazilian accounting systems at all levels. The data may include errors and omissions in certain variables, such as the likely under-counting of forest extraction (both timber and non-timber) and aquatic production. However, the data set has the virtue of permitting systematic comparison over time of more aggregated variables (such as gross production value, total land area, total land area used, and employment) among different kinds of enterprises over time.

[iv] In this chapter we use the terms "large-scale," "wage-based," "agribusiness," or "commercial" interchangeably to refer to these larger establishments, while referring to smaller-scale family systems as "smallholders," "small-scale," and "family-based".

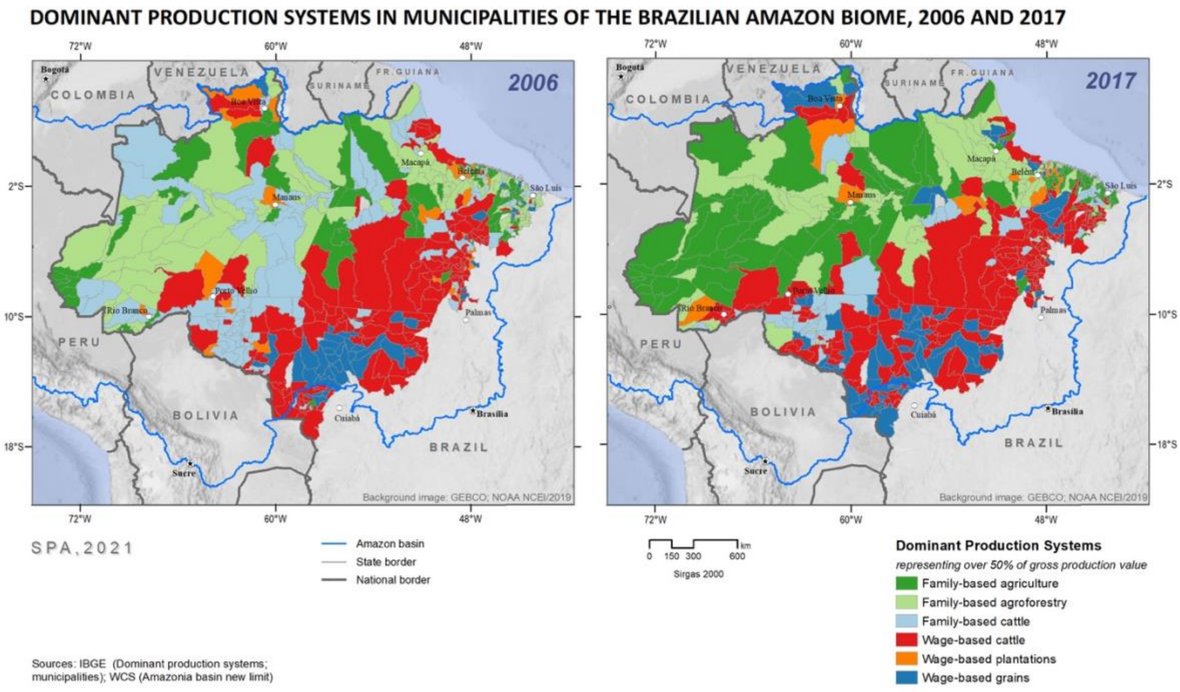

Figure 15.1: Dominant Production Systems in Municipalities of the Brazilian Amazon. Sources: IBGE and WCS.

This use of census data from Brazil and these typologies have some limitations, but nevertheless facilitate the analysis of data trends over time. These types are not necessarily “specialized,” since they may combine multiple activities, certainly with significantly greater diversity among the family-based types (Figure 15.3a, Annex): the great majority of smallholders make a living by combining agriculture, fishing, hunting, temporary labor, forest extraction, agroforestry, periodic urban migration, government welfare programs, and other activities. Forestry and fisheries were not included in the quantitative analysis of key production actors because comparable census data were not available for these as separate production systems; we have discussed fisheries, logging and forest management in terms of their dynamic relationships with other key sectors analyzed here. Importantly, all of the categories considered here had some type of livestock in their systems, and cattle pastures occupied the largest area of land use in the Brazilian Amazon, unlike other Amazonian countries such as Peru.

Family farming or *family agriculture* in Brazil has been defined (Law 11,326/2006), by four criteria: 1) size of holding: a maximum land area defined regionally; 2) reliance on mostly family labor; 3) income predominantly originating from farming activity; and 4) operated by the family. These criteria constitute the particular logic of family enterprises that includes diverse livelihood activities (agriculture, forestry, fishing, aquaculture, and both rural and urban off-farm employment) that meet their social, economic, and environmental needs. Increasingly, such households also rely on urban incomes, state transfers of various kinds, and remittances, in the creation of multi-sited, complex systems of household income formation.

Within the *"wage-based" agribusiness establishments*, those in which livestock dominated (in the same sense mentioned earlier) were grouped as "Wage-based Livestock" – basically cattle ranching or livestock enterprises. Commercial agricultural enterprises were classified as "Wage-based-Crops," usually forms of agro-industrial production, especially soy and corn, and those based on homogenous plantations of permanent crops or trees, as "Wage-based Plantations." These wage-based production structures had critical differences from family-based enterprises. In the 2017 census, on average only 8% of the workforce in all of the "family-based" structures were salaried, whereas in "wage-based" structures this proportion was 51%, with negligible variation among the respective types of production systems. With regard to property size, "family-based" enterprises held an average of 41.6 ha: "crops" 30.4 ha, "agroforestry" 34.2 ha and "livestock" 54.6 ha. The "wage based" agribusiness structures, on the other hand, had an average of 670.6 ha: "livestock" 655.5 ha, "plantation" 231.2 ha and "crops" 1,066.8 ha. Small farms maintained about 6% of their land in production, and produced a declining share over time of the value generated in rural production (Figure 15.4a, Annex).

In the analysis that follows, we focus on these six actor-structure types and their evolution over time, which we refer to as "productive, or technological trajectories," or "PTs" (Costa, 2008; 2009a; 2009b, 2016, 2021). These concurrent trajectories (Arthur, 1994; Costa, 2013) in land use, labor absorption, income generated, institutional support, and other factors showed distinctive trends in the Brazilian Agricultural Censuses data from 1995, 2006 and 2017 (Costa, 2021) and provide empirical evidence of the dramatic and significant agrarian shifts underway in the Amazon region, whose implications are explored to suggest concrete recommendations for future policies.

2. KEY FAMILY-BASED AND AGRIBUSINESS SECTORS IN RURAL DYNAMICS IN THE AMAZON

2.1. Family-based Agroforestry and Fisheries

Family-based agroforestry and fisheries systems constitute the oldest and most diverse livelihood groups in the Amazon region. They deserve extensive discussion here due to their deep historical roots, strong connection to Amazonian biodiverse resources and habitats, and their unrealized potential as a basis for more sustainable development strategies in the region. People in the Amazon have long relied on agroforestry, hunting and fishing as sources of food and livelihoods (see Chapters 8 and 9). However, large scale exploitation of these sources started to emerge during the second half of the 18th century, expanded during the rubber boom, and rubber tappers were joined by other groups of migrants coming from other regions of Amazonian countries in the second half of the 19th century and the first half of the following century. Some migrated into rubber estates while others supplied foodstuffs to urban centers (Weinstein, 1983; de Castro, 2013). With the rubber crisis triggered by plantations in Malaysia that took over the world market in the early 20th century, many rubber tappers released from bankrupt *seringais* (rubber estates) throughout Amazonia joined the ranks of small producers, settling along the region's rivers (Costa, 2019; Nugent, 1993; Nugent, 2002), and dedicating themselves to complex livelihood systems based on management of the biome's natural resources.

These "historical peasants" (Costa, 2019; Nugent, 1993) preserved a very special condition: they were heirs to Indigenous and local knowledge (ILK), and their systems of extraction, agriculture, production, management, and conservation were interconnected, complex and fundamental to both their well-being and the sustainable provision of biological resources, as well as more general environmental services (Caballero-Serrano et al., 2018; Sears et al., 2018). The multiple dimensions and functions of their forest product knowledge have been widely documented (Vogt et al., 2016; Reyes-Garcia et al., 2007). Both Indigenous and non-Indigenous Amazonians have generated a great diversity of knowledge and practices by constantly innovating and adapting their extraction, conservation and production systems and portfolios of diversified livelihoods in response to specific socio-economic and environmental changes (Reyes-Garcia et al., 2007; Vogt et al., 2016). Their systems integrate both traditional and modern knowledge to manage, produce and conserve plants, animals (including fish) and other biological resources (Thomas et al., 2017, Sears et al., 2007). Their flexibility, resilience, and linkages among extraction, conservation and production, have greatly facilitated the process of production of valuable terrestrial and aquatic resources and domestication of landscapes, and the use and management of a range of semi-domesticated species (Coomes et al., 2020; Franco et al., 2021; Levis, 2018; Levis et al., 2018; Maezumi et al., 2018; Vogt et al., 2016). The flexibility and complexity of linked systems highlight the diversity found among family-based agroforestry and fisheries production systems explored here.

In Amazonia, traditional forest extractivism – the collection of non-timber and other kinds of forest products – has been managed sustainably by Indigenous peoples and local communities (IPLCs) for generations (Almeida et al., 2016; Thomas et al., 2017).[v] Inhabitants of extractive communities in the Brazilian Amazon occupy over 8 million hectares of public forests established as sustainable use reserves, depending for their livelihoods on extraction of marketed non-timber forest products, including those for global export such as Brazil nuts (*Bertholletia excelsa*), *açai* (*Euterpe oleracea*), and rubber (*Hevea brasiliensis),* as well as products for more regional markets such as oil from *copaiba* (*Euterpe oleracea* and *Euterpre precatoria), andiroba* (*Carapa guianensis),* and *buriti* (*Mauritius flexuosa*) (Valentin and Garrett, 2015). Smallholders' understanding of the impacts of extraction allow them to manage yields and avoid the risks of over-harvesting Brazil nuts (Guariguata et al., 2017), over-tapping of rubber trees (Almeida et al., 2016) and excessive hunting of game species (Ponta et al., 2019). Women play a prominent role in forest extractivism especially in the Brazil nut economy (Lazarin, 2002; Shanley et al., 2008; Stoian, 2005), which accounted for nearly half of Bolivia's documented forest-related exports in 2005 and provided an estimated 22,000 jobs – including women working in urban processing of nuts – in the Northern Pando region in 2001 (Cronkleton and Pacheco, 2010). Other important forest products include fruits of *Mauritia flexuosa* (Peru), babassu nuts (*Attalea speciosa*) and many other tree fruits that find a niche in regional markets, and well as leaves of several palm species for thatching, artisanal and household use (*Geonoma* spp. In Bolivia) and timber (Brondizio, 2008; Cronkleton and Larson 2014; Pinedo-Vasquez and Sears, 2011; Porro, 2019; Sears et al., 2007).

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[v] In the development literature, the term extraction largely has been used to describe destructive economic systems that use up or destroy natural resources, and that have exclusionary institutional structures benefiting a small coterie; the discussion here focuses only on forest product extraction (Acemoglu and Robinson, 2012; Svampa, 2019).

Within Amazonian communities, men and women have adopted multiple strategies to manage forests, generate productive house gardens and farmlands, and produce crops for their own food consumption and for market, drawing on deep cultural traditions as they adapt to changing conditions. Women's important productive work within Amazonian family enterprises is often invisible due to their focus on family subsistence, yet women often manage homegardens with fruits, medicinal plants, and small animals, as well as taking care of water provision and quality (Grist, 1999; Mello, 2014; Mello and Schmink, 2017; Mourão, 2008; Murrieta and WinklerPrins, 2003; Schmink and Gómez-Garcia, 2015; WinklerPrins and Oliveira, 2010). They also labor in family crop fields, manage livestock and agroforestry systems, and collect and process non-timber forest products and fish; in effect, unpaid family labor constitutes a key household subsidy to family production systems in the Amazon (Hecht, 2007).

Diverse and complex livelihood strategies (drawing upon fisheries and a variety of forestry and agroforestry production and extraction) provide family-based enterprises with greater resilience to economic volatility and climate change than smallholders whose livelihoods are limited to agricultural production alone (Brondizio and Moran, 2008; de Castro, 2009; Nugent and Harris, 2004; Nugent, 1993; Nugent, 2002; Porro et al. 2012).

A highlight among agroforestry products is *açaí*, managed in the floodplain and planted on dry land (Brondizio, 2008; Costa and Costa, 2007). In 2017, 478,000 tons, or 74% of the total *açaí* produced in the Brazilian Amazon came from agroforestry. The values associated with such production increased substantially between censuses, from US$ 0.16 billion in 2006 to US$ 0.39 billion in 2017. In 2017, *açaí* represented no less than 35% of the value of the total production by Family-based-Agroforestry enterprises. This growth in production figures probably reflects the better monitoring and commercial nature of *açaí* compared with the myriad of other products that flow through Amazonian circuits, varying throughout the basin (Padoch et al., 2008; Bolfe and Batistella, 2011; Blinn et al., 2013; Vogt et al., 2015, Buck et al., 2020).

Associated with the production of *açaí* is an urban, industrial and service economy, producing and distributing pulp, processed foods, and heart of palm, that has grown rapidly: the added value of pulp production grew by 7.4% per year, reaching US$ 0.72 billion in 2011 (US$ 0.65 billion of pulp and US$ 0.07 billion of heart of palm). Employment reached 125,200 jobs, 102,000 rural and 23,200 urban, industrial, and commercial jobs (Costa, 2020b). This indicates that more diversified livelihoods drawing upon complex engagements with fisheries and agroforestry production and extraction, also lead to greater synergies with activities upstream and downstream in the production chain, increasing the dynamism of local markets and generating greater opportunities for employment in the region.

These complex agroforestry systems are prevalent through Amazonian lowlands as well as the "Andean Amazon," reflecting the long history of extensive regional settlement history in pre-Columbian times, and the adaptation and modification of these within the contexts of relatively recent colonization in the 1970s and 1980s. These systems also reflect the different logics of small and large farmers in a context of rapid land use change (Carson et al., 2016; Jacobi et al., 2015; Balée and Erickson, 2006; Erickson, 2006). Peruvian small farm agroforestry systems have been the focus of extensive research, in part because of the smallholder-focused history of much of Peruvian Amazon's development politics, the importance of the region as an "escape valve" for economic constraints in the highlands, and periodic stimulation of colonization programs where smallholders have remained an important constituency in peri-urban, rural and urban labor systems (Padoch et al., 2008; Putzel et al., 2013; Sears, 2016; Sears et al., 2018; see also Chapter 14). As in Bolivia and Colombia, peasants in this region were also subject to coca interdiction, which stimulated research on alternative cropping systems, and larger attempts at subsidizing the development of alternative production systems, largely for political but also ecological reasons (Angrist and Kugler, 2008; Antolinez, 2020; Dávalos, 2018; Huezo, 2019). As discussed in Chapter 14, the historical dynamics of coca were rooted in agroforestry systems for millennia, and in the face of precarious prices, transportation difficulties, and other kinds of vulnerabilities, coca has remained a durable smallholder commodity working through traditional, modern as well as criminal circuits, especially in the absence of other economic opportunities.

Agroforestry systems of the upper Amazon remain integrated into multiple urban and rural networks, and typically include global niche products (coca, cacao and coffee), regional and national products, and increasingly other kinds of medicinals, such as *ayahuasca* (*Banisteriopsis caapi*). However, recent transportation networks and the expansion of the hydrocarbon economies are destabilizing these systems through problems related to oil spills, expansion of access roads, other forms of pollutions such as those associated with gas flaring, and siphoning away of labor and also, in some cases, herbicide drift from coca eradication efforts (Bass et al., 2010; Brain and Solomon, 2009; Finer et al., 2008; Huezo, 2019; Lyall, 2018; Sherret, 2005; Suarez et al., 2009; Valdivia, 2015; Vargas et al., 2020).

Fisheries are a core component of these diverse agroforestry systems, providing a major source of livelihoods as well as nutrition for many people inhabiting riverine communities – including urbanized ones - throughout the Amazon (Barthem and Goulding, 2007; Begossi et al., 2019; Duponchelle et al., 2021).

Fisheries in the Amazon are multispecies, with around 40-50 species included in the catch in individual regions. However, while a wide range of species are caught, less than 10 species account for most of the local commercial catch. The composition of the catch and the importance of fisheries to local populations varies throughout the basin, associated with variations in water quality of the different sub-basins (Goulding et al., 2018). Three main types of rivers are distinguished: sediment-rich white-water rivers that originate in the Andes; and clear and black water rivers that have their origins in the older highland regions to the North and South of the basin. Amazon fisheries are closely associated with the highly productive white-water rivers with their extensive floodplains, while clear and black water rivers are far less productive (Junk, 1984).

Amazon fisheries are highly seasonal, and fishing activity is related to the seasonal rise and fall of the Amazon River (Junk et al., 1989). Along the main stem of the Amazon, high water occurs between May and June and low water in October-November. Three main groups of fish can be distinguished. Long distance migratory catfish, several of which travel across the basin, spawn in Andean headwaters and pass their juvenile phase in the Amazon estuary (Barthem and Goulding, 1997; Duponchelle et al., 2021). A second group of middle-distance migratory species, of which the *Characidae* are the most important, move in and out of the floodplain over their life cycle and feeding in flooded forests during the highwater season. The third group consists of sedentary species, such as the *pirarucu* (*Arapaima* spp.) that spend their entire lifecycle in floodplain lakes (Barthem and Goulding, 2007).

Several types of fisheries sub-sectors, often overlapping, exist in the Amazon, from those practiced by family groups in small riverside communities and urban areas to those that are primarily large commercial enterprises centered around urban areas. Fishers located in rural communities might both subsist on fish and supply boats (or *lanchas*) with fish that are then transported to the city, processed and sold either wholesale or directly to consumers in regional markets. Long-term information on the total amount of fish caught, sold and consumed in the Amazon is largely unavailable, reflecting the *invisibility* of fisheries and lack of large-scale governmental support. Community-led grassroots movements sought recognition by the government for their rights to local lake fisheries developed in the 1980s. In the state of Amazonas, Brazil, these initiatives were initially fostered by the pastoral action of the Catholic Church and came to constitute the so-called "Lakes Preservation Movement," headed by the CPT (Pastoral Land Commission) (Benatti et al., 2003; Pereira, 2004). This social movement served as a sociopolitical basis for the development of public policies recognizing decentralized and collaborative community-based management systems based on local fisheries agreements and management of key fish species such as Arapaima spp. (see below; Campos-Silva et al., 2019; Duponchelle et al., 2021; Oviedo and Bursztyn, 2017).

The diversity and resilience of family-based agroforestry and fisheries systems discussed here make them a key economic sector for the region's past, present and future, far beyond their importance in the statistics of production systems for the region (Franco et al. 2021). These statistics, however, are per se eloquent: rural agroforestry establishments in the Brazilian Amazon numbered 125,000 in 1995, and increased to 186,000 in 2017, spread over a wide area of the region (see Map 15.1). Their contributions to the economy have grown significantly, on average, from 1995 to 2017, at 4.3% annually, increasing from US$0.6 billion to US$1.1 billion (Figure 15.1a, Annex). The number of people employed in 2017, in turn, remained at around 400,000 people, 92% of them family workers.

We have discussed agroforestry systems in greater detail than some of the other production systems discussed below, due to their historical and cross-basin importance for small producers, their intimate links with the region's diverse habitats and biological resources, their demonstrated persistence, flexibility and adaptability in response to changing conditions, and their importance for future sustainability initiatives that benefit local peoples and local economies in Amazonia.

