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Land-use allocation on the Amazon Frontier: evidence from the Manaus - Porto Velho road (BR-319) in Amazonas, Brazil

Carolle U. Alarcon Eichmann

Supervisor: Prof. Dr. Jürgen Pretzsch

Co-supervisor: Prof. Dr. Philip Fearnside (INPA)

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Abstract

The presence of roads is the strongest predictor of deforestation, and the pavement of the Manaus-Porto Velho highway (BR-319) is expected to facilitate migration from the arc of deforestation to new frontiers farther north, causing a drastic change in the land cover of the region. However, there is not much information available about the process shaping frontier development in the region, and this thesis attempted to fill this gap. Case study was the methodology selected, and the specific purpose was to describe the actor groups shaping frontier development on the BR-319 road, as well as exploring the variables affecting colonists' land-use decisions with consequent impact on deforestation. Additionally, the thesis proposes to investigate the institutional and political environments, thus broadening the understanding of the challenges facing sustainable development in the region. At the local level, data were collected through survey questionnaires with 48 households and, at the regional level, data were based on 29 key-informant interviews with civil-society institutions and with the public and private sectors.

Comparing the findings of this research with previous studies the colonists on the BR-319 show resemblance with other frontier areas: there is a tendency for the consolidation of young families, with high numbers of men, low levels of education and of previous background experience. Additionally, the average household size is analogous to that in other frontier areas, as are the periods of residence in other areas away from their birthplaces previous to the final migration. The existence of a network that transmits information about available land, thus attracting people and stimulating migration, has also been observed in other regions. Having government transfers and off-farm employment as primary sources of income are also comparable to other areas. The diversification of income to many off-farm activities appears to be a tendency in frontier regions. Also typical are low dependency on farm revenue, low percentage of households receiving technical assistance and the tendency for land accumulation. Like other frontier regions, there is evidence of a speculative nature of land acquisition and deforestation driven by pasture establishment. Also in common with other areas, shifting cultivation is the principal land-use system transforming the landscape in the case of traditional communities. Additionally, the weak governance and the chaos in land regularization seen in the institutional context is a common feature of Amazon frontiers.

Nevertheless, the origins of colonists, as well as the initial settlement and tenure regimes, have dissimilarities with older frontier regions, but they resemble the results from the region of Apuí, in the southern part of Amazonas state. There is an indication that, in this new frontier zone, colonists are no longer arriving from the Northeast region, but rather from internal fluxes within the North region. Nevertheless, the flow of migrants from the South region remains. These findings are corroborated by the findings on their migration trajectories, which show a characteristic pattern of migration to the north from prior expansion frontiers. Some results could not be compared: the lack of access to credit is unique to the region; similarly, access to infrastructure and the sizes of properties were inconclusive. Lastly, the positive relationship between deforestation and welfare is analogous to other frontier regions, but, when the focus is placed exclusively on the participation of off-farm income the results of this thesis could not be generalized.

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DALR	DIRECT ACTION LAND REFORM
INCRA	NATIONAL INSTITUTE FOR COLONIZATION AND AGRARIAN REFORM
SEMA	STATE SECRETARIAT OF ENVIRONMENT OF THE AMAZONAS STATE
NGO	NON-GOVERNMENTAL ORGANIZATION
IDESAM	INSTITUTE OF SUSTAINABLE DEVELOPMENT OF AMAZONAS
MPF - AM	MINISTÉRIO PÚBLICO FEDERAL DO AMAZONAS - BRAZILIAN FEDERAL PROSECUTOR
IBAMA	INSTITUTO BRASILEIRO DO MEIO AMBIENTE E DOS RECURSOS NATURAIS RENOVÁVEIS - FEDERAL GOVERNMENTAL AGENY RESPONSIBLE FOR ENVIRONMENTAL LICENSING
DNIT	NATIONAL DEPARTMENT OF TRANSPORT AND INFRASTRUCTURE
FUNAI	FUNDAÇÃO NACIONAL DO ÍNDIO - FEDERAL GOVERNMENTAL AGENCY RESPONSIBLE FOR INDIGENOUS PEOPLE
ICMBIO	INSTITUTO CHICO MENDES DE CONSERVAÇÃO DA BIODIVERSIDADE - FEDERAL GOVERNMENTAL AGENCY RESPONSIBLE FOR PROTECTED AREAS
TL	TERRA LEGAL - FEDERAL PROGRAM OF LAND TENURE REGULARIZATION IN THE AMAZON

IPAAM	INSTITUTO DE PROTEÇÃO AMBIENTAL DO AMAZONAS - STATE GOVERNMENTAL AGENCY RESPONSIBLE FOR ENVIRONMENTAL LICENSING
SEPLANCT	STATE SECRETARIAT FOR PLANNING, DEVELOPMENT, SCIENCE, TECHNOLOGY AND INNOVATION
PGE-AM	PROCURADORIA GERAL DO ESTADO DO AMAZONAS - STATE PROSECUTOR
IIEB	INTERNATIONAL INSTITUTE OF EDUCATION OF BRAZIL
UFAM	FEDERAL UNIVERSITY OF AMAZONAS
INPA	NATIONAL INSTITUTE OF AMAZONIAN RESEARCH
GIZ	DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT
OAB-AM	BRAZILIAN LAWYERS ASSOCIATION
FIEAM	FEDERATION OF INDUSTRIES OF THE STATE OF AMAZONAS
UAV	UNMANNED AERIAL VEHICLE
PAS	PROTECTED AREAS
EIA	ENVIRONMENTAL IMPACT ASSESSMENT
APAL	AREA OF PROVISIONAL ADMINISTRATIVE LIMITATION
AII	AREA OF INDIRECT INFLUENCE OF THE ROAD
ADI	AREA OF DIRECT INFLUENCE OF THE ROAD
EEZ	ECONOMIC-ECOLOGICAL ZONING
NTFP	NON-TIMBER FOREST PRODUCTS
ARPA	AMAZON PROTECTED AREAS PROGRAM
PPG7	PILOT PROGRAM TO CONSERVE THE BRAZILIAN RAINFORESTS

1 Introduction and Statement of the Problem

The current thesis investigates the colonists of the Manaus-Porto Velho road on the Brazilian Amazon frontier and how their agricultural strategies affect deforestation. Deforestation in the Amazon is not just a local problem[1] and today, it is estimated that one-fifth of the biome has already been cleared with evidence that we may be reaching an ecological tipping point (Lovejoy & Nobre 2018). Roughly, 80% of all forest loss is located in the so-called "arc of deforestation", a crescent-shaped strip along the southern and eastern edges of the forest, representing the expanding agricultural frontier (Figure 1) (Fearnside 2017).

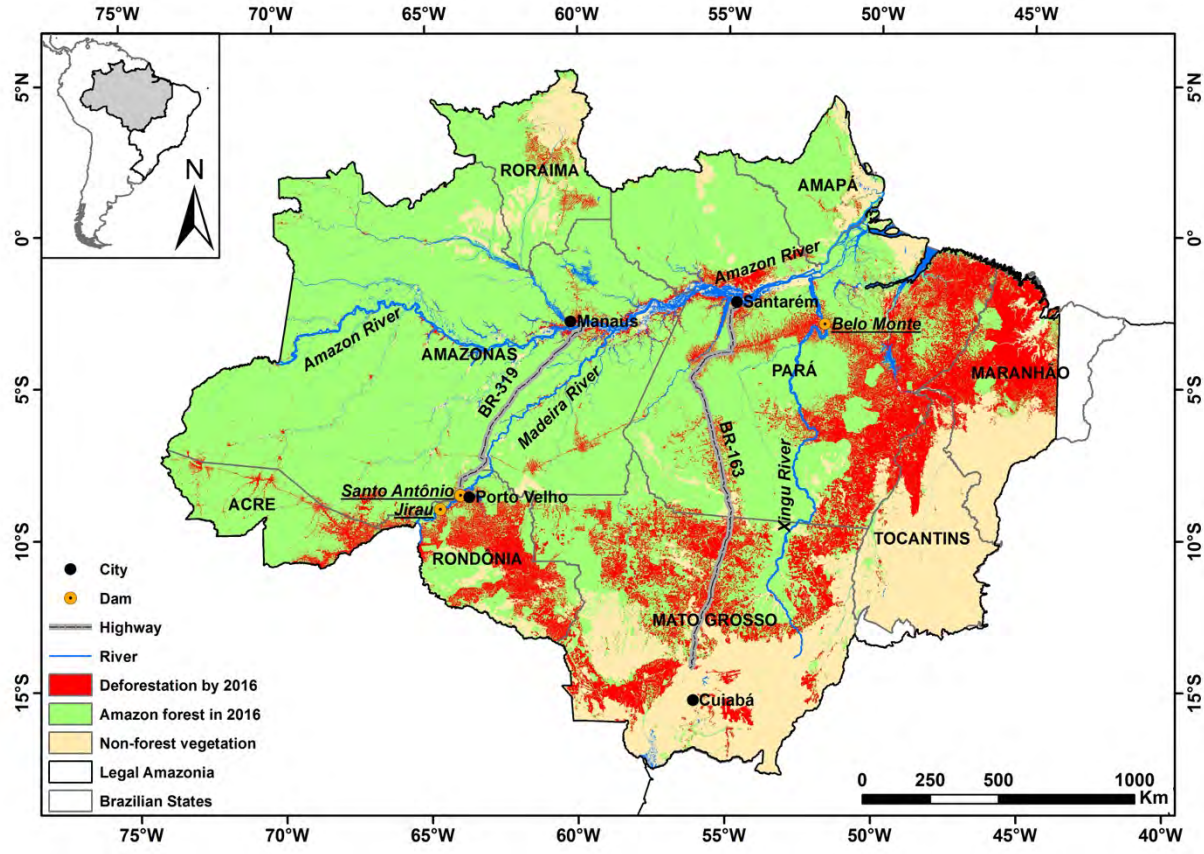

Figure 1 - Deforestation in the Brazilian Amazon. The "arc of deforestation and the BR-319 (deforestation is shown in red). Source: Fearnside, 2017

The presence of roads is the strongest predictor of deforestation (Kirby at al. 2006), up to 95% of all deforestation in the Brazilian Amazon occurs within a distance of 50 km from official roads (Nepstad et al. 2002, Laurance & Balmford 2013, Barber et al. 2014). Roads intensify migration, considerably increase land values and the profitability of agriculture and ranching (Fearnside 2017) thus driving agricultural colonization.

[1] Amazonia functions as an important center for redistribution of water vapor entering the continent from the Atlantic Ocean, thus partly regulating the annual distribution of rains in the central and southern regions of Brazil and of South America (Luizão et al. 2008), and even of the western United States (Medvigy et al. 2013).

Paved roads, specifically, have even a much farther-reaching effects on the landscapes (Kirby at al. 2006; Laurance et al. 2002).

The Manaus-Porto Velho highway, better known by its federal numeric designation, BR-319, is an emblematic case. Built in the 1970s by the military regime (Neto & Nogueira 2016), it runs 877 km north-south from Manaus to Porto Velho. Abandoned for almost two decades, it has been reestablished and paved in the last years and its reconstruction is expected to facilitate migration from the southern part of the Amazon to new frontiers farther north (Fearnside & Graça 2006) causing a drastic change in the land-cover of the region (Santos et al. 2015, 2018; Barni 2009). However, there is not much information available about the population of colonists living along the BR-319.

For this reason, this study seeks to contribute to the understanding of the actor groups shaping frontier development on the Manaus – Porto Velho highway. The research method selected is case study research, a method that excels at providing an understanding of complex issues, such as Amazonian frontier development. The current study relies on multiple sources of evidence, both quantitative and qualitative, and it benefits from the prior development of theoretical propositions. The specific goal is (1) to describe the colonists shaping frontier development on the Manaus – Porto Velho road: what are their socioeconomic characteristics, where they come from, when they arrive, what are their main sources of income or their production systems, what type of land they occupy. The specific variables and indicators considered for analysis are presented in more detail in the next chapter. The second specific goal is (2) to explore which variables predominant affect colonists' land-use decisions with consequence towards deforestation. The third goal is (3) to investigate the institutional and political environment where colonists are surrounded and with this provide insights about potential challenges for the sustainable development in the region. At the local level, data were collected through survey questionnaires with 48 colonists presenting different migration behaviors, production systems, socioeconomic characteristic, and deforestation patterns. At the regional level, data were based on 29 key-informant interviews with civil-society institutions, the public and private sectors and other individuals relevant to decision-making on land-use planning.

In frontier regions, a number of studies have already revealed that colonists usually have many similarities and are influenced by a variety of factors that shape their agricultural strategies and deforestation patterns (Moran 1977, 1981; Fearnside 1982; Goza 1994; Pichón 1996, 1997; McCracken et al. 2002; Brondizio et al. 2002, Deadman et al. 2004; Godar et al. 2012a, 2012b; Lambin 1994, 1997; Geist & Lambin 2002; Kaimowitz & Angelsen 1998). One of the tasks of this thesis is to compare the BR-319 with the findings of previous studies.

The thesis has been divided into six parts. Following this introduction, the second chapter deals with the theoretical propositions, and it is a crucial segment of the research; it grounds the case study and provides the framework and indicators of analysis. The third chapter describes the research design and methodology, as well as the study area. The fourth and fifth chapters are devoted to the empirical results, followed by the discussion in the sixth chapter and conclusions and recommendations in the last chapter.

2 Land allocation decision in the Brazilian Amazon: a two-level diagnosis

2.1 Theoretical propositions: a framework for analysis

In this section, the objective is to provide the theoretical foundation for the case study. The literature review, which at first sight may be seen as excessively long, was fundamental in pointing the appropriate indicators for data collection in the field. Frontier development is a complex process, and previously studies serve as a template to identify common variables to use as indicators of analysis. The theoretical references gathered, which will be presented in item 2.2, enabled the development of the following theoretical framework (Figure 2). This thesis is organized around this framework; it is the core of the current study, and it serves as a compass from here on.

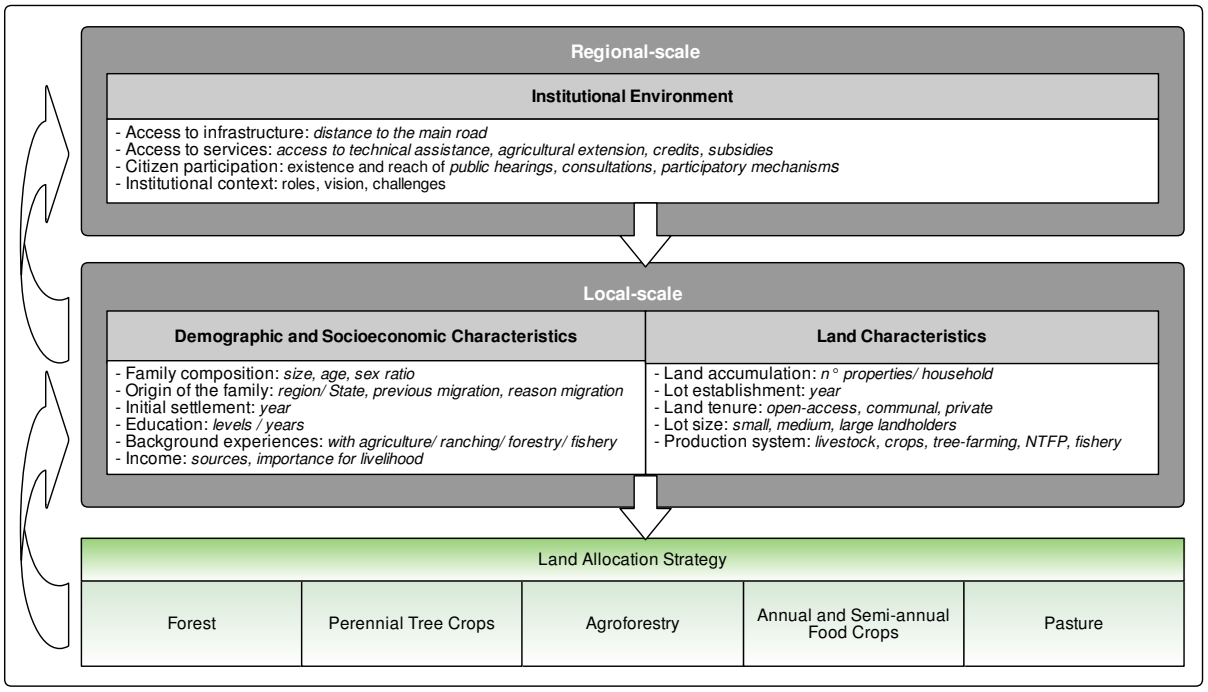

Figure 2 - Theoretical framework Source: author, 2018

The framework presents a summary of the main findings of previous studies about frontier development and land-use change. Recent developments in land-use studies have heightened the comprehension that both local and regional aspects interact synergistically affecting the agricultural strategies that individual families pursue, which in turn result in a range of land uses with direct long-term consequences for the landscapes. In Figure 2, the regional aspects comprise the institutional environment that colonists face, while the local aspects involve the household demographic and socioeconomic characteristics and the land features.

The regional-scale factors consist of the infrastructure conditions (and here namely access to the road) and government policies (i.e., access to credits and technical assistance). The current thesis additionally included for investigation citizen participation and the institutional context. Although these topics do not directly interfere in the land-use choices, and are normally not investigated by land-use studies, they help to get a better understanding of the political and institutional settings by which colonists are surrounded. The reconstruction of the Manaus-Porto Velho highway has been carried amidst an institutional conflict among different levels and sectors of the government and society, with spasms of governmental actions followed by judicial blockages, as will be described in section 3.5. The challenging institutional environment of the reestablishment led to a sense of lack of rule of law with impacts on governance in the territory. In such a manner, the institutional background (or so to say, the roles played by many institutions and the challenges and expectations they see in the future development of the territory), and the opportunities for citizen participation (i.e., public hearings, consultations, participatory mechanisms) were considered a significant topic to be addressed.

The local-scale factors, as shown in Figure 2, involve the household demographic and socioeconomic characteristics - such as the origin and composition of the family (i.e., size, age, sex ratio), origin of the family and history of migration, time of settlement, education levels, background experiences and sources of income; and the land characteristics - like time of plot establishment, land tenure and size and productions systems. The process of land accumulation, initially not forecasted for analysis, emerged as a typical behavior during the fieldwork and hence was included. Both levels (regional and local) affect the land-allocation strategies that families pursue, presented in the last rectangle in green. In general, the allocation options vary between croplands, pasture or forest and are the dependent variables included in this study. The proposition stated is that colonists have usually some similarities and are influenced by different set of variables, both exogenous and endogenous, which affect their land-use strategy.

From the grounding theories and conceptualizations were selected the most relevant variables which allowed the development of the framework aforementioned; a summary of them is presented in Table 1 below. At the left are presented the authors, and at the right, the most common local and regional variables found to affect colonists' land-use decisions.

Table 1 - Relevant variables from grounding theories

	LOCAL SCALE	REGIONAL SCALE
MORAN	Initial capital	Environmental factors: access to
1975	Origin of the family	water, distribution of soils
1977	Experience with agriculture	Distance to markets/ access to

1981	Experience with the region Education	roads
FEARNSIDE 1982	Colonist background Colonist origin Colonist and neighbor experiences Availability of capital	Financing opportunities Availability of transportation - access to roads
FEARNSIDE 1986 2001A	Financial indebtedness	-
GOZA 1994	-	Conflicts for control of land Access to roads and infrastructure
PICHÓN 1996 1997	Factors of production: land, labor, capital, technology Household consumption demands	Environmental conditions Market opportunities Government policies: subsidies, credit, different taxation
MCCRACKEN ET AL. 2002	Initial settlement Cohort Labor/ family composition	Environmental factors: access to water, soil quality Economic trends Government policies: access to credits
BRONDIZIO ET AL. 2002	Time of settlement Cohort Origin Family composition Expectations	Access to credit Inflation Environmental factors Market Infrastructural conditions
DEADMAN ET AL. 2004	Household composition and available labor Household endowment levels: available capital	Environmental factors: soil quality.
CARR 2004	Family composition	-
WALKER & HOMMA 1996	Income	Land concentration Social power by privileged groups
SIMMONS ET AL. 2016	Length of residence Kinship colonization	Availability of *terra devoluta*
BARBIERI ET AL. 2005	Initial settlement	-
BRONDIZIO ET AL. 2009	Family composition	-
PAN & CARR 2010	Family composition	Road access Land tenure
GODAR ET AL 2009, 2012A, 2012B	Cattle ranching	Soil fertility Proximity to roads Institutional context (agriculture support, pro-smallholder policies)

Overall, the current thesis has as background an investigation about the political ecology of the road. This academic discipline focus on the study of the relationships between political, economic and social aspects with environmental issues; thus, offering a more holistic understating of the social and environmental problems (Robbins 2012; Walker 2002). One of the main topics addressed by the discipline is environmental degradation, conservation and control, environmental conflict and environmental identity (Robbins 2012); and the uttermost goal of the political ecology is to engage and collaborate with the public debate (Robbins 2012). The current thesis is a problem-oriented research focusing in the challenges of frontier development; it has at the background the idea that ecological and economic variables are mostly interdependent and should thus be investigated in a holistic approach. The main focus is on the decisions that colonists make about the natural environment in the context of their political environment and socioeconomic pressures.

With this previous context delineated, further attention can be given to the literature itself. A detailed discussion of the contribution of many researchers to knowledge of land use and frontier development is presented in item 2.2 below.

2.2 Revision of grounding theories

Many authors have been interested in understanding how a frontier region develops, the interactions that happen, the underlying factors and variables associated with land use change and deforestation. The goal of this section is to summarize the main theories, frameworks and heuristics/conceptualizations about land cover change and frontier development.

A good starting point is to outline the reasons for deforestation. Geist & Lambin (2002) analyzed 95 articles of net losses of tropical forest cover, from 1880 to 1996, to investigate common patterns of deforestation. From the comparison, they were able to define two principal levels of reasons for tropical deforestation: the proximate causes and the underlying driving forces. The first refers to human activities and immediate actions at the local level, which have a direct impact on forest cover; while the second relate to fundamental social processes or policies that reinforce the proximate causes and either operate at the local level or have an indirect impact from the national or global level. According to these two researchers, tropical deforestation is then mainly driven by "regional patterns of causal factor synergies" (p. 143) of which the most obvious are, at the proximate level, agricultural expansion, wood extraction, and infrastructure extension; and at the underlying driving forces, economic factors, institutions, national policies and remote influences.

Agricultural expansion, specifically, have been recognized as an important cause for global forest loss, with special attention to the tropics; and today it has become clear

that the individual farming households are the essential local-scale actors that contribute meaningfully to the land-use change occurring on the ground (Deadman et al. 2004). Therefore, and particularly for the Amazon, studies on farm-level land use processes (reference in Table 1) have arisen as an essential component to understand deforestation dynamics, and they will be a cornerstone for the theoretical considerations here presented.

Fundamentally, colonization of remote areas is common to many countries; yet, frontiers are unique and of such complexity that it is unrealistic to try simple generalizations (Katzman 1977). Changes in land cover are caused by different options of land use, which are directed by human driving forces; this is what Turner (1994) acknowledged as "the cause-to-cover relationship". Turner argues that a better comprehension of this relationship is of fundamental importance to the study of global environmental change, and the essential forms of human land use are cultivation, livestock grazing, timber extraction, settlement, and construction, as well as protected areas. The essence of his argument is that these activities have cumulatively changed land cover at a global scale with meaningful consequences to climate and biodiversity.

Notwithstanding, Goza (1994) underlines that most theories of frontier development were inappropriate to the Amazon case since they failed to emphasize the potential for conflicts over land control, one of the primary topics on the Amazon frontier. Goza explains that the enormous size of the Amazon region and its relatively scattered population can make it difficult to imagine violent disputes over land; but, as explained by Martins (1975), in these areas a "demographic frontier" occurs first - when small farmers, minor commodity producers, and artisans originally occupy an unpopulated area. With time, this area is transformed into an "economic frontier" - as capitalist enterprises move into this semi-populated frontier region. Inevitably, the two frontiers collide as capitalist enterprises attempt to appropriate and control the means of production.

Similar to Martins, Katzman (1977) differentiates between two stages of frontier development which he named as "market" and "subsistence expansion". The difference between the two concepts is mostly determined by the degree of participation in the international market. Therefore, according to this framework, Amazon development was mainly characterized by subsistence expansion - since it was too isolated and inaccessible to any major markets, leading most producers to have their own subsistence livelihood. Katzman (1977), however, suggests that with time, and with the advent of roads and other infrastructure, the subsistence frontier gradually becomes incorporated into the market economy.

Foweraker's (1981) model adds to the previous theories presented and describes the transformation process of the frontier in three stages: non-capitalist, pre-capitalist and capitalist. Isolation from regional and national markets characterizes the first

non-capitalist stage. Continuously increased immigration, the institutionalization of private property and the buying and selling of land define the pre-capitalist phase. Foweraker claims that at this point, small-scale capitalist enterprises start to appear, and the first conflicts over land begin. During the capitalist stage, land ownership becomes increasingly concentrated in the hands of national and multinational companies, with the outcome that an initially natural environment is transformed into an environment dominated by capitalist social relations.

Foweraker's (1981) model also relates to the concept of the "boom and bust cycles", which were typical of past Brazilian economic development. The booms are marked by large, worldwide demand for a product or natural resource that stimulates massive immigration (Goza 1994). Over the course of time, the boom cycles gave way to lower demand with resultant busts and emigration. This was, for example, the case of the rubber extraction in the Amazon (Goza 1994).

Another theory of frontier development is the hollow frontier as presented by Pan & Carr (2010) and it has been observed in humid tropical forests in Central and South America. The idea is that as small farmers leave the initial frontier, an empty space or "hollow" is left as people (and thus labor) become scarce the land shifts from annual crops to pasture. Occasionally, out-migration is not to new frontiers anymore but instead to cities, as is seen in the quickly urbanizing Brazilian Amazon (Browder and Godfrey 1997).

As compared to studies of growth patterns, few studies have been dedicated to understanding the different characteristics and stages of peasant colonization in the frontier settlement in the Amazon. Among them are Wolf (1955), Wagley (1968) and Moran (1975).

Wagley (1968) developed a two-class division of Latin American peasants, the "Modern Indian", and the "Mestizo types". Wolf (1955) made a parallel distinction but label his categories as "Corporate" versus "Open peasant types". Modern Indian or Corporate peasants are characterized by being distinct units, culturally and socially. Both researchers corroborate that such groups look inward rather than outward for their identity. Whereas, Mestizo or Open peasant communities identify with the country, usually use the national language, and are closely tied to the modern economic system. They also own land privately rather than corporately.

Moran (1975) nevertheless argues that the term "peasant" is not applicable to the colonists in the Brazilian Amazon, which is particular as a consequence of governmental initiatives of planned colonization and road building. Moran studied the case of the Transamazon highway and claims that the colonists in the area are modern in nearly every conceivable way. Instead of the traditional peasant model, Moran (1975) defends the thesis that the Brazilian Amazon frontier colonists could be better divid-

ed into two major groups: brokers and clients. Brokers are those who, through their own managerial skills, generate their capital and reinvest a significant portion back into their businesses. In Portuguese, this would be understood by the term "*patrão*". The clients, by turn, are persons who depend on the brokers or on outside institutions to provide a stable flow of cash in order to survive, and most of their capital resources go for consumption items rather than for farm investment. As expected, brokers tend to be more geographically stable than clients since they often own the land or durable goods such as trucks or machinery. In contrast, clients are mostly a labor force that follows the demand for hired labor. Their constant mobility, as argued by Moran is the crucial reason that kept them from acquiring the managerial insight necessary to run their own commercial or agricultural enterprises. Ultimately, the distinction proposed by Moran divides colonists between rural managers and rural proletarians.

Another aspect studied by many scientists in order to understand land-use strategies is family life cycle. According to the theory, age and sex composition of household influence labor supply and, consequently, land use and forest conversion over time (Carr 2004; Pan & Carr 2010; Moran et al. 2003; Perz et al. 2006). As discussed by Pan & Carr (2010), as children enter working-age, food demands increase as well as labor supply, so further land clearing can happen in order to expand cash crops, which might partially replace subsistence crops. As children grow into adults, the need of using the farm to produce food or income to sustain them may decrease if they out-migrate (Pichón 1997; Pan & Carr 2010). However, this theory has some shortcomings (Vanwey et al. 2007; Walker et al. 2002 in Pan & Carr 2010). Nowadays there is a conventional compression that is much more useful and appropriate for understanding land change over time as dominated by a lot's life cycle (period effects) rather than by a household life cycle. Nevertheless, a last important demographic variable is the presence of male adults. Land-use research has frequently noted the importance of adult males as a critical factor for predicting deforestation (Barbieri & Carr 2005; Pan et al. 2007; Caldas et al. 2007).

The World Bank provided another theory of evolution of the frontier (1992 in Pichón 1997, p. 68): the peasant pioneer cycle. The framework assumes that colonists move through a similar evolution of land-use patterns over time. The cycle typically begins with road construction in previously remote forests areas, allowing the migration of poor farmers in search of land (Pan & Carr 2010). Commonly, colonization of forestlands inevitably requires some initial deforestation to establish ownership and produce food crops to achieve immediate diet needs. As colonists become settled on their plots, they later clear distant lands for perennial crops. As soil nutrient levels fall, farmers shift both perennial and annual crops to newly cleared lands, leaving the initially deforested areas for pasture or fallow. Stirred by environmental constraints and survival needs as well as the lack of affordable or available agricultural technolo-

gy to sustain soil fertility, farmers have little alternative but to encroach more and more forest areas. Alongside, rapid turnover and abandonment of degraded agricultural lands continue to be observed along the frontier. In conclusion, and as emphasized by Pan & Carr (2010), over time land is concentrated in the hands of rural elites, who raise cattle. Meanwhile, the poor move on to further extend the forest frontier, where the deforestation cycle begins anew.

According to this theory, settlers are seen as highly mobile, speculative and uninterested in long-term natural resource development; also, declining crop yields and increasing poverty force settlers to abandon their farms and seek new lands. Pichón (1996, 1997) also exposes the fact that, specifically in the Amazon, colonists usually have some similarities such as a production system characterized by intensive use of family labor and simple agricultural technologies, a strong drive for cattle ownership and overexploitation of land by the continuous incorporation of new areas with little concern for the long-term preservation of the natural resources. However, Pichón does not limit his explanations on the peasant pioneer cycle, instead he argues that government policies play a significant role in frontier development through subsidized credit, fiscal incentives, differential taxation, and a sequence of other policies that can encourage more or less efficient forms of land use and forest intervention (Pichón 1996, 1997).

Although the peasant pioneer cycle is relevant to understanding common features, studies in the Brazilian Amazon have suggested that fast farm turnover and land abandonment can be better explained by weak property rights and frequent land speculation (Brondizio et al. 2009, Carrero & Fearnside 2011) or financial indebtedness (Fearnside 1986, 2001a), rather than by decline in the fertility of the land. Also, some other researchers (Moran 1977; Pichón 1996, 1997) object the straightforwardness of this land-degradation framework and argue that the causes and underlying drivers for this straitjacket are more complex and depend on a broad set of proximate causes and underlying factors.

Moran (1977) for example observed that neighboring farms on the Transamazon often had quite divergent patterns of land use. Access to water, distribution of soils, and distance to markets are naturally common among neighbors and thus they provide less insight into the different patterns of land use at the local scale. Instead, the differences could be better explained by variations in initial capital, the origin of the family, and their experience with agriculture and with the region (Moran 1977, 1981), that is to say, the different typology categories that he had highlighted in 1975.

Fearnside (1982) gave some insights into the behavior of the colonists in the colonization area on the Transamazon Highway. He argued that a combination of strategies, rather than a pure "rational" decision, better explains land-allocation decisions. This does not mean that colonists do not seek profit maximization, but rather that

the method finally chosen depended on a more complex variety of elements. Fearnside (1982) demonstrated that the principal elements were the colonists' background, the experiences of colonists and their neighbors with different agricultural crops in the area, financing opportunities, availability of transportation (or proximity to roads) and availability of capital. In general, he stressed that the allocation decisions in this colonization area could be divided into subsistence and cash crop allocations, and sometimes, a small amount of land was also allocated for experiments with new crops. Fearnside argued that allocations for commercial cultivation were based on four possible development strategies: annual commercial crops, perennial commercial crops, livestock, additionally, off-farm jobs.

It is Important to note that the composition of the settler population was changing at the beginning of 1980 when Fearnside conducted this study, and as stressed by him, the first settlers sold or abandoned their plots and newcomers replaced them. New colonists generally brought more capital with them and thus could install more pasture and perennial commercial crops, as well as bigger farms, with 500 to 3000 hectares (Fearnside 1982). This turnover could be associated with the theories of growth patterns in the frontier area highlighted by Martins (1975), Forewaker (1981) and Katzman (1977).

More recently, McCracken et al. (2002) also recognized the drastically different patterns of land use among neighboring farms in the Transamazon highway region. He suggests that at the local scale of analysis the period of initial settlement, cohort effect[2], and labor composition throughout the domestic life were the most predominant factors. Simultaneously occurring at the regional scale were features such as environmental factors (like for example access to water and soil quality), economic trends, and government policies (like access to credits).

Pichón (1997) also argued that land-use strategies reflect colonists' management of factors of production – namely land, labor, capital, and technology - based on knowledge of environmental conditions, market opportunities, and household consumption demands. Farm management can thus be seen as evolving adaptive strategies, embracing a set of coping behaviors that attempt to improve the socioeconomic situation of the household in the face of uncertain and often changing environmental conditions. These strategies consequently impact these environmental conditions - like vegetation cover, soil quality, erosion, the incidence of pests and disease, and others - which in turn require further adjustments in adaptive strategies (Pichón 1996, 1997b). Land-use decisions would then involve the broad choice of allocation between, for example, land for pasture, crops or forest; and, the particular

[2] A cohort effect is one in which some event or process common to a group of household results in a distinctive pattern of behavior. The timing of arrival on the frontier is a clear marker for defining cohorts. Individuals and households settling during the same period experience many similar opportunities and constraints of the frontier that are markedly different for others arriving later (for example, off-farm employment opportunities, road conditions, market possibilities (McCracken et al. 2002).

choice of crops, the intensity of labor and other inputs and the allocation of land for fallow (Pichón 1996, 1997b). Pan & Carr (2010) similarly consider five categories of land use, which are the ones most likely affected by land management decisions: forest, pasture, perennial crops, annual crops, and fallow.

Deadman et al. (2004) also observed that, particularly in areas of the Amazon where settlement is characterized by agricultural colonization programs of INCRA (the National Institute for Colonization and Agrarian Reform), patterns of deforestation were affected by a variety of factors operating both at local and regional scales. Among them were household composition and consequently available labor, household endowment levels and resulting available capital and soil quality. Important to note that the majority of the settlements in the Amazon are state-led. Brazil's Legal Amazon region has over 3000 settlements (Yanai et al. 2017).

Brondizio et al. (2002) also emphasized that one of the most significant characteristics of a frontier area is the level of variability in deforestation between farms. Brondizio and coworkers viewed land-use intensification in the frontier as a "colonist footprint", which is characterized by the coexistence of intensification and extensification of production strategies. These cycles, however, have high variation within farm cohorts, resulting in different rates, extents, and directions of land-cover change across farm lots. Consequently, the "deforestation trajectories" (or the colonist footprints) are a consequence of a combination of variables related to time of settlement, cohort and household dynamics (such as aging, household labor composition, experience, origin and expectations), and period effects (for example credit and inflation), underlain by environmental, market, and infrastructural conditions. Brondizio and coworkers also stressed that, in order to inform better land-use policies and to provide better support to the colonists, more attention should be paid not only to regional dynamics but also to intraregional variability and differential conditions among colonist cohorts and farms. In their vision, both local and regional factors help to shape the agricultural strategies that individual families pursue, which in turn result in a range of land use trajectories with direct long-term consequences for frontier landscapes.

Godar et al. (2009, 2012a, 2012b) also researched colonists on the Transamazon Highway region and demonstrated that small farmers could improve their land-use productivity and reduce deforestation rates while creating a stable landscape covered by a mosaic of different land-use elements embedded in a forest matrix. They emphasized, however, that this takes time and requires specific conditions such as good soil fertility, proximity to the main road and a favorable institutional context (such as adequate agricultural support). They defended the position that adequate and location-specific pro-smallholder policies could help to lower deforestation.

A last but still important process that affects land-use change in the Amazon is spontaneous colonization, which has been identified by Simmons et al. (2010) as "direct action land reform", or DALR. DALR is a social and political process involving mobilization of the poor and the controversial occupation of public or private lands. This is a relatively new phenomenon, and the settlement formation process in the DALR is not well understood. Simmons et al. (2010), nevertheless, emphasized that land-cover impacts are unavoidably linked to the decisions of smallholders, specifically with three main factors: length of residence in the given area, the search for *terra devoluta*[3] beyond the frontier, and kinship colonization. *Terra devoluta* is found in the Amazon at significant distances from cities and has a low land value because of the existence of primary forest and lack of infrastructure, and consequently less risk of contentious occupation. However, is not easy to know the exact position of *terra devoluta*, so Simmons and coworkers (2010) argued that an informal network that transmits information outside the region exists, hence, attracting people and stimulating migration. Also, knowledge about available land can be related to the length of residence in the area. Finally, an endogenous process occurs in these settlements, as grown children of early the pioneers search for land to begin their own farms.

Comparing the conceptualizations and theories presented above it is possible to observe that the variables that affect colonist land-use decisions are vast and interrelated. Overall, frontiers seem to follow a familiar process of development, from isolation towards market incorporation. Additionally, colonists have usually some similarities and are influenced by different set of variables. Socio-economic and demographic characteristics, environmental features and government policies have a preponderant role, interacting synergistically and resulting in a range of land-use trajectories that have direct and lasting consequences for frontier landscapes. As mentioned above, the most pertinent variables and indicators for the case of the BR-319 road were extracted from this review and are presented by the theoretical framework at the beginning of this chapter in Figure 2. The theoretical framework comprises the variables and indicators that guided the data collection and further analysis; it provided the framework for investigating who are the colonists of the BR-319 and if they have similarities with actor groups shaping frontier development in other parts of the Amazon. The next chapter is dedicated to the methodologies for data collection and analysis, and also characterizes the study area.

[3] Public lands that do not have any destination specified by the Government and have also never integrated the patrimony of an individual.

3 Methods for data acquisition and analysis

3.1 Case study research: a two-level diagnosis

A case study is a research strategy that investigates a contemporary phenomenon in depth and within its real-life context. Cases are unique and at the same time related to something general (Scholz & Tietje 2002). The focus of analysis is on the relationship between the contextual factors and the entity or phenomenon being studied (Mills et al 2010; Springer 1997). As a research method case studies are one approach that supports more in-depth and more detailed investigation, and they are especially relevant to providing a richer understanding of complex issues (Springer 1997). Yin (2003) suggests that case study research is appropriate when researchers expect to investigate research topics broadly and not narrowly, cover contextual or complex conditions and not just isolated variables, and rely on multiple sources of evidence.

For this reason, a case study seemed to be the most suitable framework for investigating colonists and frontier development in the region of the BR-319 road. This case study has the specific purpose of (1) describing the actor groups shaping frontier development on the Manaus – Porto Velho road, as well as (2) exploring the variables affecting colonist's land-use decision with consequent impact over deforestation. Additionally, (3) to investigate the institutional and political environment where colonists are surrounded and with this provide insights about potential challenges for the sustainable development in the region.

The guiding questions of analysis are:

i. Who are the colonists of the BR-319?
ii. What are the characteristics of the land they occupy?
iii. Which factors predominantly influence colonists' deforestation?
iv. What are the potential challenges for the sustainable development of the territory?

It is important to clarify that case studies are generalizable to theoretical propositions and not precisely to populations or universes. In this sense, the goal is to compare the empirical results with previous theories and findings (analytical generalizations) rather than to quantify frequencies (statistical generalizations) (Yin 2009). That is why so much attention was given to the literature review and the development of a theoretical framework presented in chapter 2. The theoretical framework provided the scope for the analysis and indicated the variables and indicators for data collection both at the local and regional scales, and thus serves as a qualified validation for this thesis. As suggested by Scholz & Tietje (2002) the perceptual side is represented

by the theories and propositions, while the observed data represent the analytical side.

The study case was designed as a multiple case with embedded units of analysis. In other words, multiple case because it considers three different contexts (traditional communities, farms and rural settlement) and embedded because inside each case a few subunits (the households) were chosen and explored individually. Survey research was done inside each of the study cases and followed a simple random sampling with an estimated sampling ratio of 10%. Additionally, the three contexts were selected because they represent the most characteristic realities that co-exist along the BR-319. They were identified first by the official reports (IBAMA 2009; UFAM 2009) that provided the initial data about the population in the region, and they were reinforced later during the field research.

In Figure 3 below, the different cases/ contexts are represented by the three gray squares in the middle of the diagram, while the subunits/ households are the smaller white squares inside each case. All together they represent the analysis of the endogenous factors affecting colonist decision, similar to the local level of analysis previously presented in the theoretical framework (Figure 2). Comparatively, the regional level of analysis presented by the theoretical framework is here defined as the exogenous factors, and these data were collected mainly through the key-informant interviews. Survey research and participant observation provided additional data about specific regional factors, such as distance to roads and access to credit.

Even though the research method selected is a case study, this thesis profited from other methods of data collection such as interviews, surveys, and observations. Embedded case studies rely on more holistic data collection strategies, but they can call upon surveys or other quantitative techniques to collect data about the embedded units of analysis. In this thesis, the quantitative survey of households does not necessarily aim to provide statistically significant results to be extrapolated to a broader population, but rather it allows an objective approach and a deeper understating of actors been studied; whereas, qualitative interviews and participant observation helped to uncover the context where these actors are surrounded. Whilst the goal is not to understand all, the study case approach provides some indications and insights, in an exploratory way, allowing further elaboration and hypothesis creation. The proposition stated is that colonists have usually some similarities and are influenced by different set of variables, both exogenous and endogenous, which affect their land-use strategy.

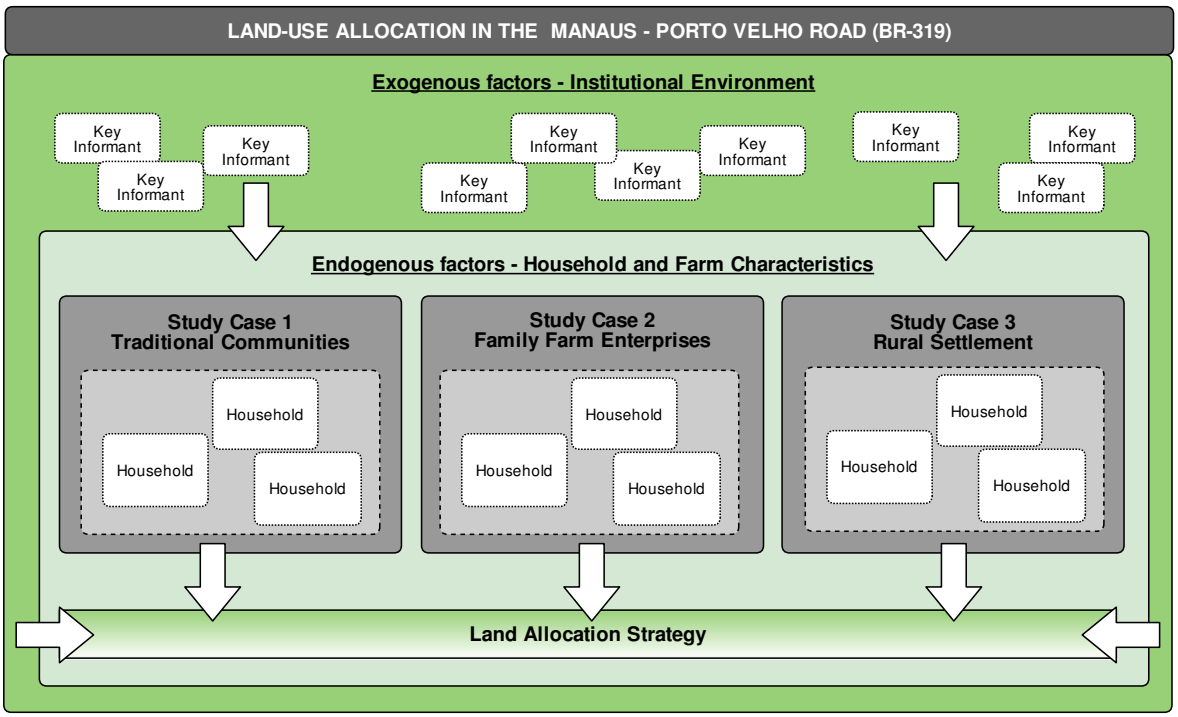

Figure 3 - Study Case design. Source: author, 2018.

Each of the different sources of information – survey and interviews - requires distinct approaches to their interrogation and is expected to yield different kinds of insights. Each source has its strengths and its weaknesses, and the richness of the case study derives mainly from this multi-faceted perspective (Rowley 2002). In order to maintain a clear chain of evidence, the data collection was guided by a protocol of field procedures, which are described later on in items 3.2 and 3.3; additionally, a case-study database was developed containing all of the original data and analyses; this database is presented in the Appendix (Case-study database).

3.2 Data acquisition at the regional scale

At the regional level, data were acquired via participant observation and key informant interviews. Participant observation included field visits with the staff of the State Secretariat of Environment (SEMA) and the local non-governmental organization (NGO) Institute of Sustainable Development of Amazonas (Idesam), additionally attendance at public hearings and meetings. Data collection was complemented by documentary material, including official government reports, existing statistics, news stories, and academic publications.

Key-informant interviews were conducted with civil-society institutions, with institutions in the public and private sectors, and with other individuals relevant to the decision-making process of regional land-use planning. In total, 29 interviews were conducted with 37 persons from 26 different institutions. The protocol for the key informant interviews was to send formal invitations directly to the headquarters of

each institution in Manaus, as well by e-mail. As many informants did not answer the first written invitation, a follow-up by telephone also had to be done. The list of institutions was defined from an extensive analysis of documentary material, including official government reports, news articles, and academic publications. After selecting the institutions, the co-advisor, as well as Idesam and some selected key informants, helped to identify the most suitable person to be interviewed in each institution. Sometimes more than one person was interviewed at the same time, as the interviewees invited other colleagues, which they considered important to provide useful information for the research. In general, all of the key informants were extremely accessible, and only one institution denied being interviewed. Some critical ethical practices were also implemented, such as: gaining informed consent from all persons involved and protecting the privacy of the participants.

The interviews served multiple research objectives. First, they provided insight to the institutional and political context in which colonists are enmeshed, the potential challenges to the future development of the territory and the overall citizen participation in the decision-making process regarding territorial planning of the region in the BR-319. Additionally, they provided the necessary details about the roles of many institutions.

The interviews were recorded and consisted of four open questions that attempted to understand: (i) the professional role (or relation) of the institutions and informants with the BR-319; (ii) their future vision for the territorial planning and development of the region, (iii) the main challenges faced to achieve this vision; and finally (iv) their opinion and practical experience about citizen participation in the land use planning of the BR-319. On average each interview lasted 35 minutes. The answers about the challenges end up assuming a broader perspective since many institutions do not have a clearly established vision for the future, or a vision that they have is exactly the one they intend to avoid rather to pursue. The original questions are available in the Appendix, within the case study database, and more details about the interviewees can be found in Table 2 below. The names of the informants are not being published as a matter of confidentiality and data protection. At the left side of the Table the institution's original name and acronym are displayed, and at the right the translation in English, as well as further explanations when needed.

Table 2 - List of key informants interviewed

	Public Sector - Federal Level	
1	Ministério Público Federal do Amazonas (MPF-AM)	Brazilian Federal Prosecutor
2	Instituto Nacional de Colonização e Reforma Agrária (INCRA)	National Institute of Colonization and Agrarian Reform

3	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA)	Federal Governmental body responsible for environmental licensing
4	Departamento Nacional de Infraestrutura de Transportes (DNIT)	National Department of Transport and Infrastructure
5	Fundação Nacional do Índio (FUNAI)	Federal Governmental body responsible for Indigenous
6	Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio)	Federal Governmental body responsible for Protected Areas
7	Terra Legal (TL)	Federal Program of Land tenure regularization in the Amazon
	Public Sector - State Level	
8	Instituto de Proteção Ambiental do Amazonas (IPAAM)	State Governmental body responsible for environmental licensing
9	Secretaria Estadual de Meio Ambiente (SEMA-AM)	State Secretariat of Environment
10	Secretaria de Estado de Planejamento, Desenvolvimento, Ciência, Tecnologia e Inovação (SEPLANCT)	State Secretary for Planning, Development, Science, Technology and Innovation
11	Procuradoria Geral do Estado do Amazonas (PGE-AM)	State Prosecutor
12	Deputado Luiz Castro	President of the State legislative assembly commission on environmental affairs
13	Deputado Platiny Soares	President of the State legislative assembly commission on municipal and territorial affairs
	NGOs, Academy, Donors, Cooperation Organizations, Grassroots organizations	
14	-	Conservation International
15	Instituto de Conservação e Desenvolvimento Sustentável do Amazonas (Idesam)	Institute of Conservation and Sustainable Development of Amazonas

16	Casa do Rio	Local NGO
17	Instituto Internacional de Educação do Brasil (IIEB)	International Institute of Education of Brazil (IIEB)
18	Universidade Federal do Amazonas (UFAM)	Federal University of Amazonas
19	Instituto Nacional de Pesquisas da Amazônia (INPA)	National Institute of Amazonian Research
20	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	German Society for International Cooperation (GIZ)
21	Associação dos Amigos e Defensores da BR-319	Association of Friends and defenders of BR-319
22	-	Gordon & Betty Moore Foundation
23	Coletivo Tupigá	Association of young leaders of the region
	Private Sector	
24	Organização dos Advogados do Brasil (OAB-AM)	Brazilian Lawyers' Association
25	Federação das Indústrias do Estado do Amazonas (Fieam)	Federation of Industries of the State of Amazonas
26	Aruanã Transportes	Bus enterprise that operates along the BR-319

3.3 Data acquisition at the local scale

At the local level, the focus was on the population living along the road, and the unit of analysis was the individual colonist household. Three expeditions were conducted: the first preliminary expedition was carried out with SEMA between 3rd and 5th of May when a pilot set of interviews was conducted to test the survey instrument. The 2nd expedition, once again with SEMA, was conducted between 14th and 19th of May. The last and longest expedition with Idesam took place between 29th of June and 14th of July.

Before the fieldwork, the most up-to-date information about the population living in the study area was from a 2009 survey conducted for the Environmental Impact Assessment (EIA) (UFAM 2009) and from an official IBAMA report (n° 078/2009), which estimated a total population of 161 households. In the first days in the field, it was

clear that this information was out of date and a new estimation of the population needed to be done. A detailed description about how this assessment was done is presented in the Appendix, but, in general, a counting strategy was developed: first, the study area was divided in three sections[4] and all dwellings found along each sector were marked, using GPS coordinates, and they simultaneously were classified into three categories: farms, villages, and isolated non-farm dwellings. "Farms" were characterized by raising cattle or by having pasture with cattle pens. "Villages" were characterized by being an agglomeration of houses with common areas such as football fields, churches or a community center. Non-farm isolated dwellings were not part of a village and did not present evidence of cattle breeding or existence of pasture. The number of houses in each village was then also estimated with the support of the village chief and additionally with the assistance of an unmanned aerial vehicle (UAVs) and the Pix4D[5] software application for drone-based mapping. It is noteworthy that the study area of this research comprises an area of approximatively 400 km along the BR-319 and to estimate the population living in the study area was one of the biggest challenges faced at the fieldwork; it was very time and resource consuming and it had an overall impact in the data-collection strategy. Realidade, which is one of the villages embraced by the study area, is a hotspot of deforestation and illegal logging in Amazonas state, and this village alone comprises 350 households; no updated information about this village was available officially. During the fieldwork a map of the village was produced to allow the estimation of dwellings; when employees of the municipality of Humaitá, where Realidade is located, learned that there was an up-to-date map of the village, they contacted the author of this research requesting access to the map.

The final estimate of dwellings accounted for a total population of around 600 households, as displayed in Table 3 below. The maps with the distribution of all dwellings in each section can be found in the Appendix, as well as the map of Realidade.

Table 3 – Study area population

	FARMS	VILLAGES	ISOLATED DWELLINGS	TOTAL
1	2	3 (45 HH)	20	**67**
2	14	0	61	**75**
3	24	5 (390 HH)	52	**466**
TOTAL	**40**	**8 (435 HH)**	**133**	**608**

Comparing the data from 2009 (IBAMA/ UFAM), there is an outstanding bigger number of occupations, especially in the stretches of the highway were the Protect-

[4] (1) the region in between protected areas, closer to Manaus; (2) the region that goes from the end of the protected areas until the village of Realidade; and (3) the region from Realidade until the end of the study area.
[5] A photogrammetry software that creates professional drone-based mapping from images.

ed Areas (PAs) do not reach the margins of the road, with special remarks to section 3, the area closer to the village Realidade. As the total population in the study area extrapolated almost four times the amount initially expected an important decision had to be made. There was not enough time and resources available at the filed to inquiry a reasonable sampling of the entire population. That said, a priority criterion[6] was adopted, and the isolated dwellings were not considered as one of the embedded study cases. Also, villages were additionally subdivided into two: traditional communities and the village Realidade. Realidade has a dynamic that is different from all the other villages in the region and it accounts for the majority of the households in the study area. Realidade was at the beginning, in the 1970s and 1980s, a traditional community, but a state led colonization driven by the municipality of Humaitá, alongside the establishment of an INCRA settlement in the surroundings, turned Realidade into a small city and one of the most critical areas of deforestation in the Amazonas state. In this order, to differentiate the context of Realidade from the other tractional villages, Realidade was considered separately as a rural settlement.

During the data acquisition, 48 households were interviewed according to the case-study design presented above in this section, in Figure 3. Eight (8) households were interviewed in case 1 (Traditional Communities), five (5) households were interviewed in case 2 (Farms), and 35 households were interviewed in case 3 (the Rural settlement Realidade). This quantity represents a sampling ratio of 10% of the population of each case study and a random method[7] of sampling was adopted. Initially, the goal was to achieve a sampling ratio of 30%, with a bigger number of households sampled, but as just explained the outstanding bigger number of households disallowed a higher sampling to be achieved. This matter will be described in detailed in the next section, and the map (Figure 4) below indicates the location of each farm, community and the settlement interviewed.

The criterion for the interview was adults aged 18 years or older, with a preference for a joint couple interview (where the two spouses are interviewed together), and secondarily for the interview of the head of the household. The survey questionnaire was performed with the assistance of a tablet and the free and open source software for humanitarian data collection Kobo Toolbox[8]. The questionnaire covered three main sets of questions: general information about demographic characteristics (such as family composition, origin, income and the others already presented in the theoretical framework), land features (such as size, tenure, etc.) and, lastly, information

[6] Half of the occupations were brand new, which means that their land use allocation strategy, the focus of analysis of this research, was not consolidated. Visibly many of the houses displayed comprised of simple structures to secure the ownership of the land, in a probable speculative behavior. As in a frontier area with speculative land appropriation, to approach isolated houses seemed too risky.

[7] Each farm along the road was assigned by a number and then selected by lottery, and in the villages every 2nd or 3rd house was selected. If the owner was not present, the next house was visited, and so on until a 10 percent sample of households was reached. In Realidade, the interviews were conducted with people who could be found and were willing to talk.

[8] More information available here: https://www.kobotoolbox.org/.

about access to infrastructure, services and consultation. The full questionnaire is presented in the Appendix, within the case-study database, but in summary, it comprises 37 initial questions that could unfold into 65 depending on the complexity of the production system adopted. On average, each interview lasted 40 minutes.

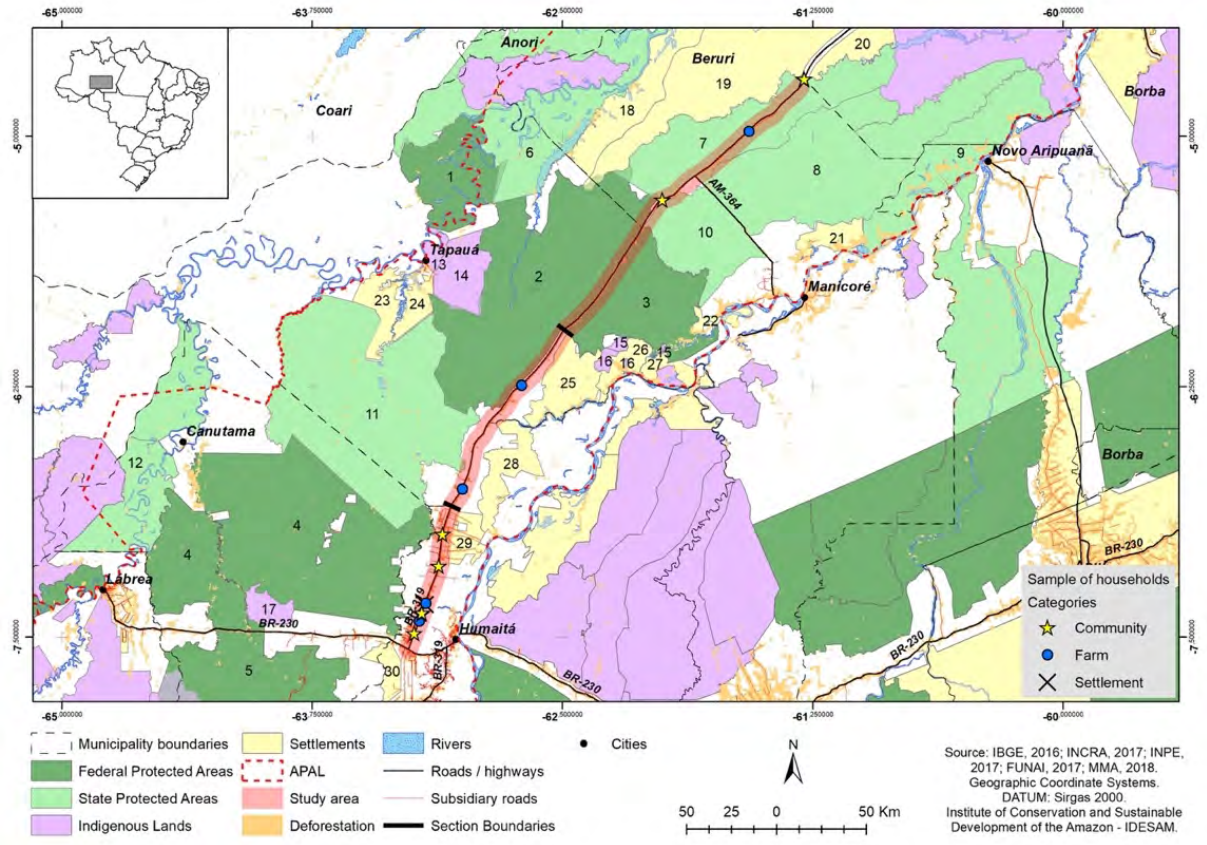

Figure 4 – Location of each household interviewed. The star icon represents the Communities, the blue circle the Farms and the X the settlement Realidade. Image granted by Idesam.

As suggested by Yin (2009), since the study focuses on a contemporary phenomenon in its real-life context some critical ethical practices were implemented, such as: gaining informed consent from all persons involved, protecting the privacy of the participants which requested confidentiality and taking special precautions to protect especially vulnerable actors, such as traditional populations. The protocol with them was first to ask for the leader, representative or president of the community association. Once with the chief, the author presented herself, the goal of the research and asked for permission to conduct the study. A letter with contacts, a summary of research goals and methodology was also delivered to the chief of each village.

3.4 Data analysis

The core process of data analysis in this thesis is analytical generalization. The different sources of evidence were examined, categorized and tabulated to assess whether the evidence supports the initial propositions presented by the theoretical frame-

work of the study described in Chapter 2 (remembering that the proposition is that colonists have usually some similarities and are influenced by different set of variables, both exogenous and endogenous, which affect their land-use strategy).

For the survey, the data analysis was concentrated in cross-tabulations and descriptive statistics using R Statistics software. A multiple regression analysis was also performed to identify correlations among the data. Even though the analysis is not generalizable to the entire universe of colonists on the BR-319, this specific assessment provides an indicator or a tendency among the sampled households. All of the R scripts developed can be found in the Appendix, within the case study database.

For the key informants, the method adopted for the qualitative data analysis was the deductive approach, which analyses data based on a predetermined structure, in the case of this thesis, the theoretical framework and the research questions. All the interviews were rerecorded and then transcribed using speechlogger software. The data were then organized and summarized into tables, and common patterns were identified, enabling the categorization of key concepts into codes. These codes were computed and then grouped into sub-sets by similarity. Logical models were also used to illustrate the patterns. The tables and diagrams developed for the qualitative data analyses are also available in the section case study database, in the Appendix. The original transcription of the interviews sums up for more than 300 pages, and thus were not included in the database, but the author is willing to share them, nevertheless, with the names and other critical information omitted, as matter of data and informant protection.

Overall, all the original evidence collected – with the exceptions of the interviews – can be found in the database.

3.5 Study Area

Figure 5 – Aerial view of the Manaus Porto Velho. This photo was taken exactly at the center of the road, in the surroundings of the village located by the river Novo. Photo: author.

The BR-319 is an interstate highway that connects Manaus, in the state of Amazonas, to Porto Velho, in the state of Rondônia; it is located along the central axis of the interfleuve between the Madeira and Purus rivers. This interfleuve has approximately 270,000 km^2 and is home to vast biodiversity, associated with extraordinary heterogeneity of ecosystems (MMA 2007). The interfleuve is located in 2 morpho-structural units, the Amazonian Plain and the Lower Amazonian Plateau, with an altitude ranging between approximately 30 and 100 meters (UFAM 2009). In general, sedimentary rocks of the Amazon Basin dominate the terrain. Soils are chiefly Red-Yellow Oxisols, Yellow Latosols, Argisols, Spodosolsols or Quartz Neosols (UFAM 2009).

According to the Köppen and Geiger classification system, the interfleuve is located in a transitional area between tropical wet climate (Am), tropical rainforest climate (Af) and tropical savanna climate (As/Aw) (Kottek et al. 2006). In general, there is noticeable seasonality, with a deficit of precipitation between June and September (UFAM 2009). The vegetation is predominantly ombrophilous forest, being 57.8% of the region occupied by dense ombrophilous forests and 28% of open ombrophilous

forests with palm trees. The anthropized area comprises 9.5%, and the remaining 4.7% is distributed among other vegetation types, chiefly savannas (UFAM 2009).

Built during the military regime, the highway was idealized to promote the economic and territorial development of the region (Nogueira & Neto 2016). Formally, construction work on the BR-319 began on June 15th, 1968 (Neto 2015). The project received numerous critics and was a target of divergences about its feasibility since the early beginning. The apparent benefits of the asphalted BR-319 included economic growth; the end of the isolation, which had (and still has) a significant appeal for the local population; and the possibility to an alternative outflow of the industrial products from the Manaus Free Trade Zone. However, such arguments were confronted by the fact of an already existent waterway on the Madeira River, the high maintenance costs of the road and the potential of intensified migration, which would consequently increase deforestation in the region (Fearnside & Graça 2009). Despite the critics, the road was inaugurated in 1976.

Due to the precarious maintenance and the severe environmental conditions of the area, the road became impassable already in 1988 (Fearnside & Graça 2005; Neto 2015). From the mid-1990s onwards, several attempts to reopen the road failed, but in 2004 the recovery work was finally started amidst difficult and somewhat confusing institutional conflicts. For a detailed timeline, please check the Appendix. The most important fact to be aware of is that for the asphalting of the so-called "middle stretch", between kilometers 250 and 655, an environmental license[9] is mandatory (MMA 2013; MPF 2005). The environmental license has already been declined three times by IBAMA (the entity which grants the license) due to non-compliance of the Environmental Impact Assessment (EIA) performed by DNIT (the entity which demands the license). The compliance to an EIA is also mandatory for the license. Despite this, a judicial maneuver resulted in a license to carry out "maintenance" being granted in 2016. Since then, maintenance works have been carried out, old bridges have been replaced, which improved considerably road conditions. In meantime, EIA's complementary studies have been conducted in order achieve the final license for pavement.

[9] As the road was left without maintenance for almost 30 years it was considered that any tentative of recovery of the road would result in an environmental impact as significant as a new road (Fearnside & Graça 2006; MPF 2005).

Figure 6 – Maintenance work being executed in May 2018. Photo: author

To control the colonization of the territory with the establishment of the road, an Area of Provisional Administrative Limitation (APAL) was declared in January 2006 (Ibama 2009). APALs are instruments provided by Brazilian law (Brasil, 2000 - Law 9.985 / 2000) and are established when there is a risk of severe damage to natural resources in a given territory due to infrastructure projects. The first time such an instrument was created in Brazil was in 2005 with the paving of the BR-163, which connects Cuiabá to Santarém (Fearnside 2007). The APAL aims to protect biodiversity and safeguard the access of local populations to natural resources. The area under this limitation is thus provisionally obstructed for any activity involving environmental degradation and is subject to studies, which aim to implement PAs.

The APAL of the BR-319 was established on a provisional basis lasting seven months and, as a result, eleven (11) PAs were created (five under federal administration and six under state administration) (WWF 2008; 2009; ICMBIO 2009). Together with the existing PAs, they add up a total of 25 in the official area of influence of the BR-319 (note, the highway project affects a much larger area than the highway's official area of influence). The APAL covers approximately 154,000 km^2, and it is displayed in Figure 7 below by the polygon within the red lines. On the map, all PAs (in green), indigenous lands (in lilac), and settlements (in yellow) in the area of influence of BR-319 are displayed. Deforestation is indicated in orange, as well as, main roads and subsidiary roads.

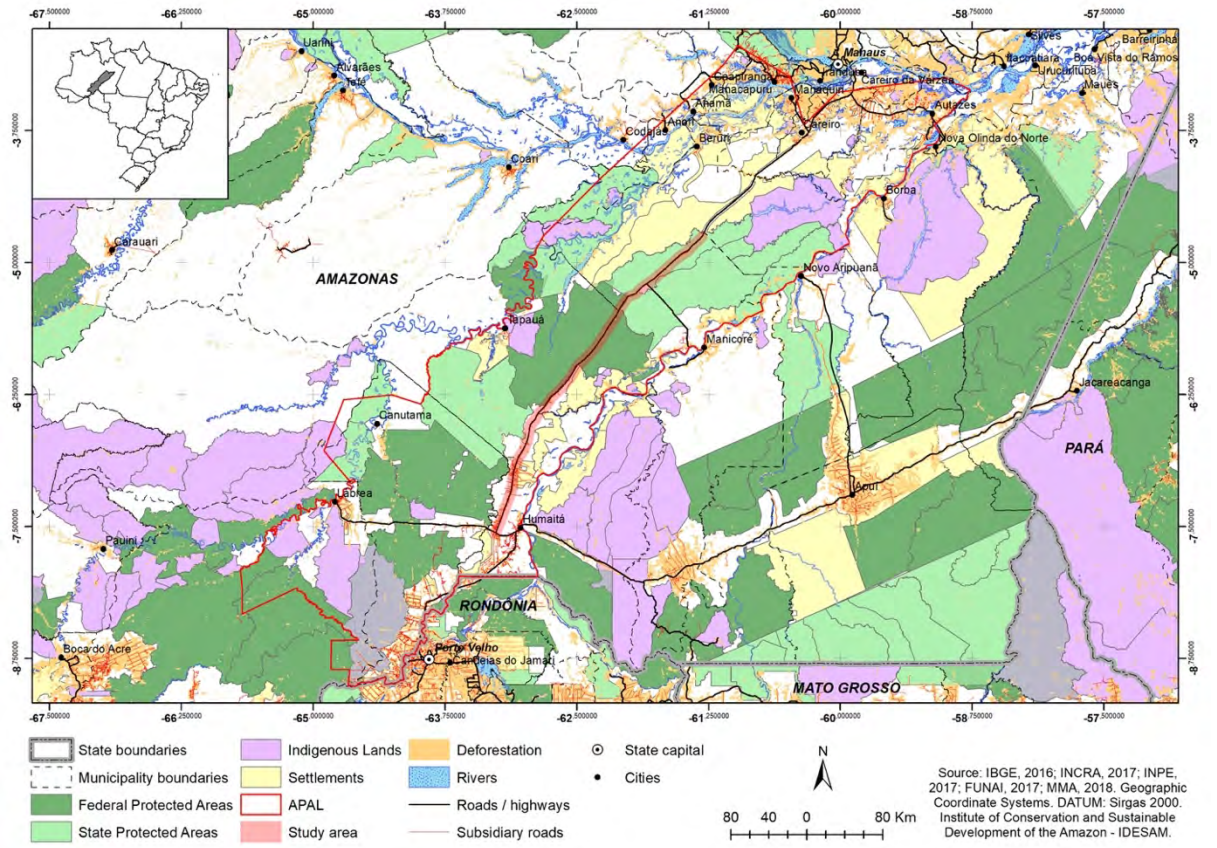

Figure 7 - APAL of the BR-319 highway. The study area is highlighted in red. Image granted by Idesam.

The APAL is divided into two parts: (1) Area of Indirect Influence - AII of the BR-319 and (2) Area of Direct Influence - ADI (UFAM 2009). The AII embraces 14 municipalities[10] and corresponds to a track containing 150 kilometers of each margin of the axis of the road. It includes in the east-west direction the whole interfleuve between the Madeira and Purus rivers; and to the north-south direction the area situated between the cities of Manaus and Porto Velho (UFAM 2009; Ibama 2009). In other words, the same boundaries of the APAL polygon presented in Figure 7.

By the year 2012, 4% (6233 km^2) of the APAL had already been deforested (Santos et al. 2015). A simulation of potential deforestation scenarios of the BR-319, predicted by Santos et al. (2015), foresees a 6% higher deforestation rate by 2030 with the recovery of the road when compared to the scenario without reconstruction. However, this simulation considered the implementation of several governance measures, chiefly PAs. Figure 8 displays the simulation predicted by Santos et al. (2015).

Another simulation conducted by Santos et al. (2018, forthcoming) considered three different deforestation scenarios for the area of influence of the BR-319: the "Historical baseline", the "Existing roads" and the "Planned roads". All scenarios consider the reconstruction of BR-319 in 2020 and the construction of the AM-364, a state

[10] Autazes, Tapauá, Canutama, Humaitá, Iranduba, Lábrea, Manicoré, Novo Aripuanã, Careiro, Beruri, Borba, Manaquiri, besides Manaus and Porto Velho

road that connects the BR-319 with Purus river, in 2024. The first scenario considers the historical deforestation rate along the road, while the second scenario considers an increase in the deforestation rate triggered by the improvement of the road network and the third and last scenario considers the same parameters as the second one, but with the additional implementation of planned roads throughout the area.

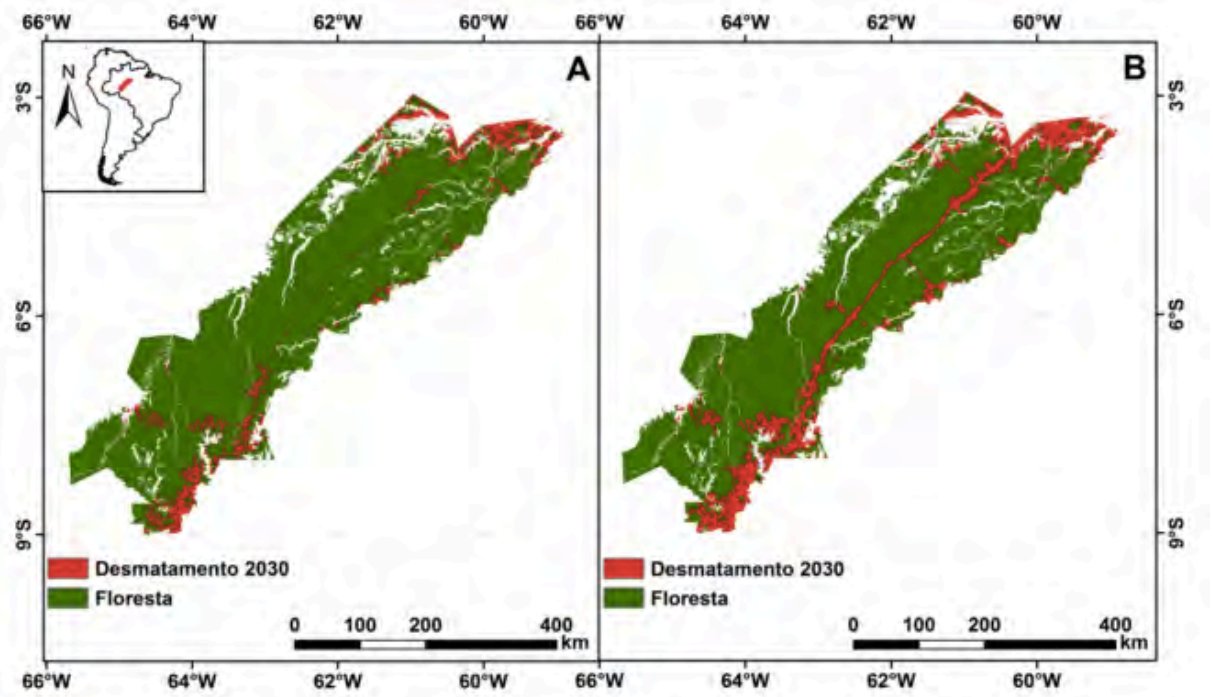

Figure 8 - Deforestation scenarios (2030) in the area affected by the reconstruction of the BR-319. At the left, the scenario without the road; and at the right with the road. Source: Santos et al. (2015).

In the "Historical Baseline" scenario, the potential increase in deforestation forecasted is 277.2% (37,637 km^2) for 2050 and 603.3% for 2100 (70,177 km^2); in the "Existing roads" scenario is 528,1% (62.669 km^2) in 2050 and 1.380,8% in 2100 (117.765 km^2), while in the "Planned roads" scenario the deforestation increase projected is 662.8 % (76,112 km^2) in 2050 and 1.291% in 2100 (138,778 km^2). All these predictions can be seen in Figure 9, Figure 10, and Figure 11. In summary, the study shows that the BR-319 and its associated side roads, have a substantial impact on deforestation in the region, way beyond the highway route itself.

Additionally, a simulation conducted by Barni (2009) concluded that the reconstruction and asphalting of BR-319 would increase deforestation by the year 2030 in the south of the State of Roraima between 18% (in a scenario "with governance measures") and 42% (in a scenario "business-as-usual") compared to the scenario without the reconstruction of the road. The study also demonstrated that the reconstruction might have impacts on the environment well beyond the area of influence of the road (Barni 2009; Barni et al. 2015).

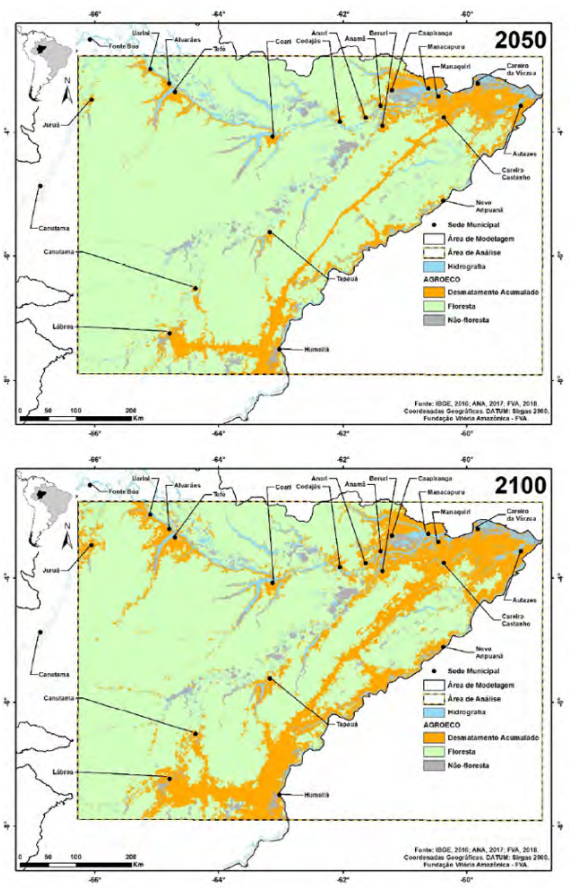

Figure 9 - "Historical Baseline" scenario

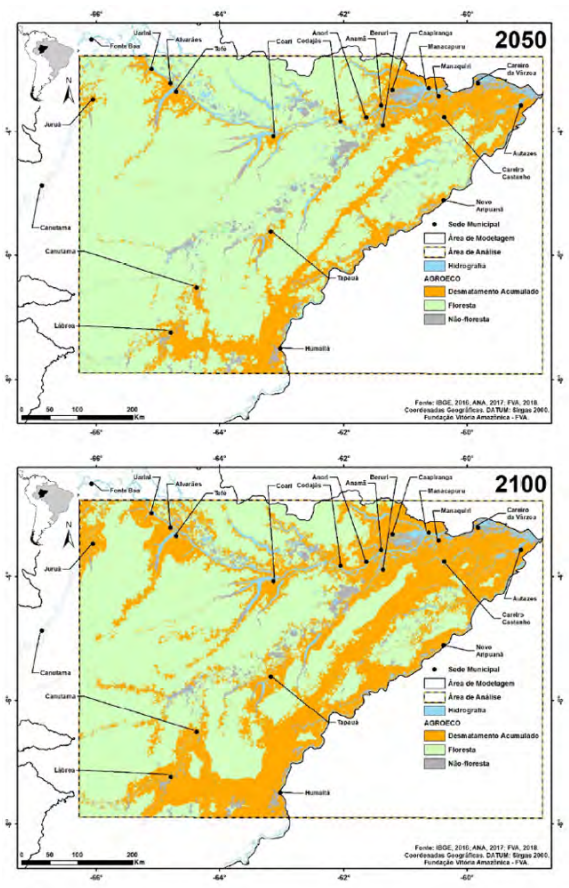

Figure 10 – "Existing roads" scenario

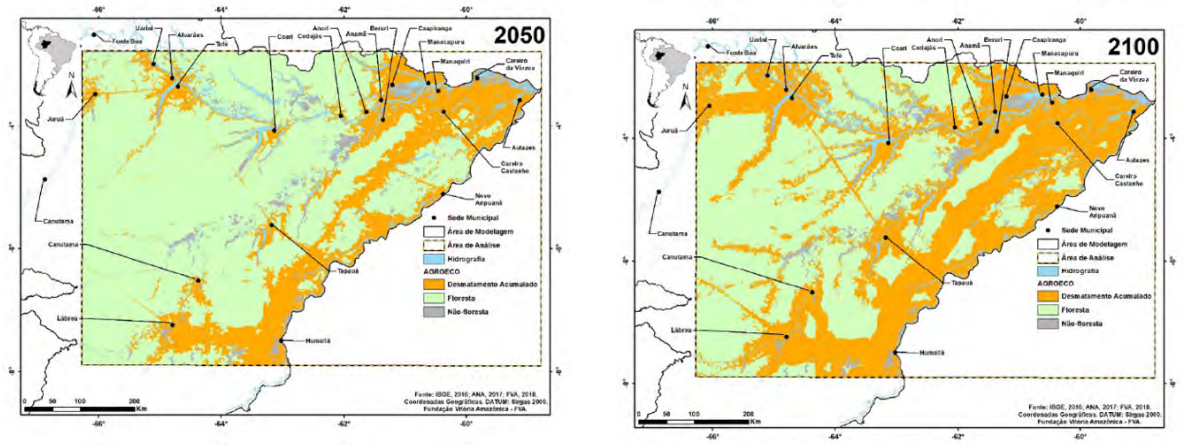

Figure 11 – "Planned roads" scenario
Source: Santos et al. (2018, forthcoming).

Ultimately, the Area of Direct Influence (ADI) is a buffer that stretches five kilometers to each margin of the axis of the road between kilometers 250 and 655, exactly the stretch that lacks the final license for pavement. This segment is located in the center of the road and was precisely the area that was inaccessible for decades, or with very difficult access, due to the lack of maintenance; therefor only a small population is found. The ADI was delineated as the focal area of the current study, and it is pre-

sented in the map below (Figure 12) by the buffer around the road, highlighted in red.

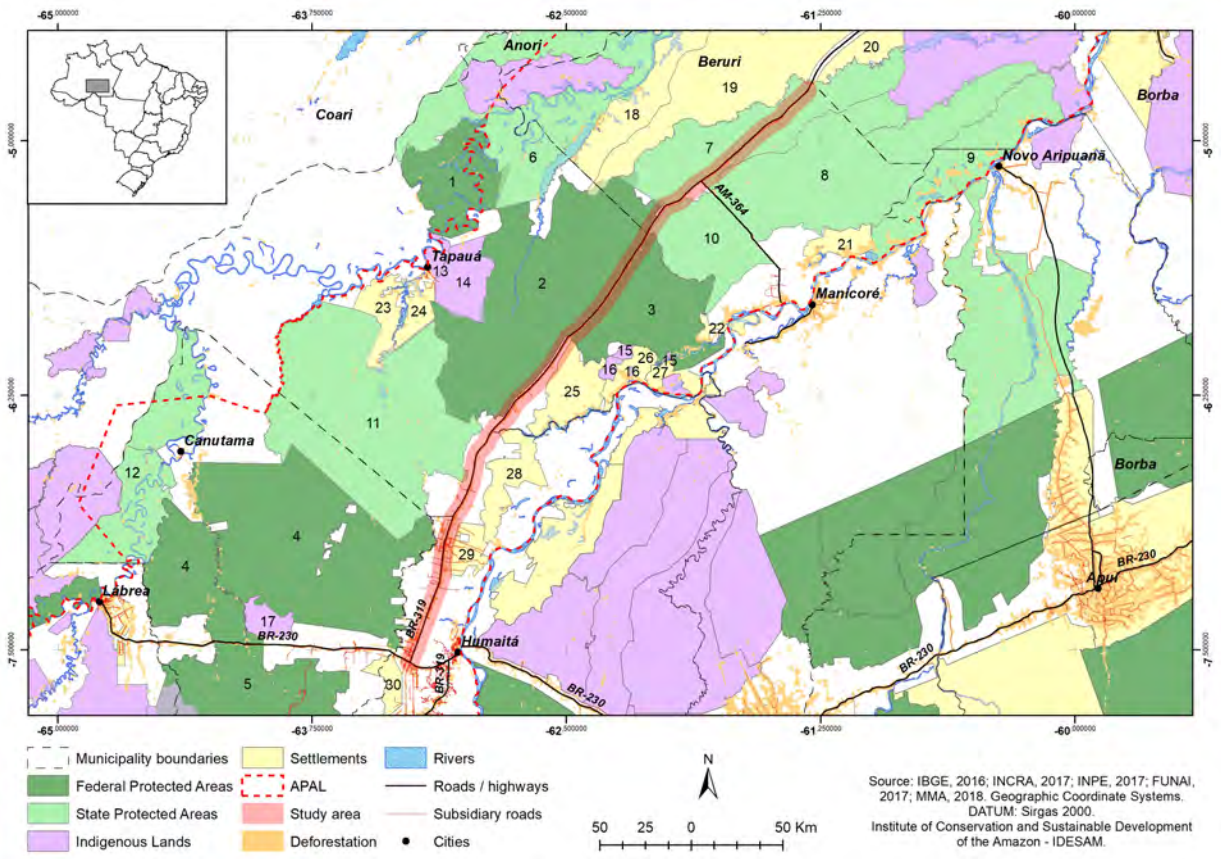

Figure 12 – Study Area (red buffer). Image granted by Idesam.

The ADI covers an area of approximately 4050 km², and it intercepts five municipalities: Borba, Beruri, Tapauá, Manicoré, and Humaitá, with only the last displaying direct access to the highway (UFAM 2009). Seven PAs and three rural settlements from INCRA overlap the boundaries of the study area[11], Three PAs are under federal administration and four PAs area under state administration. The settlement projects are under the big umbrella of the "environmentally differentiated settlement projects", which arose mainly due to the recognition of the deforestation rise driven by the traditional settlement projects of INCRA. Additionally, they were an attempt to recognize traditional forms of land use that are more compatible with the Amazon (INCRA personal communication, key-informant interview). In theory, these settlements allocate their land for collective use and are focused on agroextractivism and the sustainable use of natural resources.

The five municipalities located within the study area account for a total of 160,768 inhabitants (IBGE 2010), which in average represents a demographic density of 0.842 inhabitants per km². 52% of the population lives in the urban area (IBGE 2010) and

[11] They are identified in the map in Figure 11 by the numbers 1, 2, 3, 7, 8, 10, 11 and 25, 28 and 29.

poor parameters for human development[12], basic sanitation, child mortality, poverty, and inequality[13] are found, as it is possible to see through the indicators presented in Table 4.

Table 4 - Demographic Characteristics of the Population in the study area

		BERURI	BORBA	TAPAUÁ	MANICORÉ	HUMAITÁ	TOTAL / AV-ERAGE:
TOTAL POP.[1]	inh.	15.486	34.961	19.077	47.017	44.227	**160.768**
RURAL POP. [1]	inh.	7.708	20.527	8.459	26.668	13.726	**77.088**
URBAN POP. [1]	inh.	7.778	14.434	10.618	20.349	30.501	**83.680**
DEM. DENSITY[1]	inh./km^2	0,9	0,79	0,21	0,97	1,34	**0,842**
HDI[1]	-	0,506	0,56	0,502	0,582	0,605	**0,551**
IDEB[2]	-	4,1	3,8	4,7	4,1	3,9	**4,12**
SANITATION[3]	% total pop.	17%	17%	20%	16%	19%	**18%**
CHILD MORT.[4]	per 1.000 live births	10,35	16,93	5,22	10,44	10,33	**10,654**
POVERTY[5]	% total pop.	60%	61%	68%	51%	56%	**59%**
GINI[5]	-	0,44	0,44	0,37	0,41	0,48	**0,428**
PIB / CAPITA[6]	(x 1.000) EUR	1.726,81	1.657,47	2.770,81	2.323,22	2.194,60	**2.134,58**

Sources: (1) IBGE 2010, (2) INEP 2013, (3) DATASUS 2010, (4) IBGE 2014, (5) IBGE 2003, (6) IBGE 2015.