2.2. Family-based crop systems in the Amazon

In addition to historical peasantries and their long-term forged technical capacities, other groups of immigrant smallholders arrived in the Amazon region both before and after the rubber economy boom, from other regions of the Amazonian countries and from outside the region. These groups typically developed productive systems with a greater focus on agriculture, but their practices evolved over time in response to their experience in the Amazon environment.

Japanese migrant colonies are found in Brazil and Bolivia. In Brazil, beginning in the 1920s Japanese farmers settled in Tomé-Açu, Pará, where they introduced new crops such as jute and black pepper (Homma, 2007). Over time, their systems shifted to increasingly diversified fruit crop systems that mimicked natural succession, generating 300 polyculture combinations that used 70 different species (Serrão and Homma, 1993; Subler 1993; Subler and Uhl, 1990; Yamada, 1999).

Migrant farmers in northeastern Pará state, and agricultural colonists settled along the Trans Amazon Highway and in Rondônia state in the 1970s, also adapted their cropping systems over time, first focusing on annual crops (especially rice) using shifting cultivation methods, which led to rapid exhaustion of the soil; farmers responded to falling productivity by diversifying their production systems through intercropping of cacao or coffee with other perennial crops, including fruits (*açai,* mango, pineapple, tangerines and other fruits) and timber trees (mahogany, cedar, pines, and other local species) (Costa, 2012b: 171; Smith, 1978; Smith et al., 1996).

A number of federal agricultural policies and programs were created in the 1990s specifically to support smallholder farmers, forest extractivists, and fishers, under the purview of the Ministry of Agrarian Development (MDA) which was established to oversee land reform in Brazil and promote sustainable practices (Niederle, 2019). The National Program for Strengthening Family Agriculture (PRONAF) provides subsidized rural credit, linked to state Rural Technical Assistance and Rural Extension agencies. The Insurance for Family Farmers (SEAF) program provides insurance to farmer who adopt certain technologies that conserve natural resources on the farm and reduce their vulnerability to climatic fluctuations. In 2010, the National Policy of Technical Advisory and Extension Services for Family Agriculture and Agrarian Reform (PNATER) was established, along with the National Program of Technical Advisory and Extension Services (PRONATER) (Valentin and Garrett, 2015). However, in 2019 the MDA was demoted to the status of a Secretariat of Family Agriculture and Cooperativism, under the agribusiness-oriented Ministry of Agriculture, and many policies and programs were weakened or eliminated as resources and staff to support them were drastically reduced (Niederle, 2019). Family farms lacked access to many other forms of credit available to large scale farmers.

A technical focus on commercial crop specialization by credit, extension and research agencies in the Brazilian Amazon induced many family farmers there to concentrate on production of an ever-smaller number of products, especially commercial products. In fact, by 1995, nine products made up 90% of the production value of these Brazilian small farmers: cassava was the main product and the only regionally exported commodity. By 2017, 93% of family-based production focused on 5 products (cassava, soybeans, corn, sugar cane and pineapple) (see Figure 15.5a, Annex), crops that have to compete with larger growers and for which much more generous credit lines were available. Cassava remains the dominant commercial product in many small farms, largely serving regional markets.

The Family-based-Crops sector in the Brazilian Amazon became substantially smaller from 1995 to 2017, in terms of number of establishments (from 338 to 179 thousand), amount of owned (from 9.33 to 5.44 million ha) and used land (from 3.99 to 2.96 million ha) and workers (from 1.18 to 0.39 million) (Table Annex-15.1a,b; Figures 15.2 and 15.3). Most of its establishments migrated with their land resources into Family-based livestock and agroforestry trajectories: respectively 2.5 and 0.2 million ha in all period. While part of its released workers went as well to the other Family-based trajectories, about 0.58 million went to urban sectors or Wage-based trajectories (0.54 between 1995 and 2006 and 0.4 in the following inter censuses interval). At the end of this period, GVP of family-base-crops had shifted from 31% of total GVP in 1995 to one fifth of its earlier value in 2017.

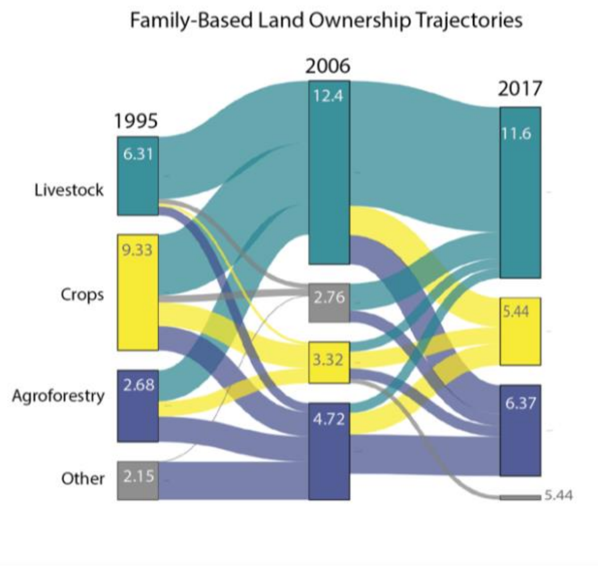

Figure 15.2: Shifts in land ownership in family-based sectors, 1995-2017 (millions of hectares). Source: IBGE, Agricultural Census 1995, 2006 and 2017.

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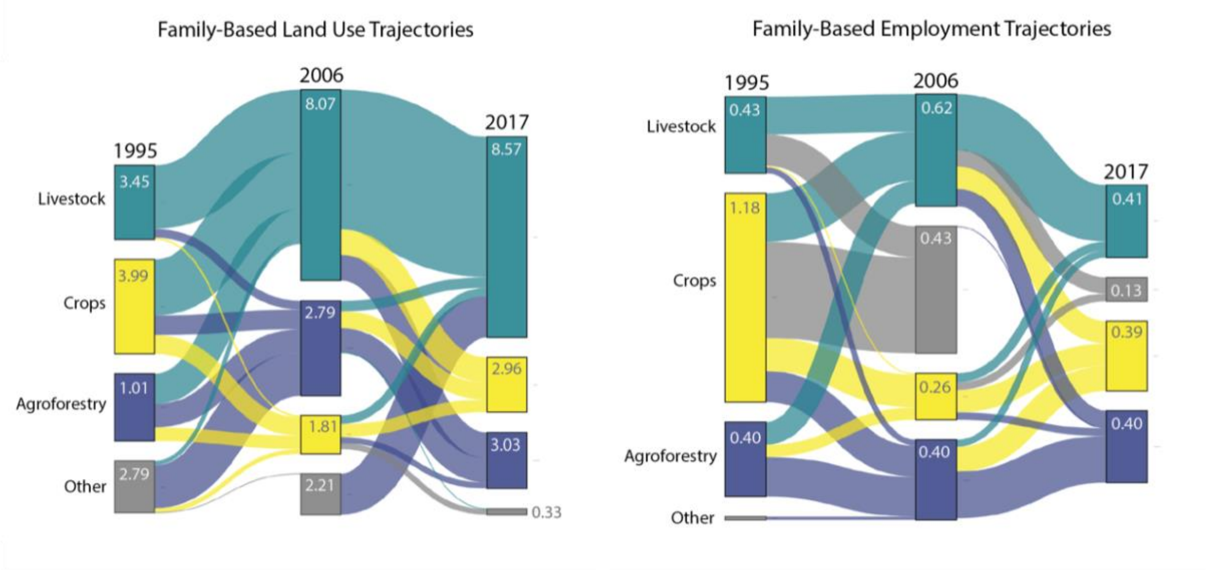

Figure 15.3: Shifts in land use and employment among family-based production trajectories, 1995-2017 (millions). Source: IBGE, Agricultural Census 1995, 2006 and 2017.

2.3. Family-based enterprises focused on livestock

Livestock ranching, introduced in the colonial period, was often dominated by ecclesiastic settlements in the 17th and 18th centuries, and has been a widespread activity in the Amazon ever since, although until the post-war period, the production was based largely on natural grasslands. Practiced in large estates since the eighteenth century in Marajó (Ximenes, 1997), it was also present, by the nineteenth century, as part of productive systems of small producers in the lower and middle Amazon in Brazil (Folhes, 2018; Harris, 1998), where it persists today using floodplains and natural grasslands (Costa and Inhetvin, 2013). Alongside the large cattle ranches that developed since the 1960s with the subsidies, land transfers, new pasture technologies, and credit policies implemented by the military governments and all subsequent governments, ranching also expanded throughout Amazonia with road construction from the 1960s onward (Hecht, 1993; Costa, 2000). Since the 1990s, when the *Fundo Constitucional do Norte* credit program was implemented in Brazil to support small livestock, beef and milk production, associated with different smallholders, this land use has continued to expand with preferential credit lines at all scales of production, and is the dominant land use throughout the basin on natural and planted pastures; in Brazil, family-based agriculture has shifted over time to cattle systems due to its low labor demand and other advantages discussed below (Veiga and Tourrand, 2000; Salisbury and Schmink, 2007).

Brazil stands out among Amazonian countries due to the strong dominance of livestock systems in the region. Surveys conducted by the Brazilian National Institute of Space Research (INPE) and the Brazilian Agricultural Research Corporation (EMBRAPA) in Brazil (INPE, 2016) pointed to 37.7 million hectares of productive pastures (albeit at low stocking rates for the most part), out of a total of 48.4 million hectares of pastures. This is compatible with the agricultural census of 2017, which identified 45.4 million hectares of pasture in the Amazonian biome region. The cattle herd in the region has almost doubled from 28.3 million head in 2006 to 52 million in 2017 (IBGE, 2017). Of this herd, 5% were held by Family-based-Crop systems, 6% in Family-based-Agroforestry systems; 2% in plantations, and 15% in commercial agribusiness enterprises, while extensive commercial livestock ranching accounted for the largest proportion: 48%. Smallholder livestock raising, the subject of this section, was responsible for 24% of the cattle herd (Figure 15.4).

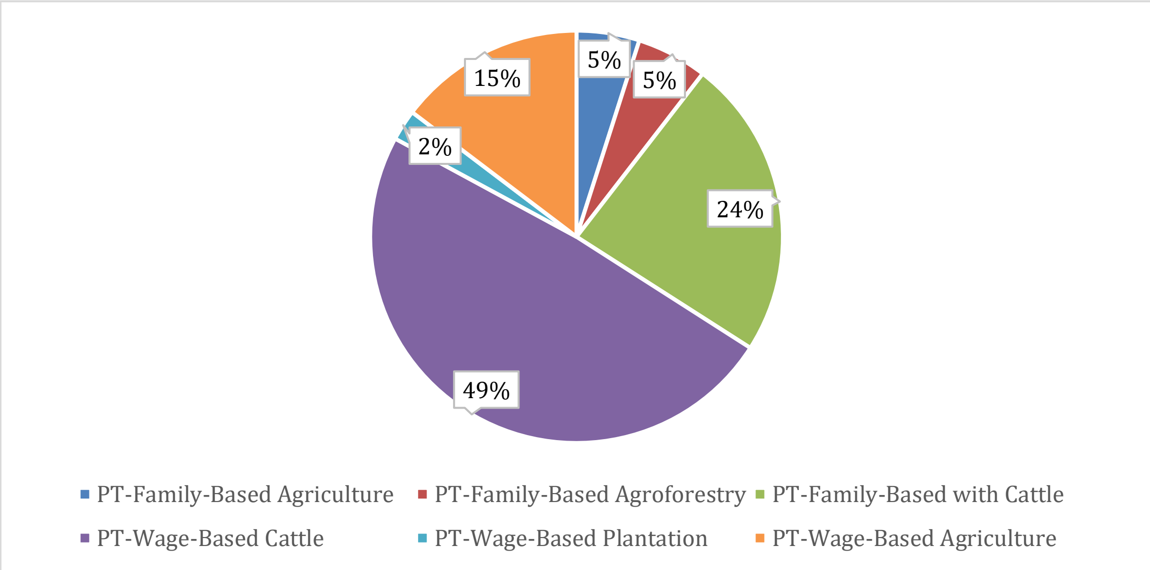

Figure 15.4: Distribution of cattle in the Amazon biome region in 2017 (% of total). Source: IBGE, Agricultural Censuses 2017.

Smallholder cattle establishments stand out as an expanding group of farmers (128,000 in 1995, 257,100 in 2006 and 198,800 in 2017), whose small farm production systems depend increasingly on livestock, mainly beef, whose share of total production value in family-based livestock systems went from 32% in 2006 to 55% in 2017. Dairy cattle, in turn, increased from 16% to 20% in the same period. Altogether, the products of cattle raising (beef and dairy) grew from 48% to 77% of the value of this small farm production sector during the same period, making it fundamentally a livestock sector, reflecting labor characteristics and credit availability.

Family-based agriculture underwent a significant shift from agriculture into livestock, as total land in livestock in 2017 reached 11.6 million hectares. Among smallholders, it was the sector that grew fastest, 4.8% annually from 1995 to 2017. The production value basically tripled over these decades, from US$ 0.67 billion to US$ 1.86 billion, even though the stocking rate, about one animal unit/hectare, has remained static for decades. The labor deployment involved reduced slightly, from 430,000 in 1995 to 410,000 in 2017, 92% of which were family laborers as opposed to salaried workers. The territorial expansion and persistence of smallholder cattle ranching must be understood in the context of growing demand for beef, a decline in peasant agriculture, relative stagnation in the number of people engaged in agroforestry and fisheries, and increase in both land area and employment in wage-based activities, both rural and urban. Ranching may continue to increase among the remaining smallholders who are unable to sustain themselves in competitive agricultural commodity chains, whether through scaling-up agricultural production or investing in more profitable diversified farming systems, agroforestry, extraction, or fishery related activities.

Family-based-Livestock enterprises are much more diversified production systems than Wage-based Livestock, and more oriented towards self-consumption and local and national economies. The systems differ significantly in terms of the average sizes of properties, pastures and herds, respectively, with a density of 1.53 and 1.06 cattle heads per hectare, respectively. In Wage-based-Livestock, close to 3,000 of the 75,000 establishments have herds over 1,000 heads.

Cattle ranching remains an appealing land use in more remote regions of the Amazon, where land is abundant and cheap relative to labor and capital, and where overland transport and marketing of crops is economically inviable. Even at low stocking rates and within more established agricultural regions, ranching is also extremely persistent. It is perceived as having lifestyle and social advantages over cropping, and much lower expenditures, which is beneficial to debt- and risk averse peasants who can use livestock as a highly mobile "savings account" to be sold for reliable prices when needed (Garrett et al., 2017; Valentin and Garrett, 2015). It also has low labor demands, and stable prices, making it useful in the portfolio strategy of households, and a part of the more general allure of this sector for large holders as well. Demand for beef is strong in Brazil, unlike Peru where beef consumption isn't as widely consumed, and where poultry consumption is growing exponentially (Heilpern et al., 2021; Kovalskys et al., 2019).

2.4. Large-scale agribusiness livestock enterprises

Commercial ranching has grown rapidly: the number of establishments more than doubled in the Brazilian Amazon from 1995-2017, while their GVP increased more than five-fold, as shown in Table 15.1.

Table 15.1: Growth in commercial ranching establishments in the Brazilian Amazon, 1995-2017. Source: Brazil, Agricultural Census 1995, 2006, 2017.

	Year			Rate of Growth		
	1995	2006	2017	1995-2006	2006-2017	1995-2017
Number of Establishments	31,900	50,300	75,000	4.20%	3.70%	4.00%
Gross Production Value (billions)	1.3	2.1	7.5	4.80%	12%	8.40%

Indeed, there is evidence in the censuses that the intensity of land use (monetary productivity of used land equivalent to total GVP, divided by total used land area) in Wage-based Livestock has grown almost four-fold: from US$ 67.2/ha in 1995, to US$ 244.4/ha in 2017 (Figure 15.6a, Annex). However, cattle ranches remain among the lowest of all production systems in land use intensity, since their profitability depends on extensive land use and grows with the scale of that use (Costa, 2016). Land use intensity grows with the potential to capture various institutional rents, land speculation and money laundering.

The history of large-scale cattle ranching presents opportunities for speculation during intense periods of land grabbing, discussed in more detail in Chapter 14. Between 1995 and 2006, 16 million hectares in Brazilian Amazonia were transferred from public to private use: 4.8 million to large plantations, 2.4 million to agricultural enterprises, and 8.8 million to family-based enterprises, through agrarian reform programs (Costa and Fernandes, 2016). Cattle enterprises bought or appropriated forested land at a relatively low market price, and, after "producing" land without forest (Costa, 2012a), transferred it at the much higher price of land covered by pasture (Figure 15.7a, Annex), operations that may have yielded US$ 4.3 billion per year in profit, equivalent to 114% of their 2006 net income.

Between 1995 and 2006, establishments focused on large-scale livestock gained about 16 million ha of land that shifted away from large-scale agriculture (9.8 million ha) and from Family-based trajectories or public land (6.2 million). Then, between 2006 and 2017, the areas owned by establishments focused on crops increased by 12.5 million hectares, transferred from establishments focused on livestock (Figure 15.5). This operation may have yielded a total of US$ 7.9 billion, or US$ 0.8 billion per year during this phase, equivalent to 21% of net income for the Wage-based livestock sector in 2017. This indicates the centrality of wage-based livestock to the process of expanding agricultural frontiers, forest clearing, land speculation, privatization of public lands, and displacement of alternative and more socio-ecologically sustainable livelihoods. Soil nutrient decline and pasture invasion by brush (the widespread "*Juquira*") contribute to the pressure to clear and burn more native forest or secondary growth in order to use the ash from burning as a kind of fertilizer for crops, while the need for timber extraction as a form of financing also stimulates further clearing.

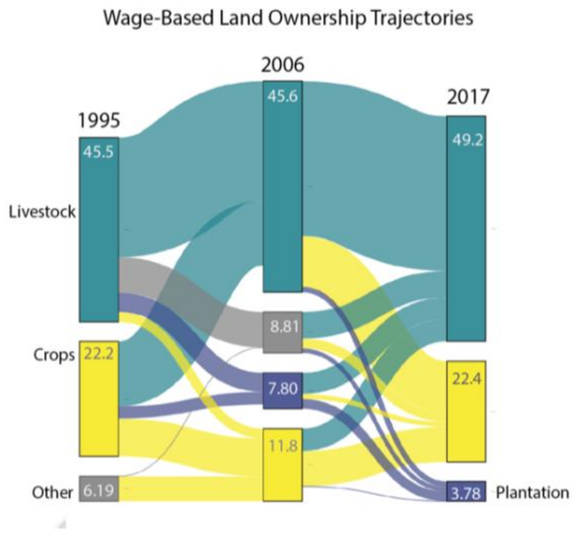

Figure 15.5: Shifts in land ownership in wage-based sectors, 1995-2017 (millions of hectares). Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

Ranching establishments are heavily involved in timber extraction to finance pasture production. Timber production occurs through "logging" or "forest management." "Logging" refers to the removal of timber from the forest, whether or not the removal is sustainable, low-impact or legal. "Forest management" in Amazonia refers to harvesting timber in such a way that the system can continue to produce indefinitely while forest cover remains intact, although empirical evidence suggests this is often not the likely outcome in practice. This requires applying reduced-impact logging (RIL) practices to minimize collateral damage from the harvest operations, while harvesting only a limited percentage of the stock of each species so that the tree populations that remain can reproduce and recover. Plots of forest in a cycle remain undisturbed for a sufficient number of years to theoretically allow harvestable stocks to recover by the end of the cycle. Brazil, for example, has a series of regulations intended to make government-licensed forest management sustainable (Brazil, CONAMA, 2009). Unfortunately, most timber comes from predatory sources, and, with some exceptions, most licensed management projects are clearly unsustainable (Brancalion et al., 2018; Condé et al., 2019; Fearnside, 2018, 2020).