Comparing the data from the last demographic Census (2010) with the estimated population for the year 2018, shows a population growth of 19% in the municipalities inside the ADI (IBGE 2018). Prior the fieldwork, the available information about the population living in the study area described a total population of 161 households (IBAMA 2009; UFAM 2009). As already mentioned in section 3.3, during the field research a new estimate of the population was done, and around 600 households were identified in 2018 in the ADI of the BR-319 and thus in the study area. Considering the average Brazilian family size of 3.3 persons per family (IBGE 2010) the estimated population of the study area is 1980 persons.

[12] IDEB is an official Brazilian indicator for the quality of basic education, which ranges from zero to ten, with ten being the best result, while HDI, the Human Development Index, is a summary measure of average achievement in key dimensions of human development, which ranges from zero to one, with one being the best score.
[13] The Gini coefficient is a measurement of inequality, which ranges from zero to one, with zero expressing perfect equality, and one maximum inequality.

This chapter delimited the study area and methodology of the current study, the next two chapters will continue dedicated to the analysis of main results and findings.

4 Results at regional scale: institutional and policy factors

Recalling the goal, this study sets out to (1) describe the actor groups shaping frontier development on the Manaus – Porto Velho highway, as well as to (2) explore the variables affecting colonist's land-use decision with consequent impact over deforestation. The study also (3) investigates the relationship between these actor groups and the institutional and political environment where they are surrounded.

The current chapter presents the analysis of the empirical data collected at the regional scale. The theoretical framework presented in chapter 2 serves as a reference all over the chapter. As seen in Figure 13 the regional scale of analysis represents the institutional environment, or in other words, the access to infrastructure, services and the opportunities for citizen participation and the institutional context that the colonists face. As already mentioned in item 2.1, the last two topics were included to get a better understanding of the political and institutional settings by which colonists are surrounded. Additionally, they help to get an insight over the potential challenges to the future of the territory. Each of the topics is presented below.

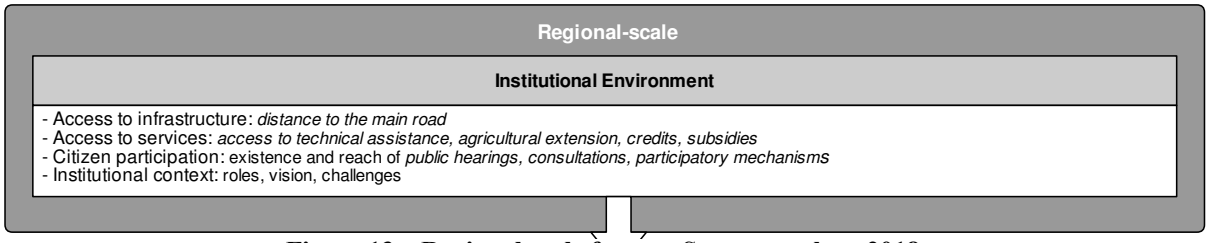

Figure 13 – Regional scale factors. Source: author, 2018

4.1 Access to infrastructure and services

Access to BR-319

Starting with the infrastructure conditions, distance to roads is an essential factor in determining the outflow of the production. The trafficability of the BR-319 is still conditioned to the dry season, and the on-going maintenance in some parts of the road does not guarantee its trafficability during the whole year, particularly to areas located in the center of the highway route and along subsidiary roads. The evidence shows that the outflow of agricultural products is highly dependent on the BR-319 since all households use the BR-319 to send agricultural production to the markets.

Additionally, 58% (28 households) had the property at the edge of the highway, another 19% (9 households) in a maximum distance of 5 km. The remaining, 6% (3 households) are at a distance of 10 km and 8% (17 households) in a maximum distance of 20 km. On average, lots are located at 3.64 km of distance from the BR-319.

Access to technical assistance

Only 21% (10 households) received any agricultural extension; 1 household in the Communities, 9 households in the settlement and none at the farms receive rural technical assistance. The public service for providing technical assistance in Brazil is focused on priority groups, such as settlers benefited by the INCRA Agrarian Reform policy, indigenous people, descendants of Afro-Brazilian slaves (*quilombolas*)[14], other traditional populations and, lastly, small family farms (Brazil 2010, Law n° 12.188/2010). In this case, farmers on the BR-319 are, in general, not priority groups.

Nonetheless, all households that reported receiving public technical assistance (in the communities or in the settlement) complained about the services offered. Colonists often reported that the service was incomplete, being only composed of meetings and no practical field assistance, and that they were extremely irregular.

Access to credit and subsidies

None of the interviewed families received credit or subsidies in the year 2018.

Citizen Participation

When asked if they were consulted about the plans to reconstruct the road, the majority of the households did not have any chance of sharing their opinion or requests. Specifically, 5 households in the communities, 2 households in the Farms and 25 households in the Settlement. For the general territorial development plans of the region, the majority of the households were not consulted. Six households in the communities, all the five farms and 24 households in the settlement. Likewise, 6 families in the communities, 4 families in the farms and 22 families in the settlement were not aware of the governmental plans for their region.

Citizen participation was also a topic addressed in the key-informant interviews. Many informants interviewed have a crucial role in the decision-making process concerning the territory of the BR-319; others act as watchdogs in monitoring public policies. Key informants were therefore able to provide an overview of the citizen participation since the beginning of the reconstruction of the road in 2005.

Similar to the answers from the survey, informants indicated that no consultation was done to understand whether the recovery of the road was needed in the first place. This is not to say that the local population does not want the road, but rather that they just did not have the opportunity to say so. In addition, there was no consultation about land-use planning.

At the other hand, there were indeed some opportunities for the participation of civil society, such as the consultation for the establishment of the Economic-Ecological Zoning (EEZ) of the region of the Madeira river, the consultation for the establish-

[14] Not present in the study area

ment of PAs resulting from the APAL, as well as for establishment of the management plans of these PAs; other tools for participatory co-management of PAs were also mentioned, such as the co-management council[15]. Moreover, citizen participation also occurs in the ongoing consultation with indigenous people, which is a formal requirement of the licensing process for repaving the road, and in the "BR-319 Forum". Social networks, such as Facebook and WhatsApp, and the "caravans" that many politicians have undertaken when they drive the road and talk with people were also mentioned as an informal method of citizen engagement. Lastly, the initiative of two local NGOs (Idesam and Casa do Rio) were mentioned. Idesam's initiative called "Observatory of the BR-319" seeks to provide authentic and accurate information about the BR-319 to all those who reside on the highway and in nearby municipalities, as well as other interested parties (Idesam 2018). Moreover, Casa do Rio with the mission of mobilization of local groups and associations.

A schematic diagram is presented in Figure 14 below; it summarizes the spaces for participation mentioned above, as well as some concerns stressed by key informants.

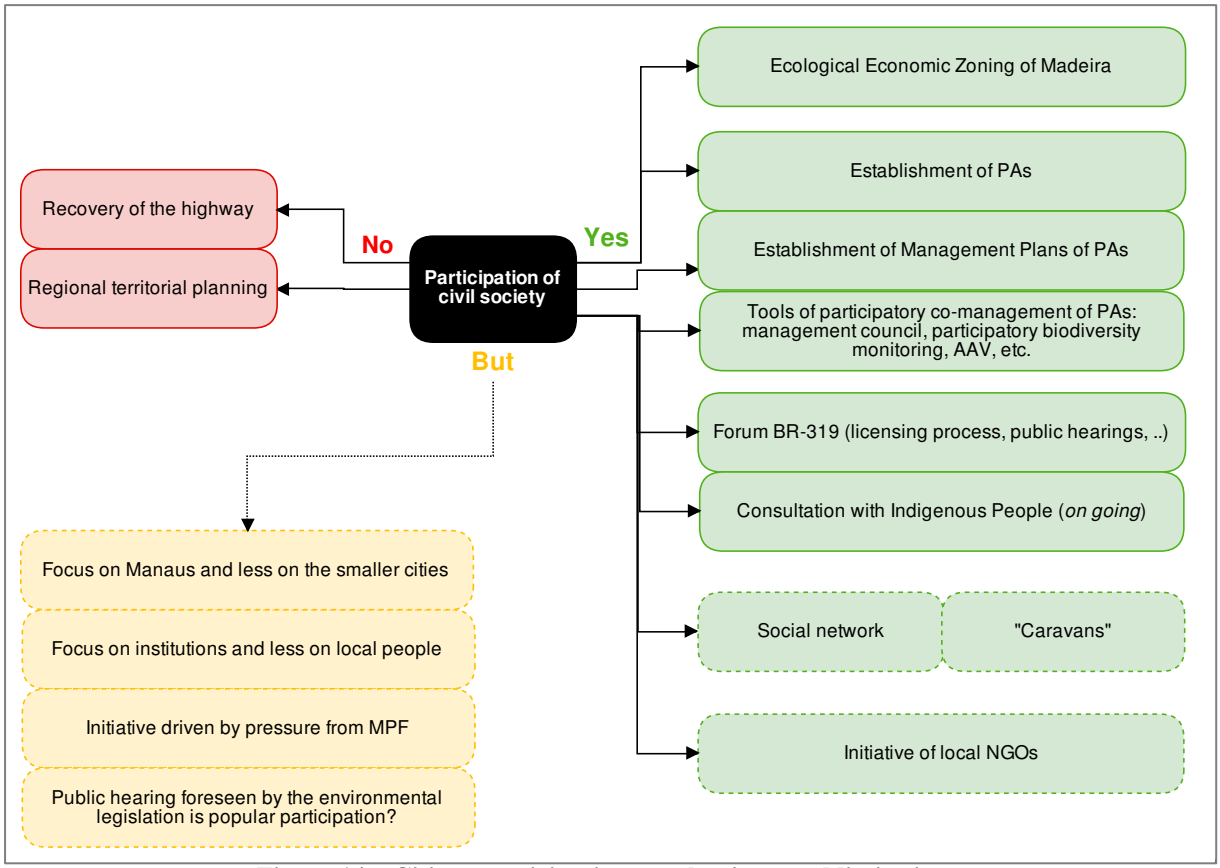

Figure 14 – Citizen participation, mechanisms and limitations

Evaluating the consultations that took place, three main problems were criticized by the informants. First, most of the consultations were held in Manaus and not in the

[15] Co-management councils are mandatory instruments of co-management of protected areas that gather the many stakeholders of public, civil and private sectors with interests or concerns about a given protected area.

smaller cities in the area of "direct influence" of the road; second, higher importance was given to institutions (such as NGOs and public entities) than to local people; and third, there is an overall criticism about the validity of public hearings as an effective process of citizen participation. Some quotes are displayed below in order to exemplify the issues accurately; the first quote mentions the EEZ, the second and third the PAs and the last one is about the validity of the public hearings:

> *"The zoning was very participative. There was a state commission, debates, and local workshops. For example, to create the mosaic of that region of Apuí, there were at least four workshops in Apuí, and one of them had at least 300 people participating. Now in the BR-319, there was only one workshop in Humaitá, very controversial, by the way, because at the time there were a number of actors interested in creating chaos to not let things happen, to not create the protected areas. They gathered a group of people to protest. So, it was very difficult to participate".*

> *"For example, the public hearing for the creation of the Igapó-açu RDS was held in (the city of) Castanho in a period when they (the residents of the RDS) could not get there. No one from Igapó was present at this hearing. For the public hearing on the management plan, they were; but for the establishment of the protected area no, no one was consulted. The teams did the data collection, but they (the residents of the RDS) did not understand that it was for the establishment of the reserve, because within the territory of Igapó-açu there are research areas of PPBio[16], of INPA, every 40 or 50 km. So, they (the residents of the RDS) had always interacted with researchers. So, they thought that on that occasion that the state was collecting the data for creation of the reserve, they thought it was something else of INPA. So, they were not consulted".*

> *"We were there at the public hearings in Humaitá, in Matupi, in Manaus and no, under no circumstances were the considerations made by the community taken into account for the definition of the perimeters of the protected areas. The perimeters were set in the office and were imposed".*

> *"So, the process of consultation respected the legislation, the public hearings were held, but what was not done at all was to take into account what people said. Do they (public hearings) comply with the law? Yes, they do, but they did not care to what people said".*

Additionally, one key informant who accompanied the environmental-licensing process since the beginning stressed that the consultation did not consider all levels of

[16] Biodiversity Research Program (PPBio)

the government, with the majority of the decisions being made by the federal government with little consideration to municipalities.

Two other initiatives are also important to mention. The first one was started by Amazonas State, to develop an integrated plan for participatory management of the BR-319 area. This process started in 2016 with the support of the international NGO Conservation International, and initial diagnostics and technical meetings were held. However, the process was suddenly interrupted with the revocation of the governor's mandate in 2017 due to corruption scandals. A new governor was elected, but held office for only 15 months, and he put the topic of the BR-319 on hold. As a consequence, no citizen involvement has occurred so far regarding participatory management of the BR-319, as expressed by the quote below:

> "*We came to a first diagnosis, identified the institutions, where they are and what they are doing in order to establish a concept, and to give a reply to the government. Then we made an initial proposal of what we thought was important for these discussions with the institutions, with the managers of the protected areas and, of course, with some state-government secretaries. From this we were able to format the first version of the Plan, which was exactly in this process of political transition, of change of government strategy,... So, we are still trying to find the best opportunity to resubmit the proposal, trying to understand if the arguments we established with the previous governor are still valid because we still do not have a definition. So, this moment (of consultation with civil society) has not really arrived. But this is already included in the schedule of proposed activities. (…). Now if the question is whether the public was included or not, they were not, because that is not how public policies are designed, with the populations -- they are drawn up in the offices. And this is not necessarily an arrangement of the state government, this is how it works in Brazil: public policies are built for these populations and not necessarily with these people. The most interested people for whom the policies could be destined never participate*".

The second initiative is the "BR-319 Forum". The Forum was a breakthrough in the process for citizen involvement, and the striking majority of key informants mentioned it as the most important mechanism of citizen consultation, as well as a crucial mechanism to facilitate inter-institutional dialogue. The Forum was created by the MPF, the Brazilian prosecutor, to monitor the environmental-licensing process, but it has emerged as the principal space of inter-institutional dialogue and civil participation. The quote below, displayed with the agreement of the MPF, explains how the Forum was created and the role it plays nowadays:

"Because there were no legal tools left for the public prosecutor to act[17]*, the permanent forum for monitoring the works and licensing of BR-319 was created, to monitor the licensing process. So, I decided to get everyone together, and when I say "everyone", I mean everyone, public entities, and civil society. The Forum has no institutional status (legal or formal establishment). It does not have a coordinator, I act more as a moderator, as an organizer directing everyone who has expressed interest in participation or all those who have been suggested to participate. Discussions take place in an organized way. In the first meeting, we tried to establish a premise that all of those who are in the forum want the recovery of the road. We work in favor of the pavement because the Federal Prosecutor does not have a position against the paving, our position is for the compliance with the law, which unfortunately is not possible anymore (…) but we are not against paving so long as it at least occurs with sustainability and responsibility. All we want is that these mitigation measures and compensation of environmental impacts are being evaluated so that there is a strict environmental mandate. So, the forum works precisely for that. This was the idea that inspired their creation, and everyone agreed on this premise of paving and sustainability, everyone also agreed that it would be an important agenda and they would have to have monthly meetings. Also, then some parallel concerns arose. And as a moderator of the forum, I also do not restrain these discussions; I just try to discuss issues that resonate with these environmental sustainability issues. We have already had six meetings. The last one was now in DNIT (…) And we also want to hold public hearings now, to also dialogue with the residents on the highway. We held the first public hearing in November 2017 in Manicoré, and the next one will be in Castanho, so we can expand this discussion and allow active participation of society. The meetings that took place in Manaus were also open to civil society. So, now we are bringing this discussion to the municipalities to address these local issues, to discuss these issues more comprehensively*".

The quote above exemplifies the political and institutional context of the reconstruction and repavement of the BR-319. Further attention is given to this topic in the next section.

4.2 Institutional context

The institutional context is the political and institutional background in which colonist's families are located. The key-informant interviews were the tool for data collection, and in this section two key topics are presented: first, the vision that each insti-

[17] The process of environmental licensing of the BR-319 overturns the jurisdiction rules established by law. This is possible due to a precedent of the Brazilian legal system that provides preference to the maintaining of the economic and public order over environmental regulations (personal communication, key-informant interview, 2018). As, the reconstruction of the Manaus-Porto Velho is considered of "public interest", and the rules can be "flexibilized" .

tution sees for the future of the territory (or, when it made sense, the personal vision[18]) and second, the main challenges posed to the development of the region.

In total, 29 interviews were conducted with 37 persons from 26 different institutions. One person represented two institutions at the same time, six interviews were conducted with more than one person and five interviews were conducted with different departments of SEMA. The answers were analyzed and computed for the total number of interviews (29).

Vision

The interviews with the key informants were analyzed and their perspectives on the future categorized into 63 key statements (later called codes). By comparing the codes of the different interviews, the key-informant statements could be grouped into three distinct visions. In the first, informants and the road as bringing economic development and connectivity to Amazons State and improving the quality of life of local populations; this is supported by the establishment of a sound participatory territorial governance in a mosaic of different land-uses operating in harmony. Seven of 29 informants support this vision.

At the other side, the second scenario asserted that the actions implemented by the government will not be enough to cope with the environmental impacts and that deforestation will increase, a boom of migration and land grabbing will happen, and conflicts over land and pressure on natural resources can be expected; this is supported by the existence of weak institutions, with lack of resources and staff and, consequently, lack of law enforcement. Nine informants supported this vision.

The third scenario, shared by 12 of 29 informants, is midway between the previous two scenarios, where regional development and improvement of the quality of life occurs, but alongside deforestation, pressure on protected areas and conflicts over land.

Despite the different perspectives, one thing the majority of them (22 of 29 informants) share in common: a future where the BR-319 road is restored and paved. Additionally, six informants affirmed that the institution does not have a formal vision established and their answers represented a personal point of view. Only one institution did not answer this question. Lastly, Table 5 below presents the ten most-voted codes:

[18] As in the case of the members of the Legislature or researchers.

Table 5 - Vision of the future, top ten codes

	VISION OF FUTURE – TOP 10 CODES	COUNT OF ANSWER
1	Recovery of the BR-319	22
2	Economic development	12
3	Pressure on natural resources	12
4	Improvement of the quality of life of local populations	9
5	Migratory boom	9
6	Increase of deforestation	9
7	Establishment of participatory governance	8
8	Mosaic of different land uses operating in harmony	6
9	Institution does not have an established vision	6
10	Environmental impact	5

Potential Challenges

The answers about the potential challenges that the region might face in the future were similarly categorized into 68 codes and subsequently grouped into 5 sub-sets of challenges: political/institutional (shared by 25 of 29 informants), environmental (shared by 22 informants), of territorial governance (shared by 14 informants), socio-economic (shared by 11 informants) and a last set related to citizen participation (shared by 8 informants). Nevertheless, different from the vision case, the grouping of answers by challenges is not exclusive; in other words, the answers of the informants point out challenges in different subgroups.

The majority of the institutions (25) believe that the core challenge is political and institutional. Common answers mentioned lack of law enforcement, institutional weakness and political instability, governmental discontinuity, bureaucracy, high centralization/federalization of governmental decisions, deficient dialogue among different government levels and agencies, lack of transparency and corruption, political instability, low capacity of local governments and poor performance of the state government in municipalities away from Manaus.

The second set is related to the specific institutional weakness of environmental agencies with consequent impact on the environment. Twenty-two informants reported concerns of this type. The environmental agencies responsible for the surveillance, licensing and management of PAs and for other functions (such as Ibama and ICMBio at the federal level, and SEMA, at the state level) have been facing a gradual decrease of budgets and staff in the last years. Informants affirm that this scenario of weak environmental institutions leads to a lack of environmental law enforcement and surveillance, which, in turn, could contribute to high pressure on natural resources and PAs, uncontrolled expansion of colonist settlements and cattle ranching and illegal activities, such as illegal logging and gold mining. Violence against the

staff of environmental agencies was also mentioned, since the region of the BR-319, and particularly the southern part of the region, it is known for confrontations between the economic sector and the environmental sector[19]. One interviewee also stressed that at the root of the environmental challenges is the dominant vision of development - espoused mutually by governments, the private sector and some local populations - that sees the Amazon as a source of resources to be extracted and that does not place value on the standing forest.

The third set emphasizes the challenges faced by territorial governance: this was an issue stressed by 14 informants, who doubt the capability of the government to establish participatory governance over the territory. Specific remarks were made about the governance of areas allocated by INCRA, the lack of integration among the many institutions that deal with territorial planning, and a particular item of concern was the "*Terra Legal*" (TL) policy of land distribution.

The fourth set, shared by 11 informants, stressed apprehension over social and economic issues, such as lack of options for the youth, the arrival of Venezuelan refugees, increase of violence and the expanding presence of drug gangs in the region. Moreover, these informants stressed the need to foster economic alternatives and counter the lack of public incentive for the rational use of the forest. Additionally, concerns about the social invisibility of traditional and indigenous population and increased social interaction between indigenous and non-indigenous people were mentioned. One informant expressed his concern with Amazonas state's competitive disadvantage as compared to the agricultural sector of Rondônia, once the road is repaved. The financial sustainability of the highway was also mentioned, as the maintenance cost is expected to be high, some informants showed concerns about the guarantee of accessibility of the road in the long term.

The fifth and last set, shared by eight informants, considered that bringing a diverse group of stakeholders together around a common vision that includes safeguarding environmental resources and including local people demands for decision-making is also a key challenge.

[19] In October last year, a crowd led by garimpeiros (gold miners) set fire to offices, vehicles and boats from Ibama, and ICMBio located in the city of Humaitá. The attacks were a retaliation for a joint surveillance operation conducted by the federal environmental agencies that destroyed mining barges that were illegally mining inside a protected area, the Humaitá National Forest. Besides the destruction of Ibama and ICMBio offices, employee's houses were also stoned, and Ipaam, which operates in the same building as INCRA, was also attacked. There is evidence the local politicians, such the mayor of the city and other counsellors, were involved (G1 Amazonas 2017; G1 Jornal Nacional, 2017; A Crítica 2017, O Eco 2017)).

Table 6 below presents the ten most-voted codes regarding the challenges:

Table 6 –Challenges, top ten codes

	CHALLENGES – TOP 10 CODES	COUNT OF ANSWERS
1	Lack of surveillance	13
2	Migration boom	10
3	Lack of staff for environmental agencies	10
4	Will the Government take responsibility?	10
5	Lack of rule of law	10
6	Establishment of participatory governance	10
7	Maintenance of protected areas	9
8	Institutional weakness	9
9	To include local people demands in decision making	7
10	Lack of resources for environmental agencies	7

The complete tables where the answers were summarized and then categorized into codes, computed and aggregated are presented in the Appendix (case-study database).

5 Local scale: colonists' characteristics and land-use strategies

At the local level, the focus was given to the population living along the middle stretch of the highway , and the unit of analysis was the 48 individual households interviewed. The results are present per each study case: Communities (which comprised 8 households), Farms (5 households) and Settlement (35 households). Using the theoretical framework presented in chapter 2 as orientation (Figure 15), the local scale of analysis comprises both sets of indicators: demographic and socioeconomic characteristics of households and land characteristics.

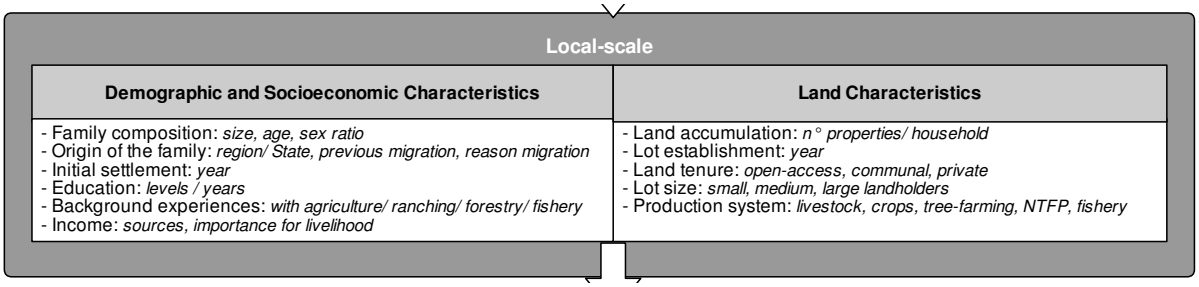

Figure 15 – Local scale factors. Source: author, 2018

5.1 Demographic and socioeconomic characteristics

The demographic and socioeconomic characteristics consider the family composition (size, age of household head and the number of men), the origin of the family (place of birth and migration history), initial settlement, education levels, background experience, and income composition. Also considered is the hiring of extra labor force and use of modern inputs such as agricultural machinery and implements.

Family composition

Starting with the demographic and socioeconomic characteristics, the average household size was 4.14 persons, with a sex ratio of 1.07 (men per woman); additionally, the average age of the household head was 48.04 years and there was a majority of young families with the average age of the remaining members of the family being 19.78 years.

As the absolute numbers of households interviewed in the case of farms and communities are very small (only 5 and 8, respectively), it makes no sense to discuss them as percentages. Nevertheless, Table 7 below presents a summary of the main findings on family composition for each of the three cases. The average numbers serve here as a reference, and the important evidence to note is that families in communities have older household heads and family members, with more men, lower levels of education and larger family size. Farms have the smallest families and have the lowest number of men per family. The rural settlement had the youngest household heads and other family members, as well as the highest levels of education.

The letter "C" in the left column represents communities, "F" farms, and "S" the settlement.

Table 7 - Summary of indicators of family composition

	Age of household head (years)	Age of family members (years)	Family size (n° of persons)	Men per family (n° of persons)	Education (years)
AVG_C	54,75	24,45	6,13	3,25	3,00
Min_C	30,00	2	4,00	2,00	0,00
Max_C	84,00	85	14,00	9,00	8,00
AVG_F	53,60	22,6	2,80	1,06	7,20
Min_F	34,00	2	2,00	1,00	0,00
Max_F	72,00	51	4,00	3,00	13,00
AVG_S	45,71	18	3,89	1,94	7,37
Min_S	19,00	0,3	1,00	1,00	0,00
Max_S	87,00	50	10,00	5,00	15,00

[1] AVG = average, Min = minimum, Max = maximum

Origin of the family

Of the interviewed families, most of the household heads were born in the North region of Brazil (25 persons or 52%), followed by 23% (11 persons) in the South, 15% (7 persons) in the Southeast, 6% (3 persons) in the Northeast and 4% (2 persons) in the Center-west. However, this result varies significantly among the three cases, as illustrated by the graphs below (Figure 16 and Figure 17). The red bars represent the communities, the green represent the farms, and the blue ones the settlement. The same color scheme was applied throughout the thesis.

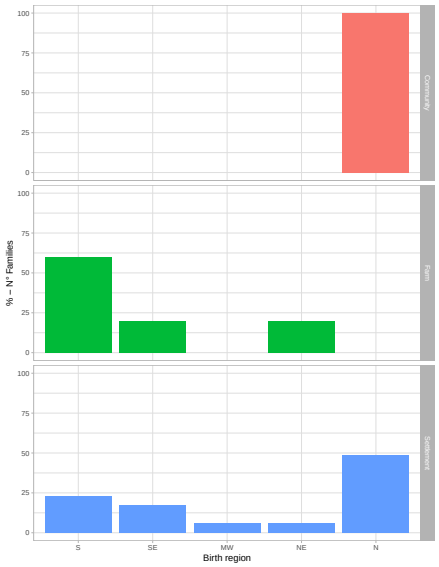

Figure 16 – Colonist's birth regions

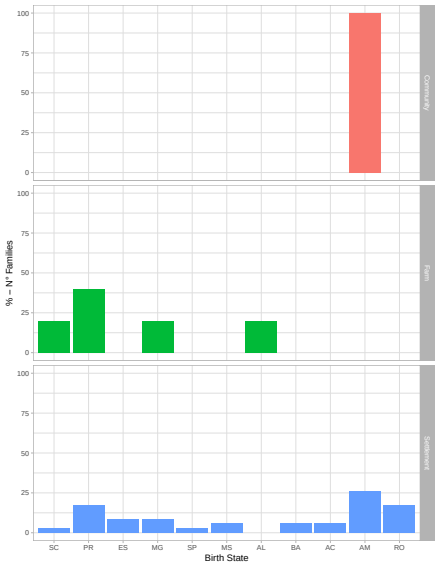

Figure 17 – Colonist's birth State

In Figure 16 it is apparent that all interviewed colonists living in communities (8) come from the North region of the country and, as seen in Figure 17, more specifically from Amazonas State. All of them have a traditional background, meaning that they have an indigenous-northeastern heritage such as riverside *caboclos* (*mestizos*); and they came mainly from the riversides of the main rivers Purus and Madeira.

Farmers, in turn, were born in the South (3), Southeast (1) and Northeast (1) regions of Brazil.

Colonists populating the settlement have much more variable origins, but nevertheless have the majority coming originally from the North (48.5% or 17 persons), mainly Amazonas (25% or 9 persons) and Rondônia (17% or 6 persons) and from the South (23% or 8 persons) and Southeast region (17% or 6 persons), especially he state of Paraná (17% or 6 persons). The remaining colonists were born in the Northeast (6% or 2 persons) and Center-west regions (6% or 2 persons).

Some of the settlers (17% or 6 persons) resembled the colonists of communities, sharing their indigenous-northeastern heritage. This is explained by the fact that Realidade was, in the beginning, a traditional riverside community. Some of the oldest families in the village state that Realidade began during the 1970s at the time of the construction on the road. Before moving to Realidade, these families lived on the banks of Madeira and Purus rivers, and they were familiar with the Realidade area through their Brazil-nut collection and hunting. With the arrival of machinery and workers, they soon realized that a road was going to be constructed, which attracted families to establish themselves in the region, seeking new opportunities. It is not clear when, but between the 1970s and the 1990s, the properties where the village is located today belonged to two owners: João and Fritz. João owned the lot on the east side of the road while Fritz owned the lot on the west side. The lots had approximately 300 meters at the front boundary and extended approximately 600 meters back from the road. João donated his property while Fritz sold his lot, both to the municipality of Humaitá (although it is unclear if Fritz actually received any money for the transaction). In 2003, both properties were divided into smaller lots, of 15 by 25 meters (called "*datas*"), and then distributed, with the assistance of the association of residents, to new families arriving in the region. The news of lots being distributed for free were a great attraction for migrants coming to the region of Realidade, and since 2003 the population more than doubled. Currently, the area of the village extends beyond the original properties of João and Fritz, without any control of the municipal government.

The colonists' origins, however, do not tell the whole history, since 65% (31 persons) had previously migrated to other regions before moving to the BR-319. Only one farmer and nine settlers migrated directly from their region of origin to the edges of the BR-319, against seven colonists in the communities. The majority of households

migrated first to the North region (75% or 36 persons), mainly to Amazonas (37% or 18 persons) and Rondônia (33% or 16 persons) and then to the BR-319.

The history of migration of colonists deserves more attention, as it is possible to see in

Table 8 below, which illustrates the migration flow of BR-319 colonists. In the column at the left side are the regions where colonists were born, followed by the states of origin, in the second column at the left. The regions and states are organized from the North (at the top of the table) to the South (at the bottom at the table). In the subsequent columns at the right, the migration States and regions are similarly presented. In the rightmost columns, the total number of household heads born in each state and region are displayed; similarly, the bottom row displays the total number of household heads from each previous migration state and region

Table 8 - Migration flow of BR-319 colonist

Birth \ Migration		N				CW	SE		S			
		AM	AC	RO	PA	MT	MG	SP	PR	SC	**Total/S**	**Total/R**
N	AM	14	-	3	-						17	24
	AC	1	-	1	-						2	
	RO	2	-	2	-	1					5	
NE	AL		-		-				1		1	3
	BA		-	2	-						2	
CW	MS		-		-	1					1	1
SE	MG		-	2	-	1	1				4	8
	ES		-	2	1						3	
	SP		-		-			1			1	
S	PR	1	1	3	-	1	2				8	9
	SC		-		-					1	1	
	Total/S	18	1	15	1	4	3	1	1	1	45	
	Total/R	35				4	4		2			

Table 8 shows two main findings: first, there are predominant internal influxes of migration in the North region; second, there is a pattern of migration to the north from older expansion frontiers in the Center-west region or southern areas of the North region. The dominant source of migration is movement of families of southern and southeastern heritage who have lived previously on older expansion frontiers. The same findings are displayed visually in Figure 18 below. The thickness of the lines is proportional to the number of colonists migrating. Additionally, the blue color repre-

sents the initial migration (from the birthplace) while the green color represents the last migration (to the BR-319). Lastly, the BR-319 road is represented in red.

Figure 18- Migration flow of BR-319 colonist (map)

Reasons for Migration

Many reasons attracted the colonists to this frontier area, and one of the questions of the survey was to evaluate the chief motivation. The results are summarized in Table 9 below.

Table 9 – Reasons for migration

	C	F	S
Cheap free land	-	3	20
Abundance of resources	1	1	-
Good land quality	2	1	9
To have one's own land	-	2	16

To not be an employee anymore	-	2	5
Rubber bust	2	-	8
Job opportunity - NTFP	2	-	-
Job opportunity - Timber	-	-	5
Job opportunity - Agriculture	1	1	1
Job opportunity - Other sector	-	1	4
Business	1	-	4
Road construction	3	-	1
Easier production flow	2	-	1
Network information	-	2	13
Family	3	-	7
Return to family´s land	-	-	5
Health service	3	-	-
School	2	-	1
Lack of knowledge about the region	-	1	-

Communities are presented in the second column, and they were attracted by the advantages of a new interstate highway, such as better health and school services or easier production flow. The bust of the rubber economy was also an essential factor, since the decline of the primary income source of the families stimulated them to seek land with better opportunities for NTFP collection and agricultural production. The presence of other family members previously in the region was also a key reason for the communities.

For the farmers, the main reasons were different as the primary goal was to acquire their own good-quality land or to change from a hired employee to an independent farmer with his or her own land. Also relevant was the network information, since before arriving they heard from friends or family members that there was cheap (or even "free") land available in the region.

With the settlers, the scenario is more diverse, but the basic motivation was also to acquire their own land, and the prospect of available cheap land was predominant. Similarly, to the communities, the rubber bust and the previous presence of family members were significant to some of the settlers.

Initial settlement

Six percent (3 persons) arrived in the 1960s, 17% (8 persons) arrived during the 1970s, another 6% (3 persons) arrived during the 1980s, 10% (5 persons) during the 1990s, 8% (4 persons) in the 2000s and the majority of 52% (25) after 2010.

It was observed that in the communities three colonists arrived during the 1960s and another two during the 1970s with the announcement and later construction of the

road, another colonist arrived during the 1980s and the last two arrived after in the 1990s.

Two farmers came with the construction of the road during the 1980s, one farmer arrived during the 1990s, and the last two others arrived more recently after 2010, boosted by the promises of the reestablishment of the highway.

Lastly, in the rural settlement analyzed, six early settlers arrived during the 1970s (17%) essentially those coming from traditional communities in the region, but the great majority of people arrived after 2010 (66% or 23 persons). The graph below (Figure 19) illustrates these findings:

Figure 19 – The Initial time of settlement

Education

Much lower levels of education are visible in the case of Communities, with the majority of the population (3 persons) having basically no education (illiterate) or only primary level of education (4 persons). This more specific finding can be seen in the graph displayed in Figure 20.

For Farms, higher levels of education can be seen, since one household reached the upper secondary education level and another one the tertiary level. Even though these were not the majority. In the settlement, the majority of the households were either at the primary (32% or 11 persons) or lower secondary (32% or 3 persons) levels, but, at the same time, there was a single case where three persons (9%) with a bachelor's degree were found. Education levels were classified according to the International Standard Classification of Education, provided by UNESCO (2011).

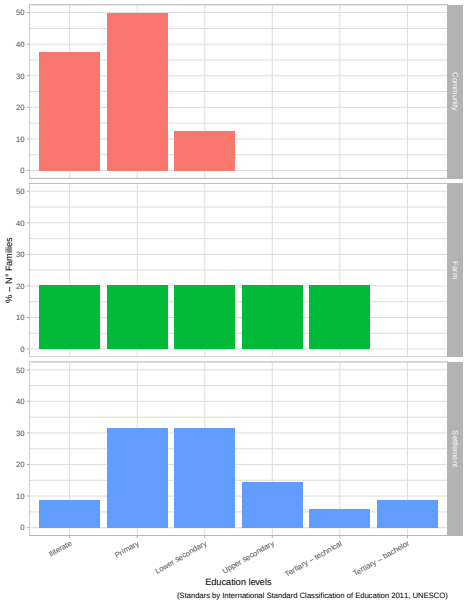

Figure 20 – Education levels per study case

Background experiences

All of the colonists had previous experience with agriculture, forestry, ranching or fishery but with some differences. Residents of communities did not have previous experience with animal husbandry, but all with agriculture and forestry and six with fishery. Farmers had much lower familiarity with forestry (only 1) and none with fishery, but they have agriculture (4 persons) and ranching (3 persons) experience instead. Settlers, in turn, had prior experience with agriculture (74% or 26 persons), ranching (43% or 15 persons), forestry (26% or 9 persons) and fishery (17% or 6 persons, and here again the ones with *caboclo/ mestizo* heritage). It is important to clarify that Forestry here means both timber and non-timber forest products (NTFP) extraction.

Income

The average overall monthly household income was R$9083.25 (EUR 2179.98), while settlers have an average income of R$13,357.90 (EUR 3250.90), farmers R$8514.00 (EUR 2043.36) and residents of communities R$5376.86 (EUR 1290.45). Given the household size of 4.14 persons, the average per-capita income was R$2194.02 (EUR 526.57), which is similar with the national per-capita average income of R$2169.00 (EUR 520.56) and higher than the per-capita average income for the North region of R$1665 (EUR 399.60) (IBGE 2018a, 2018b).

When it comes to the different sources of income, colonists presented a very diversified portfolio. Ten different sources of income were identified, as is presented by Table 10 below:

Table 10 - Different sources of income

1	Farm income, and here considering agriculture, ranching and forest utilization, both timber logging and NTFP collection. Forest utilization was considered part of the farm income as long as it was carried out inside the lot boundaries
2	Fishery
3	Collection of NTFP, and here uniquely when realized outside the boundaries of the lot
4	Job in the agricultural/ forest sector
5	Job in other sectors
6	Retirement
7	Government support, such as pensions or compensation for fishers for closed seasons for fishing (in Portuguese *seguro-defeso*)
8	*Bolsa família*[20], a particular government support that is part of the income composition of the majority sampled households, as much that it was considered apart from the others
9	Business, such as restaurants, grocery store, hotels and so on
10	Other sources, such as remittances

Two principal analyses were conducted about the income. The first considers the number of families engaged in the ten different activities mentioned above (Figure 21). The second concerns the share of each activity in the total income composition (Figure 22).

In the communities, all of the interviewed families count on *Bolsa família* and named as the main sources of income the "farm" (7 families), "collection of NTFPs" (4 families), "retirement" (4 families) and "fishery" (3 families) Fewer families also gained incomes from the categories job in *other sectors* (2 families) and *government support* (2 families) as well as *Business* (1 family) and *Job in the agricultural sector* (1 family).

Similarly, farmers dependent less on G*overnment support* compared to the Communities and most of the families have the *Farm* (4 families) and *Retirement* (4 families) as the primary sources of income. However, *Collection of NTFPs, Job in other sectors, Job in the agricultural sector, Bolsa família* and *Business* are each a source of income for, respectively, one family of the households interviewed.

In the settlement, *Bolsa família* (51% / 18 families), *Job in other sectors* (46% / 16 families) and the *Farm* (34% / 12 families) are the most frequent sources of income. Followed by *Retirement* (23% / 8 families), *Business* (23% / 8 families), *Collection of NTFP* (17% / 6 families), *Job in the agricultural sector* (14% / 5 families), *Others* (11% / 4) and lastly *Government support* (6% / 2 families) and Fishery (6% / 2 families).

[20] *Bolsa família* is a government direct cash transfer program designed to reduce poverty. The monthly payment is tied to child vaccinations and school attendance and it changes according per-person income, number of children and adolescents up to 17 years old, and number of pregnant and lactating women in the family (Caixa 2018; NASDAQ 2018). In the sample, the amount varied from 120.00 to 427.00 reais.

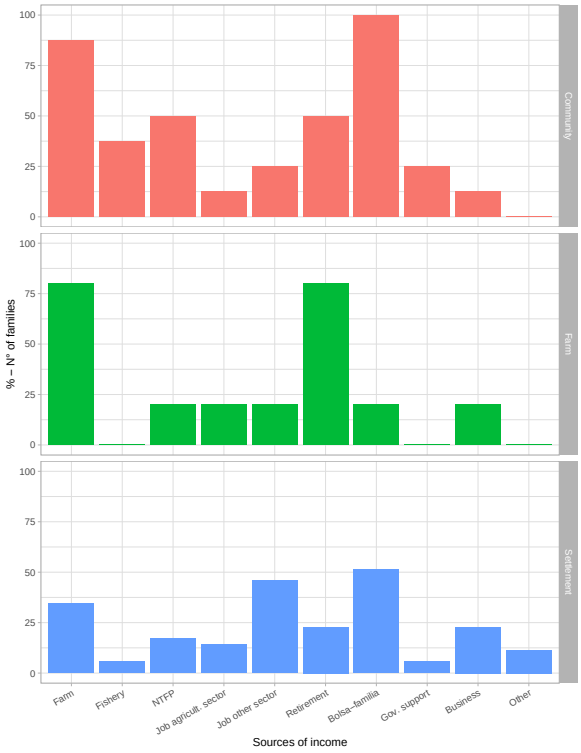

Figure 21 - Percentage of families per source of income

It is important to note that numbers such 34% of the families that live in settlements are involved with agriculture do not mean that 66% do not perform agriculture at all, but rather that only 34% of the families have agriculture as a source of income. Subsistence agriculture was not computed here.

The share of each activity in the total amount of income of the families is shown in Figure 22 below. While all of the families living in communities had *Bolsa família* as a source of income, this government support represented only 4% of the total income. Other minor contributions came from *Business* (2%), *Job in the agricultural sector* (3%), *Farm* revenue (5%) and other *Government supports* for (7%), while the major contributions came from *Collection of NTFP* (12%), *Fishery* (13%), *Job in other sectors* (23%), and the most significant share, *Retirement* (30%).

With farmers, the major contributions came from *Job in other sectors* with 44%, *Retirement* with 14% and *Farm* income with 18%. In other words, even though *Farm* income is one of the main contributors it is still not the chief source of income for farmers. *Job in the agricultural sector* accounts for 9% of the total income, *Collection of NTFPs* for 8%, *Business* for 5% and *Bolsa família* for 2%.

The findings are presented in Figure 22:

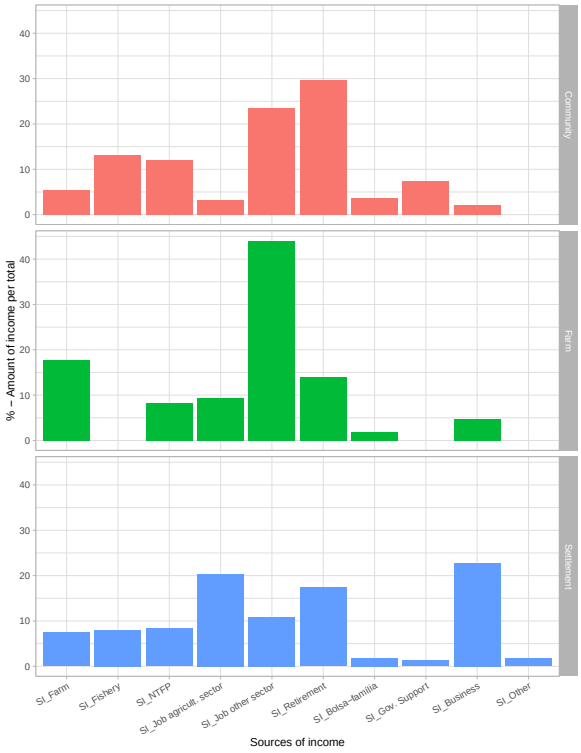

Figure 22 – Percentage share of each source of income per total amount

In the settlement, *Bolsa família* also had a small share of the total income of the families, representing only 2%. *Government support* and *Other sources* also represented only a small participation with 1% and 2% respectively. In contrast, *Business* (23%), *Job in the agricultural sector* (20%), *Retirement* (17%) and *Job in other sectors* (11%) were the most important contributors. Lastly, the income coming from the *Farm* represented 7% of the total and *Collection of NTFP* and Fishery 8% each.

A summary of the absolute values is displayed in Table 11 below. Again, the average amounts for the families and communities serve here merely as a reference, and the important evidence to note are the most-important sources of income, which are highlighted in red.

Table 11 – Summary of different sources of income (BRL)

		FARM	FISHERY	NTFP	AGR. SECTOR	OTHER SECTOR	BUSINESS	OTHER	GOV. SUPP.	BOLSA FAMÍLIA	RETIREMENT
C	AVG	290,57	711,00	647,00	167,00	1.260,00	110,00	0,00	397,50	201,29	1.592,50
	MIN	100,00	400,00	200,00	167,00	920,00	110,00	0,00	397,50	120,00	954,00
	MAX	916,00	900,00	1.275,00	167,00	1.600,00	110,00	0,00	397,50	391,00	1.908,00

F	AVG	1.507,50	0,00	708,00	800,00	3.750,00	400,00	0,00	0,00	163,00	1.186,50
	MIN	625,00	0,00	708,00	800,00	3.750,00	400,00	0,00	0,00	163,00	930,00
	MAX	3.260,00	0,00	708,00	800,00	3.750,00	400,00	0,00	0,00	163,00	1.908,00
S	AVG	1.000,25	1.062,50	1.112,50	2.725,20	1.452,19	3.041,63	225,00	175,00	241,39	2.322,25
	MIN	90,00	125,00	45,00	50,00	35,00	200,00	100,00	150,00	120,00	954,00
	MAX	4.780,00	2.000,00	5.600,00	8.150,00	6.000,00	10.000,00	300,00	200,00	427,00	6.700,00

[1] AVG = average, Min = minimum, Max = maximum

Overall, income sources can be grouped into four sets: *Farm income*, *Extractivism* (which considers *NTFPs* and *Fishery*), *Government support* (with *Bolsa família*, *Retirement* and other G*overnment supports*), *Off-farm income* (with *Job in the agricultural sector*, *Job in other sectors*, *Business* and *Others*), as displayed in Table 12 below. The table shows the average income provided by the four sets, as well the share they represent in the total income. In this manner, the primary source of income for the colonists who live in communities is *Government Support* (with 41% of the total), for the farmers is O*ff-farm income* (with 58%) and for the settlers is, again, O*ff-farm income* (56%).

Table 12 – Four main sets of income sources

	FARM INCOME	EXTRACTIVISM	OFF-FARM INCOME	GOV. SUPPORT
C	290,57	1.358,00	1.537,00	2.191,29
	5%	25%	29%	41%
F	1.507,50	708,00	4.950,00	1.349,50
	18%	8%	58%	16%
S	1.000,25	2.175,00	7.444,01	2.738,64
	7%	16%	56%	21%

In overall, *Government Support* is a relevant source of income for all, income from *Extractivism* represents a significant source of income both for Communities and the Settlement. Moreover, *Farm* income has minor importance for the composition of colonist's income, even though it is more significant in the case of farmers. When the income from the farming activity is disaggregated, five sub-sources could be identified: *temporary agriculture*, *perennial agriculture, forest utilization* and *animal husbandry* (which was divided into *small animals* and *cattle*). Hence, it is possible to make the same comparison as made before (the total number of families and share of income) for these five sub-sources, as is displayed in Figure 23 and Figure 24 below. Worthy to mention: the following analysis only considered the households that have farming activities as a source of income (23).

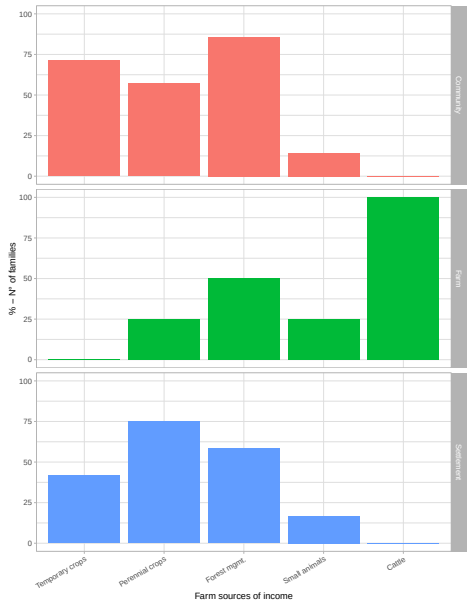

Figure 23 - Percentage of families per source of farm income

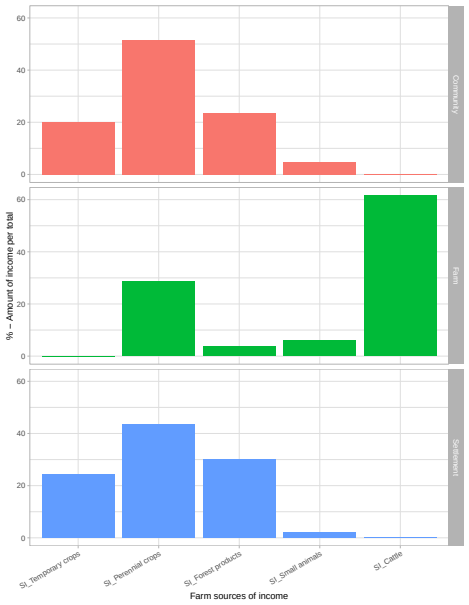

Figure 24 - Share of each source of farm income in the total amount

As seen in the Figures above, farmers were mostly involved with *Cattle ranching* (4). They are also involved with *Forest utilization* (2), *Perennial agriculture* (1) and *Husbandry of small animals* such as pigs and chickens (1). It important to clarify that the participation of farmers in forest utilization is mainly related to the collection of NTPF, since none of the farmers reported log extraction; nevertheless, farmers do not to collect NTFP but instead they allow others to collect inside their lot and receive a share of the revenue, alternatively the act as middleman transporting the production to the city. Interesting to mention is that none of the interviewed farmers were engaged in the plantation *of Temporary crops* for economic reasons. One farmer was not considered in this analysis since this household did not report *Farm* activities as a source of income. Similarly, the same happens for the communities and the settlement.

Communities, quite the reverse, do not raise *Cattle*, and they were mostly engaged with *Forest utilization* (6 families), *Temporary agriculture (5* families*)*, *Perennial agriculture* (4 families) and H*usbandry of small animals* (141 family).

In the settlement, families were mostly involved with *Perennial agriculture* (75% / 9 families), *Forest utilization* (58% / 7 families), *Temporary agriculture* (42%/ 5 families) and *Husbandry of small animals* (17%/ 2 families). None of the settlers interviewed were raising cattle for economic purposes.

About the share of each farming activity in the total farm income, the most significant share for communities came from *Perennial Crops* (51%), followed by *Forest utilization* (24%), *Temporary crops* (20%) and *Small animals* (5%). While for farmers, *Cattle ranching* accounted for 61% of the income followed by *Perennial crops* with 29%, *Forest utilization* with 4% and *Husbandry of small animals* with 6%.

Lastly, in the settlement, the most meaningful share came from *Perennial crops* (43%), accompanied by *Forest management* (30%), *Temporary crops* (24%) and *Husbandry of small animals* (2%).

Livestock

The average herd size averaged 46 head for cattle owner, but only four households (all of them farmers) reported having cattle. The maximum number of animals was 110, and the minimum was 6.

Principal non-animal farm products

Table 13 –Temporary crops, perennial crops and forests products

Temporary crops	Perennial crops	Forest products
- Cassava - Pineapple - Yam - Potato - Pepper - Ginger	- Banana - Açaí (*Euterpe oleracea*) - Cocoa - Coffee - Cupuaçu (*Theobroma grandiflorum*) - Pupunha (*Bactris gasipaes*)	- Logs - Açaí - Brazil-nut - Copaíba oil (*genus Copaifera*) - Andiroba oil (*Carapa guianensis*)

For all the families sampled, the *Temporary crops*, *Perennial crops*, and *Forest products* associated with income generation were those displayed in Table 13 above. Two remarks can be made: first, communities had the most diverse production of *Temporary crops*; second, most of the production of *Perennial*s was in agroforestry systems, with the exception of banana that is largely produced in monocultures.

The F*orest products* presented above considered both when the collection was done inside public forests or in the family's own lot. In all the three cases, colonists were engaged in the collection of NTFPs, especially açaí and Brazil-nuts, which are two very popular products in the region and an indispensable source of income during the rainy season. Nonetheless, communities were most engaged in pure extractivism in primary forests on public land, chiefly in Protected Areas, namely FLONA Balata Tufari and RDS Igapo-açu. In the settlement, 4 colonists (11%) equally engage in extractivism in the FLONA Balata Tufari. Log extraction was reported only by one household in the settlement.

Off- farm income

The off-farm income was divided into *Jobs in the agricultural and forest sectors*, J*obs in other sectors* and B*usiness,* as presented in Table 14 below. Special attention must be given to the logging sector that includes 4 sawmills in Realidade and employs

tree fellers, sawyers, and cabinet-makers, as well as businesses such as log freight. The owner of one of the sawmills was interviewed. Moreover, the demand for labor in the agricultural sector is mostly generated on larger farms in the region.

Table 14 – Main off-farm job and business

Jobs in Agriculture and Forest sectors		Jobs in other sectors	Business
Jobs in the Agriculture sector	Jobs in the Forest sector		
- Cleaning pasture - Delimiting lot boundaries - Forest felling - Building fences - Harvesting - Farm management and - Planting pasture	- Tree fellers - Sawyers - Cabinet-maker - Diagnosis of timber potential	- Health agent - Driver - Nurse - Public agent - Teacher - Nanny - Butcher - House cleaner - Maintainer of the cable lines for telephone company - Middleman - Tourism (sport-fishing)	- Restaurants - Hotels and bed and breakfast - Grocery store - Bakery - Variety shop - House rental - Auto repair - Log freight - Sawmill

Plans for future investments

One of the questions of the survey was related to the plans for the future, and some of the answers given were related to future investments. They are presented in Table 15 below:

Table 15 – Plans for the future (investments)

	C	S	F
Fish-farming	1	2	-
Tourism	2	1	-
Increase livestock/ Start to raise cattle	-	12	2
Agriculture modernization	-	3	-
Expand business	-	5	-

As presented in the Table above, colonists in communities planned on investing in fish-farming and tourism. Farmers planned to increase livestock. Settlers presented a more diverse portfolio, considering investments in fish-farming and tourism, and to modernize agriculture with the use of machinery or to expand businesses. It is important to note that in the year 2018 none of the households interviewed in the settlement had livestock, but 16% of them planned to start raising cattle in the future.

Modern Inputs

Communities had no access to machinery, pesticides or fertilizers and did not hire extra labor. On the contrary, 3 families of farmers used agricultural machinery, 4 used pesticides for cleaning pasture and another 3 families hired extra labor for helping with daily farm activities; 39% (5 families) of the settlers used agricultural machinery, 39% (5 families) used fertilizers, and another 69% (9 families) used pesticides, but only 6% (1 family) hired extra labor.

5.2 Land characteristics

The set of land characteristics comprises the process of land accumulation, time of lot establishment, land tenure, lot size and production system.

Process of land accumulation

During the survey, interviewed households were asked to talk about the land allocation inside their lot, and it was soon realized that many of the families were describing a lot which was neither where they were living nor the lot where the questionnaires were being conducted; it was therefore necessary to investigate the process of land accumulation.

A total of 75% (36 families) had more than one property in the region. Particularly in the communities, 3 families had more than one property. They were precisely the ones living in the Communities of Sao Sebastião do Igapó-açu and Nova Geração, close to Manaus. These families had lots inside the settlement projects of INCRA, PAE Igapó-açu 1 and 2, or inside the RDS Igapó-açu. They used the second lots for agricultural production but were living in another lot next to the road, where the Communities are located.

In the settlement, 83% (29 families) also had more than one property. In general, families were living in Realidade, with better access to services, in an urban context and had their agricultural production further away in INCRA settlements or in spontaneously occupied areas. Of the farmers 4 families have more than one lot in the region, to guarantee land for their children when they grow up and, to expand pasture areas or to serve as environmental compensation for already deforested areas, or, as reported by one farmer, for "safety reasons".

The following topics address the characteristics of the main lot reported by the interviewed colonists. The researcher did not interfere in the decision to define which lot was the most important one for the households.

Initial lot establishment

Seventy percent of the lots were established after 2000, 17% (8 lots) during the 2000s and 54% (26 lots) after 2010. Additionally, other 15% (7 lots) were established in the 1990s.

It was observed that in the communities one lot was established during the 1970s, one during the 1980s, two lots during the 1990s, three lots in the 2000s and the last one after 2010. In the farms, one lot was established during the 80s two lots were established during the 1990s, one lot during the 2000s and another one after 2010. With the settlers, one (3%) lot was established in the 60s, one (3%) in the 1970s, 3 (9%) lots were established during the 90s (17%), four (12%) during the 00s and the majority of lots were established after 2010 (69% or 26 lots). One settler also reported having a lot that was established during the 1940s, which is hardly possible, and another one did not remember the date of initial establishment. The graph below (Figure 25) illustrates these findings:

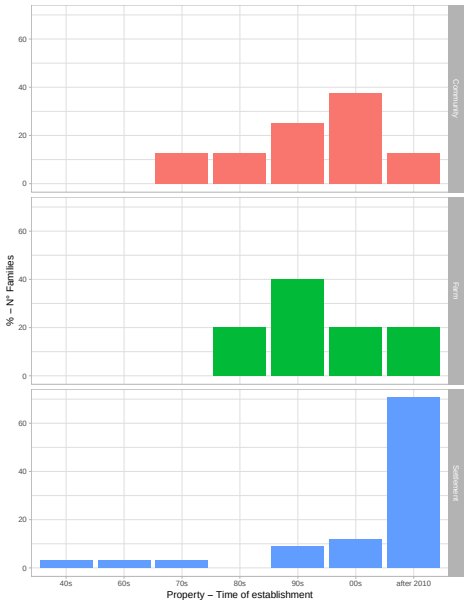

Figure 25 - Initial time of lot establishment

Land tenure

Concerning land ownership, three regimes of property rights were reported by colonists: open access, common property, and private property. Land and resources subject to open-access have no exclusive and transferable rights, they can be claimed and utilized by anyone (Bromley 1991); this is the case of non-designated public lands, or *terra devoluta* as already mentioned before in section 2.2.

Properties that are under common property are jointly owned by a limited group of individuals, who are entitled to exclude others. Usually, there are rules, such as statutes, which may guide the use of resources and bestow power to a majority to make binding decisions (Stevenson 1991). In the study area, common properties such these exist inside PAs with sustainable use of natural resources (IUCN category VI,

Dudley 2008) here specifically the RDS Igapó-açu, and the special INCRA settlement projects, such as PDS Realidade and PAE Igapó-açu 1 and 2. Both the PAs and in the settlement projects foresee collective use of natural resources with common ownership. Additionally, both are subject of some kind of collective rules established for the shared management of natural resources. In the RDS these rules are outlined by the management plan and in the settlements by the utilization plan. However, it is necessary to elucidate that hardly any utilization plan is established by INCRA with the colonists and, in practice, the settlements are colonized with an individualistic approach without taking into account any collective goal (INCRA, personal communication, key informant interview).

Lastly, private properties are those assigned exclusively to individual persons (Ekbäck 2009).

In general, 52% (25 families) reported having lots under an open-access regime, 29% (14 families) under common property and 19% (9 families) under private property. In the communities 2 families were occupying properties in an open access regime while the remaining 6 families were under common property. In the farms, 4 families claimed to have private properties, and only one family alleged to have bought the property from previous owners 38 years ago, but only possessed the buy-and-sell receipt, and thus was considered to be under the open-access regime. In the settlement, 20% (7 families) were under common property, while 66% (23 families) were in areas under open access. The remaining 14% (5 families) claimed to have private properties.

Property size

The size of the properties is another point to note: they varied between small landholders with properties up to 100 hectares, to medium landholders with properties of 100 to 600 hectares and large holders who own properties with 600 hectares or more. The evidence shows that in the BR-319, in general, there was no predominance of large holders. Sixty-five percent (31 households) were small landholders, 27% (4 households) owned medium properties, and only 10% (4 households) owned properties with 600 hectares or more. The average lot size was 202.24 ha, ranging between 0.02 ha and 3000 ha. The four large holders owned only 10% of all properties but occupied more than 55% of the surveyed area. The biggest large holder was a resident of a community, with the tenure regime under common property. Figure 26 below displays the results for each case.

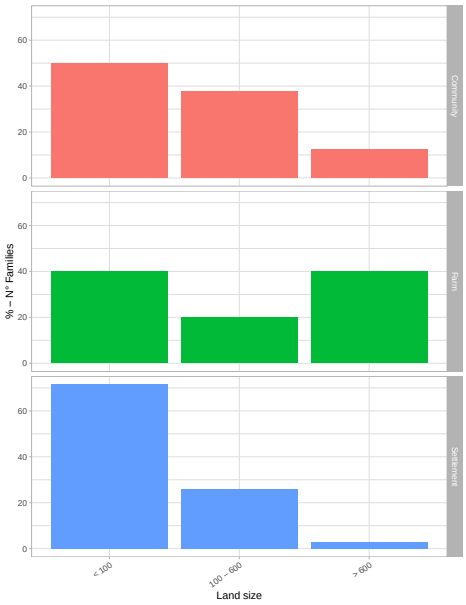

Figure 26 - Lot sizes

As seen in the graph above, in the communities, four households were small landholders, three households were medium landholders and one household was a large landholder. Residents of communities had the largest areas, averaging 501.37 ha. Of the farms, two households owned small properties, one household owned a medium property, and two households owned large properties. The average lot size was 428 ha. In the settlement the majority (71%, or 25 households) were small landholders, 26% were medium landholders (9 households), and large landholders represented only 3% (1 household). The average lot size was 101.61 ha.

Land-use allocation and production systems

Moving to the land-use allocation types, six categories are discriminated: pasture, temporary crops, perennial crops, agroforestry, secondary forest young (fallow), secondary forest old[21] and primary forest. For all families, independently where they live, there is a fair distribution of different land-use types. All families have land distributed among the above-mentioned land uses, with the exception of pasture, which communities did not acknowledge.

Figure 27 and Figure 28 below present the percentage of each land use in the total amount. To facilitate the visualization, in the second figure at the right, Primary Forest was excluded.

[21] Until 5 years: young secondary forest or fallow. After 5 years: old secondary forest.

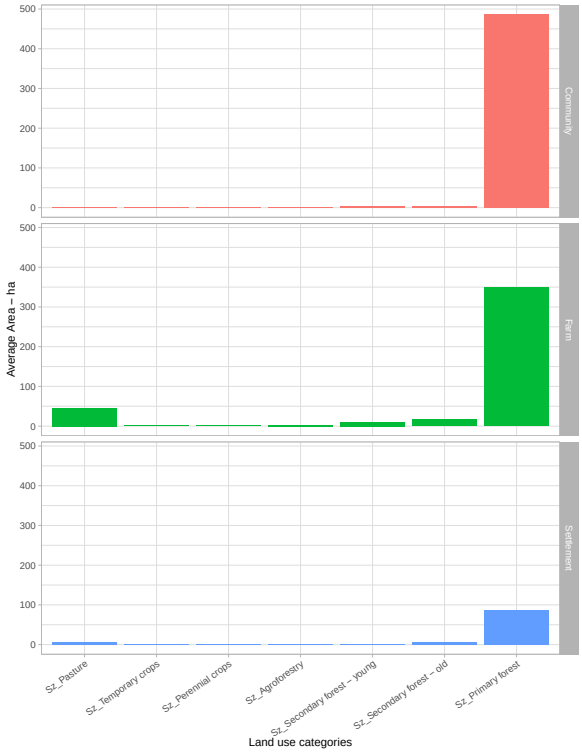

Figure 27 - Percentage share of each land use per total amount

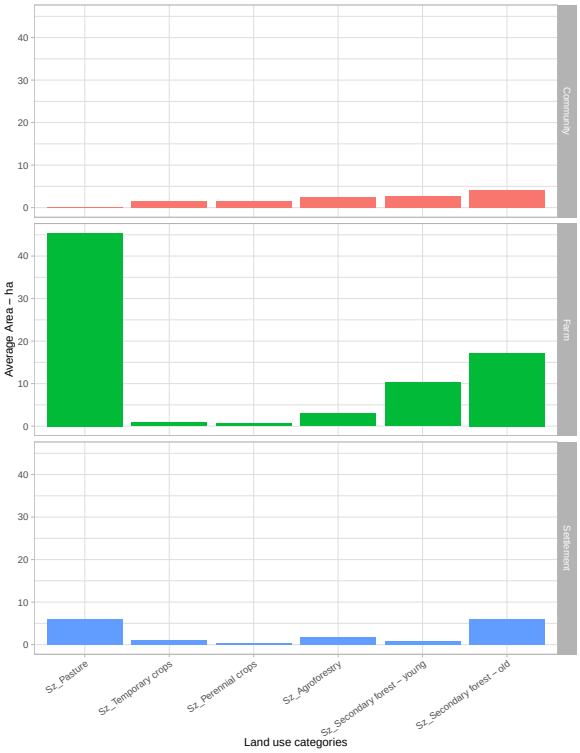

Figure 28 - Percentage share of each land use per total amount, without primary forest

Colonists who live in communities had only a small fraction of their land allocation altered to other land use types such as temporary crops, perennial crops, or agroforestry; and none was assigned to pasture. The highest amount was allocated to Agroforestry and Secondary forest and they also have the biggest areas of crops, both temporary and perennial, which besides being an important source of income, also provides agricultural products for family consumption. This is easily illustrated in Table 16 below, which shows the average amount of land allocated to each category. The distribution of land in the settlement and farms are also presented in Table 16.

Farmers had a much higher concentration of land in pasture, but also had land in disturbed secondary forests, and smaller proportions were allocated to agroforestry and agricultural crops, both temporary and perennial.

Settlers had a significant fraction of their land altered from original forests, namely to pasture, secondary forests and agroforestry. Nevertheless, the area of croplands was small, and no cattle were reported in the pasture for economic purposes.

Table 16 - Summary of land use indicators

		PASTURE (HA)	TEMP. CROPS (HA)	PEREN. CROPS (HA)	AGROF. (HA)	2ARY FOR. Y. (HA)	2ARY FOR. O. (HA	1ARY FOREST (HA)
C	AVG	0,00	1,50	1,63	2,38	2,69	4,06	590,13
	Min	0,00	0,00	0,00	0,50	0,50	0,00	47,00
	Max	0,00	3,00	13,00	5,00	10,50	15,00	2992,00
F	AVG	45,20	0,90	1,00	3,00	9,65	17,20	229,40
	Min	6,00	1,78	0,00	1,00	0,00	0,00	0,00
	Max	100,00	3,50	3,00	7,00	40,00	60,00	697,00
S	AVG	9,01	0,79	0,30	1,71	0,48	4,84	64,26
	Min	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Max	95,00	6,25	7,00	97,50	12,50	37,50	394,00

[1] AVG = average, Min = minimum, Max = maximum

Future land allocation plans

Concerning future land-allocation plans, as shown in Table 17 below, residents of communities planned to expand their area of temporary and perennial crops. Farmers and settlers intended to expand their areas of pasture and agriculture, but Farms focused on pasture, while the Settlement focused on agriculture.

Table 17 - Plans for the future (land allocation)

	C	F	S
Expand pasture	-	2	6
Expand temporary crops	3	3	16
Expand perennial crops	4	1	8
Sell and move	-	-	3
Sell and stay	2	-	7
Share land among children	1	2	6
Acquire more land	-	-	2

Additionally, residents in the communities planned to share their properties with their children or to sell their properties (but to continue in the region). For this, they counted on other properties they had accumulated. They also imagined selling a share of their properties, thus reducing their land holdings. Farmers alleged to only plan to share their properties with their children while the settlers recognized that they planned to acquire more cheap or even free land and sell it afterward.

5.3 Common indicators of deforestation

Six categories of land use are discriminated in the topic 4.1.2 (land-use allocation): temporary crops, perennial crops, agroforestry, young secondary forest (fallow), old secondary forest and primary forest. The goal in this section is to examine how the choice of land-use relates to deforestation. Deforestation here is considered to be the sum of pasture, crops, agroforestry and fallow.

To start, a comparison between the land allocation and deforestation was made. In Table 17 below the average land use in each case is presented on the left side, and the total sum of deforestation (considering all households in each case) and the average deforestation are presented on the right side:

Table 18 – Amount of deforestation in each study case

	LAND USE						DEFORESTATION	
	Pasture	Tem. crops	Per. crops	Agrof.	Secondary (Y)	Secondary (O)	SUM	AVG
C	0,00	1,50	1,63	2,38	2,69	4,06	44,00	5,50
F	45,20	0,90	1,00	3,00	9,65	17,20	250,50	50,10
S	9,01	0,79	0,30	1,71	0,48	4,84	297,50	11,80

Once again, the average numbers serve here as an objective reference, and the important evidence is that the highest average rate of deforestation is observed in farms, driven by the establishment of pasture; however, as seen in Table 18 above, the total sum of deforestation achieved by the 35 settlers (297.5 ha) is even higher than the total deforestation accumulated by the five farmers (250.50 ha). It is important to remember that the sample followed an equal ratio of 10% for the three study cases. Nevertheless, independent of being farmers or settlers, what both have in common is the drive for pasture, which is undoubtedly the principal cause of deforestation among the sampled population. As already mentioned, none of the settlers reported raising cattle for economic purposes and the income arriving from cattle ranching represented a minuscule part of total income of farmers.

When only the top 5 colonists with most area deforested are analyzed, as presented in Table 19 below, it is possible to see that farmers and settlers were the dominant factors for the overall deforestation. In Table 19 average lot size, deforestation, and the six categories of land use are presented in hectares. The Table does not include the area allocated to houses, infrastructure or the area occupied by waterbodies. The five colonists presented below were responsible for 56% of all deforestation captured by the survey.

Table 19 - Top 5 colonist that most deforest

	LOT SIZE	DEF.	PASTURE	TEMP. CROPS	PEREN. CROPS	AGROF.	SECONDARY (Y)	SECONDARY (O)	PRIMARY FOR-EST
F	800,00	103	100,00	0,00	2,00	1,00	0	0	687,00
F	220,00	101	100,00	0,00	0,00	1,00	6,3	25	85,00
S	110,00	97,5	95,00	1,00	0,00	1,50	0	0	10,00
S	65,00	28,5	25,00	2,50	0,00	1,00	0	2,5	33,50
S	35,00	20	7,50	1,00	0,00	11,50	0	0	14,50

Many variables may interfere in the outcome of deforestation. From the literature, there is plenty of evidence indicating that many variables have a prevailing impact on deforestation, and from the theoretical framework, a selected number of variables were preferred for comparison. However, is there indication of a tendency between any variable and deforestation in the case of the BR-319?

In order to investigate this question further, a multiple regression analysis was performed to determine whether there are statistically significant relationships between the independent variables and deforestation. Six variables were preferred for analysis: in the household demographic and socioeconomic factors the variables compared were the number of men, education levels and income; in the land characteristics, the selected factors were lot size, length of residence on the property and distance to the BR-319. There are indications from the literature that these selected variables generally have positive impacts on deforestation.

The regression assesses if there is a relationship between the continuous dependent variable (deforestation) and the independent variables listed above. The results (summarized in the codes below) show that there is an overall low significance between the variables. However, at least one predictor is significantly associated with the outcome (deforestation). This is indicated by the t-statistic and the associated p-value highlighted in red, as well as the significance level indicated by the star symbol. The high t-statistic and low p-values, as well as the level of significance, indicate a statistically significant relationship between income and deforestation among the sampled households.

```
##
## Call:
## lm(formula = as.formula("Deforestation ~."), data = data2)
##
## Residuals:
```

```
##       Min      1Q  Median      3Q     Max
## -30.205  -9.985  -3.893   2.937  80.271
##
## Coefficients:
##              Estimate       Std. Error    t value  Pr(>|t|)
## (Intercept)  6.692374  11.046641   0.606   0.5482
## Lot_size     0.006382   0.007912   0.807   0.4249
## Man         -1.736782   2.491107  -0.697   0.4899
## Education    0.059857   0.970337   0.062   0.9511
## Distance    -0.225691   0.639506  -0.353   0.7261
## Lot_year    -0.138829   0.251688  -0.552   0.5845
## Income       0.003966   0.001671   2.373   0.0228 *
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 23.91 on 38 degrees of freedom
## Multiple R-squared:  0.1792, Adjusted R-squared:  0.04963
## F-statistic: 1.383 on 6 and 38 DF,  p-value: 0.2465
```

A simple regression analysis considering only the variables deforestation and income was also performed. The graph (Figure 29) below displays a visualization of the analysis and suggests a linearly increasing relationship between both variables; this is also corroborated by the correlation coefficient, which measures the level of the association between the two variables and is presented by the R-value at the top of the graph (R= 0.379296), and by the p-value (p = 0.01).

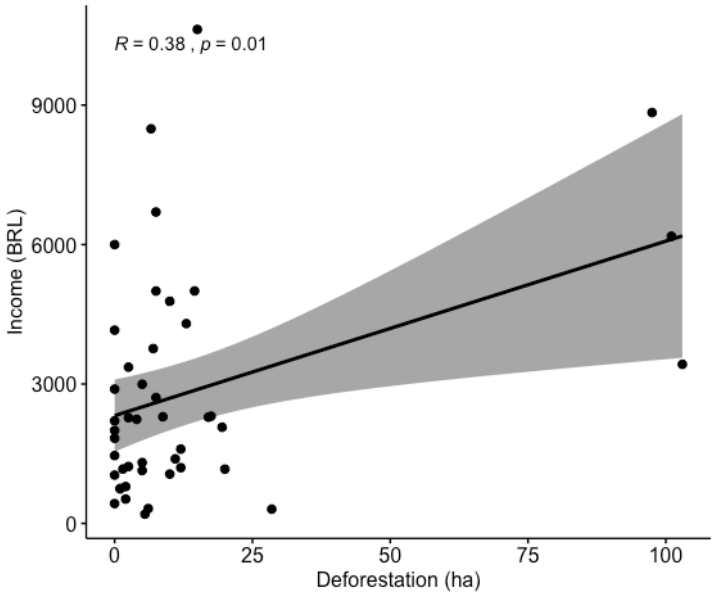

Figure 29 – Linear regression analysis (Deforestation vs Income)

Nevertheless, seeing the graph above and analyzing the Residual Standard Error (RSE), the R^2 value and the F-statistic of the multiple regression (presented in the Codes above) there is an indication that, in overall, the regression model does not properly fit the data. The high RSE (representing the average variation of the obser-

vations points around the fitted regression line) indicates that the observed deforestation values deviate from the true regression line by approximately 23.91 units on average (or a percentage error of 181%). Additionally, the low adjusted R-squared of 0.04963 suggests that the regression model did not explain much of the variability in the outcome. The low F-statistic of 1.383 and the p-value 0.2465 indicate an overall low significance of the model. Nevertheless, this was an expected result, since only a small sample of 48 households, or 10% of the population, was interviewed. The estimation of relationships among variables was done here more as an indicator of the dynamics of land-use allocation rather than to prove any linear causation.

6 Discussion

The goal of this section is to describe and interpret the implications of the findings presented in the last chapter, in light of previous studies on frontier development. Remembering that this case study has a descriptive and exploratory purpose, the goal is (1) to describe the colonists shaping frontier development on the Manaus – Porto Velho road, as well as (2) to explore which variables predominant affect colonist's land-use decision with consequence towards deforestation. Additionally, (3) to investigate the institutional and political environment and the potential challenges for the sustainable development of the region.

The guiding questions of analysis are:

i. Who are the colonists on the BR-319?
ii. What are the characteristics of the land they occupy?
iii. Which factors predominantly influence colonists' deforestation?
iv. What are the potential challenges for the sustainable development of the territory?

It is important to recall once again that case studies are generalizable to theoretical propositions and not to populations or universes. In this sense, the purpose of a case study is to compare empirical evidence with previous theories and findings (analytical generalizations), rather than to compute frequencies (statistical generalizations) (Yin 2009). The different sources of evidence were analyzed to assess whether the evidence supports the initial propositions presented by the theoretical framework of the study described in chapter 2, which states that colonists usually have some similarities and are influenced by different sets of variables, both exogenous and endogenous, which affect their land-use strategies. While this case study does not aim to explain the proposition completely, it gives some indications and helps to narrow down a very broad context and to delineate further research needs and hypotheses.

A key statement should be made first: even though this case study never aimed to produce statistical generalizations, the initial goal was to achieve a bigger sampling ratio (of at least 30%). However, as already mentioned, before the fieldwork the only available information about the population living in the study area was completely out-of-date, and once in the field a new estimation had to be done, which was very time-consuming, especially for the village Realidade. Accessing the middle stretch of the BR-319 is not an ordinary task, and a complex expedition with a rented 4 by 4 car and a team of 5 persons was carried out together with Idesam (two additional shorter and less comprehensive expeditions were also done with SEMA). To achieve a sampling ratio of at least 30%, at least double the available time and resources would be needed in the field, which was not possible for this master's thesis to achieve. Additionally, 2018 had a significantly long rainy reason, which put the field

expedition on hold while waiting longer than expected for the rains to lessen. In the end, the biggest limitation of this research was underestimating the growth pattern of the frontier. However, the new estimate of the population is already a novelty. The choice of the case study approach as the research strategy allowed benefiting from previous studies for the development of a theoretical framework that contributes to analytical generalizations and serves as a qualified explanation of the low statistical significance obtained from the current sample.

6.1 The colonists shaping frontier development on the Manaus – Porto Velho road

6.1.1 Profile and background

On the BR-319 colonists had an average household size of 4.14 persons with a sex ratio of 1.07 (men per woman), the average age of the household head was 48.04 years, and the average age of the members of the family was 19.78 years. There was a preponderance of young families, especially in the settlement. Families in communities had the oldest household heads, more men and larger family size, while the farms had the smallest families and the lowest number of men per family.

Comparing these empirical results with other frontier areas (Moran 1971; McCracken et al. 2002), there was a similar tendency for consolidation of young families, with a high numbers of men (Carrero and Fearnside 2011; Pichón 1997). The average household size is similar to the average four people found by Simmons et al. (2016) in Southeastern Pará and the 3.6 persons found by Carrero & Fearnside (2011) in Apuí, Amazonas; but lower when compared to 6,6 persons per household found by Marquette (1998) and Pichón (1997) in the Ecuadorian Amazon and 7.3 by Perz et al. (2006) in Uruará in Pará.

In the BR-319 case, most of colonists were born in the North (52%), South (23%), Southeast (15%), Northeast (6%) and Centre-west (4%) regions. However, this result varied significantly among the three cases. The findings about the birthplace of families showed a somewhat different outcome from other frontier areas. Moran (1975) found that in the Transamazon region close to Altamira, Pará, settlers came mainly from the South (38%), Northeast (32%), North (14%) and Center-west (14%), while Fearnside (2001a) found that in southern Pará migrants came predominantly from the Northeast region, specifically from the state of Maranhão. Goza (1994) found that in Rondônia the vast majority of settlers arrived from the states of Paraná, Mato Grosso and Mato Grosso do Sul.

When looking only at the results of the Settlement (where 48.5% originally came from the North region, 23% from the South and 17% from Southeast), the findings of this research indicate a slightly different pattern of migrants arriving in the region of the BR-319, when compared to the findings of Carrero & Fearnside (2011). These

authors investigated a similar scenario in the region of Apuí, in the Juma Settlement Project, which is also in the influence area of the BR-319, but there approximately 77% of the households were from the South and Southeast regions of Brazil (43.9% and 32.9%, respectively), while only 8.5% were from the North region.

There is an indication that in this new frontier of the BR-319, colonists, in general, are no longer arriving from the Northeast as had been the pattern on older frontiers, but rather from internal fluxes in the North region. Nevertheless, the flow of migrants from the South remains. These findings are also corroborated by the findings about their migration trajectories.

The majority of the colonists (62%), and remarkably farmers and settlers, had migrated previously to other regions before arriving on the BR-319. A common generalization could be made that there is an indication of a characteristic pattern of migration to the north from older expansion frontiers in the Center-west or North regions, specifically to southern Amazonas and Rondônia, followed by the final migration to the BR-319 region. The pattern of migration stemming from internal fluxes of settlers inside the Amazon region has already been noted by Becker (2001).

The migration trajectory is likewise similar to the findings of Carreiro & Fearnside (2011) where only 27.8% of the households migrated directly to Apuí from their region of origin, 24.4% first moved to the Center-west region and then to Apuí, while 41.1% of the households resided first in Rondônia and 6.7% in Paraguay. Pichón (1996) also found that in the Ecuadorian Amazon over half of the households had periods of residence in other areas away from their places of birth previous the final migration to the frontier he investigated.

As a new frontier, the majority of colonists (60%) arrived at the BR-319 after 2000. Additionally, another 17% (8 persons) arrived in the 1970s. Comparing these findings to previous studies, in the Transamazon Moran (1975) and Fearnside (1985) found the majority of migrants arriving during the 1970s. In Ecuador Pichón (1997) indicates that the vast majority of settlers arrived in the 1970s and 1980s. In Rondônia, Goza (1994) found that migrants arrived during the 1970s and 1980s as well, while Carrero & Fearnside (2011) found an average residence in Apuí of 16 years.

Farmers came mostly with the construction of the road during the 1980s (40%), but also more recently after 2010 (40%). Settlers often arrived after 2010 (66%), nevertheless, some of them (17%), born in traditional communities of the region, also arrived during the 70s. A network that transmits information about available land to outside the region attracting people and stimulating migration has a preponderant role. This evidence is visible when considered that farmers and settlers claim to arrive at the BR-319 mainly attracted by the offer of cheap or "free" land and the goal to

have its own property. The importance of this information network is also corroborated by the findings of Simmons et al. (2016) on the Transamazon highway, in Pará.

Communities arrived from riverside region of Purus and Madeira, during the 1960s, 1970s and 1990s and were mainly attracted by the announcement and later construction of the road, and the offer of better health and school services and livelihood opportunities with the decline of the rubber economy. For the residents of communities, which moved from a riverine environment to the road, a similar pattern was also found by Moran (1975), with *caboclos* from Pará arriving on the Transamazon highway.

Low levels of education are seen all over the population, and the majority (75%) of all colonists reached a maximum of only four years of school. In the communities, the education average levels achieved are even lower; while in the settlement and in the farms are found the individuals with the highest education, both around seven years of school. Similar findings were indicated by Moran (1975) in the Transamazon where Northerners (41%) and Northeasterners (28%) also accounted for a significant portion of the illiterate population. In the Ecuadorian Amazon, Pichón (1997) also found low levels of Education, where only 10% had formal education beyond primary school. In Southeast Pará, Simmons et al. (2016) found 23% of the interviewed illiterate, with the majority of the households in the first level of education.

Concerning their background, all the colonists had previous experience with agriculture, forestry, and ranching. However, residents of communities did not have previous experience with animal husbandry while farmers have a much lower familiarity with forestry. About their background, Fearnside (1982) and Moran et al. (2002) found similar results for the Altamira region, where only 29% of the settlers (according to Fearnside) and 30% (according to Moran) did not have previous experience with Agriculture.

A limitation of this research is the extremely diverse behavior of settlers. It is not clear if this is a consequence of a more diverse population, as authors frequently assert based on their experience at the field, or of a higher absolute number of households sampled. Another limitation of the research, as already mentioned more than once, is the small number of households sampled (10%), especially in the case of the Farms, where only five households were interviewed. An additional limitation was not considering the isolated dwellings as another case to be studied.

6.1.2 Production systems and income

The average overall monthly household income was R$9083.25 (EUR 2179.98) and the average per-capita income was R$2169.00 (EUR 520.56), which is similar to the national and North region per capita average income (IBGE 2018a, 2018b). The most

important sources of income were off-farm income and government support; additionally, extractivism (collection of NTFPs and fishery) had an essential significance for the communities and the settlement, while cattle ranching was significant for the farmers. None of the families reported having access to agricultural credit or subsidies.

Comparing the empirical results on production systems and income with previous findings it is possible to see common generalizations. Simmons et al. (2016) found that by far the most important income source was government transfers, representing 28% of the average annual income. Brondizio (2009) similarly realized that even in areas of active economy involving smallholder farmers - such as the açaí economy in the Amazon estuary - rural landowners relied heavily on retirement income and government aid, such as the *Bolsa família* program.

Off-farm income represented a substantial share for all households in the BR-319. Pichón (1997) also found similar results in a forest frontier area in the Ecuadorian Amazon where more educated households earned more off-farm income. Off-farm employment also provided the highest income in southern Pará, as reported by Simmons et al. (2016). Diversification of income to many off-farm activists in fact appears to be a tendency in frontier regions. Pichón (1997) also attests that in Ecuador households often sought to diversify income sources in the face of uncertainty and fragile resources. This is a way to spread risks, guarantee food security and provide resources for financing new investments.

Nevertheless, the BR-319 differs in an essential point from the findings of other studies. In Ecuador, 18% of the sampled farmers - mainly the better-educated households - had received credit, mostly for cattle and pasture expansion (Pichón 1996, 1997). On the Transamazon 56% of the families interviewed received credit at least once in their lives, while t less than 10% received credit each year (Brondizio et al. 2009). On the Manaus-Porto Velho road, agricultural credit was not mentioned at all.