2.5. Wage-based cropping production

The large commercial agriculture sector – dominated in the Brazilian Amazon by the soy-corn agro-industrial annual cropping system – responds to both comestible and industrial product demand in national economies, but remains largely export-oriented; about 80% of soy production is oriented to animal feed. In Brazil, its expansion would not have been possible without decades of state-sponsored research led by plant geneticists and agronomists from EMBRAPA, which led to the development of so-called miracle soy cultivars able to tolerate the acidic soils, uniform day length and aluminum levels in the soils (Hecht and Mann, 2008; Oliveira, 2013). EMBRAPA'S research on biological nitrogen fixation by plants allowed the elimination of nitrogenated fertilizers in soy cultivation, reducing the costs of production, to permit Brazilian soy to compete on the international market (Dobereiner, 1990).

The government promoted the expansion and modernization of Brazilian agriculture through supportive research, monetary and agricultural policies, providing credit to farmers at below market interest rates, and financing building of roads and waterways, logistical centers, ports, storage infrastructure, and equipment (Garrett and Rausch, 2015). In the Amazon, the private sector, especially seed companies, plays a critical role in providing credit, especially in the context of informal or contested land tenure claims (Garrett et al., 2013a) but more recently in the context of the shift from public credits to private financing as discussed in Chapter 14.

In 1995, soybeans already represented 43% of Brazil's production value of commercial agriculture. Along with soy, its rotational crop, corn, grew in value, from 4.4% in 1995, to 13.6% in 2017. Strongly determined by this composition, the growth of large-scale cropping as a whole reached 9.2% annually over the entire period, raising the Amazonian GVP from US$

1.2 billion in 1995 to 8.1 billion in 2017 (Figure 15.8a), and dominating Brazil's foreign exchange.

With the rapid growth of large commercial cropping, the demand for deforested land reached 13.1 million hectares in 2017. To cover this need, 7.2 million hectares of deforested land from extensive cattle, and 0.7 million from Commercial-Plantations shifted to Commercial-Crops in addition to 5.2 million hectares already in operation (Figure 15.6).

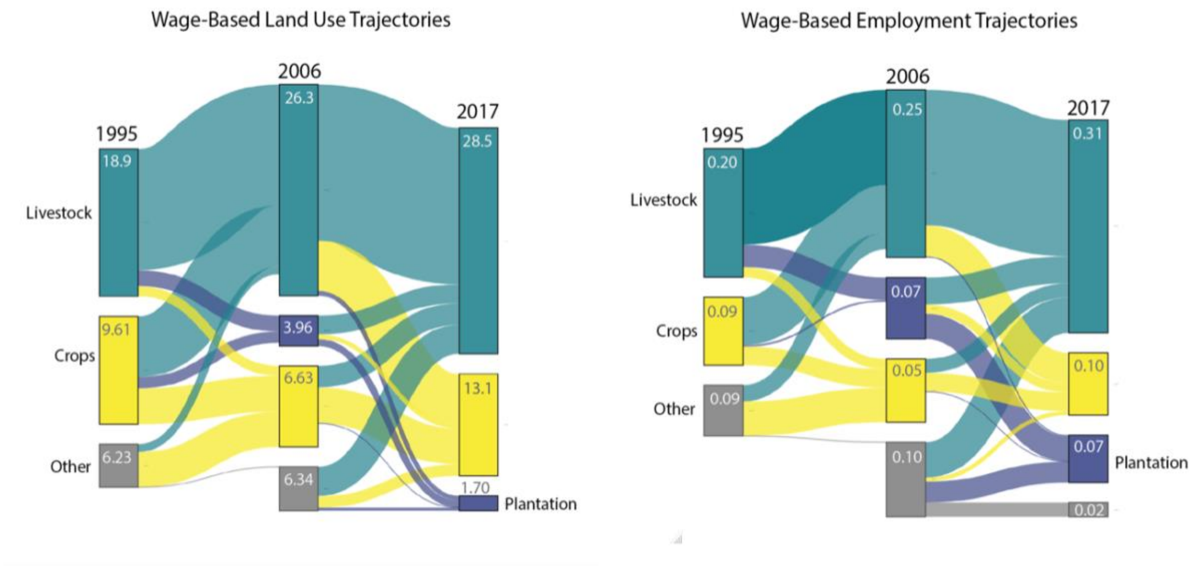

Figure 15.6: Shifts in land use and employment in wage-based sectors, 1995-2017 (millions of hectares). Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

At the end of the period, the total land stock of Wage-based-Crops was practically the same as at the beginning: 22.4 million hectares (Figure 15.5). However, there was a fundamental change: the proportion of the area deforested in relation to the total area of Wage-based-Crops, despite the soy moratorium (Box 15.5), went from 43% in 1995, to and 58% in 2017 - practically the same proportions as Wage-based-Livestock (compare Figure 15.5 to Figure 15.6).

Large-scale cropping systems, particularly soy and oilseed production that compete globally, require high levels of capital inputs and mechanization to achieve economies of scale, the best available seed technologies and chemical inputs. Soy remains the most lucrative of the commercial annuals due to large and increasing demand globally and substantial government subsidies, particularly in Brazil (Oliveira, 2016). Double-cropping corn with soy production is increasing, due to demand for animal feed in Asia, Europe and the Middle East. Meat demand is growing in Andean regions, which import from the Amazon through the new Transoceanic highway in the Western Amazon. In the Brazilian Amazon, new state aquaculture initiatives are also bolstering clusters of cropping production—largely soy for fish feed.

The evolution of soy in the Brazilian Amazon has led to a complex land possession process. At first, the entry of soy and its high level of mechanization reduced, in absolute terms, the need for land from soy cultivation. Thus, deforested lands between 1995-2006 registered large shifts of 8.8 million ha from soy to cattle, and 1.6 million to large plantations, leaving a stock of 5.2 million ha. At the same time, however, the technical and logistical requirements of the crop led to a demand for land with special characteristics - areas that are flat (slope less than 12%), with well-drained soils – in specific locations, near major highways and relevant supply chain infrastructure and supporting services (Garrett et al., 2013b). Hence, soy enterprises also registered significant acquisitions of 7.2 million hectares between 2006-2017. These either came from smallholders, associated with land conflicts and local resistance, typified by the highly publicized soy producing regions of Santarém (Steward, 2007), or from previously formed stock of deforested areas by wage-based livestock, or deforestation of new areas (Figure 15.6).

Although soy occupies only a small proportion of the agricultural area in the Brazilian Amazon compared to cattle, it has been very important for regional development trajectories and has complex interactions with land clearing and cattle via speculation, intensification, and displacement of livestock into more “frontier zones.” From a local development perspective, soy production tends to be substantially more lucrative than cattle ranching, but less lucrative than high-value horticulture and fruit on a per hectare basis and with high entry costs. For example, *guaraná* (*Paullinia cupana* Kunth var. *Sorbilis*), a plant native to the Amazon and produced only in Brazil, is known worldwide for its stimulating properties. The process of modernizing guarana production began in 1921, with the creation of a soft drink, followed by the rapid spread of beverage consumption on a national scale. Since 1974, a process of modernization of *guaraná* agricultural systems has spread in the region through the monopoly of agribusiness and agricultural research companies (Tricaud et al., 2016). Because horticulture and fruit products occupy a much smaller area in the Brazilian Amazon, soy and other annuals generate substantially more total taxable revenue than any other activity except for ranching, and participate in an expanding global market in animal feed.

When farm owners actually live in the same county where their farm is located, they spend money locally on goods and services, which can promote developments in infrastructure that benefit all members of the local community and local economic linkages (Garrett and Rausch, 2015). “Agrocities” emerge in these nascent soy regions as new businesses are established to sell non-agricultural goods and services to farm and agribusiness employees, leading to new employment opportunities both related to and outside of the agricultural sector. Because of these dynamics, soy production tends to be associated with higher incomes, educational attainment, and health access, versus other wage-based land uses and even versus non-agricultural municipalities (Garrett and Rausch, 2015; VanWey et al., 2013). This is due in part to the employment characteristics and the migration streams of relatively skilled labor into cities like Lucas do Rio Verde.

However, soy production is also a highly exclusionary process and tends to exacerbate inequality (Garrett et al., 2013b; McKay and Colque, 2016; Oliveira, 2016; Oliveira and Hecht, 2016; VanWey et al., 2013; Weinhold et al., 2013). This means that much of the concentration of benefits within “agrocities” accrue to landowning elites at the expense of migrant labor from other regions, relative dis-investment in alternative economies (including far more sustainable and lucrative agro-ecological production of fruits, vegetables, and other higher-value added products), and aggravation of socio-ecological conflicts due to rising inequality and the dynamics of land appropriation. The best-paid jobs and better quality of life often accrue to migrants to the Amazon from other regions, while locals are often excluded from these benefits but bear the brunt of the negative impacts, for example, environmental contamination due to increased agrochemical use (Oliveira, 2012). In Bolivia in particular, due to historical land development programs and a lack of legal protections for small landholders, much land was given away to foreign investors, mainly Brazilian companies (Hecht, 2005; McKay and Colque, 2016). There also is a highly active Mennonite presence in agro-industrial production in Bolivia (Hecht, 2005), and they are currently very active in land transformation in Peru and Bolivia. Most soy production in Brazil and Bolivia is exported without processing, limiting the potential value-added gains and benefits to local communities (McKay, 2017).

While historically cattle ranching and commodity crop production have been driven by different sets of actors, industries, and even development paradigms, the concept of a "specialized" commercial agricultural system is beginning to erode, as more farmers are looking for ways to add value to their land in light of declining expansion opportunities (Cortner et al., 2019). Ultimately the degree of integration and fluidity between different land use types is constricted by land use lock-ins (path dependencies), entry costs, forms of capital scarcity, and cultural dimensions. As described in Chapter 14, past practices provide a great deal of rigidity to future transformations, by requiring "big push" policies and large upfront investments to solve collective action problems (Cammelli et al., 2020).

Another major rigidity stems from the cultural norms that have co-evolved with agricultural systems in the Amazon. Ranchers and croppers tend to have different backgrounds, and ranchers look down upon cropping as an activity (Cortner et al., 2019). Ranching is linked to historical Iberian colonization processes and cattle cultures (Baretta and Markoff, 1978; Hoelle, 2015), while soy and other row crop farmers typically migrated more recently to the region via private colonization programs, come from German, Italian, and Japanese communities in the South of Brazil, and are linked to modernization and new technologies (Jepson, 2006). These historical trajectories influence land users' abilities to engage in different systems, with the soy farmers generally benefiting from higher capital access from their family networks, government subsidies, private sector financing, and both financial and technological training and assistance from the United States and Japan (Garrett et al., 2013b; Nehring, 2016; Oliveira, 2016).

2.6. Rubber, oil palm, timber and other global commodity plantations

What distinguishes agribusiness plantations is the importance of permanent tree crops in large areas of homogeneous planting. The first such business experience in the Amazon was Henry Ford's ill-fated project for a rubber plantation in Fordlândia and Belterra, from the 1920s to the 1940s (Costa, 1993; Grandin, 2009). Other experiences followed with the promotion of rubber plantations by companies such as Pirelli, and public policies, such as the Brazilian Federal Government's National Program for the Development of Rubber (PROBOR) in the 1970s, with equally disappointing results (Costa, 2000). In all cases, the homogeneous tree plantations in the Amazon had little resilience in the face of attacks by pathogens abundant in the hot and humid ecosystems of the region (Dean, 1987).

Chapter 15

In Brazil, the number of monocrop tree plantations and their economic contributions have declined in recent years. Currently, the most common Amazonian plantations are for palm oil and coconut. In 2017, according to the agricultural census, monocrop plantations produced 94% of the 659,800 tons of palm oil and 92% of the 124 million bay-coconut fruits. The Brazilian government actively promoted the expansion of oil palm in the Eastern Amazon (Pará state). Commonly called *dendê* in Brazil, oil palm was first introduced to the Eastern Amazonian lowlands in 1940, and experimental plantations were established with government finance in 1968 and 1975. But until 1980, oil palms only covered about 4,000 ha in the whole state of Pará, and most production was undertaken by small scale farmers, either organized in cooperatives or independently, supplying regional food markets.

Gradually, however, those plantations were acquired by Agropalma, currently the largest palm oil producer in Brazil, and possibly in Latin America as a whole. Agropalma (or companies that were eventually incorporated into it) continued acquiring thousands of hectares of land, mostly degraded pastures, on which to expand plantations through the 1980s and 1990s. These decades were a period of intense deforestation and violent conflicts in the region, and while Agropalma was starting to consolidate its oil palm agribusiness, the sector was also coming under pressure from international NGOs who condemned the deforestation, agrochemical contamination, and the displacement of smallholders and food production associated with the sector. This was particularly the case in Southeast Asia, where oil palm production had expanded the most, but concerns were also reaching the burgeoning sector in Brazil (Nahum, 2011; Monteiro, 2013; Alonso-Fradejas et al., 2016). Thus, in 2002, Agropalma reformulated a smallholder contract system mimicking those of Malaysia, through which it could promote the social and environmental benefits of oil palm production in Eastern Pará, arguing it would not only diversify the local small-scale commercial farming economy, but also curtail deforestation by creating a “sustainable” economic activity on “marginal” land, primarily degraded pastures (Monteiro, 2013). These arguments were adopted by the incoming Workers’ Party administration in Brazil, which included oil palm production by small-scale farmers as a pillar of its National Biodiesel Production and Use Program (PNPB) in 2004. Agropalma built the first biodiesel refinery to operate with palm oil in Brazil in 2005, and a wave of investments was unleashed by Brazilian private and state-owned companies, as well as foreign agribusinesses (Monteiro, 2013; Potter, 2015).

Since the early years of the national biodiesel program, however, it was becoming clear that oil palm agribusinesses were unable to profitably scale-up production to operate their refineries with supplies contracted from small-scale “family farmers.” The new corporate investors (from the United States, Canada, Portugal, Japan, China, and Brazil itself) began establishing their own large-scale monocultures and/or acquiring oil palm plantations from smallholders who established them, but were unable to sustain operations when labor-intensive harvests began (usually two to three years after palms are planted) (Oliveira, 2017). Thus, government support and encouragement for small-scale farmers to switch to oil palm was basically serving as a mechanism of indirect dispossession and land concentration among the new agribusinesses that were establishing themselves in the region (Nahum, 2011; Bernardes and Aracri, 2011; Monteiro, 2013; Potter, 2015). From the logic of agribusiness investors, self-managed large-scale plantations seemed the best instrument for oil palm production and processing in the region, despite the original intentions of the Brazilian government’s biodiesel plan and the “socially inclusive and environmentally sustainable” discourse still promoted by the agribusiness corporations that were quickly gaining ground in the region. Yet there continues to be partial adoption or maintenance of some contract farming with small-scale farmers, particularly by Agropalma, ADM, and the companies in which the Brazilian state itself participated, such as Petrobras and Biovale, in order to secure subsidies from the PNPB program’s support for small-scale farmers.

Similar dynamics were also present in the Ecuadoran and Peruvian Amazon, where neoliberal policies enabled company-community partnerships that captured social benefits for oil palm processors, while small-scale farmers were adversely integrated and driven to deforest additional land to remain in business. Furumo and Aide (2017) calculated land-use change for oil palm across Latin America from 2000 to 2014. They found that the Amazon region had the highest rate of forest conversion for oil palm plantations in the Americas (alongside Guatemala).

> On a national scale, Peru experienced the highest rate of woody vegetation loss from oil palm expansion (76%), amounting to 15,685 ha. This was particularly striking in the vast Loreto region of the Peruvian Amazon, where 86% (11,884 ha) of local oil palm expansion occurred at the expense of forest. In the Sucumbíos and Orellana departments of the Ecuadorian Amazon, there were 15,475 ha of oil palm plantations in 2014; 3,665 ha were associated with land conversion, including 1,582 ha of

> woody vegetation loss in these departments (43%). The Brazilian Amazon state of Pará featured the largest area of country-scale forest loss associated with oil palm expansion in the study: 70,923 ha of oil palm expansion were detected, of which 40% (28,405 ha) replaced woody vegetation (Furumo and Aide 2017, p. 6).

Wage-based-Plantations' production, however, covers a wider range of permanent crops. In the order of importance of the GVP among the permanent crops, in addition to oil palm and *coco-da-baia*, with 37.4% and 11%, respectively, there are cocoa, with 20.7%, *açaí*, with 12.6%, and oranges with 4%, to name the most important (Figure 15.9a, Annex).

Homogenous *açaí* plantations started to expand in the Amazon (and elsewhere in Brazil) during the past decade, motivated by EMBRAPA's development of varieties adapted to upland soils. IBGE started accounting for homogenously planted *açaí* in 2015. From 2015 to 2019, the area planted with *açaí* in the Northern region (mostly Pará) expanded from 136,312 ha to 194,405 ha (IBGE, 2019, table 1613). The agricultural census of 2017 confirmed 129,210 ha of *açaí* plantations, of which only 12% were Wage-based-Plantations; the most important *açaí* planters were Family Based-Agroforestry, with 64% of the total. Large-scale homogeneous *açaí* plantations are predominantly irrigated, but homogeneous *açaí* plantations are not necessarily more intensive than well-managed small-scale *açaí* agroforestry systems, particularly in riverine areas. The best managed *açaí* agroforestry areas can have equivalent productivity, and comparable density of clumps/stems/ha to more recent plantation *açaí* plantations and its value on a per hectare basis is often greater than soy (Brondizio 2008). Between 2006 and 2017, the number of establishments in plantations decreased from 20,000 to 16,000 in Brazilian Amazonia, while growing modestly, at 1.1% annually, from a GVP of R$1.8 to R$ 2.1 billion. With such a performance, the sector reduced its participation in the region's rural economy from 5% to only 3%. The number of workers remained constant at around 70,000, and there was a decline in land area from 7.8 to 3.8 million hectares and in lands used, from 4 to 1.7 million hectares.

Evidently, the expansion of commercial plantations has not taken place as fast or as widely as soy in Brazil, but it is quickly becoming a major form of land occupation in Amazonia. The is playing a role in driving direct deforestation, particularly in the lower Amazon (Pará state in Brazil) and more recently in the Western Amazon (especially Peru, Ecuador and Colombia).

Deforestation for oil palm expansion is one of the potential threats to forests in the "Trans-Purus" region in the western part of Brazil's state of Amazonas, as evidenced by the attempt of Malaysian oil palm firms to purchase land in this area in 2008 (Fearnside et al., 2020), and the purchase by Malaysian groups in the Loreto region of Peru.

3. ANALYSIS OF SECTORAL DYNAMICS AND THEIR IMPLICATIONS

The analysis above does not include all economic sectors and livelihood strategies in the Amazon. Industry and service sector economies, concentrated in a few major cities like Manaus and Belém, for example, contribute to a significant share of the region's GDP, employment, and economic dynamism. Agribusiness pressures have led to the expansion of access infrastructure (e.g., dams, fluvial ports and waterways, paved roads, and plans for additional railroads; see Chapter 14) and the consolidation of petroleum and large-scale mineral extraction, particularly in the Western Amazon (Ecuador, Peru, and Northwestern Brazil) are important phenomena that attract a significant amount of labor (albeit temporarily, as discussed in Chapter 14 regarding the construction of the Belo Monte dam), and link labor and livelihood strategies in the Amazon to global circuits of capital and commodities (Klinger, 2018).