Fearnside (1982) also stressed how financing had an important influence on land-use decisions and choices of seed varieties and crops in the region of the Transamazon. However, a survey of riverine producers in the Amazon estuary showed that more than 90% of the producers never received credit for land-use activities, although these producers represented the most critical production sector for açaí in the region (Brondizio 2009). Simmons et al. (2016) affirmed that, in Pará, 31% of the sampled households reported receiving credit for non-cattle activities, while 75% of the smallholders reported that they received government credit exclusively for investment in cattle. The lack of credit in the BR-319 region may be related with the fact that the Amazonas state was until recently closed to the internal beef-market, as discussed below.

Considering only the households that engaged in farming activities (23), communities were mostly engaged in forest utilization, temporary agriculture and perennial agriculture, which provided 24%, 20% and 51% of the total farm income, respectively. Communities had a more diverse production of temporary and perennial crops which are produced mainly in agroforestry systems. Also, all households were engaged in the collection of NTFPs, especially açaí and Brazil nuts. Nonetheless, Communities were more engaged in pure extractivism in primary public areas, chiefly within Protected Areas, and especially within the boundaries of FLONA Balata Tufari and RDS Igapo-açu. Communities also planned to engage in tourism activities in the future.

Whereas, in the settlement, families were mostly involved with perennial agriculture, forest utilization and temporary agriculture, which provided, respectively, 43%, 30% and 24% of the farm income. Farmers, in turn, were frequently involved with cattle ranching, forest utilization and perennial agriculture, which provided, respectively, 61%, 4% and 29% of the farm income. Concerning forest utilization, the participation of farmers was mainly related to NTPFs; nevertheless, it is important to note that their role was not exactly to collect the products in the forest but instead allowing others to collect in their property and receiving a share of the revenue, or acting as the middleman who receives and transports the product to the city. This pattern has resemblances to the relationship of brokers and clients depicted by Moran (1975).

All in all, farm income had low importance for the composition of colonists' income: only 18% for farmers, 7% for settlers and only 5% for residents of communities. Neither families living in communities nor in the settlement were raising cattle for economic purposes, even though 16% of the settlers intended to start this activity. Of the farms analyzed, the average number of livestock was 46, but only 4 of the five farms reported having cattle. Pichón (1997) found an average herd size of 12 animals in the Ecuadorian Amazon, while Carrero & Fearnside (2011) reported tremendous variation in herd size in Apuí, with the existence of some big herds of up to 1000 animals.

A low dependency on farm revenue also has resemblances with other frontier regions; and on the BR-319 this is possibly related to the difficulties of transporting production to market, since road conditions are still very harsh during the rainy season, making it unmanageable to bring perishable products to the city in time to get a good return. This reality is significantly harder for the colonists not living by the main road. In southeastern Pará, Simmons et al. (2016) similarly founded that agricultural production ranked only fourth as a source of income, providing less than 10% of the annual average income; however, this did not consider cattle ranching.

With respect to cattle ranching, Carrero & Fearnside (2011) provided an insight into the region of Apuí. They similarly found that, even though the majority of settlers had livestock, this did not represent a significant source of income for the families. In

Apuí 30,6% of the households that had livestock as their primary activity did not obtain any income from it. Carrero & Fearnside (2011) argue that this lack of profitability of livestock suggests a cycle of land speculation where the influx of capital for land purchases fuels the rise in land prices, creating a positive feedback between land speculation and deforestation, which drives the expansion of pasture. They emphasized that this speculative cycle justified what otherwise would be unjustifiable: the expansion of pasture despite poor returns.

Similarly, from Carrero & Fearnside (2011) there is evidence of scarce income been obtained from livestock. On the BR-319, income from cattle represented only 11% of the total income of the four families that alleged to be raising cattle for economic purposes (all of which were farmers). Moreover, 35% (17) of all households had pasture but only 8% (4) of them actually had livestock on it. Additionally, 28% of the households planned to expand the areas of pasture in the future and 36% planned to start raising cattle. There is evidence indicating a speculative nature of land acquisition and deforestation in the BR-319 as well.

It seems logical for smallholders in the Amazon to engage in cattle ranching since it is an activity that requires less labor when compared with temporary or even perennial crops, has a stable market, and often benefits from government subsidies. Herds are less vulnerable to annual variation in weather than are crops, and cattle are a highly liquid investment that allows sales to be delayed without incurring major losses. Herds also move by themselves regardless of the season, reducing transportation costs. Furthermore, they provide the added benefit of skin, manure and milk production for family consumption and, lastly, cattle ranching has traditionally been regarded as a prestigious activity in Brazilian society (Simmons et al. 2016; Kirby at al. 2006; Mertens et al. 2002; Andersen et al. 2002; Fearnside 1990).

However, the enthusiasm for pasture and cattle expansion could alternatively be a miscalculation of capacities. Fearnside (1982) found this risk-prone behavior among settlers in the region of the Transamazon highway, where many had chosen a land-use allocation that required much more capital than they had available. Many had planted pastures without having money for fences or animals, for example. Additionally, the meat processing capacity in the region of the BR-319 is small when compared to the southern regions of the Amazon; moreover, e access to credit and subsidies is not consolidated in the region.

Nonetheless, this scenario may well change, as was emphasized by Pereira and coworkers (2016), the market for meat has high potential for expansion in the Amazon region as a whole. The Brazilian company JBS, for example, which is currently the world's largest meat-processing corporation, is rapidly expanded its processing capacity in the Amazon. The beef and leather markets in Brazil are mainly dependent on exportation (Fearnside 2017), and the increase of beef exports has attractive pro-

spects for producers. Furthermore, Amazonas state was barred from international meat markets for many years due to the presence of the foot-and-mouth disease. This could explain the lack of financing and credit available for colonists in the region, which may also change with the opening of a new market. In 2017, this state was recognized as a disease-free zone, provided the cattle are vaccinated. The perspective is that by the year 2023 Amazonas will able to export its beef all over the world with no restrictions (MAPA 2017).

A limitation of this research is the inability to estimate the contribution of the timber sector for the overall economy of the region. The only contribution reported was through the income arriving from jobs such as lumberjack and wood sawyer or businesses as the sawmill, but only one household reported timber extraction inside its own lot, even though trucks transporting logs was a common scene in the region, especially close to Realidade, which had four sawmills operating in 2018.

With regard to access to technical assistance, only 21% (10) of the sampled households received any agricultural extension, but none of the farmers did. This is similar to the situation in Ecuador, where slightly less than one-third of sampled households had received agricultural assistance from the government, religious, or other organizations (Pichón 1996, 1997). Guanziroli et al. (2001 in Brondizio et al. 2009) showed that small producers, especially in the Brazilian Amazon, have minimal access to extension services and technology (only 5.7%). Brondizio et al. (2009) also blamed the lack of assistance and support to small producers to the depletion of the Technical Assistance and Rural Extension Company (EMATER) in Brazil after 1990.

6.1.3 Ownership, property size, lot accumulation and access

Seventy percent of the lots were established after 2000, 17% (8 lots) during the 2000s and 54% (26 lots) after 2010. Additionally, another 15% (7 lots) were established in the 1990s. On the Transamazon, Moran (1975) and Fearnside (1985) found the majority of lots established during the 1970s, while Carrero & Fearnside (2011) found an average residence in Apuí of 16 years.

Paralleling the empirical results of this research with previous findings, Fearnside (1982) also identified a tendency of the settlers to possess various lots on the Transamazon, and Carrero & Fearnside (2011) likewise in the region of Apuí, although with a much higher number of properties per household (varying mostly from 2 to 10 properties). Carrero & Fearnside indicated that this growing consolidation of land in larger and more capital-intensive properties suggested the potential displacement of small farmers to other frontiers and the continuation of deforestation in these areas. In Ecuador, the trend is different, since only about 16% of the sampled colonists had managed to claim or purchase additional plots (Pichón 1996).

The land ownership is composed of 18.75% (9) of the lots under private property, 29.17% (14) under common property and 52.08% (25) under an open-access regime. Nonetheless, four of five farmers claimed to have private properties. The findings on the land tenure are similar to those of Carrero & Fearnside (2011). In the Juma settlement only 17.6% of the landholders reported having a definitive land title, while the remaining landholders were under unclear tenure, most likely under an open-access regime. Carrero & Fearnside (2011) suggested that many properties in Apuí were untitled due to INCRA's limited capacity for regional oversight in inspecting and issuing land titles. They pointed out that Ludewigs et al. (2009) found 93.6% of settlement properties titled in Porto Acre (Acre), 53.2% in Santarém (Pará), and 69.9% in Altamira (Pará). In Ecuador, only over 92% of sampled households had acquired at least a provisional title and nearly half had a full legal claim to their land (Pichón 1996). Reasons for the low percentage of land titles on the BR-319 could also be related to the limited capacity for regional oversight of INCRA, as well as the limited capacities of the other environmental agencies such as Ibama, ICMBio and SEMA, to control uncontrolled migration. These institutions have been facing a gradual depletion of budgets and capability in the last years, as already emphasize in the Results (item 4.2). Moreover, the initiative of land distribution implemented by the Terra Legal program is very attractive to smallholders.

A remark needs to be made here; historically, INCRA was responsible for three central tasks: (i) land-tenure planning, (ii) agrarian reform and colonization policies and (iii) land regularization. However, in 2009 law n° 11.952 (Brasil 2009) took the allocation of public land and land regularization in public areas out of the control of INCRA, passing this function to the Terra Legal (TL) program (INCRA, personal communication, key-informant interview). Implemented by the Ministry of Agrarian Development (MDA) with the support of INCRA, the TL program was initially created to resolve land-tenure issues for small and medium landholders (~1500 ha). Supposedly, the beneficiaries would mainly be indigenous and traditional populations (MDA 2018; GIZ 2018; McIndewar 2016).The criterion of the program is to grant land to landholders who have peacefully occupied land before 2008, who claim areas smaller than 2500 hectares, do not own other lot properties, have effective agricultural crops and maintain compliance with the Forest Code, which requires in the Amazon biome 80% of the property to be in forest cover (Brasil 2009, law n° 11.952/2009).

The program emerged from the urgency of dealing with "land chaos" and the many demands for land regularization in the Amazon, but despite this intent, the program has been criticized for being dishonestly used to gain legal rights to public land, and for encouraging land grabbing (Brito & Barreto 2009a, 2009b). As the program is still recent (since 2009), assessment of its impact on long-term deforestation is limited; however, the Union Court of Accounts of Amazonas conducted an audit of TL in 2015 and found that 9% of the titles were granted to beneficiaries who did not meet

the requirements of the program, and another 39% showed signs of non-compliance with the requirements. Furthermore, there was evidence of non-compliance with the general established objectives, such as avoiding risks of land accumulation, land speculation and disorderly opening of the agricultural frontier. Additionally, the values of lots sold by the government are below market values, which encourages land speculation and further forest conversion (Brito & Barreto 2009a, 2009b). Lastly, in remote areas, laws such as the Forest Code are rarely enforced.

A limitation of thesis was not investigating the change of ownership of the properties over time, and the average turnover since first occupation.

In general, there is still no predominance of large holders (lots above 600 hectares) on the BR-319, where they represent only 10% of all households and the average lot size is 202.24 ha. However, communities have bigger lots (average 501.37 ha) followed by farmers (average 428 ha), while settlers have the smallest lots (average 101.67 ha). The size of properties in the BR-319 are bigger than those found by Pichón (1997) in the Ecuadorian Amazon, most of which were smaller than 60 ha (90%), but similar to the properties in Apuí, where the average total area possessed by the households was 345.5 ha, ranging between 25 and 4831 ha, considering the whole amount of properties owned by families (Carrero & Fearnside 2011). In southeastern Pará Simmons et al. (2016) found a property size ranging from 8 to 50 hectares, with a mean of 33 hectares. In general, the average area of family farms in the Amazon is 57 ha, while the average area of large farms is 1009 hectares (Guanziroli et al. 2001 in Brondizio et al. 2009). Moreover, Godar et al. (2012a, 2012b) found that in the region of the Transamazon highway largeholders owned around 3% of all properties but occupied more than one-third of the colonized area (2012). This is similar to the BR-319 where largeholders owned only 10% of all properties but occupied more than 55% of the surveyed area.

Fifty-eight percent of the settlers had their property at the edge of the highway. On average, lots were located 3.64 km from the BR-319. Transport of products to market is highly dependent on the BR-319, since all households use this highway to send agricultural production to the markets. In Ecuador, half of the sampled households lacked immediate access to the road (Pichón 1996). One limitation of this study was not to investigate the distance from sampled farms to the nearest market town.

6.1.4 Land use allocation and production systems

Colonists who live in communities had only a small fraction of their land allocated to other land-use types, with the highest amount allocated to secondary forest and agroforestry. Communities also had the largest areas of crops and no land assigned to

pasture. There is evidence that shifting cultivation[22], which alternates phases of crop production (swidden) and secondary forest regrowth (fallow), is the principal land-use system transforming the landscapes of the communities.

Shifting cultivation is the agricultural system usually seen in riverine areas of the Amazon, but, in general, this system has raised little concern regarding the land-use changes it triggers especially when compared to more drastic on-going processes such as the expansion of pasture or of agricultural production of commodities. Nevertheless, Jakovac et al. (2017) indicated that shifting cultivation in riverine Amazonia has gone through a process of agricultural intensification over the past three decades, resulting in a landscape predominantly covered by young secondary forests (up to 12 years old), with 20% of this area having gone through intensive use. In the long term, forest fragmentation triggered by the advent of the BR-319 road could maximize the impact of the agricultural intensification on forests.

Slash-and-burn is the most common practice in shifting cultivation in the Amazon. It is the first step (felling and burning the forest), but it is not necessarily followed by the traditionally sustainable cycle of fallowing and re-clearing that can provide a sustainable production system. Due to high costs of fertilizers, the shortage of labor, and the abundance of inexpensive forestland, several studies have argued that in the Amazon slash-and-burn is the most reasonable economical way for farmers to improve the fertility of the soils (Fearnside 1990; Nepstad 1999). Nevertheless, Fearnside 1990) emphasized that the fallow periods are hardly long enough to allow soils to recover fully, and the system is therefore not sustainable (e.g., da Silva-Forsberg & Fearnside 1997). Additionally, old fields are very often converted to pasture instead of been left for fallow, especially in settlement areas (e.g., Fearnside 1986). This can have a significant impact on deforestation (Kirby et al. 2006).

The impact of shifting cultivation on forest degradation and fragmentation in the region of the BR-319 was not addressed in this research. As of now it does not seem to be an emergent threat, but further studies to understand the dynamics of this system are recommended.

Settlers had the most significant fraction of their land altered from original forests, namely conversions to pasture and agroforestry. However, in the settlement the main production system was not so clear, since the area of cropland was small and no cattle had been raised in the pasture for economic purposes. This could be an indication of speculation as a driver of land acquisition and deforestation. This is corroborated by the fact that 4% of the settlers recognized a speculative intention in

[22] Shifting cultivation is characterized by a mosaic of swiddens (temporary cropping fields) and fallows (temporary secondary forests) that are dynamic through space and time and are mainly managed by slash and burn practices and specially focused on the production of flour (or *Farinha*, in Portuguese), the staple food in the Brazilian Amazonia (Jakovac et al. 2017).

their plans to acquire more land and sell it afterward. Furthermore, a process of land accumulation is apparent.

Establishing pastureland is a well-known strategy to secure land holdings in the Amazon (Fearnside 1990). As stressed by Fearnside (2017), both large and small actors invade land plots, clear the forest to assert the productive use of land and may ultimately gain official recognition of ownership with formal property titles. In the region of the BR-319 there is evidence that this process has been occurring, and special attention must be given to settlers and to the Terra Legal program.

In the farms, colonists had a much higher concentration of land in pastures than did the other groups. There was also more land in disturbed secondary forests in the farms. A smaller proportion was allocated to agroforestry. Farmers also intended to expand their areas of pasture. Many authors have noted a pervasive shift to cattle ranching in the Amazon. Simmons et al. (2016), Walker et al. (1998), Poccard-Chapuis et al. (2001), Pan & Carr (2010) and Vosti et al. (2003) credited this gradual transformation of crops and forestlands into planted pasture in small-scale farms to a widespread process of "*pecuarização*", or expansion of the cattle-ranching economy toward the Amazon's geographical limits. In the state of Amazonas this process is also known as "*Rondonização*", as a reference to the process already underway in the state of Rondônia. This process is one of the greatest menaces threating the forest in the region, as was stressed by many key informants.

Lastly, residents in the Communities planned to share their properties among kin or to sell their properties, but continue living in the region. Farmers planned to share their properties with their children. Pan & Car (2010) also recognized lot subdivision among kin or friends as a significant predictor of land-use change in Ecuador. Brondizio et al. (2009) similarly recognized a "secondary wave of deforestation" (p. 14) that occurred in the Ecuadorian Amazon during the 1990s to be associated with the subdivision of properties among family members.

6.2 Variables affecting colonist's land-use decision with consequent impact over deforestation

In the study area of this thesis two principal actors were responsible for the frontier expansion and deforestation: middle and large-scale cattle ranchers and small landholders living in Realidade. The highest average rate of deforestation was observed in farms, driven by land cover change towards pasture; however, it cannot be concluded that farmers were the only actors responsible for the deforestation in the BR-319. As seen in item 4.3, the total sum of deforestation by settlers, and again driven by the change towards pasture, is even higher than the total deforestation accumulated by farmers.

As discussed previously in items 5.1.1 and 6.1.4, there is evidence that the low return of cattle operations, in the case of farmers, and the lack of a clearly establish production system, in the case of settlers, could be related to the intention of asserting the productive use of land to qualify for official recognition of ownership. It seems that some colonists are less interested in raising cattle than in securing their land title.

This evidence reinforces the conclusion of many studies that have been dedicated to understanding the impacts of the shift from forests to pasture in the Amazon region. Particularly in the Brazilian Amazon, large-scale cattle ranching is considered to be the main proximate cause of deforestation (Fearnside 1993; Margulis 2003; Kirby at al. 2006), and all indications suggest that the cattle economy will continue its expansion and consequent encroachment on forests (Walker at al. 2009).

Many authors have indicated a strong correlation between commodity markets (in particular beef and soybeans), and deforestation (Fearnside 2001b; e.g., Morton et al. 2006; Barona et al. 2010; Laurance et al. 2001). Under Brazilian legislation, clearing land for pasture is considered an "effective use" of land and is a first step towards securing land ownership. Cleared land is also 5-10 times more valuable than forested land, and the cheapest and most efficient way of maintaining cleared land is by cattle grazing (Veiga at al. 2002; Fearnside 1990, 2007; Mertens et al. 2002; Verbug at al. 2014). Many authors have emphasized that the ubiquity of cattle operations with very low stocking densities in the Amazon suggests that maintaining land cleared is indeed a prime motivation for much of the cattle ranching that is underway in the region (Kirby at al. 2006; Carrero & Fearnside 2011). On the BR-319, as in other frontier regions, the process of pasture expansion poses one of the greatest menaces to forests.

Regression analysis indicated an overall statistically significant relationship between income and deforestation. However, farming activities were not the primary source of income for colonists on the BR-319; off-farm income is more important, mainly from jobs in the agricultural and forests sectors, jobs in other sectors, and business; government payments are also important(mainly retirement pensions).

A rise in income can have contradictory effects on deforestation. Increased wealth may reduce capital constraints, raising the capacity to clear the forest. Alternatively, rising wages and decreasing poverty may discourage forest clearing because clearing is a labor-intensive activity (Pfaff et al. 2007). Such theoretical ambiguity makes clear the value of empirical data. On the BR-319, the evidence suggests that colonists were receiving money mainly from retirement or from off-farm activities, and investing it in forest clearing. The income from jobs in the agricultural and forest sectors were especially significant for the settlers, and the demand for labor was generated chiefly by larger farms in the region and by the sawmills. Businesses in the village were also a significant contribution to income, as were retirement and collection

of NTPFs, remarkably Brazil nut, which provided a substantial complement to household income. For farmers, income arrived mainly from retirement, jobs in other sectors, and cattle ranching.

In Ecuador, Pichón (1997) identified a positive relationship between income level and percentage of the plot in pasture. A similar study of settler income and welfare (Murphy et al. 1997) has also demonstrated that lots with areas in pasture were significantly associated with higher-income colonists. Nevertheless, when the focus is exclusively on off-farm income, the results of Pichón (1997) showed that increases in off-farm employment tended to reduce the inclination to deforest. McCracken at al. (2002) also indicated a negative association between deforestation and having other off-farm activities, while Browder (2002) asserted that off-farm income had no effect on deforestation.

A limitation of this research is its inability to estimate the contribution of the timber sector to deforestation; as well as to provide more significant links between the independent variables and deforestation due to an overall low significance of the regression model tested, which serves more as an indicator of the dynamics of land-use allocation among the sampled households rather than as a proof of linear causation.

6.3 Institutional and political environment: challenges for the sustainable development of the region

The deforestation scenarios forecast for the area of the BR-319 highway send a clear message: the improvement of the road network will cause a drastic change in the land-cover of the region, considerably increasing deforestation (Santos et al. 2015, 2018; Barni 2009). Similarly, the majority of the key informants interviewed forecast a scenario where actions implemented by the Government will not be enough to cope with deforestation and other environmental impacts .

The opportunity to have in-depth expert-based assessments from institutions and people who have first-hand knowledge was crucial in providing insight into perspectives and challenges for the territory. The challenges informed by the key informants could be presented in five main sub-sets: political/institutional, territorial governance, environmental, socioeconomic and citizen participation. Combining these sets with the most-cited challenges (or codes), the evidence shows that the majority of the informants believed that the core challenge will be political and institutional and that an environment of lack of rule-of-law and with weak governance will be established. The informants remarked on citizen participation and on the institutional fragility of environmental agencies responsible for surveillance and management of the

Protected Areas (PAs). Each of these main challenges will be addressed in this section.

Governance and lack of rule-of-law

Governance is considered an essential tool for avoiding deforestation and for ensuring conservation (Soares-Filho et al. 2005; Umemiya et al. 2010; Verburg et al. 2012; Nepstad et al. 2002). However, Sundström (2006) stressed that the governance of tropical forests are still weak all over the world; and in Brazil, and specific in the Amazon, Kirby et al. (2006) argue that institutional mechanisms are not yet strong enough to counteract the drivers of deforestation. Additionally, many studies have indicated the positive relationship between corruption and deforestation (Wright et al. 2007; Koyuncu & Yilmaz 2009; Burgess et al. 2012; Ferreira 2004; Mendes & Porto Jr. 2012; Sundström 2006).

Governance could be basically understood as a government's ability to make and enforce rules and to deliver services (Fukuyama 2013). The concept of governance is commonly embedded in the assumption that the state should not be the single actor defining rules, and that dialogue among public entities, economic agents, and stakeholders is essential for the welfare of society as a whole (Dias et al. 2015).

Environmental governance, in turn, can be understood as the institutional framework of rules, institutions, processes, and behaviors that affect the way in which powers are exercised in the sphere of political relations related to the safeguarding natural resources (Gomides & Silva 2015). On the ground, environmental governance has been regarded as the presence or absence of institutions and mechanisms such as environmental councils, funds for the environment, availability of resources for the environmental sector, environmental licensing regulations, river-basin committees and other factors (Dias et al. 2015). In the Amazon region, recent analyses have shown that government regulatory policies can significantly contribute to the reduction of deforestation. The most important among them are the increase in command-and-control activities, embargoes and commitments to moratoria on commodity markets (such as soy and beef), enforcement of the Forest Code (the core legislation regulating land use and management on private properties), and the expansion and strengthening of PA networks (Fearnside 2017; Nolte et al. 2013, Assunção et al. 2012; Soares-Filho et al. 2010; Verburg et al 2012).

The demand for governance was an issue raised during several key-informant interviews, and it was also a recurrent topic in meetings and public consultations observed by the author. The stakeholders are simultaneously skeptical and aware that there are no successful examples of good environmental governance established along roads in the Brazilian Amazon.

The BR-364 in Rondônia is one of the examples of lack of governance. The road was paved in 1982 with financing from the World Bank (Fearnside 2007). The embarrassing consequence on the huge increase in deforestation led to the immediate creation of the Environment Department within the World Bank in 1987 (Holden 1987 in Fearnside 2007). A more recent example is the BR-163 highway, which connects Cuiabá to Santarém. Similar to the Manaus – Porto Velho road, the BR-163 was first built in the 1970s, but poor conditions impeded its trafficability until 2009, when the government started to pave and improve access (Fearnside & Graça 2006). Today almost the full length of the road is paved (DNIT 2017), and it is considered to be a vital export corridor for soybeans, connecting the high-productivity agricultural landscapes in Mato Grosso to the exporting harbors with access to the Amazon River (MAPA 2017; Hissa et al. 2018). The restoration of the BR-163 was accompanied by establishment of an APAL (Fearnside 2007) and a Sustainable Regional Development Plan for the highway's official area of influence (MMA 2018), however, these initiatives were not enough to counteract the environmental impacts and the increase of deforestation (Azevedo et al. 2017; Hissa et al. 2016), which accelerated expansion of the agricultural frontier from the state of Mato Grosso to Pará (Verburg et al. 2012).

It is difficult to believe that the BR-319 is going to be different from the others since these projects typify the current top-down planning process in the Amazon in which megaprojects are approved long before the environmental costs and risks are assessed (Laurance et al. 2001). Nevertheless, there were indeed remarkable initiatives on course along the BR-319, among them: the Ecological and Economic Zoning of the Madeira river (which provided the background and guidelines for establishment of the PAs created by the APAL), the APAL itself and the crucial PAs that were created in it; the initiative for drafting a Regional Sustainable Development Plan for the highway's official area of influence (unfortunately interrupted), and the "BR-319 Forum" (which aims to promote voice and accountability to the licensing process and to the overall scenario of the road reconstruction).

The EEZ of the Madeira river was conducted as part of the Pilot Program to Conserve the Brazilian Rainforests (also known as the "PPG7"). The program was launched in 1992 with financial support from the Governments of Germany, France, Japan, the United Kingdom, the United States and the European Commission, as well as from the Brazilian Government. It was the most significant multilateral initiative aiming to promote the conservation of Brazil´s rainforests and, after almost two decades of work and 428 million dollars, it left a legacy of 45,4 million hectares of indigenous lands demarcated, 2,1 million hectares of PAs established, and a significant increase of certified forest management across the legal Amazon (World Bank 2005; MMA 2009; Laurance et al. 2001). The PPG7 additionally focused on three crucial topics for safeguarding the long-term strategy of the Program: fostering the im-

plementation of a participatory approach to biodiversity conservation, strengthening the capacity of public institutions for environmental management and enhancing the participation of civil society organizations in policy dialogue (World Bank 2005). With the PPG7 the process of creation and consolidation of most of the PAs began in the southern portion of Amazonas state, which has been a barrier to deforestation in the region (personal communication, key-informant interview).

Furthermore, there was a promising initiative led by Amazonas State (with the support of the NGO Conservation International), to develop an integrated plan for the participatory management of the territory of the BR-319. This process started but was suddenly interrupted with the revocation of the governor's mandate in 2017. The following governor elected decided not to resume the initiative during his short mandate of only 15 months. A newly elected governor will take office in January 2019 and it is not clear how he intends to approach this topic; in his electoral proposal the only comment on the BR-319 was to "*Cooperate with the Federal Government for the complete recovery of BR-319, assisting in prevention measures in environment and land regularization matters, as well as the implementation of an integrated control and monitoring system*" (TSE 2018, p. 12).

The BR-319 Forum is, additionally, an emblematical example of enhancing the participation in policy dialogue. Initially established to monitor the licensing process, it ended up filling the gap created by the demand for participation of both civil society and governmental entities. The Forum has as a crucial role in overcoming impediments to communication among government bodies and, therefore, in helping the government to be more effective. The Forum is equally important in making the licensing process more transparent and accountable, in including the local level of administration in the discussion (in other words, the mayors and councilors who are repeatedly excluded from political decisions at the regional level), in providing a space for citizen participation, in pressuring the government to fulfill its responsibility for enforcing rules, and to deliver services. However, the BR-319 Forum initiative is not enough: it is temporary and will probably end soon after the licensing process (and the paving) is finished, as well it was not triggered by the central government. So to say, it is not part of the official government strategy for the development of the region; on the contrary, the Forum was established as a way for the Federal Public Prosecutor (MPF) to oversee the governance of the BR-319. But can it really oblige the government to assume the governance over this territory?

Maintenance of Protected areas

As just mentioned, the expansion and strengthening of the PA network is a government strategy that can significantly contribute to reducing deforestation. In fact, establishment of PAs has been one of the most effective strategies against deforestation in the Amazon (Verissímo et al. 2012; Arima et al. 2007; Soares-Filho et al. 2010; Nolte et al. 2013). Specifically, PAs near roads have been shown to have approxi-

mately 11% lower deforestation rates than unprotected areas near roads (Barber et al. 2014).

This is precisely the reason why the federal and the state governments joined efforts for the establishment of the APAL BR-319 in January 2006, which resulted in the creation of eleven (11) PAs (WWF 2008; 2009; ICMBIO 2009). Together with the already existing PAs now there is a total 25 PAs in the BR-319 area, and these PAs represent the most relevant strategy adopted by the government to counteract the negative impacts of the reconstruction of the highway.

The impact of PAs was particularly visible during the estimation of the number of dwellings in the study area, which was already mentioned in chapter 3 and is explained in detail in the Appendix. The number of dwellings on the edges of the road was obviously much greater in the stretches of the road passing through unprotected land adjacent to the protected areas. There is no doubt about the importance of this mechanism for halting deforestation; nevertheless, many informants expressed their concerns about the pressures and challenges menacing the consolidation and adequate protection of the PAs on the BR-319.

Carlos & Meirelles conducted a study in 2018 analyzing the status of implementation of the PAs in the vicinity of the BR-319. They compared their results with a previous study conducted in 2013 by the Union Court of Accounts of Amazonas. They evaluated 14 indicators in 11 protected areas, both under State and Federal administration. The indicators assessed the existence of management plans and co-management councils, staff, financial resources, structure, surveillance capacity, development of research, biodiversity monitoring, public use, existence of a forest concession, territorial consolidation and others. The study concluded that there was a 50% increment in the performance of the PAs indicating a considerable advance in the management practices in the last five years. However, Carlos & Meirelles (2018) emphasized that the PAs have performance levels that are still only half the level of the best evaluation possible, and some of them scored poorly in 2012. It is important to highlight that four of the PAs evaluated were created in 2009, shortly before the first evaluation in 2012, which may justify their low initial scores.

Furthermore, two of the indicators showed a general decline in all PAs: structure and territorial consolidation. These two indicators are not trivial because the structure is essential to uphold the surveillance activities, and territorial consolidation is crucial for the long-term capacity of the PAs to cope with the pressure of frontier settlement. Moreover, there were three indicators with very low average levels: public use, forest concession, and financial resources. All of these are important for the long-term financial sustainability of PAs.

The Amazon Protected Areas Program (known as ARPA) has a fundamental role for the long-term sustainability of the PA on the BR-319 region, as well in other areas of the Amazon. The Program was initially structured with donations from external agencies – namely the Global Environmental Facility (GEF), the German government and WWF (with a technical partnership with GIZ) - with the goal of protecting Amazon biodiversity and, through the creation of a network of PAs, resisting the ever-increasing deforestation threats (WWF & Funbio 2017). ARPA supports 41 PAs in Amazonas state, both under state and federal administration (ARPA 2017), and on the BR-319 ARPA supports 18 PAs, 13 at the state level and 6 at the federal level. Four of the PAs under state administration and six at the federal level overlap the study area of this thesis.

At the State level, ARPA is the primary source of financial support for the PAs, thus enabling much of the biodiversity monitoring, structure expansion and maintenance, acquisition of goods (such as vehicles and fuel), and all costs involving the decentralized and participatory activities involving the local population. Without ARPA, Amazonas state would hardly be able to ensure the financial viability of these PAs. ARPA not only has impacts on financial aspects, it also influences deforestation rates. PAs supported by the Program have deforestation rates about 2.3 times lower than similar PAs that are not part of the program; similarly, ARPA-supported PAs had a 17% increase in management effectiveness as compared to those not supported by the program (WWF & Funbio 2017).

Nevertheless, ARPA is in its third and last phase, with its end forecast for 2038. One of its withdrawal strategies is a Transitional Fund (FT). In 2014, public and private donors pledged financial resources of approximately 215 million dollars to ensure, over the next 25 years, the permanent maintenance of PAs supported by ARPA. The goal is that, over the next 25 years, the Brazilian government will steadily increase its contributions until it is responsible for the full and permanent funding of the PAs now sponsored by ARPA. This initiative is also called "ARPA for life", and it pools the efforts of WWF, the Linden Trust for Conservation, the Gordon and Betty Moore Foundation, the Brazilian Ministry of Environment and ICMBio (WWF 2014).

The political scenario for PAs in Brazil is, nonetheless, unsure. Since 2009 Brazil has seen an increase in PA downgrading, downsizing, and degazettement (PADDD) (Bernard et al. 2014). The frequency and extension of PADDD events point to a shift in the government's attitude, towards its national PAs system, especially the federal administration. Bernard et al. (2014) stressed that not all of the PADDD events tracked by the study were necessarily bad from a conservation perspective, but also none of them were based on technical studies or involved any consultation with civil society. On the contrary, legislative chambers have been sensitive to political lobbying from the agribusiness, construction, and energy sectors.

On the other side, the group of congressional representatives that embody the agribusiness lobby (known as "ruralists") only reelected 51% of its candidates in the 2018 election (Bassi 2018). However, they lost importance to another voting block (known as the "Bullet block"), which defends a more radical position towards public security including broad access of the population to firearms. This group is represented by the political party of the recently elected president Jair Bolsonaro. Bolsonaro pledges unparalleled changes[23] in the legal framework for environmental protection in Brazil. A recent economic modeling study (Soterroni et al. 2018) estimates that Brazilian deforestation and carbon emissions under Bolsonaro's policies would cause unprecedented Amazon forest loss. Soterroni and coworkers forecasted an increase of 268% in the average annual loss of primary forest in the Amazon by 2030 when compared with the loss in 2017. This represents 25,600 km^2 per year, a figure similar to the deforestation rates measured at the beginning of the 2000s when deforestation in the Brazilian Amazon was at its peak. As stated, the political scenario for PAs in Brazil is definitely unsure.

Institutional fragility of environmental agencies

Key informants stressed that the environmental agencies responsible for surveillance, licensing, management of protected areas and other functions - such as Ibama and ICMBio at the federal level and SEMA at the state level - have been suffering from budgetary constraints in the last years.

This is especially true after 2010 and 2015. At the federal level, the establishment of federal law n° 140/2011 (Brazil 2011) had a significant impact on Ibama. The objective of the law was to decentralize the licensing processes, sharing competence among federal entities and establishing norms for cooperation between the union, the states and the municipalities (counties), but the consequence was a restriction of Ibama's power of surveillance without an adequate replacement of the agency's attributions by states or municipalities, which have neither the capability nor the infrastructure for this task (personal communication, key-informant interviews). Additionally, both Ibama and ICMBio, as well as FUNAI and INCRA, suffer a shortage of staff due to a lack of public tenders and, more importantly, a high rate of employee evasion. One of the key informants argued that it is difficult to maintain staff in remote areas in the Amazon and it is even more difficult without incentives - such as home loans or additional money for living in remote or frontier zones. In 2011, field institutions like those mentioned above saw a reduction by almost half of their budgets for field activities, blocking concrete actions for surveillance or community engagement (Brazil 2011, Decree n° 7.446/2011 later substituted by Decree n° 7.689/2012).

[23], for example, to shut down Brazil's environmental ministry, open indigenous reserves to mining, ban international environmental NGOs like Greenpeace and WWF from the country, relax environmental law enforcement and licensing, and back out of the Paris climate agreement.

At the State level, an administrative reform conducted in 2015 by the former governor who did not finish his mandate, abolished the Secretariat of Science and Technology and reduced the budgets and staff of the state environmental agencies (Farias 2015). The reductions targeted mainly the Secretariat of Environment and Sustainable Development of Amazonas, which was renamed as the Secretariat of Environment (SEMA). The primary objective of the reform, as stated by the Government at the time, was to rationalize expenditures and improve efficiency and effectiveness of public management (Ficha Verde 2015). One of the examples representing the setback of the reform for the state environmental sector is the lack of staff: of the six state PAs created in the APAL in the official area of influence of the BR-319, only two still have a designated manager in 2018.

The financial sustainability of PAs is a cornerstone of safeguarding natural resources on the long term, and the scenario with weak environmental institutions leads to a lack of environmental law enforcement and surveillance, which, in turn, contribute to high pressure on natural resources, uncontrolled expansion of spontaneous settlements and cattle ranching and other illegal activities, such as unauthorized logging and gold mining.

Citizen participation

The last topic to be addressed is citizen participation. Citizen participation is comprehended as opportunities to redistribute power, enabling citizens to deliberately decide their future (Arnstein 1969). Arnstein (1969) emphasized the critical difference between going through an empty ritual of participation and having the real power needed to affect the decisions.

Arnstein (1969) saw participation as a gradation of power distribution, which could be understood as divided into eight levels, like the steps of a ladder. At the lowest levels are (1) Manipulation and (2) Therapy; these two steps describe levels of "non-participation" where the real objective is not to enable people to participate but rather to enable powerholders to "educate" or "inform" the participants. Steps (3) Informing and (4) Consultation progress in "symbolic" participation, allowing civil society to hear and to have a voice, but not power to decide. In step (5) People are allowed to advise, but the final verdict remains with the government. Further up the ladder are levels of citizen power, with increasing degrees of decision-making: (6) Partnership, (7) Delegated Power and (8) Citizen Control. In Partnership, there is negotiation with the traditional power holders, and on the topmost rungs, (7) Delegated Power and (8) Citizen Control, with citizens obtaining the majority of decision-making seats or full managerial power.

In the case of the BR-319, the many public hearings conducted for the establishment of the EEZ, or for the PAs created in the APAL, or for the establishment of the management plans of these PAs and even the “BR-319 Forum” could be classified as a

type (4) Consultation. As emphasize by Arnstein (1969), informing can be a legitimate step toward full participation, but if consulting is not combined with other modes of participation that assure that citizen concerns and ideas will be taken into account, the process turns into a solemn ritual. Many key informants criticized the public hearings, affirming that they were rituals, even nice ones, but that he final power to decide remained inside the government.

The other tools of participatory co-management of PAs mentioned, such as the co-management council and the ongoing consultation with Indigenous People could figure as a more advanced form of participation: (6) Partnership. In a Partnership, power is redistributed through negotiation between citizens and powerholders who agree to share planning and decision-making responsibilities. Nevertheless, Partnership is still not the uppermost level of power delegation. In the case of indigenous peoples, although consultation does not necessarily mean that the decision requires their acceptance, the lack of consultation is in direct violation of the Indigenous and Tribal Peoples Convention (ILO-Convention 169 of 1989), which Brazil ratified.

Kirby at al. (2006) emphasized that engagement of local peoples should be a priority for conservation-oriented activities. This is particularly true for indigenous peoples, whose lands cover 22.5% of the Amazonian biome (Veríssimo et al. 2002; Ferreira 2001).

The other forms of civil involvement mentioned, such as the use social networks and the "caravans" that many politicians had undertaken, fit into the lowest level of participation: Manipulation, where citizen are educated, persuaded, and advised -- not the reverse.

Participatory processes have been undertaken on the BR-319. Proof of this is the holding of numerous public hearings and consultations. However, it is common for these events to be limited to identifying the demands of certain groups that are represented in these spaces of dialogue, but without a proper follow-up of demands. Participation without redistribution of power is an empty and frustrating process; it allows the powerholders to claim that all sides were considered, but without really delegating power (Arnstein 1969). To overcome this limitation, the establishment of pacts for the common good are required. Also recognized is the need for strong institutions capable of reducing the uncertainties that permeate the interactions between the different actors. This is necessary in order to enforce the agreed rules in each process.

7 Conclusion

The majority of deforestation in the Brazilian Amazon occurs in the proximity of official roads, and it is still mostly concentrated in the so-called "arc of deforestation", which is the expanding agricultural frontier from the center-west of the country towards the fringes of the Amazon Biome. The recovery and paving of the BR-319 are expected to facilitate migration from the southern parts of the Amazon to new frontiers farther north, increasing deforestation and causing a drastic change in the land cover of the region. Additionally, different from other roads, the Manaus – Porto Velho road will give access to the central region of the Amazon, opening a large block of forests that has remained almost entirely intact until now.

Many studies have been published about the colonization of the Brazilian Amazon frontier, especially in Pará in the area surrounding the Transamazon highway. However, as a new frontier, there is not much information available about the process shaping frontier development in the BR-319 region. Before the fieldwork for this study, almost no information was available about the population living along the road, and even less about the fast-growing village Realidade, one of the most important hotspots of deforestation in Amazonas State. This thesis attempted to fill this gap of lack of information about the colonists on the BR-319, and, since it would exceed the possibility of this master's study to interview a large sample of the population, the strategy of using a case study was adopted. The prior development of a theoretical framework - based on previously established theories and academic findings - allowed the identification of variables and indicators for analysis and comparison, which, in turn, allowed analytical generalizations to be made that provide a good representation of reality and to partially overcome the limitations imposed by a small sampling survey.

In this manner, the current master's thesis relied on case study research to investigate the actor groups shaping frontier development in the region. Additionally, it examined the relationship between these actor groups and the institutional context by which they are surrounded. The thesis contributes a descriptive characterization of the actor groups (the colonists) and provides an exploratory insight into the actor-specific deforestation outcomes and the institutional and policy challenges. The extreme heterogeneity and complexity of the Amazon and the speed at which the region is being occupied demand fast and location-specific solutions. Understanding the actor groups, their drivers and the institutional context is the first step to delineating further research questions and investigations as more appropriate environmental policies.

Concerning the (1) first research objective, three contexts or cases were considered in the study: communities, farms, and a settlement. An extensive overview about them has been presented in the Discussion, but an overview of the final outcomes

indicates that, comparing the three cases, communities have the smallest fraction of their land cover altered; they also have the most significant areas of crops (both temporary and perennial) of the three cases, and they have a more diverse and intertwined mosaic of forested landscapes. There is evidence that shifting cultivation is the principal land-use system transforming landscapes in the communities. In the case of farms, there is a more dual and homogeneous use of land, with the highest concentration of land in pasture. Consequently, farmers have the highest average rate of deforestation. In the case of the settlement, settlers also have a significant fraction of the land altered from original forests. Nevertheless, the central land-use system is not clear, since the areas of croplands are small and no cattle have been raised in the pasture for economic purposes. Despite the average deforestation rates of the settlers being smaller than those of the farmers, the total sum of deforestation achieved by the settlers is even more significant.

A limitation of this research was the inability to estimate the exact contribution of the timber sector for the overall economy of the region, as well for the deforestation dynamic. Another limitation is the always more diverse behavior of settlers; it is not clear if this is a consequence of a truly more diverse population, as it seems, or of a higher absolute number of households sampled. Additional limitations of the research were not considering the isolated dwellings as another case to be studied, and not investigating the changes of ownership of the properties since first occupation.

With regard to the (2) second research objective, about the factors predominantly influencing colonists' deforestation, an overview of the final outcomes indicates that for all the three cases the drive for pasture is undoubtedly the principal proximate cause of deforestation. The shift from forests to pasture in the Amazon region is a phenomenon that has been widely identified, and pasture expansion on the BR-319 is the greatest menace to the forests. There is evidence that the low return of cattle operations, in the case of farmers, and the lack of a clear establish production system, in the case of settlers, could be related to their intention to assert that they are making productive use of the land, thus facilitating official recognition of their ownership. Furthermore, investigation of the relationship among variables indicates a significant correlation between deforestation and income, indicating that colonists are receiving money, mainly from government payments and off-farm sources and investing in deforestation. A limitation of this research is the inability to provide more significant links between the independent variables and deforestation because of an overall low significance of the regression model tested based on the small sample size.

Many researchers have already identified the urgency of adequate legislation to control deforestation in a way that is appropriate to the Amazonian reality. This will require an end to considering clearing land to be an "effective use" and a prerequisite

for land ownership. Recommendations about how to change this rush to convert forests to agricultural and ranching uses are related to broader structural and policy changes. Specifically in the BR-319 region, nine main recommendation can be delineated:

1. The primary step would be for INCRA and Terra Legal, with the support of ICMBio and SEMA, to develop and implement a plan for land management and regularization. Terra Legal has a vital role in this process, but oversight should be re-enforced to avoid non-compliance with the program's requirements.

2. Further investigation is needed to understand the impact of this program in the region, even though the focus of this thesis was not to access Terra Legal, it is clear that land grabbing is happening, as well as speculative land purchases.

3. Undoubtedly, there is an urgent need for INCRA to improve governance inside the settlements. It can be seen that many of the rural settlement projects created by INCRA have, over time, undergone a process of decharacterization of the original proposal, usually leading to deforestation and land-tenure concentration.

4. It was identified that, even though residents of communities are the ones who have lived longest in the region, many of them do not have their land ownership recognized. There is evidence that some of them have abandoned old lots to occupying new areas without much control or oversight. Resolving land-tenure issues, especially inside PAs, should be a priority for the government.

5. Farmers have the majority of land under private property, which could mean that they are more stable and interested in the long-term use of resources. For them, information and enforcement of the Forest Code are mandatory. It is urgent to continue with the process of implementing and enforcing this law in the region. The Forest Code is an instrument that could allow the reconciliation between agricultural production and conservation, promoting progress and competitiveness of Brazilian agribusiness as well as bringing legal security for the rural producers and companies along the value chains. The CAR (Rural Environmental Cadaster) is a prerequisite for implementation of the Forest Code, and its implementation is the task of the day.

6. The process of opening the state of Amazonas for exporting beef should be followed by strict control of deforestation, hand-in-hand with the implementa-

tion of the CAR and the Forest Code and with special attention to supply-chain monitoring and industry agreements restricting purchases from properties with illegal deforestation (or from areas cleared after a specified deadline).

7. To avoid the shift of forests towards big-scale ranches is emergent to support the livelihood of smallholders in family farming systems. Location-specific pro-smallholder policies could help increase income while lowering deforestation, and in the BR-319 area these policies should be focused on three priority issues:

    a. The collection of NTFPs in primary forests on public land, both by communities and settlers, occurs without monitoring of where the collection is done, how many families are involved, or how significant this activity is to the families. The establishment of a participatory diagnostic survey and planning process is recommended in order to promote better management and use of the resources and avoid over-exploitation while maximizing benefits. Some NTFPs, especially Brazil nut, do play an important role in rural-livelihood strategies and can contribute to the conservation of forests. Therefore, additional actions to strengthen NFTP value chains would be beneficial. The village Realidade, specifically, is one of the most important regions for Brazil nut production in the southern portion of the state of Amazonas, and more attention should be given to this value chain.

    b. Residents of the communities Igapo-açu and Nova Geração have interest in investing in tourism, but they are mostly unaware of the costs and difficulties associated with the rapid development of tourism activities. Focus on the establishment of community-based tourism is recommended in order to deliver benefits for the families as well as fostering community-based conservation initiatives.

    c. Communities and settlers are engaged in agricultural production, and they may benefit from the paving of the road and access to new consumer markets, such as Manaus. However, to compete with the already established agricultural sector of Rondônia, technical assistance and extension services targeting these populations are necessary.

    d. Overall, the advance of agricultural and extractive activities in the central region of the state will demand greater attention from the government, both for technical assistance and for control and inspection.

8. Lastly, the impact of shifting cultivation on forest degradation and fragmentation was not addressed by this research, but further studies to understand these dynamics in the region are recommended. Further investigation is also needed to understand the differences in deforestation related to soil and to general environmental conditions among the colonists.

Comparing the findings of this research with previous studies – and here using the theoretical framework presented in chapter 2 as a reference – the colonists on the BR-319 show resemblance with other frontier areas: there is a tendency for the consolidation of young families, with high numbers of men and low levels of education, but with previous background experience with agriculture. Additionally, the average household size is also similar to that reported in other frontier areas, as well as the periods of residence in other areas away from their birthplaces previous the final migration. The existence of a network that transmits information about available land, thus attracting people and stimulating migration, was also observed in other regions. Having government transfers and off-farm income as primary sources of income is also comparable to other frontiers. The diversification of income to many off-farm activities appears to be a tendency in frontier regions. Also typical is a small dependency on farm revenue, low percentage of households receiving technical assistance or extension services and the tendency for land accumulation. A summary of these findings is presented visually in Figure 30.

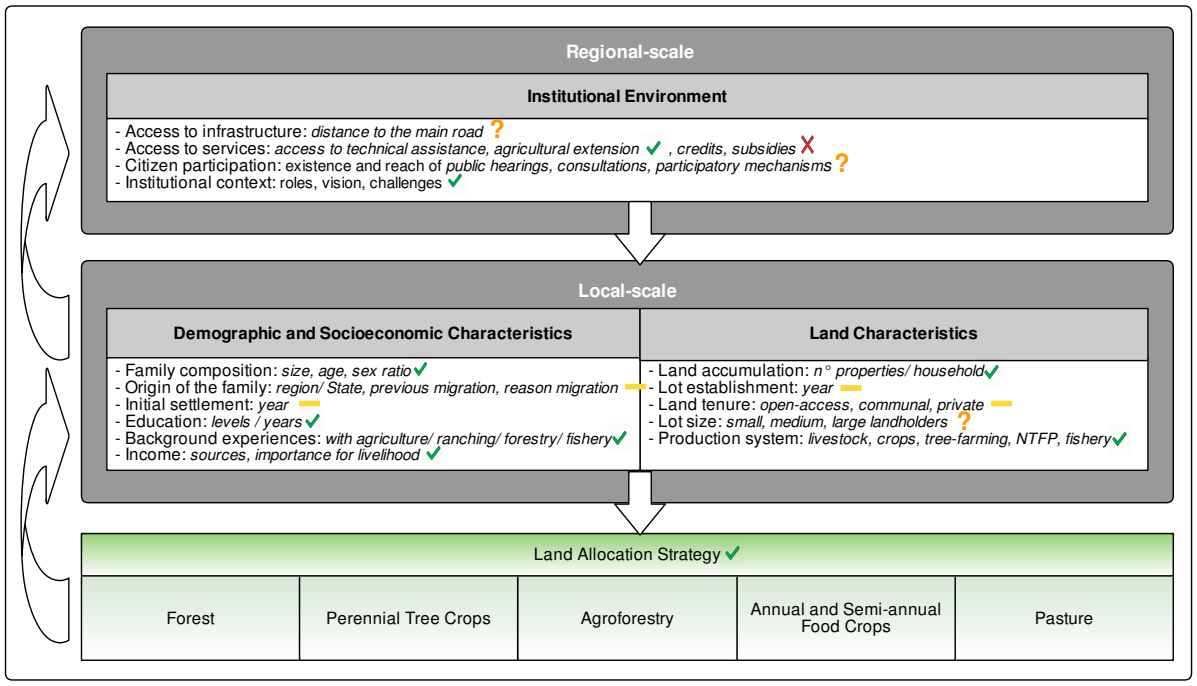

Figure 30 - Conclusion theoretical framework. The red X indicates no correlation between the empirical findings of this research with variables identified by previous studies, while the green check mark indicates similar results, the yellow dash indicates correlation specifically with the region of Apuí and the orange question mark indicates inconclusive assumptions. Source: author, 2018.

Like other frontier regions, there is evidence indicating a speculative nature of land acquisition and deforestation, driven by pasture establishment; also similar to other areas, shifting cultivation is the principal land-use system transforming landscapes of communities. Concerning land-use change, cattle ranching and small-scale farming have historically played the most significant role in the clearing of Amazonian forest, and this is also the case on the BR-319. Additionally, weak governance and the chaos in land regularization seen in the institutional context are common features of Amazon frontiers.

Lastly, the study confirms the proposition of other researchers that colonists usually have some similarities and that they are influenced by different sets of variables, both exogenous and endogenous, which affect their land-use strategies. Nevertheless, the origins of colonists, as well as the initial settlement and tenure regimes, found in the present study have some dissimilarities with older frontier regions. However, these features of the BR-319 resemble results from the region of Apuí, in the southern portion of Amazonas state. There is an indication that in the new frontier zone on the BR-319 the colonists are no longer arriving from the Northeast region of Brazil, but rather from internal fluxes within the North region. Nevertheless, the flow of migrants from the South continues. These findings are also corroborated by the colonists' migration trajectories, which show a characteristic pattern of migration to the north from prior expansion frontiers. Some results could not be compared: the lack of access to credit is unique to this region; comparisons of access to infrastructure and the size of properties were also inconclusive. Lastly, the positive relationship between deforestation and welfare is analogous to other frontier regions. However when the focus is placed exclusively on the participation of off-farm income, the results of this thesis could not be generalized.

A critical review of the case study method needs to be done. On one hand, experience has shown that case studies allow context-specific and holistic analyses; they are flexible, thus allowing introduction of new and unexpected results; the multiple sources of evidence contribute richness and a multi-faceted perspective. On the other hand, to collect and analyze different sources of evidence poses time and resource constraints, and these studies require an integration that is challenging, especially in a master's thesis; additionally, there is a lack of prescribed mechanisms for performing the coding of qualitative data. This thesis had a problem-oriented focus and aimed to provide knowledge and inputs to help counteract the challenges of frontier development in the region of the BR-319. The final statement is that the case-study method excels in providing complex and in-depth analysis but, in the end, it may be too demanding to embrace such complex and wide-ranging topic for a master's thesis. The final outcome is that the current thesis was not able to explain completely all of the topics it embraced, but rather it gives an exploratory overview

of a broad context, and it would be more significant if complemented by a more thorough survey.

The last topic to be addressed comprises the last research objective, concerning (3) the potential challenges for the sustainable development of the territory.

Weak Governance and lack of rule-of-law were identified as the primary challenges, and thus represent underlying driving forces of deforestation in the region. The need for governance is obvious. The question, however, is how this would be achieved in practice. It appears highly improbable that the expectations of development alongside conservation will be achieved if no change in governance happens. Available institutional mechanisms are not yet strong enough to counteract the drivers of deforestation. Unfortunately, the recent history of the BR-319 adds to the recurrent history of deficiencies in Brazil's environmental-licensing system, where environmental-impact assessment and licensing procedures are subject to pressure from those interested in speeding the construction of infrastructure. The central role of infrastructure in driving deforestation in Brazil makes understanding and improving the decision-making process for major infrastructure projects a matter of primary interest for environmental management.

It is crucial to strengthen successful mechanisms, such the Environmental Economic Zoning, the APAL, and the BR-319 Forum, and to continue formulating the Regional Sustainable Development Plan for the highway's official area of influence (which was unfortunately interrupted). The BR-319 Forum has a tremendous role in overseeing law enforcement, and the Federal Public Prosecutor (MPF) must be strengthened, not only by the government, but also by a supporting network of partners in civil society and academia.

This research did not evaluate the performance of governance, but instead relied on the opinions of informants who have in-depth knowledge or power in the decision-making process. More in-depth studies are needed to address governance performance, as well its implementation.

The expansion and strengthening of the network of PAs is the most significant government strategy contributing to containing deforestation on the BR-319. However, the PAs on the BR-319 are under pressure and are understaffed. They should be priorities for ARPA and other initiatives and should receive special attention in the "Arpa for life" transition project. New PAs should also be created, especially in the area were planned roads are forecasted. Coordinated interinstitutional actions Involving IBAMA, ICMBio, SEMA, IPAAM, INCRA and FUNAI should be established for the protection and surveillance of the area. These institutions also need to be strengthened in order to face the numerous illegal operations and pressures on natural resources that are affected by the BR-319.

The most successful initiatives on the BR-319 involve civil society, NGOs and bilateral cooperation. These stakeholders have played a critical role with funding and technical advice, as well as with monitoring and watchdogging. Especially when the political scenario is as uncertain as it is now, initiatives that strengthen the capacity of public institutions for environmental management and that enhance the participation of civil-society organizations in policy dialogue are fundamental. The influence of multilateral cooperation to steer development policies that protect the Brazilian Amazon are more welcomed than ever. Equally important is the social aspect of development; formulation and implementation of strategic programs for the social and economic development of the region should look beyond the pavement of the highway.

8 References

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9 Appendix

9.1 Chronology of the construction of the BR-319

The history of the BR-319 spans more than three decades. . For better clarity, the history of the road is divided into three main stages: the construction between 1970 and 1990, the abandonment between 1990 and 2010; and the period of acceleration of conflict after 2010. The same chronology is also summarized in Figure 31 which follows, with the main points and remarks shown both for the BR-319 (in green) and for the national background context (in black).

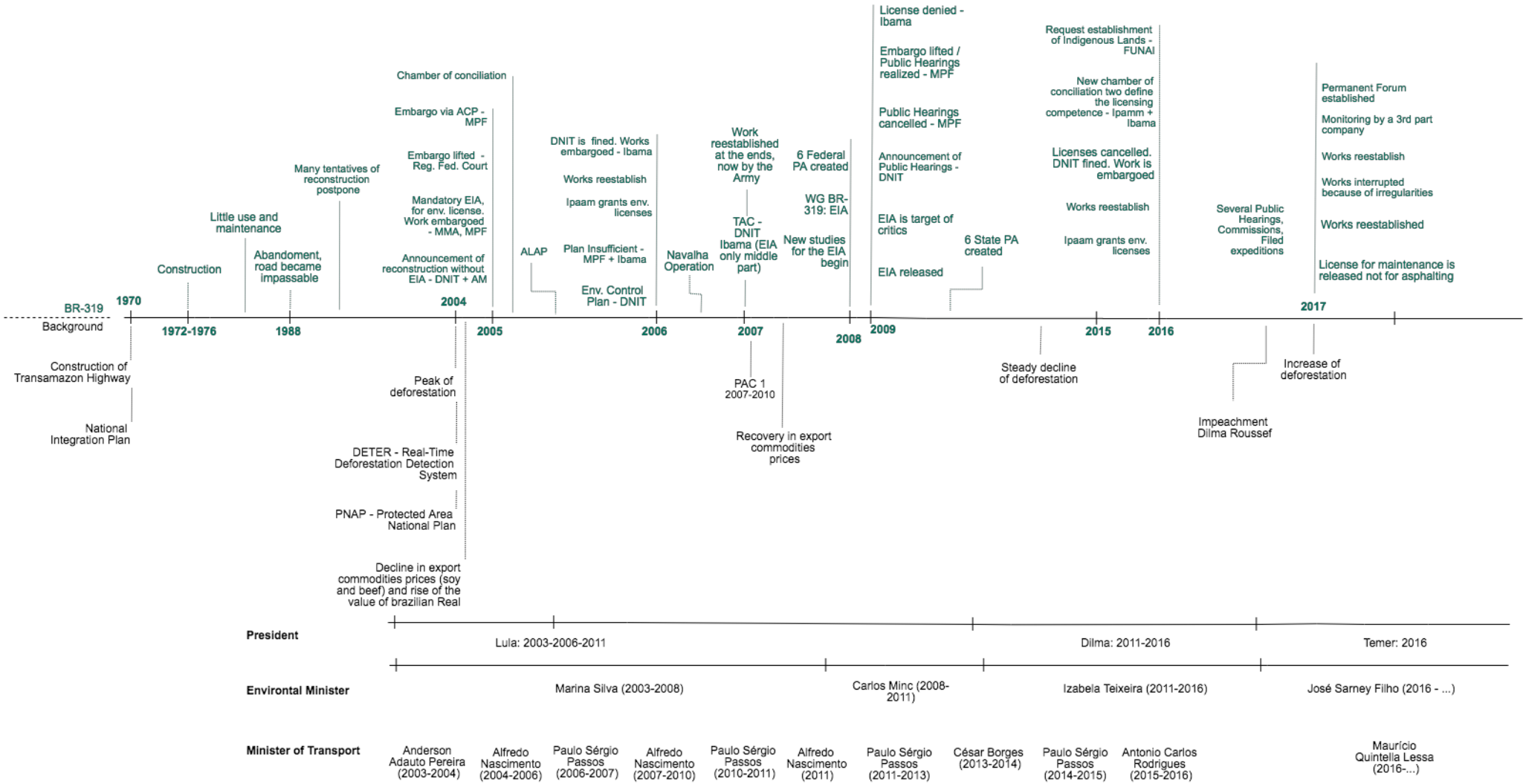


Figure 31 - Chronology of the BR-319, from 1970 until today (in green) and in the national background context (in black). Author, 2018

9.1.1 1970-1990: the construction of the road

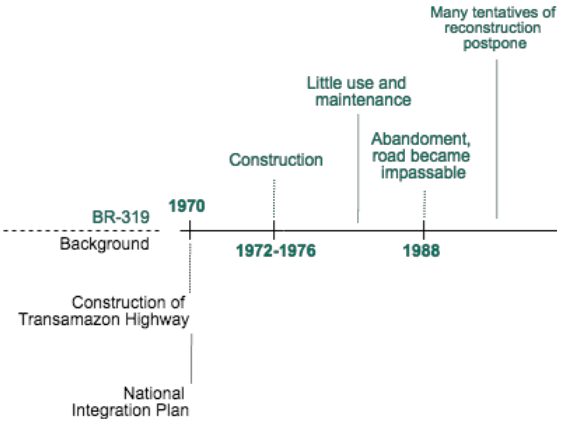


Figure 32: Chronology of the BR-319, from 1970 until 1990 (in green) and in the national background context (in black). Author, 2018.

In the 1970's and 1980's, the military regime in Brazil launched the Plan of National Integration (PIN), an ambitious infrastructure plan that aimed to promote the economic and territorial development of the Amazon region (Nogueira & Neto 2016). This policy invested in the opening of highways such as the Transamazon (BR-230), Santarém-Cuiabá (BR-163), Porto Velho-Manaus (BR-319), Manaus-Boa Vista (BR-174) and the BR-364, which connects Acre to other states. Large hydroelectric were also built, such as Tucuruí, in Pará, and Balbina, in Amazonas. Incentives for colonization through settlement programs were designed to open a "land without people" to a "people without land" (Simmons et al. 2016) with little in the way of impediments to the deforestation of large areas.

Formally, construction of the BR-319 began on June 15th, 1968 (Neto 2014). The connection was planned to facilitate the trade and transport of products from factories in the Manaus Free Trade Zone to São Paulo and other parts of the south of the country (Fearnside & Graça 2005; Neto 2015). The project received numerous criticisms and was a target of divergences about its feasibility since the early beginning. On the one hand, the highlighted benefits included an end of the isolation, which had a significant appeal for the local population, the outflow of the industrial products from the Manaus Free Trade Zone and the need for economic growth. However, such arguments were confronted by the fact of an already existing waterway on the Madeira river, the high maintenance costs of the road and the potential for intensified migration that would consequently increase deforestation (Fearnside & Graça 2009).

Despite the criticisms, the road was inaugurated in 1976. Due to the precarious or even non-existent maintenance, the severe environmental conditions of the area (where rainfall averages up to 2200 mm annually), the low economic importance (since industrial production from Manaus was more cheaply sent to markets in

south-central Brazil by ship); and the limited resources available for the investments in infrastructure, due to the crisis of the Brazilian state in the late 1980s(including the events leading to the end of military dictatorship in 1988), the road became impassable (Fearnside & Graça 2005; Neto 2014). Various local newspapers reported an additional theory about the abandoning of the highway: they claimed that the BR-319 was purposely destroyed in the 1980s by river transport companies that feared losing their business with the arrival of trucks (*A Crítica*, 21/04/88, p. 1). Residents reported that a construction company mysteriously removed several kilometers of the road pavement (*A Crítica* 1988, p. 10 in Neto 2014).

It is important to note that both the ends of the road, which had more traffic and maintenance than the central section, remained trafficable until more or less 100 km away from the state capitals of Rondônia and Amazonas (Fearnside & Graça 2005; Bernard et al. 2009; Freire 1985).

9.1.2 1990-2009: the abandonment and the establishment of the conflict

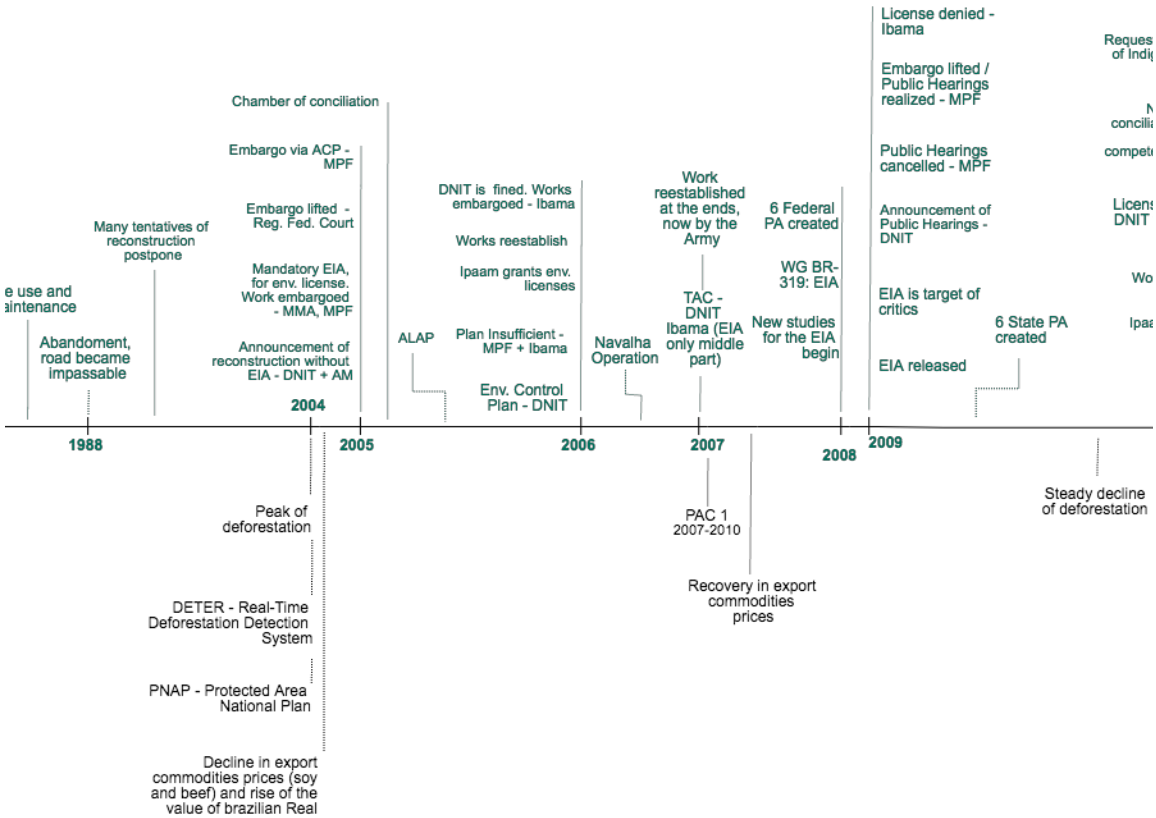


Figure 33 - Chronology of the BR-319, from 1990 until 2009 (in green) and in the national background context (in black). Author, 2018.

From the mid-1990s onwards, several attempts to reopen the road failed. However, only in 2004 were concrete actions carried out that aimed at completing the reconstruction project (Fearnside & Graça 2006) when then-President Luiz Inácio Lula da Silva launched a federal infrastructure program (Brazil, MPOG 2004). In this, the BR-319 project appeared listed as expected for ''after 2007'', meaning that it would

not be built during the term of the plan. Nevertheless, the Minister of Transportation, Alfredo Nascimento, also the former mayor of Manaus, made the project a personal priority. Nascimento's political party made extensive use of his promises to build the highway in television and other advertisements in preparation for the elections in October 2006 (Fearnside & Graça 2006).

The schedule announced by the Minister of Transportation was drawn up approximately three months before the intended date for beginning the work, which implied that he considered an Environmental Impact Assessment (EIA) to be unnecessary (Fearnside & Graça 2006). The Minister of Transportation and the Amazonas state governor inaugurated the beginning of the construction on July 9th, 2005, but a judicial order (precautionary action) from the federal public prosecutor (known as the "MPF", the acronym in Portuguese) halted the project on August 4th. The Minister of Environment announced on August 11th, 2005 that the BR-319 reconstruction project would have to go through the environmental licensing process, which demanded an EIA. The disagreement here was related to different conceptions of the work: for the Ministry of Transportation, the highway was already built, and this was just a maintenance project. For the Ministry of Environment the highway was entirely covered by forest, and any attempt to recover the road would result in an impact as significant as a new establishment, and for this the license was mandatory (Fearnside & Graça 2006). EIAs are required and the normal licensing process is followed even in the case of reconstruction projects for roads that have never been abandoned, such as the BR-163 (Santarém-Cuiabá).

On September 1st, the Regional Federal Court issued an order lifting the judicial embargo and the Minister of Transportation announced the immediate resumption of the reconstruction (Fearnside & Graça 2006). After in September, the federal public prosecutor (MPF) issued a Public Civil Suit (used in case of urgent protection) requesting that the bidding be nullified and forcing the National Department of Transportation Infrastructure (DNIT), which is responsible for the construction project, to apply for the necessary environmental licenses (MPF 2005; Fearnside & Graça 2006; Bernard et al. 2009; Ibama 2009).

Several months later, instead of presenting an EIA, which must conform to federal norms and be approved before the beginning of construction, DNIT hired the Federal University of Amazonas (UFAM) to draft an "Environmental Report" to be done simultaneously with the reconstruction of the road (Fearnside & Graça 2006; Bernard et al. 2009: Ibama 2009). The report was presented in November and considered insufficient by the Brazilian Institute of Environment and Renewable Natural Resources (Ibama), which is the federal body responsible for environmental licensing, monitoring and control (Fearnside & Graça 2006; Ibama 2009). Ibama declared that the report "did not meet the minimum criteria required for licensing purposes, and the document does not replace the need to present the EIA, concluding by returning the document to DNIT due to technical insufficiency" (Ibama 2009, p. 6).

In August 2006, Ibama issued a fine of R$ 3 million (or € 1 million at that time) to a company sub-contracted by DNIT for the execution of works in the domain of the BR-319. This raised the dispute to higher levels of conflict, since the company had no previous authorization from the environmental bodies (Ibama 2009). This situation of institutional discord persisted until the establishment of a Term of Adjustment of Conduct (TAC) between DNIT and Ibama in June 2007. The negotiation was conducted by the Chamber of Mediation, Conciliation and Arbitration, within the scope of the Attorney General´s office. The TAC divided the road into three segments and authorized the reestablishment of works, such as maintenance, conservation and restoration, as well as recovery of environmental liabilities, at the ends of the road; but the part in the middle still needed the EIA to be carried out.

Table 20 - The division of the road established by the TAC

Segments	Initial Km	Final Km	Works authorized
A	0,00	177,8	Maintenance, conservation and restoration
C	177,8	250	Paving and reconstruction
----	250	655,7	Paving and reconstruction – with obligatory EIA
B	655,7	877,4	Maintenance, conservation and restoration

Data: Ibama Technical Advice n° 078/2009.

The division of the licensing process was also agreed through the TAC. Auxiliary environmental licensing in segments A, B and C would be carried out by the state environmental body, in this case, the Environmental Protection Institute of Amazonas (Ipaam); any necessary suppression of vegetation, as well as the construction of bridges, would depend on specific licensing under Ibama's responsibility (Ibama 2009). The TAC also included actions to monitor and control social and environmental impacts, monitor wildlife and manage risk (Ibama 2009).

In 2006, a federal decree established the Area of Provisional Administrative Limitation of the BR-319 region, known as the "ALAP" in the Portuguese acronym, with the purpose of conducting studies for the establishment of protected areas along the highway (Fearnside & Graça 2006; Ibama 2009; Brasil 2006).

In 2007, the Federal Police launched the Navalha (razor) Operation, which dismantled a corruption scheme related to public works carried out by the federal government, among them the recovery of the BR-319 (Bernard et al. 2009). More than 225 people, including ministers, senators, deputies and civil servants, were involved in the scheme, including the Minister Alfredo Nascimento (Bernard et al. 2009). The Navalha operation may give a hint about the reasons behind the rush to approve and carry the reconstruction of the road, and it is estimated that between 1998 and

2007, more than R$100 million (more than € 25 million) were diverted (Bernard et al. 2009). This operation also resulted in the deposition of Alfredo Nascimento from his post as Minister.

In September 2008, DNIT sent the first version of the EIA for the middle segment of the road to Ibama, which, after several changes and corrections, was finally accepted in 2009 (Ibama 2009). The EIA was the target of many criticisms from academia and from civil society, mainly due to the potential environmental impacts, the lack of participation of civil society, the economic infeasibility and the lack of consultation of indigenous populations in the area (Bernard et al. 2009; Fleck 2009).

After many criticisms and a worsening of the dialogue, Ibama denied the license for the middle segment of the road in July 2009, concluding that "there is a need for several enhancements, including field surveys, thus the environmental feasibility of the highway cannot be analyzed at this time" (Ibama 2009, p. 14). The most significant hindrance to the study was in the analysis of the fauna and flora. According to experts, due to the tremendous seasonal variability in the region, field surveys should be conducted in both the dry season and the wet season, which had not been performed (Ibama 2009). There was also a lack of studies about the impacts on indigenous and traditional populations (Ibama 2009; Bernard et al. 2009).

9.1.3 2010-today: the acceleration of the conflict

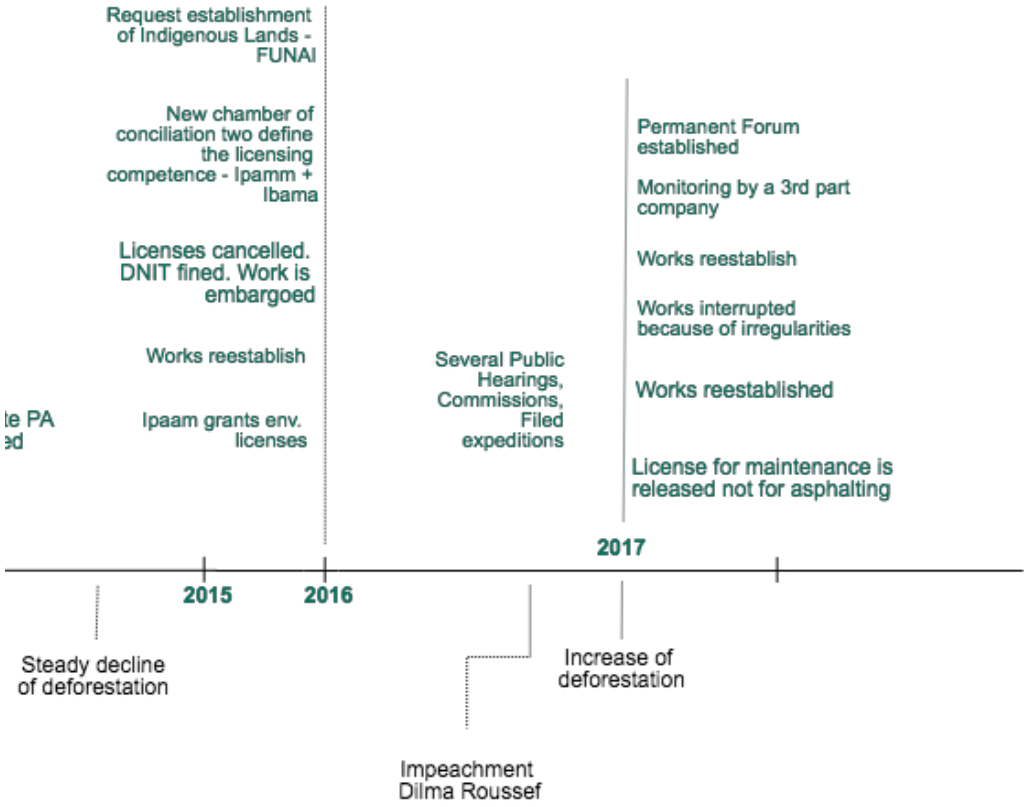


Figure 34 - Chronology of the BR-319, from 2010 until today (in green) and in the national background context (in black). Author, 2018.

After many years, in 2013 DNIT hired a new sub-contractor for the development of the flora and fauna studies (G1 Amazonas 2013).

Paving the BR-319 highway had great public appeal in the region (Fearnside & Graça 2009). Between 2009 and 2013, many tentative actions from politicians in Amazonas and Rondônia took place. An initiative to change the law that regulates the environmental-licensing process, several expeditions to the road by senators, deputies and mayors, chambers of conciliation, public hearings and discussion committees (BBC 2016; O Estado de São Paulo 2016; Rondônia Ao Vivo 2013; G1 Amazonas 2015; G1 Amazonas 2017; D24 Amazonas 2018; AGU 2007;ISA 2009; A Crítica 2015; Amazônia na Rede 2015; A Crítica 2016; TV Senado 2017).

In 2014, contrary to all of the environmental licensing legislation, Ipaam (the public body responsible for the environmental license at the state level) issued a Single Environmental License authorizing DNIT to carry out the maintenance and recovery of the full length of the highway (but without pavement). According to the MPF, this was a single license that, at the same time, replaced the three successive and complementary phases of the environmental licensing procedure demanded by law (MPF-AM 2015). Later that year, the MPF issued a judicial order to suspend the works on the BR-319 undertaken without authorization in the middle segment of the road, and Ibama issued DNIT a fine of R$ 7.5 million (€1,875,00).

decision further determined that Ipaam was not allowed to grant any new licenses or authorizations for activities related to the BR-319 (MPF-AM 2015).

With the works stopped, once more the institutional conflict was a topic for many public audits and conciliation meetings between all levels of the government until, in November, the courts and Ibama allowed the resumption of the works. Some conditions were included in the authorization: the actions permitted were to be only those related to maintenance, while significant actions, such as asphalt or the suppression of vegetation, still needed to await both the approval of the EIA (which still lacked the flora and fauna studies) and the license from Ibama (G1 Amazonas 2015a).

In March 2015, FUNAI (the federal body responsible for the protection of indigenous populations) demanded the delimitation of Indigenous Lands in the domain of the BR-319 (G1 Amazonas 2015b).

In July 2017, the works were suspended once more due to irregularities committed by DNIT, but the works restarted after a few months after some corrections, but with other issues merely included in the "conditions" with which the proponents promised to comply in the future (Rede TV 2017). In October, a third party compa-

ny was hired to supervise and oversee the works of DNIT on the BR-319 and a permanent forum presided by the Federal Public Prosecutor (MPF) was established to monitor the works (MPF-AM 2017). Until now, the EIA for asphalting and recovering the middle part of the highway has still not been concluded.

9.2 Case study database

9.2.1 Data acquisition at regional scale

Transcriptions of key-informant interviews

The transcriptions of the 29 key-informant interviews total more than 300 pages. The author is happy to make them available by email: carollealarcon@gmail.com. However, names, institutions and other critical information are omitted as matter of data and informant protection.

Tabulations and codes

Table 21 - Institutional role

Institution	Role - Codes
C1	Mobilization of organized civil society
C1	Lobbying
C1	Personal motivation
C2	Personal motivation
C2	Social assistance
C2	Education
C2	Income generation
C2	Community empowerment
C2	Strengthening networks
C2	Strengthening value chains
C2	Conservation
C3	Conservation
C3	Support to regional and long-term strategies
C3	Enabling collaboration between government and civil society
C3	Technical support
C3	Providing funds
C3	Government support
C3	Support to public policies
C4	Conservation
C4	Government support
C4	Providing funds
C4	Technical support
C4	Support to public policies
C4	Support to regional and long-term strategies

C5	Conservation
C5	Community empowerment
C5	Government support
C5	Strengthening value chains
C5	Income generation
C6	Research
C7	Corporate social and environmental responsibility
C7	Private business interests
C7	Lobbying
C7	Watchdog
C7	Policy monitoring
C8	Conservation
C8	Research
C8	Policy monitoring
C8	Advocacy
C8	Watchdog
C9	Personal motivation
C9	Mobilization of organized civil society
C10	Private business interests
C10	Personal motivation
C10	Lobbying
C11	Research
C11	Outreach
C11	Technical support
C11	Support to the management of PA
P1	Lack of clarity of the institutional role
P1	Institutional role established by law is not the same as in practice
P1	Facilitator and operational logistics of indigenous people consultation in the process of environmental licensing
P1	Contribution in participatory decision-making spaces
P1	Support to the environmental management of indigenous lands
P2	Defend citizens against possible abuses and omissions of Public Authorities
P2	Defense of the interests of the population
P2	Defend the public patrimony against attacks (mainly environment and natural resources)
P2	Oversee the environmental licensing process
P2	Oversee the actions of the state government
P3	Creation, implementation and management of protected areas
P3	Territorial management
P4	Defense of the interests of the population

P4	Defense of a balanced environment
P4	Legislate
P4	Oversee the actions of the state government
P4	Oversee and support the implementation of environmental and sustainable development laws
P5	State lawyer
P5	Support for land regularization
P5	To advise the State Public Administration on legal issues
P5	Defend the public patrimony against attacks (mainly environment and natural resources)
P5	Combating land grabbing
P6	Defense of the interests of the population
P6	Defense of a balanced environment
P6	Legislate
P6	Oversee the actions of the state government
P6	Provoke the State executive powers in favor of road construction road construction
P7	Land regularization
P7	Land registry
P7	Georeferencing of the national land tenure database
P7	Contribution in participatory decision-making spaces
P8	Manager of environmental public policies
P8	Creation, implementation and management of protected areas
P8	Territorial management
P9	Command and control
P9	Oversight and surveillance
P9	Combating deforestation
P10	Manager of PA
P10	Preparation of management plans
P10	Articulation
P10	Community organization
P10	Interface state and communities
P10	Monitoring of pressures and threats over PA
P10	Steering the governance process
P11	Environmental licensing
P11	Oversee the works authorized by the environmental licensing process
P11	Contribution in participatory decision-making spaces
P12	Manager of environmental public policies
P12	Creation, implementation and management of protected areas
P12	Territorial management
P12	Contribution in participatory decision-making spaces
P13	Executor of the reconstruction work

P14	Land regularization
P14	Land registry
P14	Public land allocation
P14	Agrarian reform policies
P14	Agricultural credit policies
P14	Creation of settlement projects
P15	Manager of PA
P15	Preparation of management plans
P15	Articulation
P15	Community organization
P15	Interface state and communities
P15	Monitoring of pressures and threats over PA
P15	Steering the governance process
P16	Manager of PA
P16	Preparation of management plans
P16	Articulation
P16	Community organization
P16	Interface state and communities
P16	Monitoring of pressures and threats over PA
P16	Steering the governance process
P17	Regional planning
P17	Socioeconomic development
P17	Lack of clarity of the institutional role
P17	Institutional role established by law is not the same as in practice
P17	Contribution in participatory decision-making spaces
C12	Addressing main drivers of deforestation
C12	Conservation
C12	support to the management of PA
C12	Support to public policies
C12	Providing funds
C12	Enabling collaboration between government and civil society
C12	Support to local organizations and stakeholders

Table 22 - Institutional vision

Institution	**Vision - Codes**
C1	Economic development
C1	Restoration of the BR-319 highway
C1	Establishment of participatory governance
C1	Improvement of the quality of life of local populations
C1	Economic alternative to PIM
C1	Respect to Protected Areas

C1	Sense of belonging from the local population
C1	Civil society participation
C2	Economic development
C2	Improvement of the quality of life of local populations
C2	Use of human potential
C2	Sustainable territory
CI	Establishment of participatory governance
CI	Pressure over natural resources
CI	Restoration of the BR-319 highway
CI	Economic development
CI	Economic alternative to PIM
C4	Institution does not have an established vision
C5	Institution does not have an established vision
C5	Restoration of the BR-319 highway
C5	Pressure over natural resources
C5	Environmental impact
C5	Unsatisfactory actions to minimize environmental impact
C5	Migratory boom
C5	Institutional weaknesses
C5	Uncertainty of the political process
C6	Institution does not have an established vision
C6	Increase of deforestation
C6	Environmental impact
C6	Migratory boom
C6	Increase of violence
C6	Uncertainty of the political process
C6	Institutional weaknesses
C7	Restoration of the BR-319 highway
C7	Economic development
C7	Establishment of participatory governance
C7	Improvement of the quality of life of local populations
C7	Establishment of a new mode of transport
C8	Institution does not have an established vision
C8	Restoration of the BR-319 highway
C8	Increase of deforestation
C8	Environmental impact
C8	Unsatisfactory actions to minimize environmental impact
C8	Uncertainty of the political process
C9	Restoration of the BR-319 highway
C9	Improvement of the quality of life of local populations

C10	Restoration of the BR-319 highway
C10	Economic development
C10	Improvement of the quality of life of local populations
C10	Establishment of a new mode of transport
C11	Restoration of the BR-319 highway
C11	Institution does not have an established vision
C11	Pressure over natural resources
C11	Increase of deforestation
C11	Unsatisfactory actions to minimize environmental impact
C11	Riverside cities losing economic importance with the emergence of cities by the road
C11	Uncertainty of the political process
C11	Institutional weaknesses
C11	Migratory boom
P1	Pressure over natural resources
P2	Pressure over natural resources
P2	Pressure over PA
P2	Increase of deforestation
P2	Migratory boom
P2	Establishment of State roads
P2	Lack of rule of law
P2	Lack of land-use planning
P2	Lack of surveillance
P2	Lack of staff for environmental agencies
P3	PA established as an efficient mitigation strategy
P3	Pressure over natural resources
P3	Lack of staff for environmental agencies
P3	Lack of resources for environmental agencies
P3	Restoration of the BR-319 highway
P3	Challenging harmonization of different land uses
P4	Economic development
P4	Restoration of the BR-319 highway
P4	Pressure over natural resources
P4	Mosaic of different land-uses operating in harmony
P4	Potential for eco-tourism
P4	Potential for research
P4	Potential for biotechnology
P4	Potential for small-scale agriculture
P4	Presence of Army
P4	Regional inclusion
P4	Improvement of the quality of life of local populations

P4	Establishment of participatory governance
P5	Restoration of the BR-319 highway
P5	Establishment of agrobusiness
P5	Land concentration
P5	Mining
P5	Conflict over land
P5	Expulsion of traditional populations
P5	Migratory boom
P6	Economic development
P6	Restoration of the BR-319 highway
P6	Pressure over natural resources
P6	Mosaic of different land-uses operating in harmony
P6	Potential for eco-tourism
P6	Establishment of a new mode of transportation
P7	Mosaic of different land-uses operating in harmony
P7	Land regularization
P7	Establishment of PA
P7	Public land allocation and emancipation
P7	Migratory boom
P7	Process of consolidation of the agrarian reform
P7	Process of consolidation of the georeferencing of rural properties
P7	Establishment of a new governmental body responsible for territorial management
P7	Restoration of the BR-319 highway
P8	Regional inclusion
P8	Increase of deforestation
P8	Economic development
P8	Improvement of the quality of life of local populations
P8	Economic alternatives
P8	Restoration of the BR-319 highway
P9	Increase of deforestation
P9	Migratory boom
P9	Institutional weakness
P9	Illegal logging
P9	Conflict over land
P9	Lack of staff for environmental agencies
P9	Lack of resources for environmental agencies
P9	Restoration of the BR-319 highway
P10	Establishment of participatory governance
P10	Economic development
P10	Improvement of the quality of life of local populations

P10	Sustainable territory
P10	Pressure over natural resources
P10	Increase of deforestation
P10	Migratory boom
P10	Effects of climate change
P10	Restoration of the BR-319 highway
P11	Institution does not have an established vision
P11	Pressure over natural resources
P11	Restoration of the BR-319 highway
P11	Supervise of compliance to the conditions established by the environmental licensing
P12	Challenging harmonization of different land uses
P12	Co-management of PA
P12	Increase of deforestation
P12	Institutional weakness
P13	Restoration of the BR-319 highway
P13	Compliance to the conditions established by the environmental licensing
P14	Lack of surveillance
P14	Land regularization
P14	Public land allocation and emancipation
P14	Process of consolidation of the agrarian reform
P14	Pressure over natural resources
P14	Pressure over PA
P14	Migratory boom
P15	Restoration of the BR-319 highway
P15	Establishment of PA
P15	Pressure over PA
P15	Co-management of PA
P15	Increase of deforestation
P15	Challenging harmonization of different land uses
P15	Economic development
P16	Restoration of the BR-319 highway
P16	Mosaic of different land-uses operating in harmony
P16	Establishment of participatory governance
P17	Restoration of the BR-319 highway
P17	Mosaic of different land-uses operating in harmony
P17	Establishment of participatory governance
P17	Economic development
P17	Improvement of the quality of life of local populations
P17	Compliance to the conditions established by the environmental licensing
P17	Connectivity

P17	Establishment of agrobusiness
P17	Lack of long-term planning
C12	Economic development
C12	Improvement of the quality of life of local populations
C12	Establishment of participatory governance
C12	Environmental impact
C12	Social impact
C12	Stakeholders participation
C12	Mosaic of different land-uses operating in harmony
C12	Pressure over natural resources
C12	Maintenance of biodiversity and forest cover
C12	Restoration of the BR-319 highway
C12	Environmental impact

Table 23 - Challenges

Institution	**Challenges - Codes**
C1	Will Government Take Responsibility?
C1	Lack of rule of law
C1	Lack of surveillance
C1	Illegal logging
C2	Will Government Take Responsibility?
C2	Lack of rule of law
C2	Governmental discontinuity
C2	To include local people demands in decision making
C2	Establishment of participatory governance
C2	To adopt development models that do not respect the idiosyncrasies of the Amazon
C2	Arrival of large companies
C2	Incapacity of local governments
C3	Political focus in the PIM
C3	Poor public performance outside Manaus
C3	Lack of policy monitoring
C3	To include local people demands in decision making
C3	Transparency and ethics
C3	Governmental discontinuity
C3	Resources management
C3	Incapacity of local governments
C3	Long-term planning
C4	Illegal logging
C4	Cattle ranching
C4	Migration boom

C4	To include local people demands in decision making
C4	Will Government Take Responsibility?
C4	Lack of rule of law
C4	Establishment of participatory governance
C5	Will Government Take Responsibility?
C5	Establishment of participatory governance
C5	To include local people demands in decision making
C5	Lack of staff for environmental agencies
C5	Lack of rule of law
C5	Maintenance of Protected Areas
C5	Lack of staff for environmental agencies
C6	Migration boom
C6	Lack of resources for environmental agencies
C6	Lack of staff for environmental agencies
C6	Lack of rule of law
C6	Maintenance of Protected Areas
C6	Lack of surveillance
C6	Respect to the conditions established in the of environmental licensing
C6	Establishment of State roads
C7	Migration boom
C7	Will Government Take Responsibility?
C7	Maintenance of Protected Areas
C7	Lack of rule of law
C7	Lack of surveillance
C8	Maintenance of Protected Areas
C8	Lack of rule of law
C8	Lack of surveillance
C8	Presence of militias (drug traffic)
C8	Will Government Take Responsibility?
C8	Lack of resources for environmental agencies
C8	Lack of staff for environmental agencies
C8	To foster economic alternatives
C8	Illegal logging
C8	Cattle ranching
C8	Migration boom
C8	Respect to the conditions established in the of environmental licensing
C8	Transparency and ethics
C8	To include local people demands in decision making
C8	Establishment of State roads
C9	Safety

C9	To foster economic alternatives
C9	Lack of options for youth
C9	Establishment of participatory governance
C9	Lack of surveillance
C9	Will Government Take Responsibility?
C9	Transparency and ethics
C11	Maintenance of Protected Areas
C11	Migration boom
C11	Governance over areas allocated by INCRA
C11	Institutional weakness
C11	Governmental discontinuity
C11	Establishment of State roads
P1	Pressure over natural resources
P1	Increase social interaction between indigenous and non-indigenous peoples
P1	Will Government Take Responsibility?
P1	Pressure over indigenous lands
P1	Bureaucracy
P1	Dialogue between institutions
P1	Institutional weakness
P1	Different institutional culture
P1	centralized government
P1	Lack of surveillance
P2	Political instability
P2	Lack of rule of law
P2	Electoral interests
P3	Institutional weakness
P3	Pressure over natural resources
P3	Dialogue between institutions
P3	Lack of surveillance
P4	Transparency and ethics
P4	Personal interests above collective interest
P4	Social invisibility of traditional and indigenous population
P4	Establishment of participatory governance
P4	Lack of integrated territorial planning
P4	Lack of political leadership focused on the common good
P4	Lack of political awareness
P4	competition with the agricultural sector of Rondônia
P5	Social invisibility of traditional and indigenous population
P5	Lack of political leadership focused on the common good
P6	Will Government Take Responsibility?