In some locations, as in Madre de Diós, Peru, and the Tapajós region in Brazil, small scale (artisanal) mining (particularly for gold) plays a determinant role in local labor markets and livelihood strategies. However, it is often associated with boom-and-bust cycles of mineral exploration, and socio-ecological ills associated with the footloose economy of mining booms and busts (e.g., trafficking, violent crimes) (Bebbington et al., 2018a; Kolen et al., 2018), and can lead to invasion of National Parks and Indigenous lands (RAISG, 2020). Moreover, the socio-economic and environmental impact of infrastructure and extractivist activities exceeds the number of people employed and the area occupied, as these activities literally lay the foundation for further rounds of speculative land clearing, expansion of cattle ranching and illicit crops such as coca as a means of money laundering, and agricultural production in their wake, to supply workers in these activities. They also make distant markets more accessible through the roads built to access these new infrastructure construction sites and extractivist activities in the first place.

3.1. Large-scale appropriation of public resources and reduced employment

The dynamics described above involved large scale private appropriation of public lands in the Brazilian Amazon, generally those covered with primary forest. Figure 15.7 shows the total public lands incorporated into the agrarian sector.

Between 1995 and 2006 there was no increase in the total 86 million hectares land stock in the rural sector - in fact, there was a small decrease, which could be explained by transfers to urban sectors, to infrastructure and to mining. There was an internal shift among the production systems, with emphasis on transfers of 8.8 million hectares from large-scale agribusiness cattle enterprises, accounted for in the sector aggregate by the increase in the stock of large commercial agricultural enterprises (via the land market), and Family-Based agroforestry and fisheries (through agrarian reform programs).

Between 2006 and 2017, with the exception of Family-Based-Agriculture, all production systems in the Brazilian Amazon registered the incorporation of new land, which totaled 12.9 million hectares. Family-based enterprises added 2.8 million hectares, explained, as in the previous period, by agrarian reform programs (considering all forms of settlement, 4.5 million hectares were transferred by the Brazilian National Institute for Agrarian Reform (INCRA) between 2006 and 2016, according to INCRA (2016). Wage-based structures added 10.1 million hectares: Commercial Extensive Cattle 6.5 million hectares, Wage-based-Soy 2.5 million and Wage-based-Plantations 1.1 million. Much of this huge volume of resources was the result of widespread mechanisms of informal, usually illicit, appropriation of public lands in the region. As a fundamental result, the process reinforced the profound inequality of access to vital resources in Brazilian society, as 78% of new lands were incorporated at the end of the period in the assets of the 12.5% of establishments that already held 76% of all the lands.

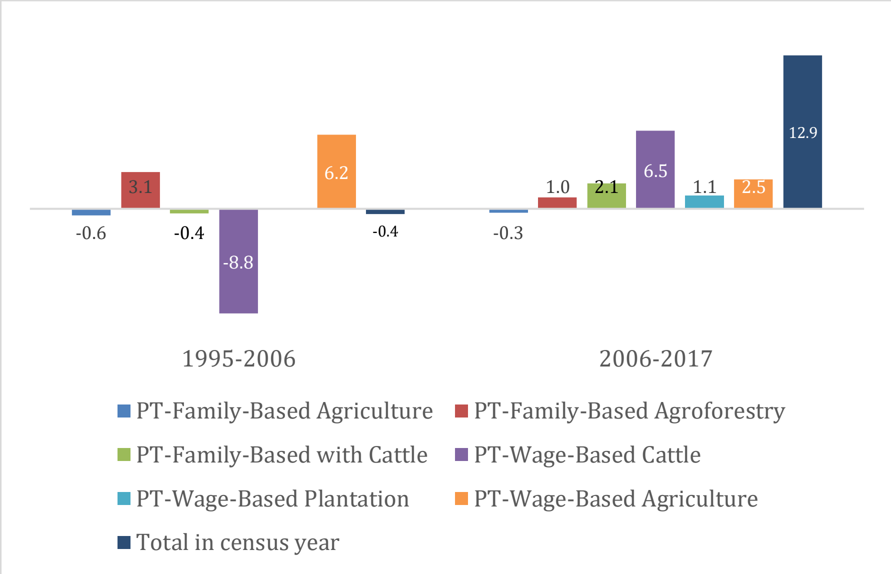

Figure 15.7: Dynamics of appropriation of public lands in the agrarian sector of the Amazon by PT (Millions of hectares of appropriated land in the period). Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

These significant shifts in control over land were associated with corresponding shifts and reductions in employment in the agrarian sector over the past few decades, and had significant repercussions for the livelihood possibilities of Amazonian communities. From 1995 to 2006 there was a massive reduction in employment (541,800 people) in Family-based Agriculture, and a significant loss (176,400 people) in the Family-based Cattle sector, combining for an overall loss of 610,200 jobs in the family-based agrarian sector (Figure 15.3). Some 131,700 workers were added in the wage-based sectors, and many more would have shifted to work in urban employment, mining, infrastructure, and the clandestine economies (see Chapter 14). Agrarian employment continued to decline by an overall 24,700 workers in the following period, from 2006-2017, especially in Family-based Cattle and Agriculture systems, which respectively lost 90,300 and 43,600 jobs. These losses were not offset by the employment gains in Wage-based Cattle enterprises (61,900) and Wage-based Plantations (36,800), nor could they be sustainably absorbed by the temporary construction labor that goes into new infrastructures and extractivist activities. The rapid loss of land and employment among family-based enterprises highlights the growing challenges for Amazonian agrarian communities.

3.2. Intensification and deforestation

Ultimately the degree of integration and fluidity between different land use types is constricted by land use lock-ins, capital scarcity, and cultural dimensions. Consequently, the intensification of large commercial agriculture and ranching itself becomes a driver in the further expansion of these large-scale commercial production systems, dashing the common hope that intensification can “spare land” for conservation. This belief that intensification may reduce pressure for land clearing if strict conservation regulations are established and enforced (Nepstad et al., 2019), overlooks how Amazonian landholders are not isolated subsistence farmers who would stop clearing when their stomachs are full, but instead are participants in a market economy and respond to opportunities for greater profits by expanding those activities rather than limiting them (Fearnside, 2002; Muller-Hansen et al., 2019; Thaler, 2017).

The soy-livestock integrated systems may have substantially higher profits and shorter payback periods, as compared to extensive pasture systems (Gil et al., 2018), but most analytics do not include the returns to land speculation. However, intensification also increases political and economic incentives for further expansion of agricultural production and ranching if it enhances productivity and profits. This is known as “Jevons paradox” - that agro-industrial innovation can exacerbate, rather than curtail, deforestation and other forms of socio-ecological degradation (Oliveira and Hecht, 2016; McKay and Colque, 2016; Thaler, 2017). Moreover, deforestation alone is an extremely narrow metric to gauge environmental impacts and socio-ecological sustainability, and when the intensification of agricultural production occurs through increased mechanization and application of agrochemicals (pesticides, herbicides, and synthetic fertilizers), they also significantly exacerbate ecosystem degradation through pollution of soils and waters, loss of biodiversity, soil erosion, and other impacts (Oliveira, 2012).

Privatized lands were subjected to different uses in Brazil, which mainly entailed removal or impoverishment of forest and water resources. The deforested area grew from 37.2 million hectares in 1995 to 57.8 million hectares in 2017. Between 1995 and 2006, 12.6 million hectares were added to production, 2.3 million in Wage-based-Cattle (deforested in processes that predominantly produced pasture), and 6.0 million in Wage-based cropping (in processes that, in the end, produced temporary plantations). Together they represented two-thirds of the total (Figure 15.8).

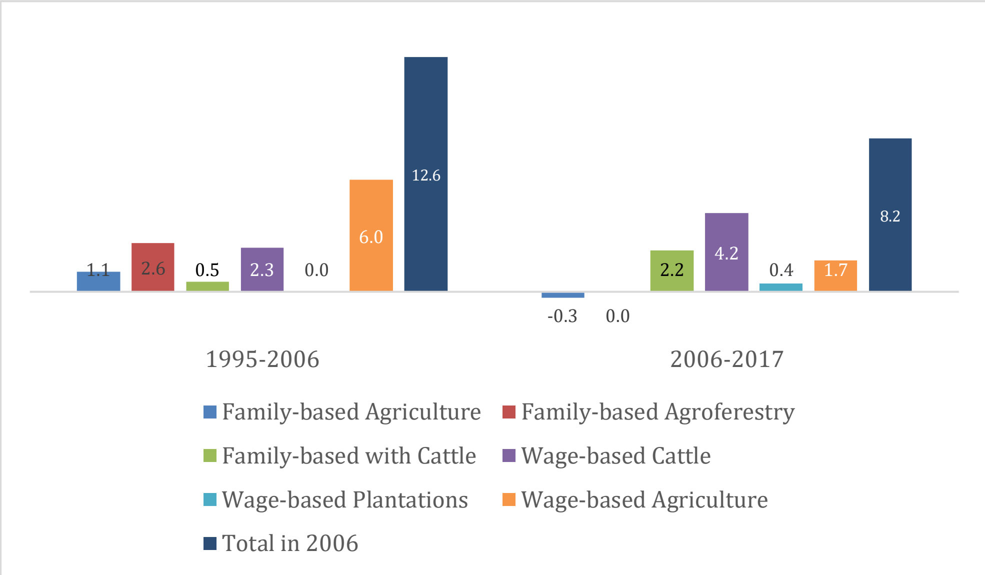

Figure 15.8: Used/deforested lands in inter-census periods (in Million ha). Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

Between 2006 and 2017, an additional 8.3 million hectares were converted to non-forest production, 72% of which by Wage-based-Cattle and Agriculture.[vi] Throughout the period, a systemic cooperation was established between these two productive systems (as discussed above): the former functioned as a supplier of deforested land, the latter as its client. Among smallholder systems, only Family-based-Cattle deforested 2.2 million hectares. It is important to note that these figures measure only deforestation associated with land clearing, but not other forms of disturbance such as degradation, or pollution from agrochemical use (Matricardi et al., 2020).

3.3. Carbon emissions and sinks, and land degradation

According to Walker et al. (2020), forest degradation accounts for a large majority of carbon loss in the Brazilian Amazon (68.8% in 2016), a proportion that was even higher in the other Amazonian countries: for Pan Amazon as a whole, forest degradation accounted for 87.3%, of carbon losses. This forest degradation is from all sources, such as logging, fire, edge effects

[vi] To corroborate the census data, an equivalent area, of 8.6 million hectares, was recorded by Brazil's Program to Calculate Deforestation in the Amazon (PRODES) in the same period (MapBiomas, 2020).

and tree death during droughts, but logging together with the fires that occur due to the disturbance from previous logging are undoubtedly a large part of this enormous impact.

Based on the census statistics from Brazil, average net CO_2 emissions (without considering emissions from equipment and tractors, fertilizer application, and subsequent soil management) were estimated to be 0.144 Gt per year between 1995 and 2006 and 0.109 Gt per year between 2006 and 2017 from forest clearing alone, which can cause an equally substantial or even larger amount of climate-change inducing emissions over time. The model applied (Costa, 2016) linked the balance sheets of deforestation-linked emissions to the different production systems: between one period and the next, the contributions of emissions from Wage-based-Cattle grew, respectively, from 60% to 65% while large commercial agriculture fell from 11% to 1%. The systemic cooperation between these two production systems explains these results, which should be read in aggregate (i.e., for a total of 66% in 2017), as land cleared proximately for cattle ranching typically is then turned over for soy production a few years later after pastures become degraded. The contribution to CO_2 emissions by Family-based-Cattle also grew from 22% to 33% in the same period.

In turn, Family-based-Agriculture turned into a CO_2 sink, Wage-based-Plantations reduced their contribution from 5% to 2% of CO_2 total net emissions, and Family-based-Agroforestry continued to contribute virtually no CO_2 emissions through the whole period (Figure 15.9). This is because these production systems do not rely upon or drive further deforestation, and even increase the organic content in the soils, capturing CO_2 from the atmosphere and transforming it into plant nutrients, although over time cleared areas can release more carbon than native forests.

Figure 15.9: Contributions of productive trajectories to total net emission of CO_2 of the agrarian economy within the Brazilian Amazon Biome, 1995-2006 and 2006-2017: % of total. Source: IBGE, Agricultural Censuses 1995, 2006 and 2017. Costa, 2016.

The same model, as an assumption for the calculation of CO_2 balances, estimated the area of three different forms of secondary vegetation, reaching a total in 2017 of 8.6 million hectares in the Brazilian Amazon.[vii] The three types of land with secondary vegetation included: “fallow lands” associated with shifting cultivation (they totaled 580,000 hectares, distributed among the peasant production systems); “degraded land” (mainly degraded pastures – these were 2.9 million hectares, half of which was associated with cattle ranches); and finally, the largest portion was “land in unspecified reserves” of 5.1 million hectares. Half of this belonged also to commercial cattle ranches; the other half was distributed among the other land uses, without distinction of note (Figure 15.10a, Annex). One can only conjecture about the nature of these reserves: one hypothesis is that they are part of the stocks of “land producers” – they are explained by the logic of speculation with land.

[vii] This estimate converges with the estimate of 8.9 million hectares of secondary forests reported in the Fourth National Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases for the United Nations Framework Convention (see BRAZIL, Ministério de Ciência, Tecnologia e Inovações, 2020, Matrizes de dados de atividade e resultados de emissões e remoções de CO_2, Figure 21, Matriz de conversão de uso e cobertura da terra do bioma Amazônia de 2010 a 2016, column 3, line FSEC).

3.4. Predatory versus sustainable commercial production systems

Cattle ranching and commercial agricultural enterprises occupy the largest land use category in the region, and their development has required deforestation, with also greater environmental impact expressed in the largest shares of net carbon emissions that occur in the rural sector of the Amazon. Both have been rewarded with increasing profitability, with additional returns derived from the processes of speculation with land (described above), given the dominant illicit appropriation, and also the illegal production of wood (Brazil, 2002; Fernandes, 1999; Araújo, 2001; Benatti, 2003; Treccani, 2001). Both have also been the preferred recipients of favorable policies, institutions and political support, securing critical technological knowledge for homogenous agriculture and livestock establishments (Hecht and Mann, 2008; Oliveira, 2013; Gasques et al., 2011). Indeed, in 2006 and 2017 the largest volume of development credit was granted to agricultural enterprises (25% and 28% of GVP in those years), while cattle ranchers obtained financing that corresponded to 10% and 29% of its GVP in the same years, essentially tripling the support received (Figure 15.10). Access to official technical assistance corroborated precisely with what was observed with credit (Figure 15.11). In addition, the expansion of road systems, storage infrastructure and an array of agricultural services provided a reinforcing production matrix. While these data show that agribusiness was favored in access to extension services, comparisons among regions in Brazil showed that, across all size categories, less than 15% of farmers in the North Region received extension services from the government (IBGE, 2017).

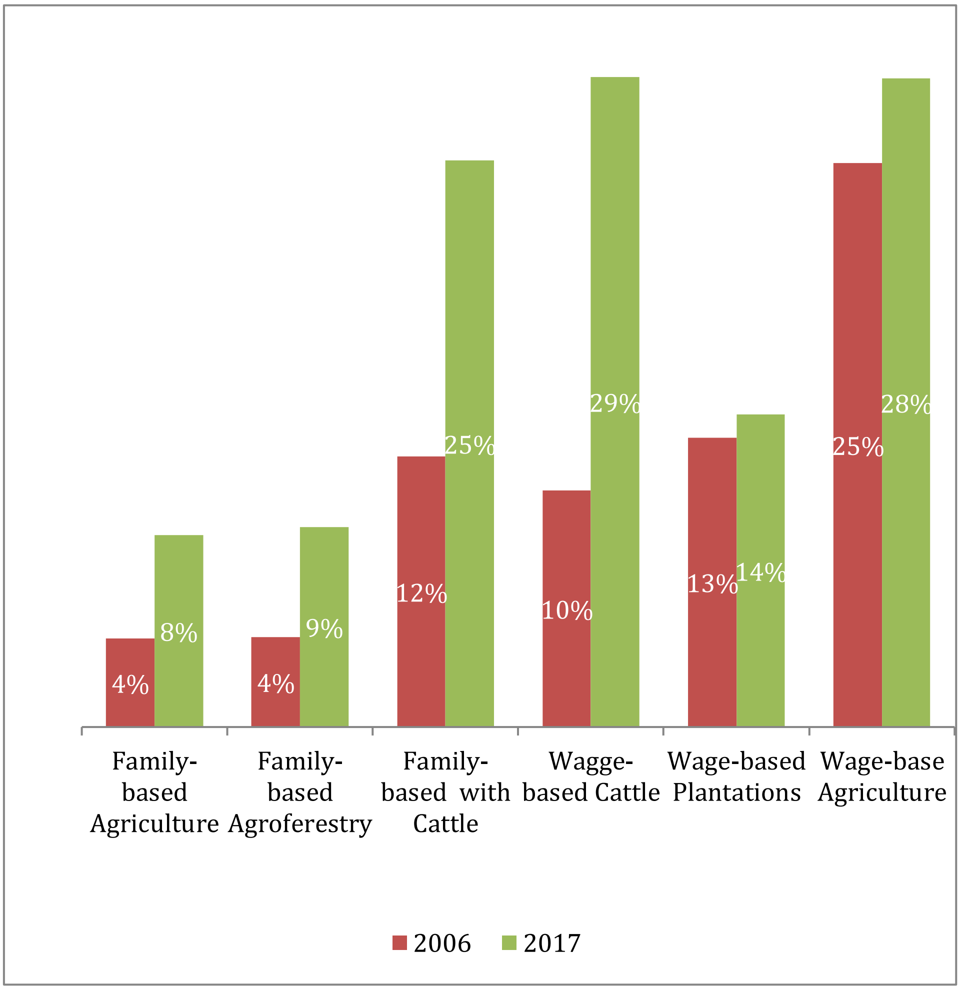

Figure 15.10: Ratio of credit to GVP by techno-productive trajectories in the agrarian economy within Brazilian Amazon Biome in 2006 and 2017: %. Source: IBGE, Agricultural Censuses 1995, 2006 and 2017. Brazilian Central Bank.

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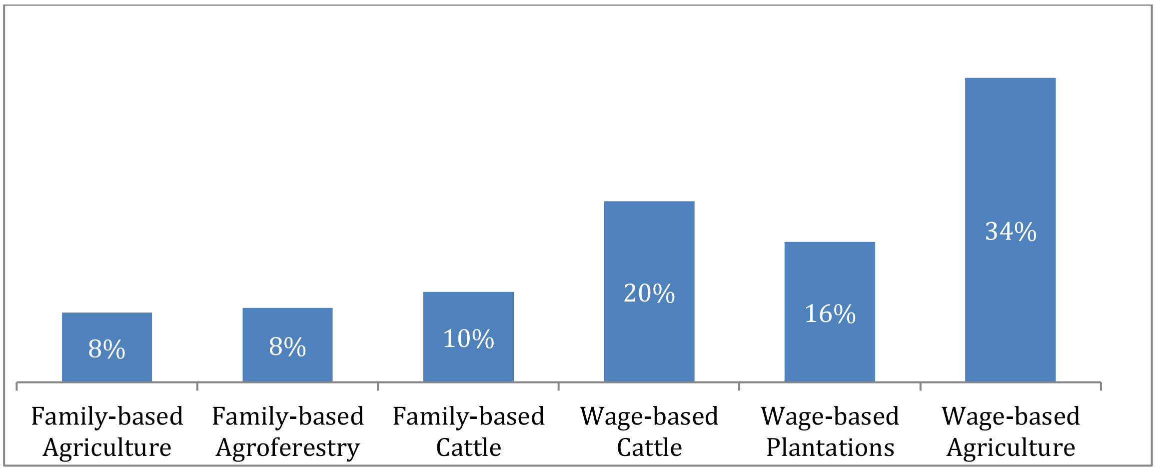

Figure 15.11: Ratio of number of establishments with technical assistance to total establishment of PTs in the agrarian economy within Brazilian Amazon Biome in 2017: % Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

Given these advantages, the competitive power of these large-scale production systems has proved overwhelming: in 2017 they represented 77% of the rural economy in the Amazon. Their considerable competitive power to shape institutions often relies upon unequal access to resources, encourages deforestation, and unleashes other environmental impacts on land and rivers that undermine environmental services and possibilities for more resilient, equitable and more sustainable development pathways.