P6	Lack of surveillance
P6	Maintenance of Protected Areas
P7	Will Government Take Responsibility?
P7	Lack of surveillance
P7	Institutional weakness
P7	Migration boom
P7	Lack of long-term planning
P7	Migration boom
P7	To include local people demands in decision making
P7	Lack of political leadership focused on the common good
P7	Incapacity of local governments
P7	integration and modernization of land tenure databases
P7	Lack of resources for environmental agencies
P7	Lack of staff for environmental agencies
P8	lack of public incentive for the rational use of the forest
P8	convergence of many land uses and demands
P8	centralized government
P9	Lack of resources for environmental agencies
P9	Lack of surveillance
P9	Institutional weakness
P10	Migration boom
P10	Establishment of participatory governance
P10	Maintenance of Protected Areas
P10	Illegal logging
P10	Personification of the State
P10	Governmental discontinuity
P10	Lack of integrated territorial planning
P10	Governmental bipolarity
P11	Institutional weakness
P11	Lack of long-term planning
P11	Migration boom
P11	Pressure over natural resources
P11	To include local people demands in decision making
P11	financial sustainability of the highway
P11	Lack of staff for environmental agencies
P11	Lack of resources for environmental agencies
P12	Lack of resources for environmental agencies
P12	Lack of staff for environmental agencies
P12	Institutional weakness
P12	Violence against environmental staff

P12	Policy of land distribution of Terra Legal
P12	Dialogue between institutions
P12	Maintenance of Protected Areas
P12	Lack of surveillance
P13	compliance with environmental requirements
P14	Lack of surveillance
P14	Lack of rule of law
P14	Institutional weakness
P14	Lack of resources for environmental agencies
P14	Lack of staff for environmental agencies
P14	fragility of the land registry process (notary´s office)
P15	Governmental discontinuity
P15	Institutional weakness
P15	Lack of surveillance
P15	Illegal logging
P15	Migration boom
P15	Lack of staff for environmental agencies
P15	Maintenance of Protected Areas
P15	Dialogue between institutions
P15	Lack of management procedures
P15	Personification of the State
P15	Violence against environmental staff
P15	Establishment of participatory governance
P15	Presence of militias (drug traffic)
P16	Establishment of participatory governance
P16	Lack of staff for environmental agencies
P16	Lack of integrated territorial planning
P17	Arrival of Venezuelan refugees
P17	To convince people that we need less protection and more development
C12	Dominant vision of development that sees the Amazon as a source of re-sources to be extracted and that doesn't place value on the standing forest
C12	Pressure over natural resources
C12	Illegal logging
C12	Gold mining
C12	Land grabbing
C12	Pressure over indigenous lands
C12	Pressure over PA
C12	Lack of rule of law
C12	Climate change
C12	Lack of government enforcement
C12	Lack of environmental law enforcement

C12	Governmental emphasis on infrastructure
C12	Establishment of participatory governance
C12	Social impacts
C12	Bring diverse stakeholders together around a common vision that includes safeguarding environmental resources

Table 24 - Vision, count of codes

Row Labels	Count of Institution
Restoration of the BR-319 highway	22
Pressure over natural resources	12
Economic development	12
Improvement of the quality of life of local populations	10
Increase of deforestation	9
Migratory boom	9
Establishment of participatory governance	8
Mosaic of different land-uses operating in harmony	6
Institution does not have an established vision	6
Environmental impact	5
Uncertainty of the political process	4
Unsatisfactory actions to minimize environmental impact	3
Challenging harmonization of different land uses	3
Pressure over PA	3
Lack of staff for environmental agencies	3
Establishment of agrobusiness	2
Process of consolidation of the agrarian reform	2
Potential for eco-tourism	2
Compliance to the conditions established by the environmental licensing	2
Regional inclusion	2
Conflict over land	2
Land regularization	2
Economic alternative to PIM	2
Co-management of PA	2
Institutional weakness	2
Public land allocation and emancipation	2
Institutional weaknesses	2
Establishment of a new mode of transport	2
Lack of resources for environmental agencies	2
Lack of surveillance	2
Establishment of PA	2
Economic alternatives	1
Supervise of compliance to the conditions established by the environmental licensing	1
Respect to Protected Areas	1
Increase of violence	1

Lack of rule of law	1
Land concentration	1
Lack of land-use planning	1
Expulsion of traditional populations	1
Riverside cities losing economic importance with the emergence of cities by the road	1
Civil society participation	1
Sustainable territory	1
Mining	1
Social impact	1
Effects of climate change	1
Process of consolidation of the georeferencing of rural properties	1
Maintenance of biodiversity and forest cover	1
Lack of long-term planning	1
Potential for biotechnology	1
Connectivity	1
Illegal logging	1
Sense of belonging from the local population	1
Potential for research	1
Sustainable territory	1
Potential for small-scale agriculture	1
Establishment of a new mode of transportation	1
Presence of Army	1
Use of human potential	1
Establishment of State roads	1
Stakeholders participation	1
Establishment of a new governmental body responsible for territorial management	1
Institutional weaknesses	1
PA established as an efficient mitigation strategy	1
Grand Total	**179**

Table 25 - Challenges, count of codes

Row Labels	**Count of Institution**
Lack of surveillance	13
Migration boom	10
Will Government Take Responsibility?	10
Lack of rule of law	10
Lack of staff for environmental agencies	10
Establishment of participatory governance	9
Institutional weakness	9
Maintenance of Protected Areas	9
Lack of resources for environmental agencies	7
To include local people demands in decision making	7
Illegal logging	6

Governmental discontinuity	5
Transparency and ethics	4
Pressure over natural resources	4
Dialogue between institutions	4
Lack of integrated territorial planning	3
Lack of political leadership focused on the common good	3
Establishment of State roads	3
Incapacity of local governments	3
Lack of long-term planning	2
To foster economic alternatives	2
Presence of militias (drug traffic)	2
Pressure over indigenous lands	2
Personification of the State	2
centralized government	2
Violence against environmental staff	2
Respect to the conditions established in the of environmental licensing	2
Social invisibility of traditional and indigenous population	2
Cattle ranching	2
Land grabbing	1
To convince people that we need less protection and more development	1
Governance over areas allocated by INCRA	1
lack of public incentive for the rational use of the forest	1
Lack of policy monitoring	1
Governmental bipolarity	1
Lack of environmental law enforcement	1
Arrival of Venezuelan refugees	1
financial sustainability of the highway	1
Arrival of large companies	1
Lack of management procedures	1
Bureaucracy	1
Dominant vision of development that sees the Amazon as a source of resources to be extracted and that doesn't place value on the standing forest	1
Long-term planning	1
Climate change	1
competition with the agricultural sector of Rondônia	1
Social impacts	1
Electoral interests	1
Safety	1
Personal interests above collective interest	1
To adopt development models that do not respect the idiosyncrasies of the Amazon	1
compliance with environmental requirements	1
fragility of the land registry process (notary´s office)	1
Policy of land distribution of Terra Legal	1

Lack of options for youth	1
Political focus in the PIM	1
Lack of political awareness	1
Political instability	1
Gold mining	1
Poor public performance outside Manaus	1
Pressure over PA	1
Different institutional culture	1
Lack of government enforcement	1
Increase social interaction between indigenous and non-indigenous peoples	1
Governmental emphasis on infrastructure	1
convergence of many land uses and demands	1
Bring diverse stakeholders together around a common vision that includes safeguarding environmental resources	1
Resources management	1
integration and modernization of land tenure databases	1
Grand Total	**188**

Table 26 - Scenarios

Codes	Scenario 1	Scenario 2	Scenario 3	Scenario 4	No common scenario
	Economic development	Pressure over PA	When institutions answered with codes of both scenarios 1 and 2	Institution does not have an established vision	Riverside cities losing economic importance with the emergence of cities by the road
	Establishment of participatory governance	Establishment of State roads			
	Improvement of the quality of life of local populations	Lack of rule of law			Presence of Army
	Economic alternative to PIM	Lack of land-use planning			Effects of climate change
	Respect to Protected Areas	Lack of surveillance			
	Sense of belonging from the local population	Lack of staff for environmental agencies			
	Civil society participation	Lack of resources for environmental agencies			
	Connectivity	Challenging harmonization of different land uses			
	Use of human potential	Establishment of agro-business			
	Sustainable territory	Land concentration			
	PA established as an efficient mitigation strategy	Conflict over land			
	Mosaic of different land-uses operating in harmony	Expulsion of traditional populations			
	Potential for research	Institutional weakness			
	Potential for biotechnol-	Illegal logging			

ogy				
Potential for small-scale agriculture	Migration boom			
Regional inclusion	Lack of long-term planning			
Potential for eco-tourism	Supervise of compliance to the conditions established by the environmental licensing			
Establishment of a new mode of transportation				
Establishment of PA	Social impact			
Public land allocation and emancipation	Environmental impact			
Process of consolidation of the agrarian reform				
Process of consolidation of the georeferencing of rural properties				
Economic alternatives				
Co-management of PA				
Compliance to the conditions established by the environmental licensing				
Establishment of a new governmental body responsible for territorial management				
Stakeholders participation				
Maintenance of biodiversity and forest cover				

Informants					
C1	C5	C3	C4	C11
C2	C6	P3	C5	P4
C7	C8	P4	C6	P7
C9	C11	P7	C8	P10
C10	P1	P8	C11	P11
P13	P2	P10	P11	
P16	P5	P12		
	P9	P15		
	P11	P17		
		P14		
		P6		
		C12		
7	**9**	**12**	**6**	**5**

Table 27 - Group of challenges

Codes				
Political/ Institutional	Environmental	Territorial Governance	Social/Economic	Participation
Lack of rule of law	Violence against environmental staff	Establishment of participatory governance	To adopt development models that do not respect the idiosyncrasies of the Amazon	To include local people demands in decision making
Will Government Take Responsibility?	Illegal logging	Governance over areas allocated by INCRA		Bring diverse stakeholders together around a common vision that includes safeguarding environmental resources
Governmental discontinuity	Arrival of large companies	Lack of integrated territorial planning	Lack of options for youth	
Incapacity of local governments	Cattle ranching	Integration and modernization of land tenure databases	Safety	
Political focus in the PIM	Establishment of State roads		Arrival of Venezuelan refugees	
Poor public performance outside Manaus	Compliance with environmental requirements	Convergence of many land uses and demands	To convince people that we need less protection	

Lack of policy monitoring	Pressure over natural resources	Fragility of the land registry process (notary´s office)	and more development	
Transparency and ethics	Pressure over indigenous lands	Policy of land distribution of Terra Legal	Presence of militias (drug traffic)	
Lack of management procedures	Compliance with environmental requirements		Increase social interaction between indigenous and non-indigenous peoples	
Governmental bipolarity	Pressure over PA			
Resources management	Respect to the conditions established in the of environmental licensing		Social invisibility of traditional and indigenous population	
Personification of the State			To foster economic alternatives	
Long-term planning	Lack of staff for environmental agencies		C	
Institutional weakness	Maintenance of Protected Areas		Lack of public incentive for the rational use of the forest	
Bureaucracy	Lack of surveillance		financial sustainability of the highway	
Dialogue between institutions	Migration boom		Social impact	
Electoral interests	Land grabbing			
Different institutional culture	Gold mining			
centralized government	Lack of environmental law enforcement			
Political instability	Climate change			
Personal interests above collective interest	Dominant vision of development that sees the Amazon as a source of resources to be extracted and			
Lack of long-term planning				

	Lack of political leadership focused on the common good	that doesn't place value on the standing forest			
	Lack of political awareness				
	Lack of government enforcement				
	Governmental emphasis on infrastructure				
Informants	C1	C1	C2	C2	C2
	C2	C6	C4	C8	C3
	C3	C2	C5	C9	C4
	C4	C4	C10	P1	C5
	C5	C5	C11	P4	C8
	C6	P3	P4	P5	P7
	C7	P6	P7	P15	P11
	C11	P7	P8	P17	C12
	C8	C7	P12	P8	
	C10	C8	P10	P11	
	P6	C10	P14	C12	
	P7	C11	P15		
	P8	P1	P16		
	P9	P9	C12		
	P10	P10			
	P11	P11			
	P12	P12			
	P14	P13			

P15	P15			
P1	P16			
P3	P14			
P2	C12			
P5				
P4				
C12				
25	**22**	**14**	**11**	**8**

9.2.2 Data acquisition at the local scale

Estimation of population in the study area

The previous data available from the official reports about the population living in the study area accounted for 14 farms and 5 villages (traditional communities and non-traditional communities), which totaled approximately 150 households. When the author arrived on the BR-319 a much larger number of occupations was found, especially on the portion of the road close to Humaitá. There was an exceptional number of isolated houses popping up all along the road, which fitted neither of the two previously defined categories of "villages" or "farms"

.

To estimate the total population in the study area a counting strategy had to be developed: first, all of the occupations found in the course of the study were counted, marked (with GPS coordinates), and classified into four categories: Farms, Villages, Isolated dwellings (which included Occupied houses, Unoccupied houses, Businesses and Recent dwellings). These occupations were counted and marked in a pre-developed table while traveling the length of the road.

Farms were characterized by having cattle raising and/or pasture with cattle pens. Villages were characterized by being an agglomeration of houses with common areas such football fields, a church or a community center. The number of dwellings in each village was estimated later. Occupied dwellings that were not part of a village and had evidence that there were people living in them (such as presence of dogs, cars, motorcycles, a well-maintained garden, and so on). In contrast, an unoccupied dwelling was one that had evidence of abandonment such as rotten wood, broken windows, or abandoned gardens, and also was not part of a village. Finally, Recent dwellings, had visible signs of novelty, such as a recently burned area, newly installed fences and signs, houses made with fresh timber, lack of an established garden, and also without being part of an agglomeration of houses. Finally, Businesses were the markets, restaurants, and small hotels, found along the road. It is important to note that the collection of data about businesses and unoccupied houses did not contribute to the estimate of the population in the study area, but rather contributed to having better understanding of the dynamics of occupation along the highway.

The final estimate of the population living in the study area was 608 dwellings or households distributed as presented in the table below:

Table 28 - Estimation of the population living the study area

	FARMS	VILLAGES	ISOLATED DWELLINGS	TOTAL
1	2	3 (45 HH)	20	**67**
2	14	0	61	**75**
3	24	5 (390 HH)	52	**466**
TOTAL	**40**	**8 (435 HH)**	**133**	**608**

In the interests of simplification and better visualization, the study area was divided in three sections: (1) the region in between protected areas, closer to Manaus; (2) the region that goes from the end of the protected areas until the village of Realidade; and (3) the region from Realidade until the southern end of the study area.

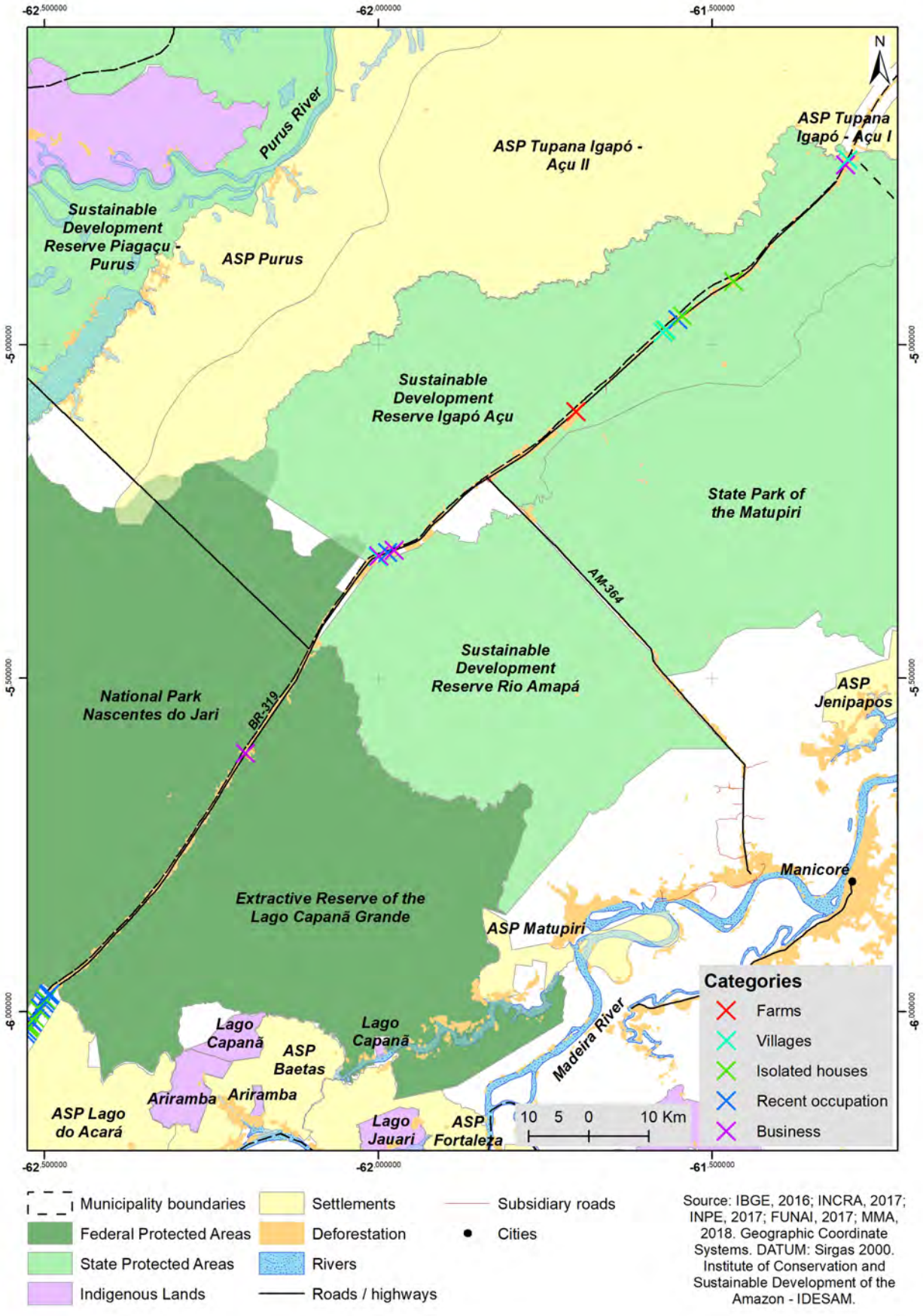


Figure 35 -Counting of dwellings section 1

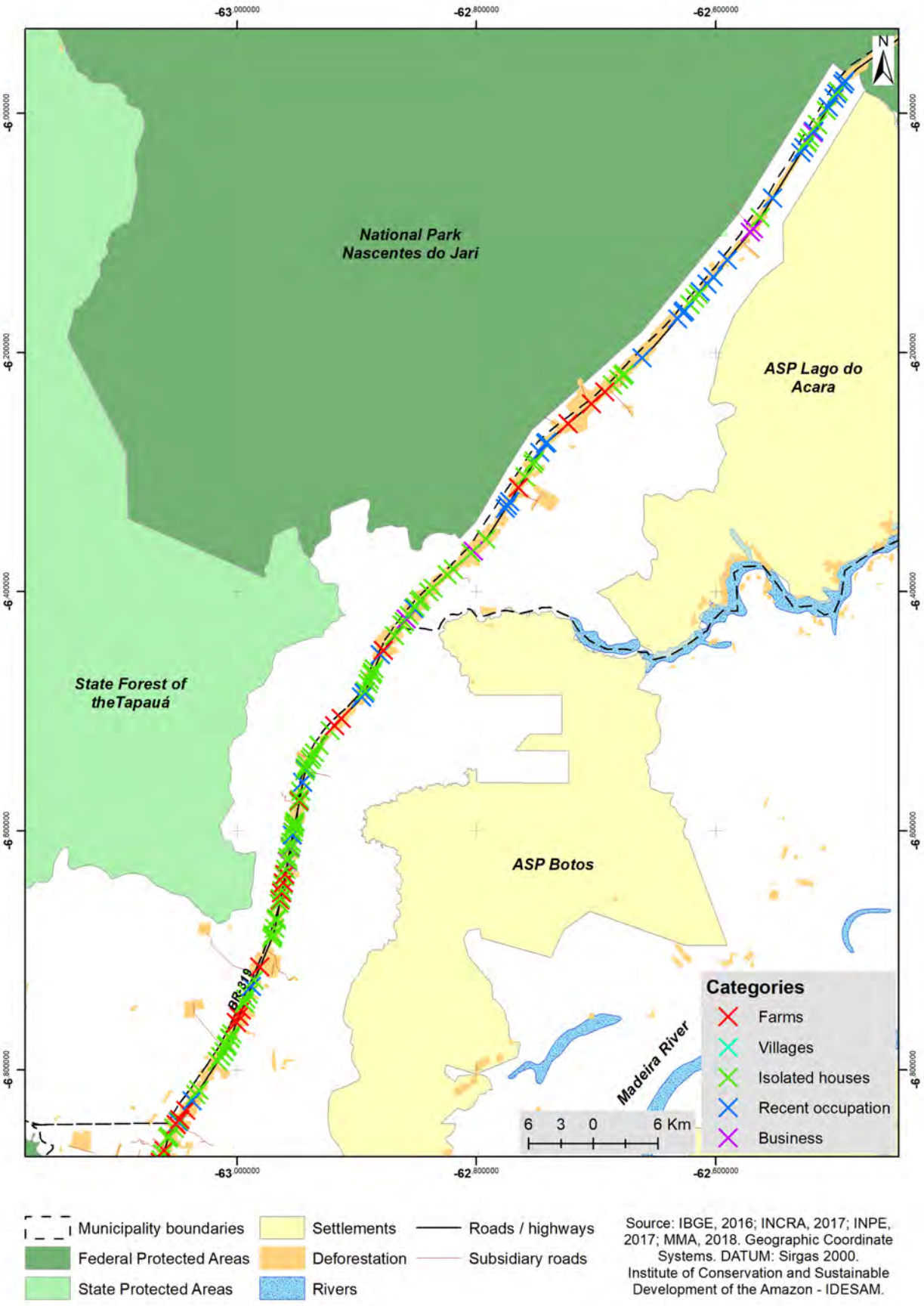


Figure 36 - Counting of dwellings section 2

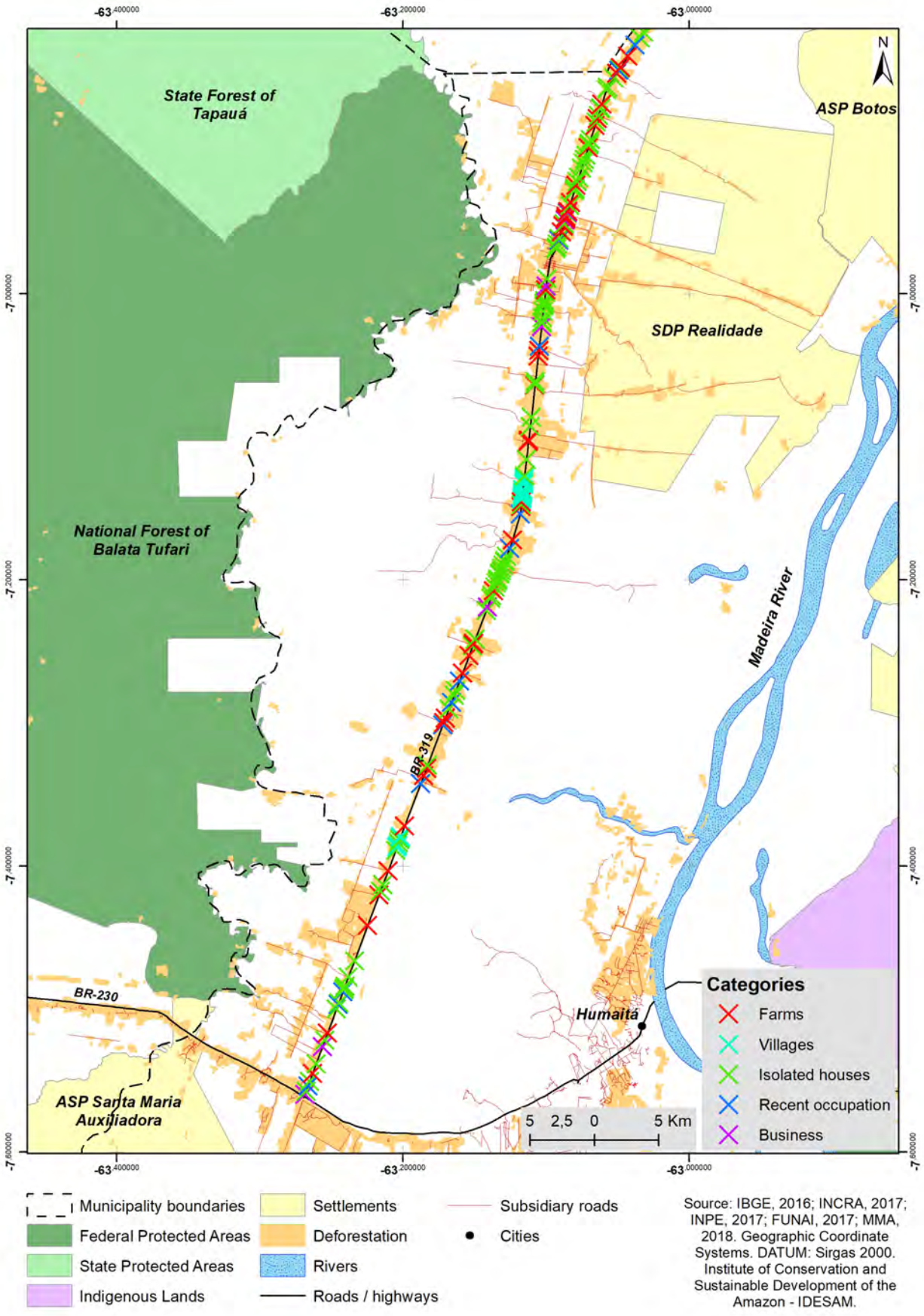


Figure 37 - Counting of dwellings section 3

The number of houses in the villages was also estimated. First, the number of households in each village was obtained in a conversation with the chief, and later the houses were counted by walking through the village. Aerial photographs were taken with the

UAV (drone) . As the unit of analysis was the household, when there was more than one family leaving in the same house, this was regarded as one unit.

Figure 38 - Nova Geração

Figure 39 - Rio Novo

With the village of Realidade the strategy had to be different. Realidade can be considered to already be a small city or a district, with a school, a health center and various bakeries, restaurants and markets. However, there was no official estimate of the population of Realidade, and to estimate it was one of the biggest challenges of the field expedition. Realidade is known to be a violent place due to the illegal logging activities, and it is growing rapidly. Additionally, there are two "Realidades", the village and the INCRA Sustainable Development Project (PDS). As it is quite difficult to access PDS Realidade, particularly in the rainy season, the majority of the settlers with lots awarded by INCRA decided to build their houses in a village near by, also named "Realidade", which is located just by the BR-319 road. In general, settlers live in the village, where there is better infrastructure, such as electricity, piped water, and a health center, but they have their crops and production area inside the PDS. This situation creates confusion about what is really "Realidade": the village, the settlement or the area of influence considering both?

Because the study area of this research considers a buffer of only 5 km from the road, only the village of Realidade was consider in the sampling. The first step to estimate the number of families in Realidade was to develop a map. This was done using the drone application called Pix4D[24], and the result can be seen in Figure 40 in below.

With the map, the village was divided into four neighborhoods with similar sizes and numbers of houses (also displayed in Figure 40). The third step was then to divide the neighborhoods into blocks, which were then randomly select for counting; 50% of the blocks were selected and all houses counted during a transect made with a motorcycle. With the motorcycle the use of the clipboard was not so convenient, so the counting was made with the assistance of an audio recorder and the results were transcribed to the paper afterwards. The counting was also made according to similar categories: occupied houses, unoccupied houses, recent occupations and businesses. Again, the col-

[24] A photogrammetry software that creates professional drone-based mapping from images.

lection of data about businesses or unoccupied houses did not contribute to the estimate of the population, but rather to better understanding the dynamics of occupation. Lastly, the occupied houses and the recent occupations were summed, totaling 177 households. This estimation was then extrapolated to the entire village, which resulted in a final estimate of approximately 355 families.

The map of Realidade produced and displayed in Figure 40 was printed and delivered to the president of the Association and was also sent to the municipality of Humaitá and to local stakeholders contacted during the field expedition, such as INCRA and IDAM. During the stay in Realidade the municipality was conducting maintenance works in the streets of the village, but they did not have an updated map of the village. The file of the map was also sent to this maintenance team.

Because the total population in the study area was almost three times greater than initially expected, an important decision had to be made. There was not enough time and resources available for the field inquiry to obtain a reasonable sampling of the entire population. That said, a priority criterion was adopted, and the isolated occupations were not considered in the sampling.

The three main reasons for this decision were:

- Half of the occupations were characterized as "recent occupations", which means that their land-use allocation strategy, the focus of analysis of this research, was not yet consolidated;
- Visibly, many of the houses were comprised of simple structures that were more to mark presence and to display occupation of the land as part of a probable speculative behavior.
- Since this is a frontier area with speculative land appropriation, approaching isolated houses appeared to be too risky.

The sampling frame of the population was organized as it follows in the Table 29:

Table 29 - Sampling design

	Farm	HH	% of population	N° of HH interviewed
1	Acará	1	2,5%	0
2	Itamarati	1	2,5%	0
3	Dos Catarinos - Marlise	1	2,5%	1
4	Dos Catarinos - Rubens	1	2,5%	0
5	Dos Catarinos - Wilson	1	2,5%	0
6	Dos Catarinos - 4° irmao	1	2,5%	0
7	Dois Irmãos	1	2,5%	0
8	Bandeirantes	1	2,5%	0
9	Jacaretinga	1	2,5%	1
10	Santa Rosa	1	2,5%	1
11	Nazaré	1	2,5%	0
12	Terra Alta	1	2,5%	0
13	Cleuciane	1	2,5%	0
14	Lages	1	2,5%	0
15	Dom Bosco	1	2,5%	0
16	Nova Esperança	1	2,5%	0
17	Sîtio Três Estrelas	1	2,5%	1
18	Sítio Agua Boa	1	2,5%	1
19	No name	1	2,5%	0
20	No name	1	2,5%	0
21	No name	1	2,5%	0
22	No name	1	2,5%	0
23	No name	1	2,5%	0
24	No name	1	2,5%	0
25	No name	1	2,5%	0
26	No name	1	2,5%	0
27	No name	1	2,5%	0
28	No name	1	2,5%	0
29	No name	1	2,5%	0
30	No name	1	2,5%	0
31	No name	1	2,5%	0
32	No name	1	2,5%	0
33	No name	1	2,5%	0
34	No name	1	2,5%	0
35	No name	1	2,5%	0
36	No name	1	2,5%	0
37	No name	1	2,5%	0
38	No name	1	2,5%	0
39	No name	1	2,5%	0
40	No name	1	2,5%	0
	Total=	**40**	**8%**	**5**
	Samping ratio 10%=	**4**	**HH interviewed**	

	Community	HH	% of population	N° of HH interviewed
1	Nova Geração	18	22%	2
2	São Sebastião do Igapó-Açu	22	27%	2
3	Rio Novo - Paulo	5	6%	1
4	Fortaleza	17	21%	2
5	São Carlos	2	2%	0
6	Santa Terezinha	5	6%	1
7	Nova Aliança	12	15%	1
	Total=	**81**	**17%**	**8**
	Samping ratio 10%=	**8**	**HH interviewed**	

	Settement	HH	% of population	N° of HH interviewed
1	Realidade	354	100%	35
	Total=	**354**	**75%**	35
	Samping ratio 10%=	**35**	**HH interviewed**	

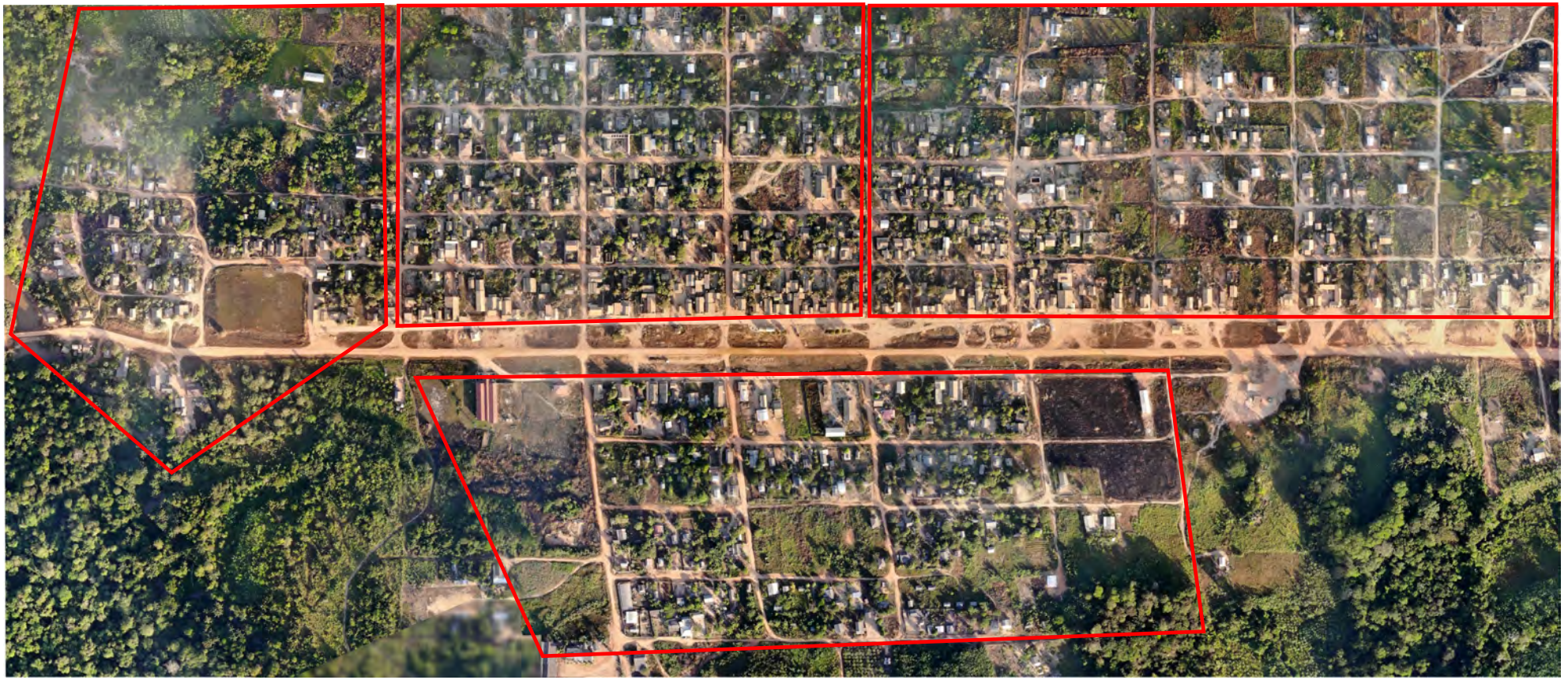


Figure 40 - The village Realidade seen from above

Survey questionnaires

Ocupação e uso da terra na ADI da rodovia BR-319 - Atualizado

Local da entrevista

_____

Informações gerais sobre o/a entrevistado(a)

Nome do entrevistado (1)

_____

Chefe da família/ fazenda?

- ◯ Sim
- ◯ Não

Qual a relação com o/a chefe?

- Familiar
- Gerente
- Trabalhador
- Outro

Especifique

_____

Nome do entrevistado (2)

_____

Chefe da família/ fazenda? (2)

- Sim
- Não

Qual a relação com o/a chefe? (2)

- Familiar
- Gerente
- Trabalhador
- Outro

Especifique (2)

_____

Local de nascimento

_____

Profissão

_____

Educação

- ◯ Básico
- ◯ Fundamental
- ◯ Técnico
- ◯ Superior
- ◯ Outro

Especifique

_____

Há quanto tempo mora aqui na região? (1)

_____

Há quanto tempo mora aqui na região? (2)

_____

Antes de morar aqui (ou mesmo família e antepassados) morava onde? (1)

_____

Antes de morar aqui (ou mesmo família e antepassados) morava onde? (2)

_____

Mudou para cá sozinho(a), ou veio acompanhado(a) por familiares, amigos, outros vizinhos? (1)

- ◯ Sozinho
- ◯ Acompanhado de familiares
- ◯ Acompanhado de amigos
- ◯ Acompanhado de vizinhos
- ◯ Acompanhado de desconhecidos
- ◯ Outro
- ◯ Outro

Especfique outro:

_____

Mudou para cá sozinho(a), ou veio acompanhado(a) por familiares, amigos, outros vizinhos? (2)

- Sozinho
- Acompanhado de familiares
- Acompanhado de amigos
- Acompanhado de vizinhos
- Acompanhado de desconhecidos
- Outro
- Outro

Especfique outro:

_____

O que atraiu a sua vinda para cá? (1)

_____

O que atraiu a sua vinda para cá? (2)

_____

Já trabalhava com agricultura/ pecuária/ floresta/ pesca antes daqui? (1)

- ☐ Não
- ☐ Agricultura
- ☐ Pecuária
- ☐ Floresta
- ☐ Pesca

Já trabalhava com agricultura/ pecuária/ floresta/ pesca antes daqui? (2)

- Não
- Agricultura
- Pecuária
- Floresta
- Pesca

» Composição da família

1

Nome (irrelevante, apenas para organizar do formulário)

_____

Idade

_____

Gênero

- ◯ Feminino
- ◯ Masculino

Trabalha na fazenda?