But there are issues specific to the context created by the dynamics of large-scale cattle and agricultural enterprises in the Brazilian Amazon. One problem is the antagonism generated in relation to well-recommended "forest management" practices. Well intentioned management companies face competition from illegal logging and unsustainable legal forest management. Right from the start, there are economic impediments that stem from the widespread availability of wood from illegal, predatory and unsustainable sources. Besides, the system can be unsustainable due to various loopholes that have been created to legalize unsustainable management, as well as frequent violation of regulations both by government licensers and by those who receive the licenses. Various ways have been devised to allow harvesting to deviate from the theoretical formula in which one plot is harvested each year until the cycle is completed, after which the cycle would be repeated, beginning with the plot harvested in the first year. If the entire management area is harvested in the first few years (or even in the first year) and the management company or property owner is expected to remain without income for the remainder of a 30-year cycle, the theoretical sustainability of the system becomes meaningless (Fearnside, 2020). Further, timber systems are often sold after selling the best wood.

Forest management in Brazilian Amazonia has yet to face the challenge of passing beyond the first management cycle to the second cycle, because virtually all management projects have been in operation for less than the required 30-year cycle length. In the first cycle, the large trees being harvested have been growing in the forest for centuries, a "subsidy from nature" as described in Chapter 14, with no investment from the property owner to guard and manage the area. In later cycles, however, to maintain sustainability, all that can be harvested is what has grown back while the owner has been managing the area, and the discontinuity of passing beyond the first cycle implies a lower financial return (Fearnside, 2003). In addition, the most valuable tree species will be depleted in the first cycle, and subsequent harvests will be of less-valuable species. This is already happening on a large scale, with management plans in Eastern Amazonia being granted in areas where the most valuable species have already been removed, as shown in a study by Richardson and Peres (2016), who "find no evidence that the post-logging timber species composition and total value of forest stands recovers beyond the first-cut."

The production systems based on permanent crops and reforestation of plantations have recurring problems related to the vulnerability of homogeneous botanical systems that show low resilience in the region (see section 2.6). Also, the high opportunity cost of managed wood, resulting from the relatively low growth rate of trees in the original forest compared to the yield rates of investment alternatives from the results of the immediate liquidation of forest assets, is a problem for forest management worldwide (Clark, 1973; Fearnside, 1989, 1995a). However, there is a strong component in shifting cultivation systems that produce wood for local systems and construction, using fast-growing species such as *Bolaina* (*Guazuma crinita*) (Sears, 2016).

3.5. Volatility of family-based production net income and vulnerability

As for Family-based production systems in Brazil, two things stand out. Firstly, Family-based-Cattle followed the trend among the wage-based production systems, as it doubled net income per family worker. Also, like the latter, Family-based-Cattle was strongly supported with credit capital, which represented 25% of its total GVP in 2017, an increase from only 12% in 2006. In 2006, the participation of Family-based cattle enterprises in credit was the most important among all Family-based systems. In turn, Family-based Agriculture and Agroforestry had the lowest access to credit compared with other producer groups (about 4% in 2006, about 9% in 2017, Figure 15.10), and the lowest access to technical assistance (10% for Family-based-Cattle, and less than 1% for agriculture and agroforestry, Figure 15.10).

Secondly, the net income per family worker of Family-based-Agriculture and Agroforestry, after experiencing strong growth, decreased severely for the former and stagnated for the latter: respectively from US$ 1,141.20 in 1995 to US$ 3,051.60 in 2006, dropping to US$ 2,034.40 in 2017 (for agriculture), and for agroforestry, from US$ 918 to US$ 2,059.20 (Figure 15.12). The volatility of Family-based-Agriculture's income produced a crisis, certainly heightened by the tensions surrounding land, materialized in the transformation into urban or rural wage workers of over half a million workers, and in the reduction of their role in local supply. The income stagnation of Family-based-Agroforestry, notable for its sustainability attributes, indicated limits on its capacity to expand and to improve the living conditions of those involved. Considering the fact that the prices of its key products were increasing, this situation implied reductions of physical productivity. Indeed, climate change and increasing urbanization are posing new and considerable challenges to Family-based Agriculture and Agroforestry systems.

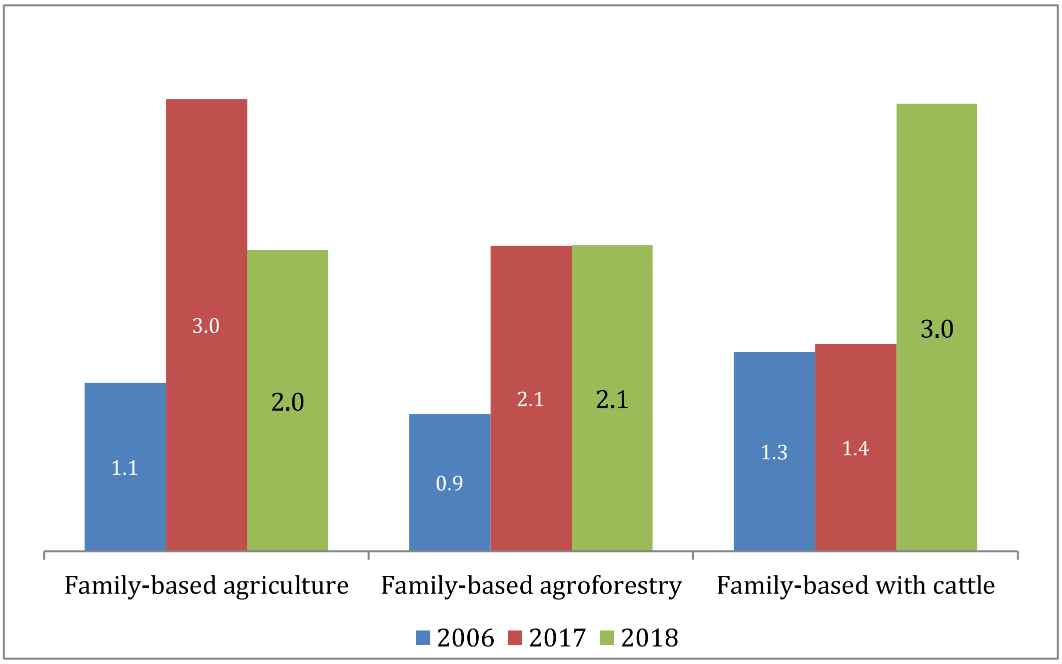

Figure 15.12: Net income per family worker [(GVP-Costs)/Family worker-equivalent] in family-based TPs, 2006 and 2017 in US$ 1.000,00/ year. Source: IBGE, Agricultural Censuses 2006 and 2017.

4. KEY QUESTIONS AND PROPOSALS TO IMPROVE FAMILY-BASED PRODUCTION SYSTEMS

4.1. Adaptation to climate change and urbanization

The traditional methods by which Amazonian local communities manage landscapes and exploit natural resources are changing in response to the region's growing urbanization (Eloy and Lasmar, 2012; Franco et al., 2021). In much of the Amazon region, originally and through the present, the economy and ways of life of the rural populations have been based on different combinations of subsistence and commercial activities of annual and perennial agriculture, gathering of forest products, fishing, and hunting (Moran, 1991; 1994). This polyvalent strategy, which combines a multiplicity of primary subsistence activities, allows these populations to adapt and utilize the diverse Amazonian ecosystems, from dense forests and savannahs of drylands to the aquatic environments of the small tributaries and great river's floodplains (Witkoski, 2010). This adaptability underlies the ability of diverse local production systems to persist and adapt, even under unfavorable conditions, as well as their importance for future strategies to support more sustainable production systems (Brondizio et al., 2021; Eloy and Lasmar, 2012; Franco et al., 2021).

Climate variability is changing the timing as well as the frequency and intensity of heat waves, severe storms, floods, drought spells and other hydro-climatic extreme events, which have produced catastrophic impacts on livelihoods and environments (Espinoza et al., 2020; Marengo et al., 2013). Localized short-lasting and intense hydro-climatic events have become the main constraints for farming annual and perennial crops in Amazonia (Rios et al., 2017), while urban expansion and the integration of Amazonia to regional, national and international markets are mentioned by policy makers, producers and experts as factors that have changed patterns of production and supply of food crops to Amazonian cities (Abizaid et al., 2018, Coomes et al., 2016).

The annual and perennial crop fields of Amazonians are highly vulnerable to short-duration and highly damaging floods, droughts and rainstorms (Espinoza et al., 2019; Kawa, 2011; List et al., 2019, Sherman et al., 2016). Based on interviews and published information, producers in the Amazon delta are dealing with two types of extreme tidal flooding (locally known as *lava praias* and *lançantes*) and producers from upper to low Amazonia are dealing with damaging out-of-season floods. These floods, locally known as *repiquetes,* are produced by fairly local extreme rainfall events causing sudden increases in river level during the dry season (Espinoza et al., 2019; List et al., 2019; Ronchail et al., 2018).

Climate change is interfering negatively in the production of *açaí* in hot years (Tregidgo et al., 2020), whose productivity more generally has been affected by the erosion of diversity of *açai* varieties resulting from the greater intensification of the management of *açaizais* (Freitas et al., 2015; Campbell et al., 2017). Amazonians are adapting in diverse ways to these challenges. They are increasingly planting cassava, corn, beans and other annual crops in upland (*terra firme*) on the highest sections of levees, locally known as *restingas altas* to protect from floods (Coomes et al., 2020; Gutierrez et al., 2014). Similarly, the data show that farmers are increasingly engaging in collective action to control fire during land preparation to avoid accidental or escaped fires (Gutierrez et al., 2014). In the delta, farmers are planting vegetables, spices and other annual crops in suspended platforms, locally known as *canteiros* or *girais*; in the floodplains, farmers are planting flood-tolerant varieties of rice, beans and other annual crops to attract and harvest fish in low areas of the floodplain that are vulnerable to *repiquetes* (Kawa, 2011; Steward et al., 2013). In the Amazon delta, the adaptive processes of farming annual crops are leading to the expansion of house gardens, enriched and managed fallows and forests for the production of *açaí*, fruits and other perennial crops (List et al., 2019). The conversion of banana fields to enriched and managed fallows and forests, has greatly increased the production of *açai*, fruits and other perennial crops (Vogt et al., 2015). In the levees along the floodplains of upper Amazonia, agriculture fields have been converted into enriched fallows with fast-growing timber species, fruits and other perennial crops (Sears et al., 2018). Amazonians' capacity to adapt to climate changes explains why annual and perennial crops continue to be important sources in sustaining the livelihood of millions (Sherman et al, 2016; WinklerPrins and Oliveira, 2010), and underscores the importance of their systems for the future.

While hydro-climatic disturbances are considerably impacting the yield and diversity of annual and perennial crops, Amazonian producers continue relying on a great diversity of annual and perennial crops to manage vulnerability and risks associated to changes in the market produced by the process of urbanization (Coomes et al., 2020; Abizaid et al., 2019). In all Amazonian countries, producers are responding to the constraints and opportunities produced by urban expansion by: (i) changing their focus or decision making, in some cases in the direction from market oriented to subsistence oriented cultivation of rice, corn, beans and other annual crops and in other cases from subsistence oriented to market oriented production of perennial corps (Coomes et al., 2020); (ii) changing food processing systems, from manual to mechanical processing (Brondizio, 2008); (iii) changing their sources of seeds and other planting materials, by integrating seeds that are sold in the markets to the local seeds systems (Abizaid et al., 2018; Oliveira et al., 2020; Coomes et al., 2020); and (iv) changing trade systems, from randomly selling in all markets to direct selling to distributors or contributors (locally known as *pedidos*) or contracts (locally known as *habilitación*) mediated by social networks and cell phones (Abizaid et al., 2018).

4.2. Fisheries development

The expansion of modern commercial fisheries greatly increased pressure on floodplain lake fisheries, mobilizing floodplain communities throughout the Amazon floodplain network to implement collective agreements called "*acordos de pesca*" to regulate local fishing activity (McGrath et al., 1993; Smith, 1985). Community management of floodplain fisheries was based on traditional land tenure systems, which considered lakes to be collective property, and on the logic of the diversified household economy. Households employed economic strategies including various combinations of commercial and subsistence fishing, annual and perennial crops, forest management, hunting and collecting (turtles), and small and large animal husbandry (ducks, chickens and cattle). Fishing was central to these strategies, providing the main source of animal protein, cash to purchase household necessities, and working capital for investment in the other productive activities. Community management sought to maintain the productivity of local fisheries so that fishers could optimize time spent fishing, with the allocation of household labor to other productive activities (McGrath et al., 1999).

Among the most important innovations in fisheries management has been the development of a management system for the *pirarucu* or *paiche* (*Arapaima* spp.), one of the largest and highest-priced fish species in the Amazon. A highly successful management system that combines scientific and local fisher knowledge and skill was developed for *pirarucu* at the Mamirauá Sustainable Development Reserve (Castello, 2004; Duponchelle et al., 2021). This system made it possible to simultaneously increase annual catch rates, numbers of fishers and populations of *pirarucu* in managed lakes (Castello et al., 2009). The management system has been widely disseminated in the state of Amazonas (Brazil) and in the Peruvian Amazon. In Amazonas, total catch of managed *pirarucu* increased from 20 tons in 2003 to more than 2,600 tons in 2019 (Campos-Silva and Peres, 2016; McGrath et al., 2020). The ability to count individual fish reduced uncertainty, and motivated fisher groups to invest in sustainably managing *pirarucu*, and in the process created governance conditions that benefitted other important fish species and, more generally, aquatic biodiversity.

While some researchers have questioned the viability of community-managed fisheries, studies have shown that lake fisheries with effective management agreements can be 60% more productive than unmanaged lakes (Almeida, 2006). Other studies have shown that migratory species, such as the *tambaqui* and *surubim*, which spend their juvenile phase in managed lakes, tend to be significantly larger than those in unmanaged lakes (Castello et al., 2011). With adequate government support and technical assistance, the community-based management system could be extended to the entire Amazon floodplain and ensure the sustainable management of floodplain fisheries (Duponchelle et al., 2021). Progress has been made in managing floodplain fisheries, but there has been minimal progress in sustainably managing stocks of the long-distance migratory catfish (Fabré and Barthem, 2005; Goulding et al., 2018). While these species continue to play a major role in the Amazon's commercial fisheries, largely uncontrolled fishing and dam construction threaten their viability (Castello et al., 2013).

This is a critical time for Amazon fisheries. After centuries of largely uncontrolled exploitation, important commercial fish species are overexploited. Yet, as a whole, Amazon fisheries are still productive, and continue to sustain hundreds of thousands of rural and urban families. In some states, effective management systems are contributing to the recovery of regional fisheries, and if such policies were implemented throughout the floodplain system, the decline of Amazon fisheries could be reversed, improving the livelihoods of IPLCs, urban fishers and other supply chain actor groups (Duponchelle et al., 2021).

Beyond capture fisheries, federal and state government policy makers are enthusiastically promoting aquaculture as the modern way to produce fish and fill the gap created by the depletion of the Amazon's wild fisheries (McGrath et al., 2015). Aquaculture's rapid expansion in the Amazon holds the potential to provide an alternative to cattle production, helping diversify local incomes and rural and urban food supplies while reducing the land footprint of animal-based foods (McGrath et al., 2020). However, the degree to which aquaculture will become an environmentally sustainable, nutritious, and equitable component of Amazonian food systems depends on myriad factors, including improving production efficiency, culturing a diverse set of native species, reducing initial investment costs, and ensuring that farmed fish are accessible to people who rely heavily on fish, including rural, poor and Indigenous people (Heilpern et al., 2021). While much uncertainty remains around the tradeoffs between aquaculture, capture fisheries, cattle and other animal-sourced foods, it is clear that well-managed fisheries, both wild and farmed, could continue to be a culturally relevant and sustainable component of the Amazon's future bioeconomy.

4.3. Integrating Local, and Scientific Knowledges

Local or Indigenous systems integrate both traditional and modern knowledge to manage, produce and conserve plant, animal, fish and other biological resources (Franco et al., 2021; Thomas et al., 2017; Sears et al., 2007). Amazonians have demonstrated over millenia that these systems can be adapted successfully to changing conditions, persisting and even expanding over time despite relatively weak supportive policies compared to agribusiness. They have proven their ability to support food security and promote agrodiversity through such strategies as shifting crop fields, adopting new varieties and preserving germplasm, and managing enriched fallows and homegardens. They have also successfully developed networks to collectively manage fire use, lake fisheries, processing plants and marketing, to the benefit of linked rural and urban communities in the Amazon, strengthening regional economies. The many encouraging examples of ways to reduce environmental impacts while improving the well-being of Amazonian populations provide a strong foundation for future efforts to support more sustainable production alternatives.

Rural and urban populations are increasingly linked through multi-sited households and networks across the Amazon, as discussed in Chapter 14, posing both challenges and opportunities for more sustainable development efforts. Increased urbanization can translate into stronger demand for locally produced goods of multiple types, if it is accompanied by effective supports for peri-urban, urban and regional small farm agricultural systems. While large scale supermarkets now dominate urban food supply, more extensive systems of small-scale markets could enhance the viability of such systems, and preferential purchase by schools, hospitals and cafeterias can help create a more predictable demand. In addition, "niche market" chains for organic goods, cooperatives, and fair-trade items are mechanisms that can also support small scale producers. International environmental markets for *açai*, Brazil nuts and cacao can provide significant income and employment, if supported by improved supply chain practices, branding of producer organizations, and supportive infrastructure (e.g., refrigeration, better drying and sanitation systems).

Recently the relations of Amazonian small producers with research institutions have intensified. In Brazil, EMBRAPA has generated new drought-resistant cultivars and new technologies for family producers, as well as supporting community forest management; for example, the highly organized agroforestry systems managed by the RECA community in Rondônia produce Brazil nuts, *pupunha* (*Bacris Gasipaes*) and *cupuaçu* fruits (*Theobroma grandiflorum)* and process them into fruit pulp and palm heart to supply regional and national markets (Valentin and Garrett, 2015). Furthermore, there is a growing relationship between local systems and industrial arrangements that have been rapidly building up around the processing of *açaí*, *cacao*, oils and cosmetics. De-centralized education and inter-cultural dialogue are needed for applied ecology, bio-economies and new technologies rooted in local knowledges, and oriented to equitable returns to ILK, for both local and broader markets.

For this relationship to become a positive long-term process, which protects the capacities of the Amazon biome and offers a dignified life to those who interact with it in their productive and reproductive processes, a strategy of Science, Technology and Innovation (ST&I) is needed, aiming at new competencies for economies based on, and compatible with, the Amazon biome. Rural smallholders and urban producers should participate integrally in the construction of new policies to support their evolving systems, to support food security and regional economic health. Coordinated mechanisms should integrate rural producers with already existing centers, and others yet to be formed, for the production and dissemination of appropriate knowledge for local and regional actors with alternative development approaches. In rural areas, a shift is required from a focus on specific crops, to a portfolio of diverse products and activities including forest and fisheries management, and climate change adaptation; in industrial and marketing, a shift is needed from a focus on scale to explore scope and branding economies, and to support production and consumption systems that bridge and support rural, peri-urban, and urban areas.

5. CONCLUSIONS

Amazonia is home to diverse populations who depend on the region's natural resources for their agricultural, extractive, agroforestry, hunting, fisheries, and other productive activities to make a living and to generate important economic returns. The different actors involved in both large-scale and family-based systems of production interact in complex ways that vary across Amazonian countries, with important impacts on ecosystem services. Supportive pro-growth policies regarding land tenure, agricultural credit and technical assistance, as well as the expansion of roads, waterways and other infrastructure have favored the rapid expansion of agribusiness and its increasing appropriation of public lands, especially cattle ranching and soy enterprises, with increasingly negative social and environmental consequences. These transformations have empowered agribusiness as well as speculative interests and undermined the ability of local communities to defend their own interests and practices, which are more attuned to the sustainability of the Amazon's resource base and the well-being of Amazonian peoples. The findings in this chapter point to the need to re-orient development to support small-scale, diverse production systems that provide employment and economic dynamism for local communities, building on the rich biodiversity and local knowledge that supports many promising initiatives to adapt those systems to climate change and growing urbanization in the region, focused on improving forestry, agroforestry and fishing systems managed by local communities.

6. RECOMMENDATIONS

- Amazonian communities and populations have long relied upon a combination of subsistence and commercial activities for their livelihoods. They are adopting diverse strategies and practices in response to a changing climate, including reliance on a greater diversity of annual and perennial crops for managing vulnerability and risks associated with changes in the market linked to processes of urbanization. These promising examples of more sustainable and equitable systems of production should constitute a core focus of future policies.
- Community-managed local fisheries provide rural families with a reliable source of animal protein, cash to purchase household items and working capital that can be used to invest in other productive activities. With adequate government support and technical assistance, the community-based management system could be extended to the entire Amazon floodplain and lake fisheries to benefit of rural families, and to ensure more sustainable management of floodplain fisheries to the benefit of both rural and urban families.
- Across the Amazon, Indigenous and place-based ecological knowledge integrate both traditional and modern knowledges to produce, manage and conserve plant, animals (including fish), and other biological resources. Collaborations between local producers, cooperatives, research institutes and industrial and manufacturing processing facilities around açaí, cacao and cosmetic oils based on native Amazon palms have shown promising results. A strategy of Science, Technology and Innovation (ST&I) with participation by smallholder producers could further enhance these initiatives and support the development of diverse, local production systems that provide both rural and urban employment and economic opportunities for Amazonian populations while reducing deforestation, greenhouse gas emissions and other environmental threats.

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8. CORE GLOSSARY

Accumulation of capital – the continuous growth of capital by retention of interest or earnings.

Agrarian – relating to land, land tenure, or the division of landed property.

Agribusiness – business connected to agriculture, either owning or operating larger scale farms for profit.

Agroforestry – diverse forms of integrated land management, including trees on farms and in agricultural landscapes, farming in forests and along forest margins, and collection of tree products.

Aquaculture – breeding, raising and harvesting fish, shellfish, and aquatic plants; basically, farming in water.

Biodiversity – all the different kinds of life found in one area – the variety of animals, plants, fungi, and microorganisms like bacteria in the natural world.

Carbon emissions – Release of CO2 (one of the greenhouse gases that absorbs radiation and prevents heat from escaping our atmosphere) from the exchange of carbon dioxide between the oceans and the atmosphere, from respiration of animals and, and from organisms within the soil, which creates disrupted weather patterns, higher global temperature averages, and other changes in the climate.

Colonization – official or spontaneous occupation of an area by migrants from other regions, for the purpose of land claiming and agricultural development.

Commodity – a product for trade or commerce.

Deforestation – also forest conversion; the clearing of natural forests (deforestation) to use the land for another purpose, often agricultural but also for mines, infrastructure or urbanization.

Environmental Services – the many and varied benefits to humans gifted by the natural environment and from healthy ecosystems.

Chapter 15

Extension – Agricultural extension is the service that provides technical advice to farmers, helps farmers acquire required inputs including credit for farming, provides training and evaluates new agricultural technologies on farmers' fields in close collaboration with farmers, and helps link farmers to supply chain and markets.

Fallow – land that has been cultivated and then left unseeded for one or more growing seasons to improve future agricultural production.

Floodplain – a low plain adjacent to a river that is formed chiefly of river sediment and is subject to flooding.

Forest conversion – See deforestation.

Forest degradation – the long-term reduction of the overall potential supply of benefits from the forest, which includes carbon, wood, biodiversity and other goods and services.

Forest extraction – the collection of non-timber and other kinds of non-agricultural forest products.

Forest management – harvesting timber from the forest in such a way that the system can continue to produce indefinitely while forest cover remains intact.

Household – one or more people who live in the same dwelling and share meals.

Hydro-climatic change – ecosystem service and function losses of wetlands and their surroundings due to climatic changes.

Hydrocarbons – a naturally-occurring organic chemical compound composed of hydrogen and carbon atoms that forms the basis of crude oil, natural gas, coal, and other energy sources.

Indigenous peoples -- ethnic groups in Amazonian independent countries whose social, cultural and/or economic conditions distinguish them from other sections of the national community, and whose status is regulated wholly or partially by their own customs or traditions or by special laws or regulations.

Infrastructure – basic physical systems of a region or nation, including transportation systems, energy grids, communication networks, sewage, and water systems.

Chapter 15

Institutions – important social entities such as the state, the church, the family, policies, and the law.

Institutional rents -- value that comes from government infrastructure and services, including various fiscal incentives (credit lines, trade policy,) research, and favorable policies.

Intensification – additions which increase or expand the area or amount of an existing use, or the level of activity.

Land grabbing – Securing secured through title fraud, violence, and amnesty; also, nation states selling off or allocating national areas to other nations or corporations on lands already occupied by other claimants

Land speculation – the acquisition of real estate with the hope that the price will increase.

Land tenure – rules that define how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints.

Livelihood – means of securing the basic necessities of life; a set of activities essential to everyday life including securing water, food, fodder, medicine, shelter, and clothing.

Lock-ins – situation in which a producer is unwilling or unable to change production strategies because of policy and/or market disincentives associated with doing so.

Logging – removal of timber from the forest.

Moratorium – an official suspension or delay of some activity.

Neoliberal – a policy model that seeks to transfer the control of economic factors from the public to the private section, enhancing the workings of free-market capitalism and placing limits on government spending, government regulation, and public ownership.

Peri-urban – landscape interface between town and country; also the rural-urban transition zone.

Production systems – systems by which specific actors produce economic value by combining labor, resources and technology

Chapter 15

Production trajectories – evolution over time of a production system

Resilience -- capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop.

Shifting cultivation – an agricultural system in which plots of land are cultivated temporarily, then abandoned to fallow while the cultivator moves on to another plot.

Socio-ecological – perspective that emphasizes the need to address intertwined social and ecological issues and concerns in striving for sustainable development.

Stocking rate – relationship between the number of animals and the size of forage resource on which they are placed.

Subsidy – a direct or indirect benefit to individuals or firms, usually in the form of a cash payment from the government or a targeted tax cut, or a "subsidy from nature" in the form of access to natural resources at no cost.

Subsistence – having the means of support or livelihood, including the minimal needs for food, clothing, and shelter.

Sustainable – meeting the needs of the present without compromising the ability of future generations to meet their needs.

Traditional -- local or traditional communities in Amazonia, generally descendants of migrants who intermarried with local Indigenous peoples, are strongly connected with place, territory and biodiversity, as well as with each other, in symbolic as well as physical, economic and political ways.

9. BOXES

Box 15.1. Historic Amazon fisheries

For more than 350 years, until the second half of the 20th century, the immense fisheries resources were the major source of animal-derived nutrients, such as protein, fatty-acids, iron and zinc for Amazon populations (Crampton et al., 2004). Beyond providing a major source of subsistence for riverine communities, fish were a main staple of the *aviamento* credit and supply system through which virtually all Amazon production and trade was organized. Fish were processed in salting stations on the shores of floodplain lakes and river margins where they were cleaned, salted and dried, and stored for sale to river traders and/or transported to urban merchants who shipped dried fish upstream to rubber and Brazil nut producing areas (McGrath, 2003; Veríssimo, 1895; Weinstein, 1983).

This commercial system began to change with technological innovations including smaller diesel engines, synthetic fibers for nets, ice making technology, and Styrofoam for ice boxes. These innovations enabled fishers to travel further and catch and store larger amounts of fish, as well as to ship fish across larger distances (McGrath et al., 1993). Commercial fisheries shifted from a seasonal activity producing and selling dried, salted fish, to a year-round activity involving fresh iced and frozen fish for growing urban markets, and the developing fish processing industry (Smith, 1985). Through this process, commercial fisheries developed two distinct, though overlapping supply chains, one focused on migratory catfish to supply fish processing industries that exported fish to other parts of Brazil, and the other focused on fish with scales, especially *characins*, to supply regional Amazon urban markets (Isaac et al., 2008, Crampton et al., 2004). In Peru, Ecuador and Colombia, Amazonian fisheries supply local markets, since stiff competition with well-developed marine fisheries challenges expansion of jungle fish into coastal and Andean markets.

Box 15.2. Land grabbing in the Amazon: clearing for claiming

In many places of the world land grabbing involves nation states selling off or allocating national areas to other nations or corporations for food or biofuel, plantation production or, as mining or timber concessions on lands already occupied by other claimants. These can be historical territories, as is the case with Indigenous peoples and local communities whose tenurial regimes may not be recognized by the state, or settler/ peasant farmer lands that may be simply expropriated by fiat or violence.

Amazonian lands can involve such large-scale international transnational transfers for corporations for land development. The classic case here is Fordlandia, but other international land grants during the Brazil's authoritarian times included Daniel Ludwig's *Jari*, the Volkswagen ranch, the Caterpillar ranch (among many others who received fiscal incentives), as well as transfers to many large-scale national corporations. Rights over large-scale subsurface resources for hydrocarbons, minerals and concessional timber rights are common, and typically worked out through state concessions and complex sharing agreements. Because nation states typically assert subsurface rights, allocation and auction of such rights to international consortia (and sometimes with national partners) occurs widely, even if the lands and resources associated with such concessions are occupied by people whose livelihoods, lives, resources, cultures and histories can be dramatically undone by these actions (Finer et al., 2008; Perreault and Valdivia, 2010; Valdivia, 2015; Bebbington et al., 2018; see also Chapter 18 on the Ecuador case study). The impacts on local populations can involve displacement, destruction of critical resources or subsistence resources like fish and tree crops, resource theft, contamination, introduction of disease, as well as cultural assaults including violence, local enslavement and attacks on women, leaders and forest guardians. Well documented cases include the Yanomami and informal gold mining, formal mining on *quilombos* on the upper Trombetas river, and pipelines on *quilombo* land near the Barcarena port in Pará State, Brazil. Indigenous land was opened for oil extraction in Ecuador, Bolivia Peru and Colombia (Oil & Gas Journal, 1999; Finer et al., 2009; Widener, 2009; Hindery, 2013; Bebbington et al., 2018; Bebbington et al., 2018).

Large-scale infrastructure such as dams also involve expulsion and appropriation of land and resources of current occupants, and the overflooding of catchment ponds can lead to "river murder". Displacement, flooding, alteration of access rights, loss of resources and destruction of cultural heritage and overriding of legal occupation rights are a repeating and common story (Hernández-Ruz et al., 2018; de Lima et al., 2020).

Land grabbing can also reflect overlapping tenurial regimes that are a function of land laws and property rights enacted at different historical times but that still are more or less legal, like land tenure granted in the Brazilian State of Acre and by Bolivia over the same territories before the adjudication of national territories occurred. Sometimes simple occupation rights have been validated for a period, and then new regimes change the legality of the holding, as when collection concessions were transformed into legal property (Emmi, 1988). Sometimes different land agencies with different jurisdictional remits (federal and state for example) have validated claims to the same holding with competing owners. Sometimes historical rights have been validated---as in Indigenous territories and *quilombo* lands or traditional communities---or new categories of land categories have come into play, such as various kinds of protected areas. Because land is important as an asset, a means of production, a way to launder money from illicit or clandestine activities (Davalos et al., 2014), as mechanisms for capturing institutional rents such as credit and other production subsidies, and as a vehicle for speculation with relatively low entry costs (Merry and Soares, 2017), shifting forest to cleared land has been among the best ways of "conjuring property"(Campbell, 2015). Land rights have also been secured through title fraud, violence, and more recently in the Bolsonaro regime, with amnesty. In this complexity of tenurial regimes, or the case of undesignated federal lands (*terras devolutas* as they are known in Brazil) competing surface land rights are resolved through clearing for claiming, the ancient dictum in Roman law, *uti possedetis*: he who has, keeps. Into this maelstrom of tenurial regimes, cattle ranching and the infrastructure that attends it has had a special role.

Cattle have multiple logics in Amazonian contexts: they do not need much labor, they are both an asset and a means of production of other assets (more cattle), they can be flexibly harvested, can be subsistence or market, local or regional goods, as well as a global commodity. The development of pasture itself is relatively simple and cheap: it involves cutting forest, letting it dry, and setting it on fire. Subsequent seeding with exotic pasture grasses follows, and what had been a highly diverse forest of hundreds of species is reduced to a few in order to create a habitat for one species: bovines that roam at low densities over increasingly depauperate landscapes. The creation of pasture from forest largely nullifies any alternative, forest-based or most agricultural land uses that don't employ herbicides, which is why gatherers of forest products and forest people more generally, and small scale farmers, have resisted the expansion of livestock, and why ranching has become such a central feature of land encroachment on protected and Indigenous areas, areas of road expansion and new colonization, and why this land use so often contested (Simmons et al., 2007; Grajales, 2011; Ballve, 2013; Botia, 2017; Schmink et al., 2019).

The usefulness of cattle as a product, however, mediates a far more valuable asset which is via "clearing for claiming" –the showing of effective land use- which is an element required for the defense of land claims, and the transformation of seemingly "amorphous" lands into private property. In this context, title, however dubious, helps in real estate transfer and has given rise to a gamut of fraudulent practices, including most recently, the ability to buy georeferenced Amazonian but illegally claimed and cleared land on Facebook.

The increase in land prices "heats up" the land market and everything it mobilizes, including the mark-up of "producing" land and expanding the land grab effort. The great growth in the volume of appropriated lands in recent years in other countries than just Brazil, corresponding to a rate of 1,2 million hectares a year, may indicate a harbinger of a new cycle of land grabbing which precedes a corresponding cycle of "producing land"--that is, turning it into a commodity (Araújo et al., 2006; Rajão et al., 2020; Campbell, 2015). The expanding infrastructure programs for all of Amazonia with its vast new regional road networks and the strong association of roads and land clearing (Pfaff et al., 2007; Perz et al., 2013; Pfaff et al., 2018) and with speculation, suggest accelerated clearing, especially under current lax regulatory conditions, which mimic those of earlier times (Hecht, 1985; Hecht, 1993; Barona et al., 2010; Bowman et al., 2012; Davalos et al., 2014). The speculative aspect is especially relevant in the context of land tenure uncertainty, expanded infrastructure development, and advancing crop frontiers (Bowman et al., 2012; Richards et al., 2014; Campbell, 2015). Ranching can be financially appealing in the context of land speculation, as a way to cheaply secure large areas of land until land prices rise, and as a means of capturing an array of institutional rents (Hecht, 1993; Miranda et al., 2019; Meyfroidt et al., 2020; Mann et al., 2014; Escolhas, 2020). By institutional rents we refer to value that comes from government infrastructure and services, including various fiscal incentives (credit lines, trade policy) research, and favorable policies. Deforestation for livestock expanded 1.2 million hectares per year between 1985 and 1995, and 1.9 million hectares per year between 1995 and 2006 (IBGE, 2020; INPE-MapBiomas, 2020).

Box 15.3. Logging and Deforestation for Cattle

In many places of the world land grabbing involves nation states selling off or allocating national areas to other nations or corporations for food or biofuel, plantation production or, as mining or timber concessions on lands already occupied by other claimants. Amazon lands can involve such international transnational transfers for production, although rights over subsurface resources for oil, minerals and concessional timber rights are more common. Because nation states typically assert subsurface rights, allocation of such rights to international consortia (and sometimes with national partners) is common, even if the lands and resources associated with such concessions are occupied by people, whose livelihoods, lives, resources, cultures and histories can be dramatically undone by these actions (Finer et al., 2008; Perreault and Valdivia, 2010; Valdivia, 2015; Bebbington et al., 2018; see also chapter 18 on the Ecuador case study). Large scale infrastructure such as dams also involve expulsion and appropriation of land and resources of current occupants. Displacement, flooding, alteration of access rights, loss of resources and destruction of cultural heritage and overriding of legal occupation rights (Hernández-Ruz et al., 2018; de Lima et al., 2020).

Land grabbing can also reflect overlapping tenurial regimes that are a function of land laws and property rights enacted at different historical times but that still are more or less legal, like land tenure granted in the Brazilian State of Acre and by Bolivia over the same territories before the adjudication of national territories occurred. Sometimes simple occupation rights have been validated for a period, and then new regimes change the legality of the holding as when collection concessions were transformed into legal (Emmi, 1988; Schmink and Wood, 1992). Sometimes different land agencies with different jurisdictional remits (federal and state for example) have validated claims to the same holding with competing owners. Sometimes historical rights have been validated---as in Indigenous territories and *quilombo* lands or traditional communities---or new categories of land categories have some into play such as various kinds of protected areas. Because land is important as an asset, a means of production, a way to launder money from illicit or clandestine activities (Davalos et al., 2014), as mechanisms for capturing institutional rents such as credit and other production subsidies (in the Brazilian Amazon 62% of agricultural credit concessions went to livestock (Escolhas, 2020), and as vehicle for speculation with relatively low entry costs (Merry and Soares, 2017), shifting forest to cleared land has been among the best ways of "conjuring property" (Campbell, 2015). Land rights have also been secured through title fraud, violence, and amnesty. In this complexity of tenurial regimes, or the case of simple undesignated federal lands (*terras devolutas* as they are known in Brazil) competing surface land rights are resolved through clearing for claiming, the ancient dictum in Roman law, *uti possedetis*: he who has keeps. Into this maelstrom of tenurial regimes, cattle ranching and the infrastructure that attends it has had a special role.

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Box 15.4. Soy Moratorium

The small number of traders who handle South American soy have made commitments to limit deforestation in the Amazon –which was called the Soy Moratorium. This agreement, which is basically non-binding, was triggered by threats by the EU to boycott Brazilian soy, and like other global commodities ---think organic, or fair-trade goods and certifications---involved the use of the supply chains as levers on the sources of commodities. Brazil's Soy Moratorium was the first voluntary zero-deforestation agreement implemented in the tropics, and set the stage for supply-chain governance of other commodities, such as beef and palm oil. In response to pressure from international retailers and mostly conservation non-governmental organizations (NGOs), major soybean traders signed the agreement to not purchase soy grown on *Amazon* lands deforested after July 2006. The soy industry extended the Soy Moratorium to May 2016, by which time they expected that Brazil's environmental governance and land use monitoring would obviate the need for such an agreement. Deforestation in the Arc of Deforestation, and in the Brazilian Amazon more generally, declined by close to 80% in the 2004-2014 period, and reflected intensification to some degree, but this decline in deforestation did not slow forest loss, but rather deflected clearing (de Waroux et al., 2016; de Waroux et al., 2019; Nolte et al., 2017; Hecht, 2005). This process is called leakage. In this case, deforestation exploded in the Argentine Chaco, Bolivia's Chiquitania, the Brazilian Central *Cerrado* and the eastern *Cerrado* and *Caatinga* areas that form part of the new soy frontier known as Matopiba, an acronym composed of the first syllables of the states of Maranhão, Tocantins, Piaui, and Bahia. The dynamics of this leakage are complex, reflecting the impacts of more lax regulation (these other areas have far less monitoring), cheaper land prices, credit dynamics, promotional settlement land policies, among others, as well as displacement of livestock systems into new forest areas, speculation along roads, and pressure for paving and expanding existing road networks with their associated clearing (Meijer, 2015; de Waroux et al., 2016; de Waroux et al., 2019; Nepstad et al., 2019; Meyfroidt et al., 2020).

The stickiness and concentration of market power in the hands of a few companies is subject to intense debate: some believe this opens up the opportunity to leverage private sector interventions for improved sustainability governance in the Amazon (Reis et al., 2020), while others maintain this consolidates unsustainable practices, enhances institutional capture, and forecloses more agroecological and socially just alternatives for rural development (Oliveira and Hecht, 2016). As a partner to the soy moratorium, the idea of an Amazon beef moratorium also emerged. Brazil is now the world largest beef exporter, so the beef moratorium, crafted along the lines of the Soy Moratorium and relying on some super markets and the major slaughterhouses, dominated by meat packers JBS, Marfrig and Minerva, hoped to restrain ranching expansion and enhance intensification of beef production. The division of labor between cow-calf breeding operations and fattening operations, however, meant that animals reared on deforested frontier land (cow-calf) could be "finished" on deforestation free ranches, thus using the production division as a loophole to evade full compliance. JBS has been mired in multiple corruption scandals (Nishijima et al. 2019). The low market share of slaughterhouses that have made stringent sustainability commitments (de Waroux et al., 2017) is minimal compared with more than 80% of beef cattle slaughter likely going to domestic markets, which is more difficult to track (Hoelle, 2017; SEI, 2020). Recent research revealed that least 17% of beef shipments to the European Union from the Amazon region and *Cerrado*, Brazil's savanna, may be linked to illegal forest destruction (Rajão et al., 2020). According to an investigation by Global Witness, JBS, Marfrig and Minerva bought cattle from a combined total of 379 ranches between 2017 and 2019 where illegal deforestation had taken place. The firms also failed to monitor 4,000 ranches in their supply chains that were connected to large areas of deforestation in the state. This illegal deforestation contravenes these beef giants' public no-deforestation pledges and agreements with federal prosecutors in Brazil (Global Witness, 2020, "Beef, Banks and the Brazilian Amazon"). Other reviews focused on vaccination records also revealed a great deal of non-compliance (Klingler et al., 2018).

The period of the soy moratorium did show a decline in deforestation, but the over-emphasis on the moratorium as a kind of silver bullet is problematic Ascribing the decline in clearing to only the Soy Moratorium ignores the multiplicity of other processes: these included demarcation of more than 50 million ha of protected areas, declaration of extractive and Indigenous reserves along major deforestation corridors to slow active clearing frontiers, community organizations that tried to block forms of land grabbing and speculation (Campbell, 2015), global commodity price slowdowns, changes in exchange rates (Fearnside, 2007; Richards et al., 2012), acceleration of monitoring and enforcement, leakage, evasion of detection by clearing smaller lots, credit black-outs in high deforestation areas, among a broad array of other institutional and civil society initiatives (Oliveira and Hecht, 2016).

Box 15.5. Climate challenges faced by Amazonian farmers

Current challenges faced by farmers, particularly smallholders, of annual and perennial crops call for better dissemination of climate information and forecasting, sharing and diffusion of adaptive solutions, and better integration of existing production, processing, trading and consumption systems that improve economic return for farmers:

1) While Amazonia has experienced catastrophic flood and drought events, for producers, the main hazards are localized extreme hydro-climatic disturbances that have increased in frequency and intensity (List and Coomes, 2019; Espinoza et al., 2019). The provision of information on timing, frequency and intensity of severe floods, droughts, strong wind and other disturbances are needed to promote sustainable production of annual and perennial crops.

2) Information on adaptive responses is as critical as information on climatic disturbances and the impact of changes in urban markets. In all Amazonian countries there are examples of families that are successfully producing annual and perennial crops by innovating and adapting farming and marketing systems. A process for documenting, evaluating and promoting can help to achieve the sustainable development goals.

3) The fields of farmers that are successfully producing annual and perennial crops are reported to have high levels of agrobiodiversity (includes all landraces, varieties and species of annual and perennial crops) that help them to reduce the losses produced by floods and droughts. Programs such as agriculture credits should focus on promoting crop diversity rather than promoting of a single species. Experts have reported that agriculture credit programs for the production of rice, corn, *açaí*, cacao and other single crop have been demonstrated to be unsustainable and highly risky to climate changes (List et al., 2019; Flores et al., 2017; Schmit, 2003).

4) Programs to foster the production of annual and perennial crops should integrate existing adapted production systems, techniques, practice and other forms of local agrodiversity (includes production systems, techniques, practices and strategies used by farmers to produce, process, trade and consume annual and perennial crops) as technological resources for managing vulnerability and risky associate to hydro-climatic disturbances and changes in urban markets (Sherman et al., 2016; Kawa, 2011; Pinedo-Vasquez et al., 2003; Futemma et al., 2020).

5) Urban expansion has attracted private investors in the food market to supply the demand for rice, beans, corns and other products of urban Amazonia. Private investors have established supermarkets that are bringing grains, vegetables and other food staples that are produced outside Amazonia. Large supermarkets often rely on more distant suppliers of products like rice and beans, while small shops sell more local products, a pattern which may have changed with the impact of small farmer declines (Roberts, 1991). While urbanization has had mixed effects on the demand for locally produced annual corps, it has created markets for perennial corps such as fruits. For instance, an increase of taste and preference for rural food and diets of urban residents have created regional, national and international markets for fruits such as *açaí*, *cupuaçu*, *graviola*, and a variety of other perennial crops.

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Box 15.6. Challenges to Fisheries Development

Progress in fisheries management in the Brazilian Amazon reached its peak with the creation of the Ministry of Fisheries and Aquaculture (MPA) in 2009. However, the creation of the MPA also marked the beginning of the disruption of the government fisheries sector. With the creation of the MPA, responsibility for fisheries management was to be shared between IBAMA and the MPA, despite the fact that the new Ministry lacked the technical and institutional capacity to manage Brazilian fisheries (McGrath et al., 2015). Then in 2015 President Dilma Rousseff extinguished the MPA and transferred its functions to another agency. Over the next few years, the federal government fisheries sector became a pawn in the alliance-forming strategies of two presidents, finally ending up in a Secretary in the Ministry of Agriculture and Ranching. Subsequently, responsibility for managing fisheries was transferred to state governments with varying interest and capacity for managing their fisheries.

Contrasts in state-level commitment to fisheries management and development are illustrated by the states of Amazonas and Pará, which have the lion's share of the fisheries resources of the Amazon. Amazonas embraced its fisheries early, implementing co-management policies largely through the network of state and federal reserves. In contrast, the state of Pará has rarely invested in the fisheries sector (McGrath et al., 2015). Amazonas also developed policies for *pirarucu* management based on the management system developed by the Mamirauá Institute (Castello et al., 2009). As a result, while sustainably managed *pirarucu* production is growing in Amazonas, *pirarucu* populations in Pará are declining due to unregulated fishing (Castello et al., 2014).

In addition to the lack of government effort in managing fisheries, two other issues exacerbate the problem: 1) the absence of monitoring programs to collect data on commercial fish landings that can be used to analyze trends in fish stocks and fishing activity (Cooke et al., 2016), and 2) the absence of state inspection facilities to ensure that fish entering Amazon urban markets meet legal, sanitary and fiscal requirements (McGrath et al., 2015). The major exception to the latter issue is the industrial fisheries sector, which is required to register and inspect fish entering *frigoríficos*, and to pay any taxes and fees owed to the government. Consequently, the Amazon's small-scale fisheries are an invisible sector, with no information on the legality or quality of Amazon fish supplied to consumers, nor data to assess the economic importance of the fisheries sector to the regional economy, and inform government policies and private sector investment decisions (Bartley et al., 2015; Cavole et al., 2015).

In addition to the direct impacts of uncontrolled fishing pressure, Amazon fisheries are vulnerable to the range of impacts that have led to the decline of inland fisheries throughout the world (Cooke et al., 2016). These include large-scale land use change that can affect water quality and discharge, and pollution from urban centers and mining, especially placer mining (*garimpos*) and oil extraction (Castello et al., 2013). Dams on major tributaries can disrupt the migration routes of major commercial fish species, accelerating their decline. In addition, six major Andean dams scheduled for construction could capture 70% of the sediment transported by Amazon rivers, with major long-term impacts on the productivity of Amazon rivers, their floodplains and fisheries (Forsberg et al., 2017).

ANNEX FIGURES

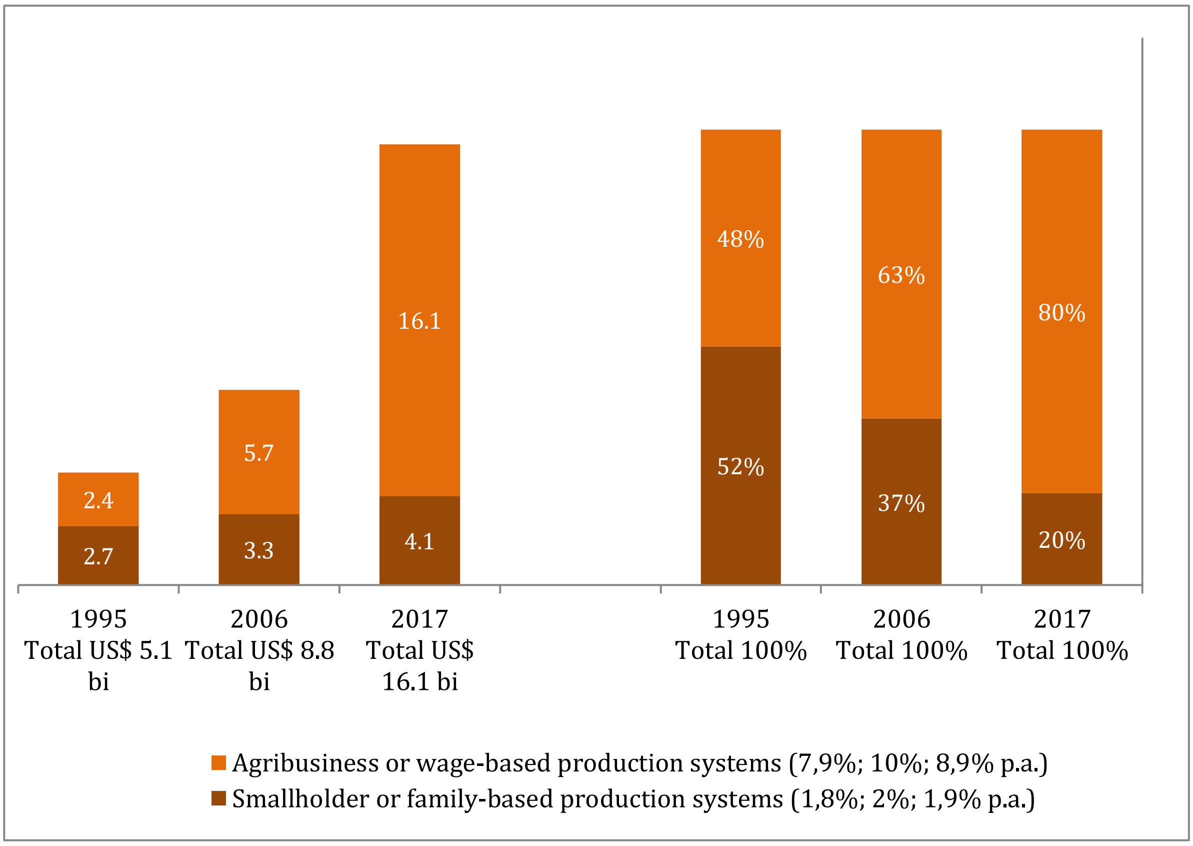

Figure 15.1a: Gross Value of Production (GVP) of the rural sector by agribusiness (wage-based) and smallholder (family-based) within Brazilian Amazon Biome in 1995, 2006 and 2017: absolute values in US$ billion at 2019 prices and relative structure in % of total; in the subtitles, the percentages refer to the annual growth, respectively, in the periods 1995 to 2006, 2006 to 2017 and 1995 to 2017. Source: IBGE, Agricultural Census 1995, 2006 and 2017. Current values in reais were restated for 2019 by the IGP-FGV and divided by the exchange rate of 12.31.2019 to get US$ values.

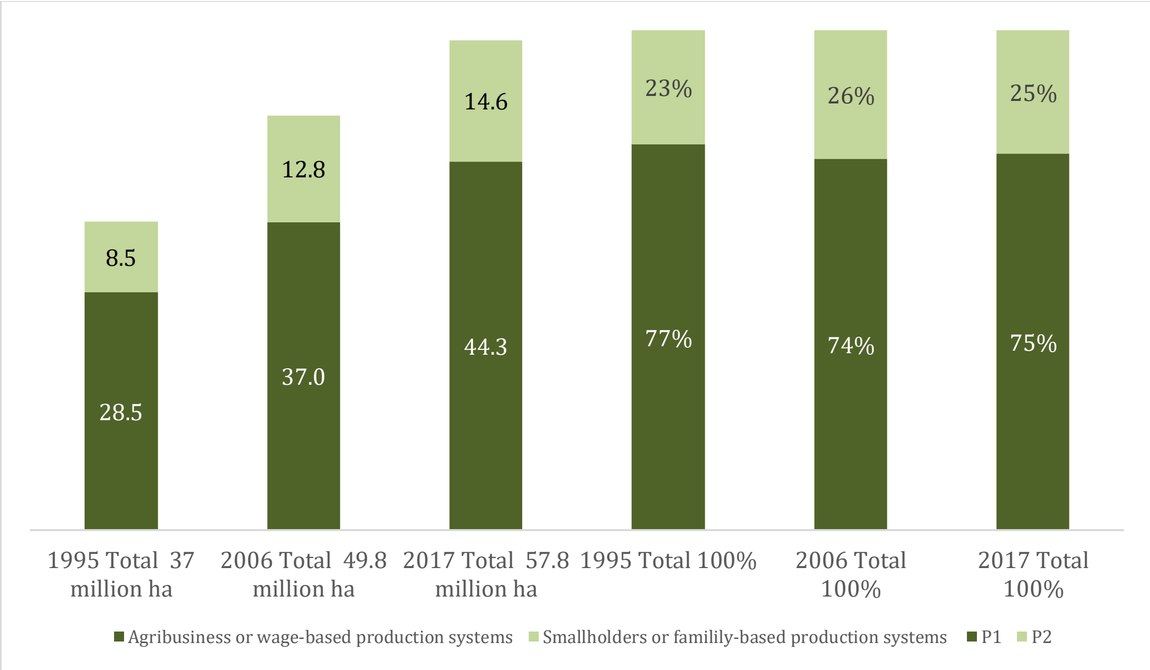

Figure 15.2a: Land used in agriculture and pastures in the agrarian economy within the Brazilian Amazon Biome in 1995, 2006 and 2017: absolute values in million ha and relative structure in % of the total; in the subtitles, the percentages refer to the annual growth, respectively, in the periods 1995 to 2006, 2006 to 2017 and 1995 to 2017. Source: IBGE, Agricultural Censuses 1995, 2006 and 2017. Note: Lands used for agriculture, cattle ranching, and forestry plus degraded areas.

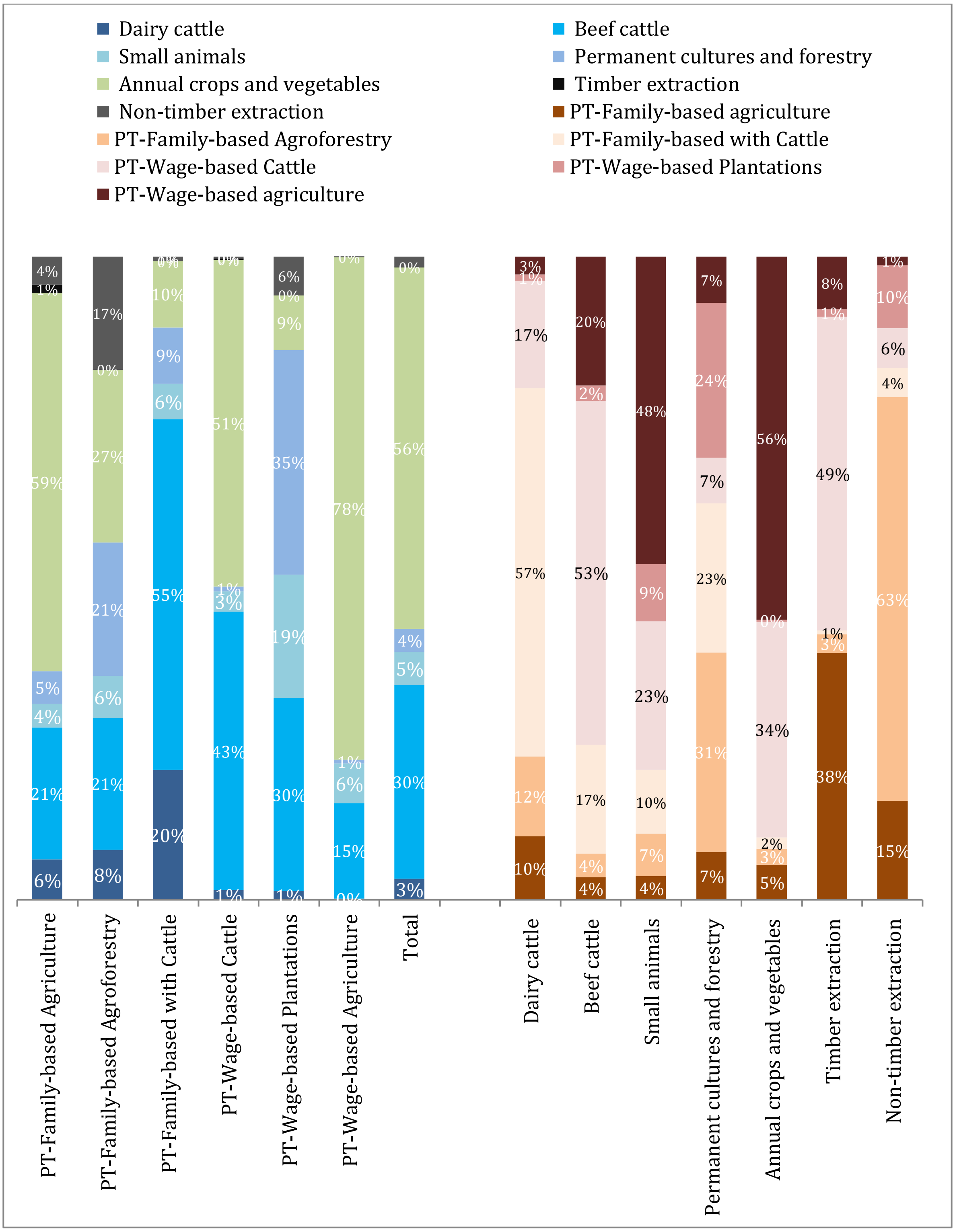

Figure 15.3a: Production composition by PTs of the agrarian economy within Brazilian Amazon Biome, 2017 as % of GVP. Source: IBGE, Agricultural Census 2017.

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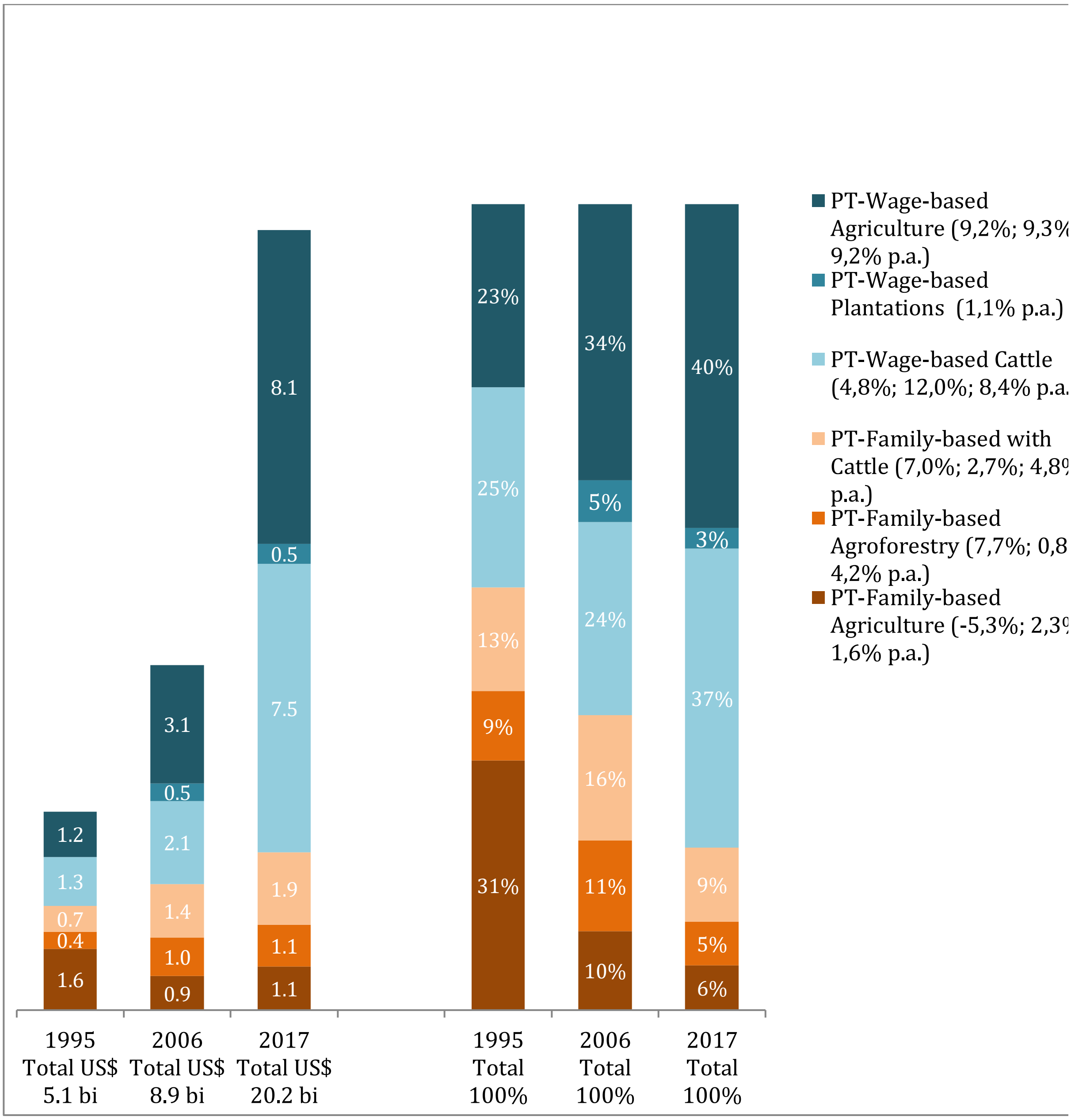

Figure 15.4a: Gross Value of Production (GVP) of PTs within Brazilian Amazon Biome in 1995, 2006 2 and 2017: absolute values in US$ billion at 2019 prices and relative structure in % of total; in the subtitles, the percentages refer to the annual growth, respectively, in the periods 1995 to 4 2006, 2006 to 2017 and 1995 to 2017. Source: IBGE, Agricultural Censuses 1995, 2006 and 2017. Current values in reais were restated for 2019 by the IGP-FGV and divided by the exchange rate of 12.31.2019 to get US$ values.

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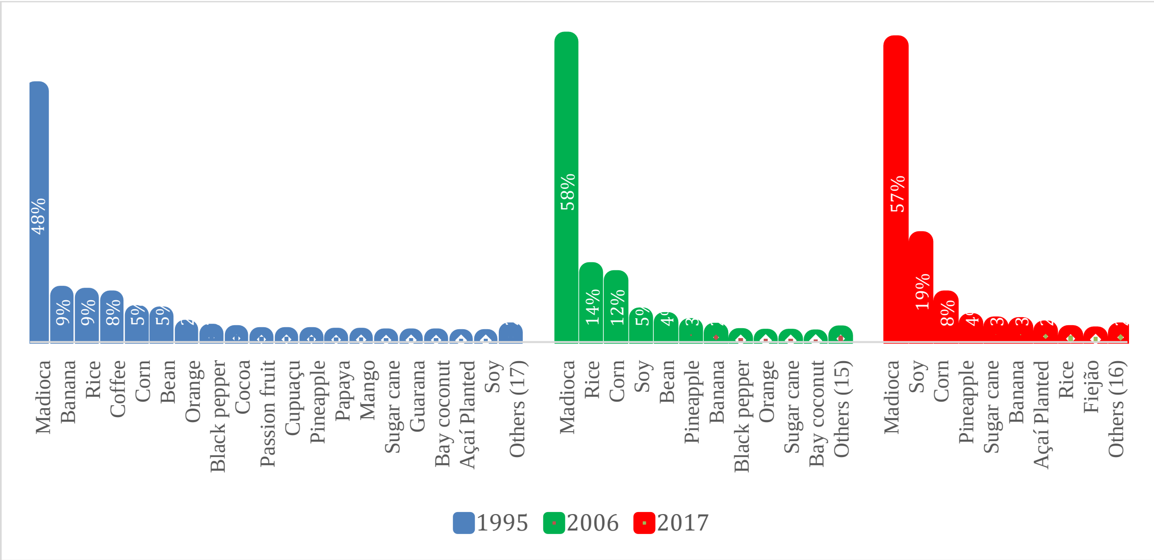

Figure 15.5a: Evolution of PT-Family-based Agriculture production (% of GVP). Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

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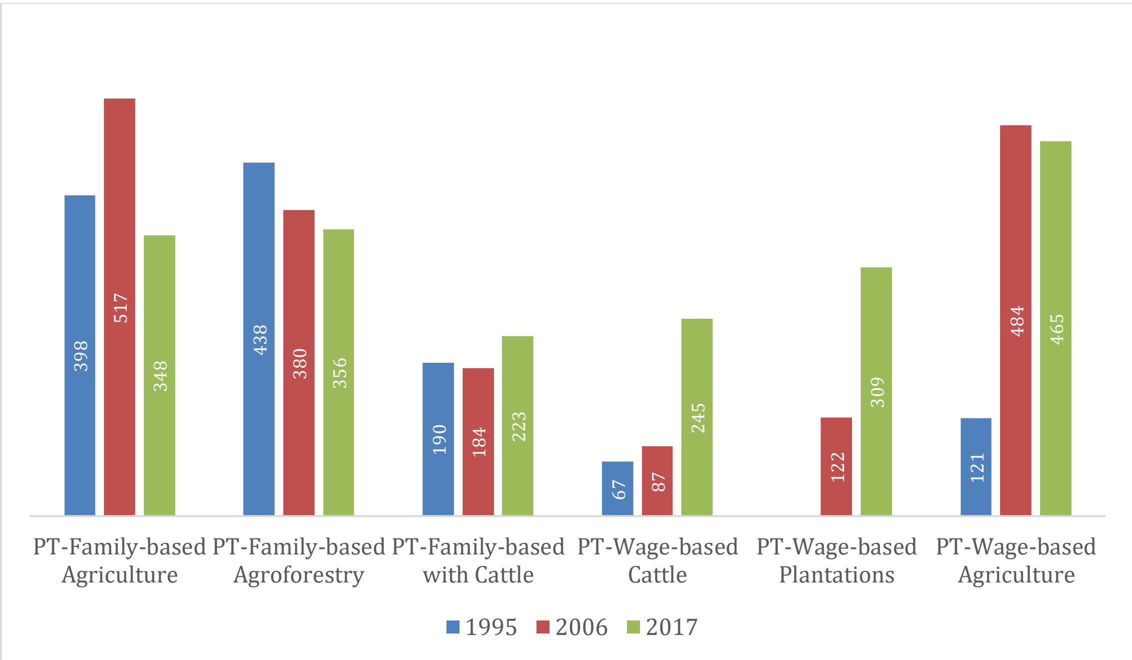

Figure 15.6a: Gross value of production per unit of applied area by PT in the agrarian economy of the municipalities within Brazilian Amazon Biome in 1995, 2006 and 2017: in US$. Source: IBGE, Agricultural Censuses 1995, 2006 and 2017. Current values in reais

were restated for 2019 by the IGP-FGV and divided by the exchange rate of 12.31.2019 to get US$ values.

1

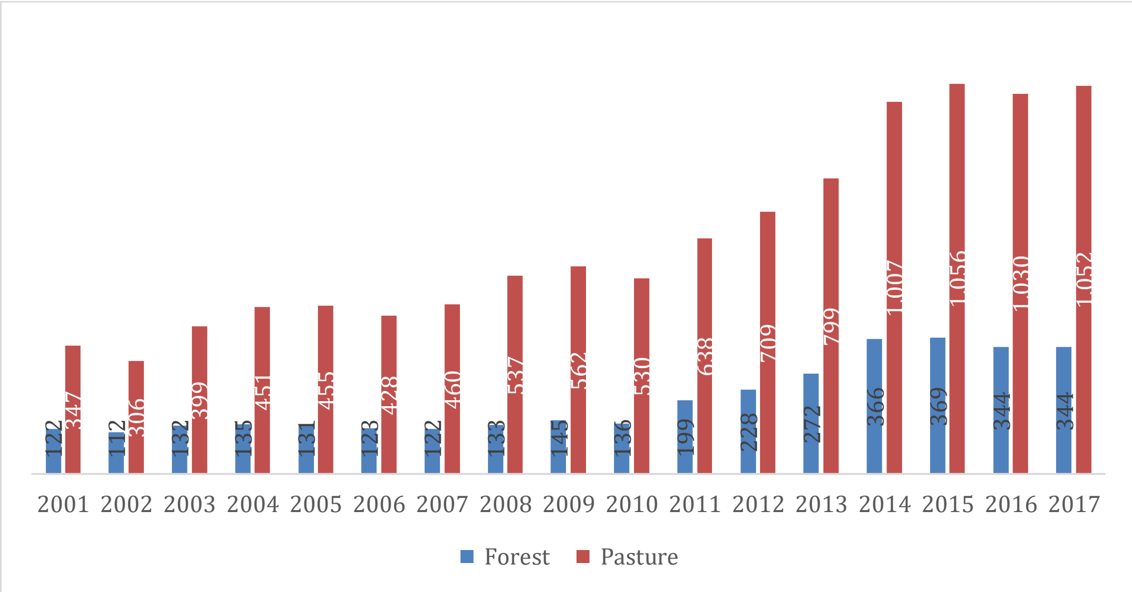

Figure 15.7a: Evolution of land prices in the Amazon - 2001 to 2017 (Prices in US$). Source: FNP, Agriannual several years. Current values in reais were restated for 2019 by the IGP-FGV and divided by the exchange rate of 12.31.2019 to get US$ values.

2

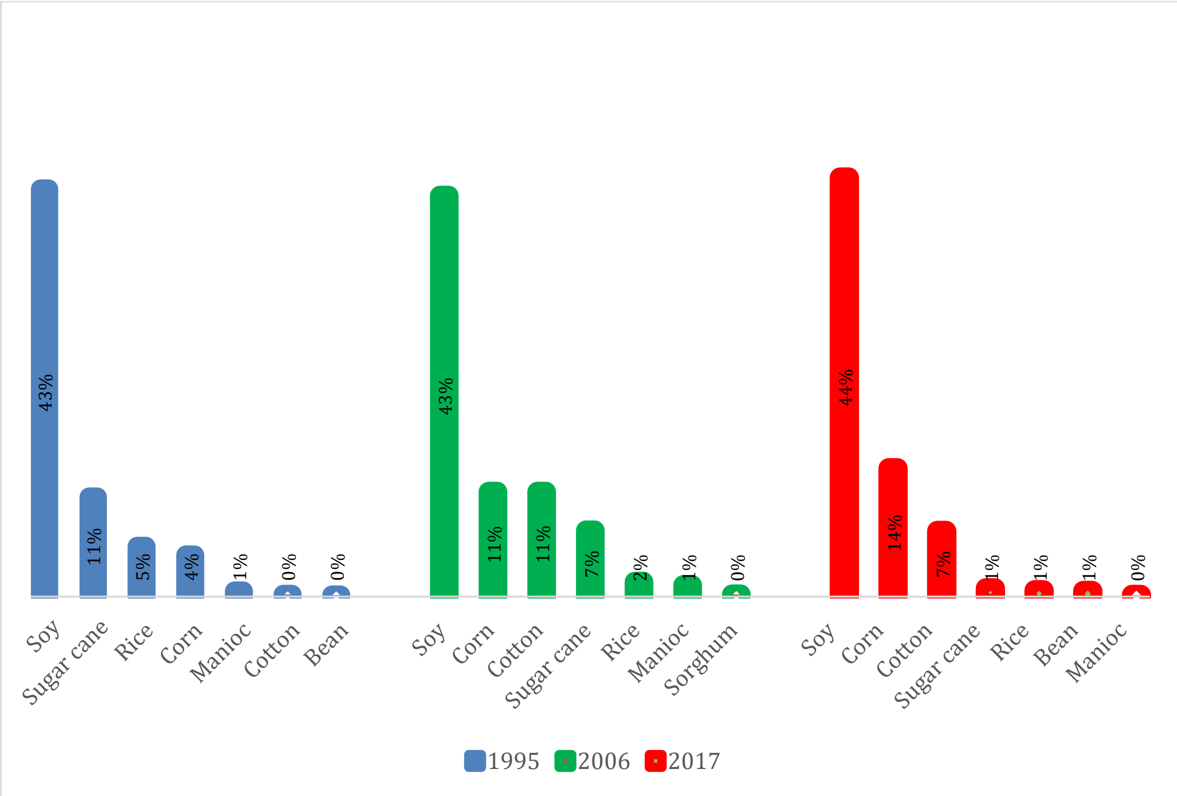

Figure 15.8a: Evolution of PT-Wage-based Agriculture production (% of GVP). Source: IBGE, Agricultural Censuses 1995, 2006 and 2017.

1

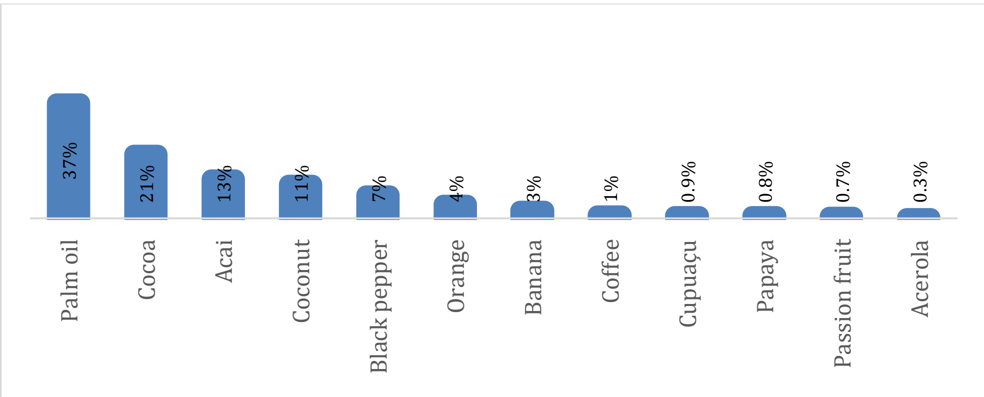

Figure 15.9a: Order of importance of different permanent crops at PT-Wage-based Plantations. Source: IBGE, Agricultural Census 2017.

2

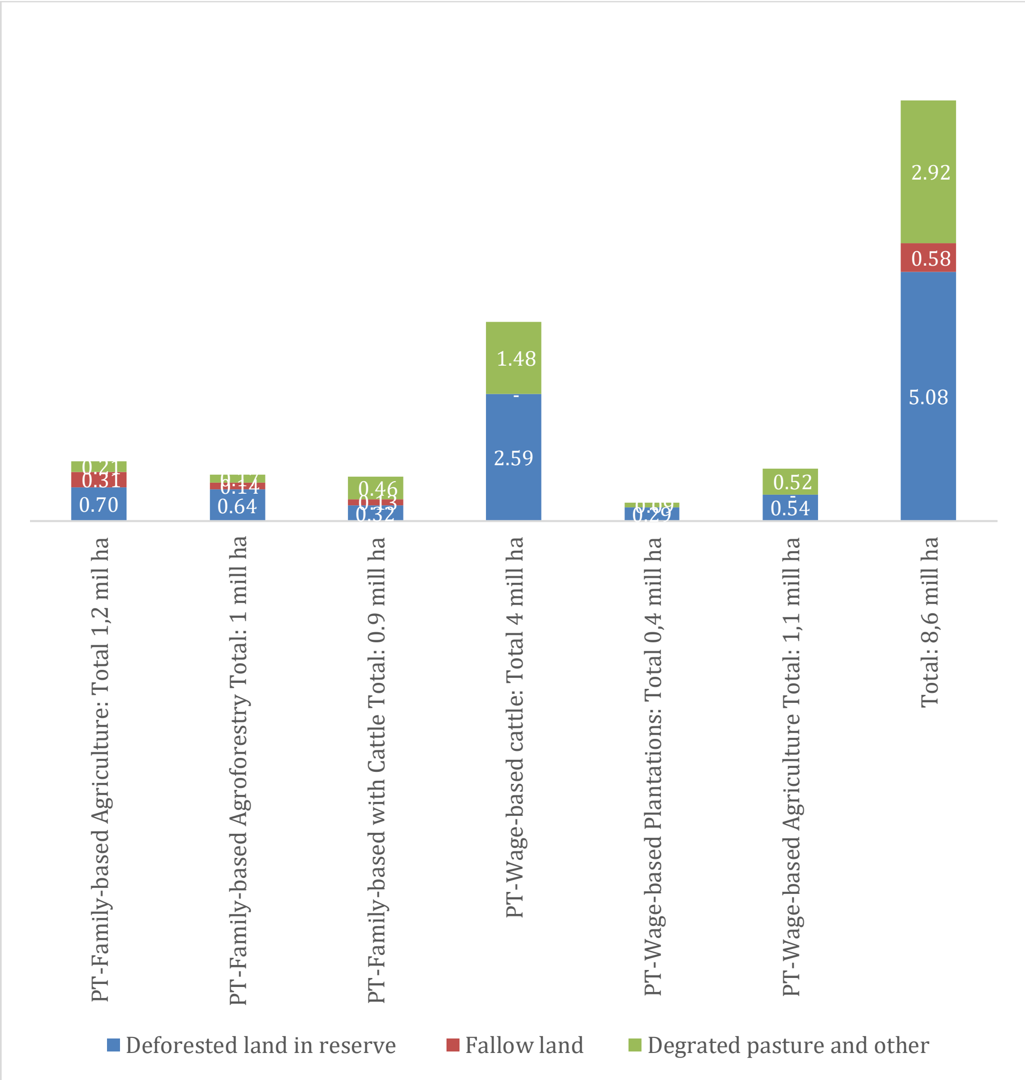

Figure 15.10a: Lands with secondary vegetation in PTs: fallow land, deforested land in reserve and degraded land by PT in mill ha - 2017. Source: IBGE, Agricultural Censuses 1995, 2006 and 2017; Costa, 2016

1