- ◯ Sim
- ◯ Não

Exerce alguma outra profissão?

_____

Renda e Produção

» Fonte de Renda

Qual a principal fonte de renda da sua família?

- ☐ Própria fazenda/ empreendimento
- ☐ Emprego no sector agropecuário
- ☐ Pesca
- ☐ Extrativismo
- ☐ Dividendos de empresa comunitária/ cooperativa
- ☐ Emprego em outro sector
- ☐ Aposentadoria
- ☐ Bolsa família
- ☐ Crédito ou subsídio agrícola
- ☐ Outro tipo de apoio do governo
- ☐ Apoio de ONG
- ☐ Pagamento por serviços ambientais
- ☐ Herança
- ☐ Renda de políticos locais
- ☐ Outro negócio ou empreendimento
- ☐ Outro

» Própria fazenda/ empreendimento

Especifique própria fazenda/ empreendimento: quais são as principais atividades realizadas?

- Pecuária de corte e/ou leiteira
- Agricultura temporária
- Agricultura perene/ SAF
- Manejo Florestal
- Outro

» » Pecuária

Especifique pecuária: quantidade de cabeças no rebanho

Possui outros animais (uso comercial)?*

- Peixe
- Galinha
- Porco
- Cavalo
- Búfalo
- Cabra
- Ovelha
- Outro

Especifique outros

Quais os principais produtos?

- Carne
- Leite
- Queijo
- Manteiga
- Coalhada
- Estrume
- Outro

Especifique outros

Renda média mensal com pecuária

» » Agricultura temporária

Especifique agricultura temporária: quais cultivos?

Renda médio mensal com agricultura temporária

» » Agricultura Perene/ SAF

Especifique agricultura perene: quais cultivos?

Possui consorcio com agricultura ou criacao de animais (SAF)?

Renda média mensal com agricultura temporária

» » Manejo florestal

Especifique manejo florestal (quando realizado na área do próprio lote): produtos:

- Toras
- Madeira serrada
- Poste
- Carvão
- Palha
- Frutas
- Plantas medicinais
- Mel
- Resina
- Látex
- Caça
- Outro

Especifique outro:

Possui consorcio com agricultura/ criacao de animais (SAF)?

Renda mensal com manejo florestal

» » Tecnologia e mercado

Que tipo de equipamentos e suplementos são usados?

- [ ] Maquinários
- [ ] Equipamentos
- [ ] Fertilizantes
- [ ] Agrotóxicos
- [ ] Outros

Especifique maquinários

Especifique equipamentos

Quais outros equipamentos e/ou suplementos agrícolas?

Contrata mão de obra de fora?

- ◯ Sim
- ◯ Não

De onde contrata mão de obra?

Quanto paga pela mão de obra?

Qual o mercado que você vende os produtos?

Qual é o principal meio de escoamento da produção para os mercados?

O Sr.(a) utiliza a BR-319 como meio de transporte da produção?

- ◯ Sim
- ◯ Não

» Emprego no sector agropecuário

Especifique: trabalho no sector agropecuário

_____

Renda média com trabalho no sector agropecuário

_____

» Pesca

Especifique pesca: local de pesca, principais peixes, outros

_____

Renda média mensal com pesca

_____

Qual o mercado que você vendo os produtos?

_____

Qual é o principal meio de escoamento da produção para os mercados?

_____

O Sr.(a) utiliza a BR-319 como meio de transporte da produção?

- ◯ Sim
- ◯ Não

» Extrativismo

Especifique extrativismo (em área de floresta fora do próprio lote): Produtos

- [ ] Tora
- [ ] Madeira serrada
- [ ] Poste
- [ ] Carvão
- [ ] Palha
- [ ] Frutas
- [ ] Plantas medicinais
- [ ] Mel
- [ ] Resina
- [ ] Látex
- [ ] Caça
- [ ] Outro

Especifique outro

Em qual área o extrativismo é realizado?

Qual o mercado que você vendo os produtos?

Como é o principal meio de escoamento da produção para os mercados?

O Sr.(a) utiliza a BR-319 como meio de transporte da produção?

- ◯ Sim
- ◯ Não

Renda média mensal com extrativismo

» Dividendos de empresa comunitária/ cooperativa

Especifique: Dividendos de empresa comunitária/ cooperativa

Renda média mensal com Dividendos de empresa comunitária/ cooperativa

_____

» Crédito ou subsídio agrícola

Especifique: Crédito ou subsídio agrícola

_____

Renda média mensal com Crédito ou subsídio agrícola

_____

» Aposentadoria

Especifique: renda média mensal com aposentadoria

_____

» Bolsa-família

Especifique: renda média mensal com bolsa-família

_____

» Outro tipo de apoio do governo

Especifique: Outro tipo de apoio do governo

_____

Renda média mensal com Outro tipo de apoio do governo

_____

» Apoio de ONG

Especifique: Apoio de ONG

_____

Renda média mensal com Apoio de ONG

_____

» Pagamento por serviços ambientais

Especifique: Pagamento por serviços ambientais

_____

Renda média mensal com Pagamento por serviços ambientais

» Herança

Especifique: Herança

Renda média mensal com Herança

» Renda de políticos locais

Especifique: Renda de políticos locais

Renda média mensal com Renda de políticos locais

» Emprego em outro sector

Especifique: emprego em outro sector

Renda média mensal com emprego em outro sector

» Outro negócio ou empreendimento

Especifique: Outro negócio ou empreendimento

Renda média mensal com Renda de políticos locais

» Outro

Especifique: Outro

Renda média mensal com Outro

Caracterização das principais atividades realizadas

Qual a área total (ha) da propriedade?

_____

Como é dividida a sua propriedade?

- [ ] Areas residencias
- [ ] Outras infraestruturas
- [ ] Pasto
- [ ] Cultivo temporário
- [ ] Cultivo perene
- [ ] Floresta 2ária intermediária (capoeira)
- [ ] Floresta 2ária adiantada (capoeira)
- [ ] Agrofloresta (sítio)
- [ ] Floresta primária
- [ ] Floresta plantada
- [ ] Rios, lagos, etc

Especifique áreas residencias: quantos hectares?

_____

Especifique outras infraestruturas: quantos hectares?

_____

Especifique pasto: quantos hectares?

_____

Especifique cultivo temporário: quantos hectares?

_____

Especifique cultivo perene quantos hectares?

_____

Especifique floresta 2ária intermediária (capoeira) quantos hectares?

_____

Especifique floresta 2ária adiantada (capoeira) quantos hectares?

_____

Especifique agrofloresta (sítio) quantos hectares?

Especifique floresta primária quantos hectares?

Especifique floresta plantada quantos hectares?

Especifique rios, lagos, etc quantos hectares?

O Sr./Sra. poderia fornecer mais detalhes sobre cada atividade? Como são organizadas essas atividades na propriedade? Poderia fazer um desenho da sua fazenda?

- ◯ Desenhar no papel
- ◯ Desenhar no tablet

Desenhe no tablet

Tire uma foto do desenho

Click here to upload file. (< 10MB)

Quais são os seus planos para os próximos 10 anos?

- [ ] Recuperação degradada ou área de desmatamento
- [ ] Expandir a área da agricultura
- [ ] Expandir área de pastagem
- [ ] Alterar / aumentar a área florestal
- [ ] Vender a terra e sair da região
- [ ] Venda a terra e mude para dentro da região
- [ ] Outro

Quais outros planos?

_____

Caracterização da propriedade

Nome da fazenda

_____

Ano de estabelecimento

yyyy _____

Município

_____

Selecionar área da fazenda no mapa

GPS coordinates can only be collected when outside.

latitude (x.y °)

_____

longitude (x.y °)

_____

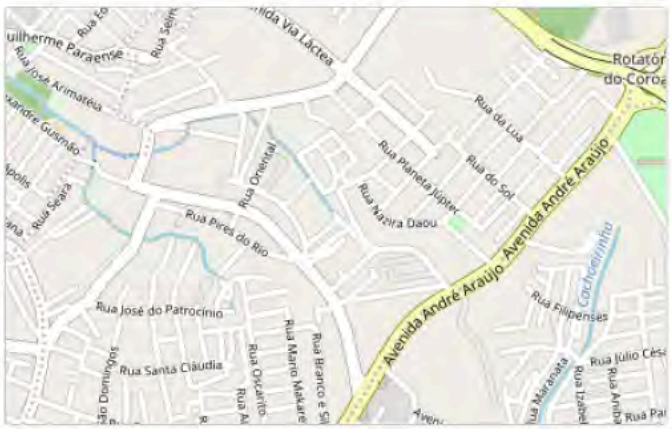
altitude (m)

_____

accuracy (m)

_____

KML



Tipo da propriedade

- ◯ Fazenda privada
- ◯ UC
- ◯ Assentamento INCRA
- ◯ Assentamento espontâneo
- ◯ Outro

Que outro tipo?

_____

A área pertence ao Sr.(a) ou à sua família?

- ◯ Terra pública sem direitos claros à terra (open access), uso individual/ familiar
- ◯ Terra pública sem direitos claros à terra (open access), uso comunitário
- ◯ Terra pública sem direitos claros à terra (open access), uso empresa privada
- ◯ Terra pública com direito concedido à comunidade, uso individual/ familiar
- ◯ Terra pública com direito concedido à comunidade, uso comunitário
- ◯ Terra pública com direito concedido à comunidade, uso empresa privada
- ◯ Terra privada, uso individual/ familiar
- ◯ Terra privada, uso comunitário
- ◯ Terra privada, uso empresa privada
- ◯ Outro

Especifique outro

_____

Se lembra qual o valor pago pela fazenda por hectare?

_____

Possui mais de uma propriedade?

- ◯ Sim
- ◯ Não

Quantas?

_____

Qual o tamanho dessa(s) outra(s) propriedade(s)?

_____

Acesso, participação e politicas públicas

Faz parte de cooperativa ou associação agrícola?

- ◯ Sim
- ◯ Não

Qual cooperativa ou associação agrícola?

_____

Recebe Assistência técnica?

- ◯ Sim
- ◯ Não

Que tipo de assistência e oferecida por qual órgão?

_____

Qual a distância da sua propriedade até o próximo ramal ou estrada?

_____

Qual a distância da sua propriedade até a rodovia BR-319?

_____

Qual a distância da sua propriedade até a escola mais próxima?

_____

Qual a distância da sua propriedade até o hospital mais próximo?

_____

Tem acesso a outro tipo de assistência à saúde (AAV, ou outros)?

- ◯ Sim
- ◯ Não

Qual tipo de assistência à saúde?

_____

Recebe algum outro tipo de assistência governamental?

- ◯ Sim
- ◯ Não

Qual?

_____

Quando foi a última vez que algum agente governamental passou por aqui?

Qual o motivo da passagem dele?

O Sr.(a) foi consultado alguma vez sobre a sua opinião quanto ao asfaltamento da BR-319?

- ◯ Sim
- ◯ Não

Como foi consultado?

E para planos de desenvolvimento / ordenamento territorial para a região?

- ◯ Sim
- ◯ Não

Como foi consultado?

O Sr.(a) sabe quais são os planos governamentais para a região?

- ◯ Sim
- ◯ Não

Quais são os planos que você conhece?

Coordenadas

Tipo de coleta

- ◯ Automática
- ◯ Manual (copiar do GPS)

Households survey database

_index	Occupation	Age1	Born_TC	Birth_state	Birth_region	Education	Time_migration1	Lived _TC_before	Migration_state1	Migration_region	Migration directly	Cohort1	Family	Return to family?	Health services	School	Job opp. - other	Job opp. - timber	Job opp. - agricul	Job opp. - NTFP	Business	To not be employ	Cheap/free land	Abundance of res	Good land quality	To have own land	Road construction	Easier production	Network info	Lack of knowledg	Rubber bust	BC_Agriculture	BC_Animal husba	BC_Forestry	BC_Fish	Age2	Time_region2	Lived_TC_before2	Migration_state2	Migration_region	Cohort2	No_BC_experienc	Agriculture_BC	Catlle_BC2	Forest_BC2	Fish_BC2	Children	Teenagers	Adults	Elderly
2	Community	49	Yes	AM	N	Iliterate	60s	1	AM	N	S	Homeplace	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	48	1983	1	AM	N	Familiares	0	1	0	0	1	0	1	2	0
4	Community	30	Yes	AM	N	Lower secondary	80s	1	AM	N	S	Homeplace	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1												1	1	2	0
5	Community	52	Yes	AM	N	Primary	70s	1	AM	N	S	Family	1	0	0	0	0	0	0	1	1	0	0	0	0	0	2	1	0	0	0	1	0	1	1												4	2	8	0
10	Community	32	Yes	AM	N	Primary	90s	1	AM	N	S	Family	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1												2	0	2	0
11	Farm	72	No	AL	NE	Iliterate	80s	0	PR	S	N	Family	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	61	1995	0	SC	SE	Familiares	0	1	1	0	0	0	0	2	1
12	Community	46	Yes	AM	N	Iliterate	90s	1	AM	N	S	Family	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	1	1												1	1	1	2
13	Community	68	Yes	AM	N	Primary	60s	1	AM	N	S	Family	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0												2	5	2	0
14	Community	84	Yes	AM	N	Iliterate	60s	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	1	1	0	0	48	Juntos	0	RO	N	Familiares	0	1	0	0	0	0	1	1	0
15	Community	77	Yes	AM	N	Primary	70s	1	AM	N	S	Family	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1												2	0	2	0
16	Settlement	58	No	PR	S	Iliterate	00s	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	1	1	0	1	1	79	1973	1	AM	N	Familiares	0	1	0	1	1	0	0	2	0
17	Settlement	40	No	AM	N	Upper secondary	70s	1	AM	N	S	Homeplace	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	78	1972	0	MG	SE	Familiares	0	1	0	0	0	0	2	0	1
18	Settlement	54	Yes	AM	N	Lower secondary	70s	1	AM	N	S	Family	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0												0	1	3	0
19	Settlement	87	No	MG	SE	Primary	70s	0	MG	SE	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0												2	1	2	0
20	Settlement	35	No	RO	N	Lower secondary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	32	2012	0	RO	N	Sozinho	1	0	0	0	0	0	0	2	0
21	Settlement	32	No	MG	SE	Tertiary - bachelor	after 2010	0	MT	MW	N	Family	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	1	64	1968	0	RO	N	Familiares	0	1	0	1	1	0	1	0	1
22	Settlement	46	No	ES	S	Primary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0												0	2	1	1
23	Settlement	54	No	BA	NE	Primary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	1	1	0	0	49	2017	0	RO	N	Familiares	0	1	1	0	0	3	0	2	0
24	Settlement	55	No	MS	MW	Primary	after 2010	0	CE	NE	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0												0	0	2	0
25	Settlement	53	No	PR	S	Tertiary - technical	70s	0	AM	N	S	Family	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	44	2004	1	AM	N	Familiares	0	1	0	1	1	1	0	1	0
26	Settlement	50	No	AM	N	Primary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	1	0	64	2011	0	RO	N	Familiares	0	1	0	0	0	1	0	1	0
27	Settlement	55	No	BA	NE	Primary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0												0	0	2	0
28	Settlement	36	Yes	AM	N	Lower secondary	after 2010	0	RO	N	N	Family	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0												1	2	2	0
29	Settlement	53	No	MG	SE	Upper secondary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0	0	1	1	0	0												0	2	3	0
30	Settlement	57	No	PR	S	Lower secondary	00s	0	MG	SE	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	47	2008	0	MG	SE	Familiares	0	1	0	0	0	1	2	2	0
31	Settlement	60	No	MS	MW	Tertiary - bachelor	after 2010	0	MT	MW	N	Family	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0												0	0	1	0
32	Settlement	42	No	AC	N	Iliterate	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	1	0	0	0	0												0	0	3	0
33	Settlement	37	Yes	AM	N	Primary	after 2010	1	AM	N	S	Family	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1												1	2	2	0
34	Settlement	27	No	SP	SE	Lower secondary	after 2010	0	SP	SE	S	Family	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0												2	0	2	0
35	Settlement	33	No	AM	N	Upper secondary	after 2010	0	AM	N	S	Family	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	31	2018	0	AM	N	Familiares	1	0	0	0	0	1	1	1	0
36	Settlement	47	No	RO	N	Primary	90s	0	AM	N	S	Family	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0												0	0	2	0
37	Settlement	46	No	RO	N	Lower secondary	70s	1	AM	N	S	Family	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	36	1982	1	AM	N	Nasceu aqui						2	3	4	0
38	Settlement	54	Yes	RO	N	Lower secondary	70s	0	RO	N	N	Family	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	50	1977	1	AM	N	Familiares	0	1	0	1	1	4	1	4	0
39	Settlement	35	Yes	AM	N	Lower secondary	after 2010	1	AM	N	S	Family	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0												1	2	2	0
40	Settlement	58	No	PR	S	Lower secondary	after 2010	0	RO	N	N	Alone	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	31	2016	0	MG	SE	Familiares	0	1	1	0	0	2	0	1	0
41	Settlement	51	No	PR	S	Primary	after 2010	0	MT	MW	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	1	59	1989	0	RO	N	Familiares	0	1	1	0	0	0	0	2	0
42	Settlement	57	No	ES	SE	Iliterate	after 2010	0	RO	N	N	Alone	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0												4	0	1	0
43	Settlement	35	No	RO	N	Primary	after 2010	0	MT	MW	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0												1	0	1	0
44	Settlement	26	No	RO	N	Upper secondary	after 2010	0	SC	S	N	Family	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0												0	1	2	0
45	Settlement	19	No	AM	N	Tertiary - technical	after 2010	0	AM	N	N	Family	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	1	1	0	0												0	0	1	0
46	Settlement	43	No	ES	SE	Lower secondary	00s	0	PA	N	N	Alone	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	1	0	0	1	1	0	0												0	0	2	0
47	Settlement	35	No	AC	N	Lower secondary	90s	1	AM	N	N	Family	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	1	1	0	0												4	0	2	0
48	Settlement	35	No	PR	S	Primary	after 2010	0	RO	N	N	Family	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0												2	0	1	0
49	Settlement	44	Yes	AM	N	Tertiary - bachelor	00s	0	AM	N	N	Alone	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0												0	1	1	0
50	Settlement	51	No	SC	S	Upper secondary	after 2010	0	RO	N	N	Alone	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0												2	1	2	0
	Farm	47	No	PR	S	Primary	80s	0	AC	N	N	Family	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0												0	0	1	0
52	Farm	61	No	SC	S	Tertiary - technical	90s	0	SC	S	S	Family	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	1	1	1	1												2	1	2	0
	Farm	34	No	PR	S	Lower secondary	after 2010	0	MG	SE	N	Family	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	76	1980	0	PR	S	Familiares	0	1	0	0	0	0	0	1	1
	Farm	54	No	MG	SE	Upper secondary	after 2010	0	RO	N	N	Family	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0												0	0	1	0

Farm	Job agricult. sector	Fishery	NTFP	Job other sector	Retirement	Bolsa-familia	Gov. support	Business	Other	Cattle	Temporary crops	Perennial crops	Forest mgmt.	Small animals	Livestock	Pig	Chicken	Farm products	Farm products meat	Farm products milk	SI_Cattle	SI_Small animals	Cassava	Pineapple	Yam	Potato	Pepper	Vegetables	Ginger	SI_Temporary crops	Banana	Açaí	Cocoa	Coffee	Cupuaçu	citrics	Pupunha	SI_Perennial crops	Logs	Açaí	Brazil nut	Oils	SI_Forest products	Forest mgt plan	SI_Farm	Fishery place	Fishery in PA	Fishery name PA	SI_Fishery	NTFP	Ext_açaí	Ext_oils	Ext_brazil nut	Ext_furniture	NTFP_place
1	0	1	1	0	0	1	0	0	0	0	1	1	0	0							0,00		1	1	1	1	1	1	150,00	1	1			1		1	150,00							300,00	rio igapo-acu	1	RDS Igapo-acu	400,00	Frutas Castanha	1	0	1	0	rio igapo-acu
0	0	0	0	1	1	1	0	0	0																																													
1	0	1	1	1	0	1	1	0	0	0	0	1	1	0							0,00								0,00	1	1						40,00	0	0	1	0	60,00	1	100,00	rio igapo-acu	1	RDS Igapo-acu	900,00	Outro	0	0	0	1	
1	0	1	0	0	0	1	1	0	0	0	1	1	1	0							0,00		1	1					15,00	1							133,00	0	0	1	0	66,00	0	214,00	rio igapo-acu	1	RDS Igapo-acu	833,00						
1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	110			Carne	1	0	1500,00								0,00															1500,00												
1	1	0	1	0	1	1	0	1	0	0	1	0	1	0							0,00		1						167,00									0	1	0	0	15,00	0	182,00					Frutas Castanha Outro	1	1	1	0	
1	0	0	0	0	0	1	0	0	0	0	0	0	1	0							0,00								0,00									0	0	1	0	134,00	0	134,00										
1	0	0	0	0	0	0	0	0	0	0	1	1	1	0							0,00		1						2000,00	1	1	1	1				2600,00	0	0	1	0	180,00	0	4780,00										
1	1	0	1	1	0	1	0	0	0	0	0	1	1	0							0,00								0,00	1							700,00	0	0	1	0	1120,00	0	1820,00					Frutas Outro	1	1	0	0	
0	0	0	1	1	1	0	0	0	0																																								Frutas Castanha Outro	1	1	1	0	
0	0	0	0	1	1	1	0	1	0																																												
0	0	0	0	1	0	0	0	1	0																																											
0	0	0	0	0	0	1	0	1	0																																											
1	0	0	0	1	0	0	0	0	0	0	1	1	1	0									1	1					300,00	1							600,00	1	0	0	0	200,00	1	1100,00										
1	0	0	0	0	1	1	0	0	0	0	1	0	1	1		0	1	Carne	1	0		20,00	1						83,00									0	0	1	0	105,00	0	188,00										
1	0	0	1	0	1	1	0	0	0	0	1	1	1	0							0,00		1		1				175,00	1	1						533,00	0	0	1	0	208,00	0	916,00					Castanha	0	0	1	0	
0	0	0	1	0	0	1	0	0	0																																							Castanha	0	0	1	0	sitio vizinho proximo ao assentamento
0	0	0	0	0	1	0	0	0	0																																											
0	0	0	1	1	0	0	0	0	1																																								Castanha	0	0	1	0	rio ipixuna
1	0	0	0	0	1	1	0	0	0	0	0	1	0	1		0	1	Carne	1	0		40,00						1	0,00	1		1			1		50,00							90,00										
1	0	0	0	0	0	0	0	0	1	0	0	1	0	0								0,00							0,00	1							208,00							208,00										
1	0	0	0	1	0	1	0	0	0	0	0	1	0	1		0	1	Carne	1	0		50,00							0,00	1							500,00							550,00										
0	0	0	0	1	1	0	0	1	0																																											
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0									1						750,00															750,00										
0	0	0	0	0	1	0	0	0	0																																											
0	1	0	0	0	0	0	0	0	0																																											
1	0	0	0	1	0	1	0	0	0	0	0	0	1	0							0								0,00									0	1	1	0	260,00		260,00										
0	0	0	0	1	0	1	0	0	0																																											
0	0	0	0	0	0	0	0	0	1	0																																											
0	0	0	0	1	0	1	0	0	0																																											
1	1	1	0	0	0	1	0	0	0	0	1	1	1	0							0,00		1						50,00	1	1						50,00	0	1	1	1	833,00	0	933,00	rio santo antonio	0		125,00						
0	0	0	0	1	1	1	0	0	0																																											
0	0	0	0	0	0	1	1	0	0																																											
1	1	0	0	0	0	1	0	0	0	1	0	0	1	1	51	1	1	Carne	1	0	3000,00	125,00							0,00									0	0	1	0	135,00		3260,00										
1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	17			Carne	1	0	625,00								0,00									0	0	1	0	20,00	0	645,00										
0	0	0	0	1	0	0	0	0	0																																										
1	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0						0,00								0,00	1							500,00	0	0	1	0	22,00		522,00										
1	0	0	0	0	1	0	0	0	0	0	0	0	1	0							0,00								0,00									0	0	1	0	185,00		185,00										
0	1	0	0	0	0	0	0	0	0																																										
1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	6			Leite	0	1	25,00								0,00	1	1	1					600,00							625,00					Resina Castanha	0	1	1	0	Fundiaria perto do ipixuna area da uc
0	1	0	0	1	0	1	0	0	1																																										
0	0	0	0	0	0	1	0	0	1																																										
1	0	0	0	1	0	0	1	0	0	0	1	1	0	0							0,00		1				1		800,00				1				5,00							805,00										
0	0	0	0	0	0	1	0	1	0																																										
0	0	0	1	1	0	1	0	0	0																																								Castanha Outro	0	0	1	0	entre realidde e rio santo antonio
0	0	1	1	0	0	1	0	0	0																																							rio Ipixuna	1		2000,00	Castanha	0	0	1	0	rio Ipixuna, no acarazao 35km de ramal
0	0	0	0	0	1	0	0	1	0																																										
0	0	0	0	0	0	0	0	1	0																																										

_	NTFP in PA	NTFP name PA	SI_NTFP	SI_Extractivism	Machinery	Motor-manual	Fertilizers	Pesticides	Hires labor force	Payment labor force	Cleaning pasture	Delimitation of land boundaries	Diagnosis of timber potential	Forest felling	Building of fences	Harvest	Farm manager	Planting pasture	SI_Job agricult. sector	SI_Retirement	SI_Bolsa-familia	Gov support type	SI_Gov. Support	SI_GovSupport2	Sportfishing	Health agent	Driver	Nanny	Butcher	Public agent	House cleaner	Teacher	Tree feller	Sawyer	Cabinet-maker	Nurse	Middle man	Telephone company	SI_Job other sector	Restaurant	B&B	Grocery store	Bakery	Log freight	Variety shop	House rental	Sawmill	Auto repair shop	SI_Business	SI Other type	SI_Other	SI_off	Market	Flow via middle man	Outflow via river	Outflow via subsidiary roads	Outflow via BR-319
	0		400,00	800,00	0	1	0	0	N												125,00				125,00																											na propria comunidade, Manaus	Yes	Yes	No	Yes
					0	0	0	0												1600,00	163,00				1763,00	1	0	0	0	0	0	0	0	0	0	0	0	0	1600,00													1600,00						
	1	RDS Igapo-acu	713,00	1613,00	0	1	0	0	N												362,00	Seguro-defeso	397,50	759,50	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	920,00													920,00	na propria comunidade, Manaus	Yes	Yes	No	Yes
				833,00	0	1	0	0	N												124,00	Seguro-defeso	397,50	521,50																																	na propria comunidade, Manaus	Yes	Yes	No	Yes
					0	0	0	1	S	70										930,00				930,00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3750,00													3750,00	Realidade	No	No	No	Yes
	1	FLONA Balata Tufari, exercito	1275,00	1275,00	0	1	0	0	N		1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	167,00	1908,00	120,00			2028,00																0	0	1	0	0	0	0	0	0	110,00			277,00	Humaita	Yes	No	No	Yes
					0	1	0	0	N												391,00			391,00																															Humaita	Yes	No	No	Yes
					1	1	1	1	S	70																																												Realidade, Humaitá	No	No	No	Yes
	1	FLONA Balata Tufari	280,00	280,00	1	1	0	1	N		0,00	1,00	1,00	0,00	0,00	0,00	0,00	0,00	8150,00		128,00			128,00	0	0	0	0	0	0	0	0	1	0	1	0	0	0	250,00													8400,00	Realidade, Humaitá	Yes	No	No	Yes
	1	FLONA Balata Tufari	5600,00	5600,00	0	0	0	0	N											2000,00				2000,00	0	0	1	0	0	0	0	0	1	0	0	0	0	0	891,00													891,00	Humaita	Yes	Yes	No	Yes
					0	0	0	0												1908,00	200,00			2108,00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1750,00	1	0	1	0	0	0	0	0	0	300,00			2050,00					
					0	0	0	0																	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1333,00	1	0	1	0	0	0	0	0	0	500,00			1833,00					
					0	0	0	0													375,00			375,00																0	0	0	1	0	0	0	0	0	2333,00			2333,00					
					1	0	1	1	N	0															0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	100,00													100,00	Realidade, Humaitá	Yes	No	No	Yes
					0	1	0	0	N											1908,00	124,00			2032,00																															na propria comunidade, Humaita	Yes	No	No	Yes
	1	FLONA Balata Tufari	200,00	200,00	0	1	0	0	N	0										954,00				954,00																															Humaita	Yes	No	No	Yes
	0		80,00	80,00	0	1	0	0	N												120,00			120,00																															Humaita	Yes	No	No	Yes
					0	0	0	0												1908,00				1908,00																																			
	1	?	45,00	45,00	0	0	0	0	N																0	0	0	0	0	0	0	0	0	1	0	1	0	0	1980,00											prestanista	250,00	2230,00	Humaita	Yes	No	No	Yes
					0	1	1	1	N											954,00	124,00			1078,00																															Humaita	Yes	No	No	Yes
					0	1	0	1	N																																										apoio familia	100	100,00	Humaita	Yes	No	No	Yes
					1	1	0	1	N												208,00			208,00	0	0	0	0	0	0	0	0	0	1	0	0	0	0	35,00													35,00	Humaita	Yes	No	No	Yes
					0	0	0	0												3200,00				3200,00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	600,00	0	0	0	0	1	0	0	0	0	500,00			1100,00					
					0	1	0	0	N																																												Realidade	No	No	Yes	Yes
					0	0	0	0												6700,00				6700,00																																			
					0	0	0	0			0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	5000,00																																						5000,00					
					0	1	0	0	N												248,00			248,00	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1700,00													1700,00	Humaita	Yes	No	No	Yes
					0	0	0	0													160,00			160,00	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1300,00													1300,00						
					0	0	0	0																																			0	0	0	0	0	1	0	0	0	2000,00			2000,00					
					0	0	0	0													120,00			120,00	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1270,00													1270,00						
				125,00	0	1	0	0	N		1,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	50,00		202,00			202,00																															50,00	Realidade, Humaitá	Yes	Yes	No	Yes
					0	0	0	0												954,00	212,00			1166,00	0	1	1	0	0	0	1	0	0	1	0	0	0	0	3836,00													3836,00						
					0	0	0	0													427,00	Pensão	150,00	577,00																																			
					1	1	0	1	S	70	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	800,00		163,00			163,00																															800,00	Humaita	No	No	No	Yes
					1	1	0	1	S	70										954,00				954,00																															Realidade	No	No	No	Yes
					0	0	0	0																	0	0	1	0	0	0	0	1	0	0	0	0	0	0	6000,00													6000,00						
					1	1	0	1	N												340,00			340,00																																			
					0	1	1	1	N											954,00				954,00																																			
					0	0	0	0			0,00	0,00	0,00	0,00	1,00	0,00	0,00	1,00	320,00																																						320,00						
	1	FLONA Balata Tufari	708,00	708,00	1	1	0	1	N											954,00				954,00																															Realidade, Humaitá	Yes	No	No	Yes
					0	0	0	0			0,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	106,00		241,00			241,00	0	0	0	0	0	0	0	0	0	1	0	0	0	0	100,00											venda de salgado	300,00	506,00						
					0	0	0	0													240,00			240,00																											apoio familia	250,00	250,00						
					0	1	1	1	N													Pensão	200,00	200,00	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1490,00													1490,00	Realidade	Yes	No	No	Yes
					0	0	0	0													340,00			340,00																0	0	0	0	0	1	0	0	1	8500,00			8500,00					
	0		170,00	170,00	0	0	0	0	N												270,00			270,00	0	0	0	0	0	0	0	0	1	0	0	0	0	0	600,00													600,00	Realidade	Yes	No	No	Yes
	1	?	500,00	2500,00	0	0	0	0	N												390,00			390,00																																			
																				1908,00				1908,00																1	1	0	0	0	0	0	0	0	400,00			400,00					
					0	0	0	0																																			0	0	0	0	0	0	0	1	0	10000,00			10000,00					

Expand temporary crops	Expand pasture	Expand perennial crops	Sell and move	Sell and stay	Fish-farming	Tourism	Remain the same	Share to land owned	Share land among children	Raise cattle	Agriculture modernization	Expand business	Acquire more land	Cooperative	Name coop	Tech Assist	Tech Assist agent	Distance road	Distance BR- 319	Distance school	Distance hospital	Other type of health services	Type of health services	Last gov visit	Gov visit body	Gov visit reason	Consult BR	Consultation BR- 319 type	Consult plans	Consultation territorial plans type	Awareness plans	Awareness of any plan type
0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	Yes Associacao da comunidade	No		7,00	7,00	0,00	147,00	1	Agente de saude	Nao lembra		Yes	jornalistas	Yes	jornalista	No	
1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Yes Associacao da comunidade	No		0,00	0,00	0,00	147,00	1	Agente de saude	05-2018	soltura de quelonios	sema, demuc, politicos, dnit	Yes	jornalistas, politicos, forum permanente da BR-319	No		Yes	Pavimentação, criação de reserva
1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	Yes Associacao da comunidade, Colonia de Pescadores Z-49	Yes	IDAM	14,00	14,00	0,00	145,00	1	Agente de saude	04-2018	soltura de quelonios	sema, demuc, politicos, dnit	Yes	jornalistas, sema, idesam, ufam	Yes	pesquisadores	No	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	No	No		3,00	3,00	0,00	145,00	1	Agente de saude	Nao lembra			No		No		No	
0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	Yes Associacao da comunidade	No		0,00	0,00	50,00	200,00	0			turismo	sema	Yes	viajantes, pesquisadores	No		No	
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	1,00	82,00	1	Agente de saude	Nao lembra			No		No		No	
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	18,00	82,00	1	Agente de saude	05-2017	censo	ibge	No		No		No	
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	50,00	50,00	1	Agente de saude	Nao lembra			No		No		Yes	Acabar com a estrada por causa do transporte via balsas
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	Yes Associacao da comunidade	No		0,00	0,00	40,00	40,00	1	Agente de saude	07-2018	controle malaria	fvs	No		No		No	
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	No	Yes	IDAM	0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	05-2017	agente de saude	SUS	No		Yes	censo agropecuario	No	
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	Yes	IDAM	2,00	2,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	Yes	jornalistas, associacao amigos e defensores da BR-319, pesquisadores, INCRA	Yes	jornalistas, associacao amigos e defensores da BR-319, pesquisadores, INCRA	No	
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	Yes	IDAM	0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	01-2018	censo	ibge	Yes	jornalistas	Yes	jornalistas	No	
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	Yes	jornalistas	Yes	jornalistas	No	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		No		No	
0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	Yes	IDAM	0,00	0,00	0,00	102,00	1	Posto de saúde, agente de saúde	06-2016	censo	ibge	No		No		No	
1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	No		2,00	2,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		No		No	
1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	No	No		0,00	2,00	0,00	102,00	1	Posto de saúde, agente de saúde	Nunca			No		No		No	
1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	No	No		1,00	4,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	No		No		No	
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	15,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	Yes	jornalistas	Yes	politicos	No	
1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	Yes	IDAM	0,00	17,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	assistencia técnica	idam	No		No		No	
1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	No	No		0,00	14,00	0,00	100,00	1	Posto de saúde, agente de saúde	Nao lembra			No		No		Yes	Criacao do distrito de realidade e construção das vicinais
1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	Yes ASPRU AssociaCAo de Produtores Rurais da Comunidade Extrativista de Realidade	Yes	IDAM	0,00	2,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	controle malaria	fvs	No		No		No	
1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	Yes Associacao de Produtores de Nova Esperanca	Yes	IDAM	0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	Yes	associacao comunidade, politicos	No		Yes	distrito, recuperacao ramais
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	No	Yes	IDAM	0,00	8,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	No		No		No	
1	0	1	0	1	0	0	0	0	1	0	1	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	Nunca			No		No		Yes	Esta a par do processo de asfaltamento via andre marsilio recebe email
0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	No	No		0,00	20,00	0,00	100,00	1	Posto de saúde, agente de saúde	06-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	No		No		No	
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	No	No		0,00	2,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		No		No	
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	Yes	grupo whatsapp	Yes	distrito, recuperacao ramais		
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	No			0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		No		Yes	distrito, recuperacao ramais
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	No	Yes	IDAM	0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	Yes	jornalistas	No	jornalistas	Yes	jornalistas
1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	Yes Sindicato rural de humaita	No		0,00	2,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		No		Yes	asfaltar a estrada
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	No	No		0,00	0,00	1,00	99,00	1	Posto de saúde, agente de saúde	07-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	Yes	politicos	Yes	politicos	Yes	distrito, recuperacao ramais
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	No			0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	controle malaria	fvs	No		No		No	
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	16,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		Yes	associacao comunidade	Yes	distrito, recuperacao ramais
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	No	No		8,00	16,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2019	agente de saude	sus	No		Yes	politicos	Yes	distrito, recuperacao ramais
1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	No	No		0,00	0,00	25,00	185,00	1	Posto de saúde, agente de saúde	Nunca			No		No		No	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	No		No		No	
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	No	No		0,00	6,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	controle malaria	fvs	No		No		Yes	distrito, recuperacao ramais
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	Nunca			No		Yes	Reuniao em realidade	Yes	Apoitar as linhas vicinais, plano para virar distrito e possibildaes de financiamento para agricultura
0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	agente de saude	sus	Yes	politicos	No		Yes	distrito, recuperacao ramais
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	Yes	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	Nunca			Yes	Estava em reuniao na escola e na rodoviaria _ pessoal da comitiva, ano passado Andre marsilio passa direto clm q comitiva dele, querendo a br	Yes	Reuniao prâfeito no mes passadoou retrasado. Na escola	Yes	Abertura de vicinais, q iriam mexermasd ruas de realidade, encanação de água, e o plano de virar distrito
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0 No	No		15,00	15,00	0,00	100,00	1	Posto de saúde, agente de saúde	Nao lembra			No		No		No	
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	07-2018	reuniao sobre distrito ramais e fomento agricola	prefeito de humaita, vereadores de humaita, idam	No		No		No	
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	No	No		0,00	0,00	0,00	100,00	1	Posto de saúde, agente de saúde	04-2018	fiscalizacao	ipaam	No		No		No	
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	Yes Associacao de Produtores de Nova Esperanca	No		0,00	0,00	42,00	142,00	1	Agente de saude	07-2018	agente de saude	sus	No		No		No	
1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	Yes Associacao de Produtores de Nova Esperanca	No		0,00	0,00	100,00	200,00	1	Agente de saude	06-2018	censo	ibge	Yes	jornalistas, viajantes	No		No	
1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	No	No		0,00	0,00	27,00	127,00	1	Agente de saude	03-2018	censo	ibge	No		Yes	Reunião prefeitura e luz para todos sobre trazer energia pra ca		
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	No	No		0,00	1,00	2,50	102,50	1	Posto de saúde, agente de saúde	04-2018	uso castanhais FLONA Balata Tufari	icmbio	No		No		No	

R codes

Demographic characteristics

```
library(readxl)
library(tidyverse)
library(dplyr)
library(tidyr)
library(reshape2)
library(scales)
library(ggplot2)
library(tibble)
library(fmsb)
library(ggplot2)
library(ggradar)
library(devtools)
library(rCharts)

data <- read_xlsx(path = "/Users/marco/Dropbox/Marcolleta/Thesis/Data Analysis/HH/Database_adapted_2.3_divided.xlsx",
sheet = 1) #choose file

# Birth Region
Birth  <- data %>% group_by(Occupation, Birth_region) %>% summarise(Total= n())

Birth.com <- Birth %>% filter(Occupation == "Community")
Birth.com <- Birth.com %>% mutate(Percentage = Total / 8 * 100)

Birth.farm <- Birth %>% filter(Occupation == "Farm")
Birth.farm <- Birth.farm %>% mutate(Percentage = Total / 5 * 100)

Birth.sett <- Birth %>% filter(Occupation == "Settlement")
Birth.sett <- Birth.sett %>% mutate(Percentage = Total / 35 * 100)

Birth.merg <- rbind(Birth.com, Birth.farm, Birth.sett)

Birth.merg  %>% mutate(Birth_region = factor( Birth_region, levels =  c("S", "SE", "MW", "NE", "N"))) %>%   ggplot(., aes(x= Birth_region, y= Percentage, fill= Occupation))+ geom_col(position = 'dodge') + ylab("% - N° Families") +   xlab("Birth region") + facet_grid(Occupation~.) + theme_light(base_size = 13) +  theme(legend.position = "none")

# Birth state
Birth2 <- data %>% group_by(Occupation, Birth_state) %>% summarise(Total= n())

Birth2.com <- Birth2 %>% filter(Occupation == "Community")
Birth2.com <- Birth2.com %>% mutate(Percentage = Total / 8 * 100)

Birth2.farm <- Birth2 %>% filter(Occupation == "Farm")
Birth2.farm <- Birth2.farm %>% mutate(Percentage = Total / 5 * 100)

Birth2.sett <- Birth2 %>% filter(Occupation == "Settlement")
Birth2.sett <- Birth2.sett %>% mutate(Percentage = Total / 35 * 100)

Birth.merg <- rbind(Birth2.com, Birth2.farm, Birth2.sett)
```

```
Birth.merg  %>% mutate(Birth_state = factor( Birth_state, levels =
c("SC","PR","ES","MG","SP","MS","AL","BA","AC","AM","RO"))) %>% ggplot(., aes(x=
Birth_state, y= Percentage, fill= Occupation))+ geom_col(position = 'dodge') + ylab("% - N°
Families") +    xlab("Birth State") + facet_grid(Occupation~.) + theme_light(base_size = 13) +
  theme(legend.position = "none")

# Birth (no separation)
Birth3 <- data %>% group_by(Birth_state) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)

Birth4 <- data %>% group_by(Birth_region) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)

# Born in traditional communities
Ribeirinho <- data %>% group_by(Occupation, Born_TC) %>% summarise(Total= n())

Ribeirinho.com <- Ribeirinho %>% filter(Occupation == "Community")
Ribeirinho.com <- Ribeirinho.com %>% mutate(Percentage = Total / 8 *100)

Ribeirinho.farm <- Ribeirinho %>% filter(Occupation == "Farm")
Ribeirinho.farm <- Ribeirinho.farm %>% mutate(Percentage = Total / 5 *100)

Ribeirinho.sett <- Ribeirinho %>% filter(Occupation == "Settlement")
Ribeirinho.sett <- Ribeirinho.sett %>% mutate(Percentage = Total / 35 *100)

Ribeirinho.merg <- rbind(Ribeirinho.com, Ribeirinho.farm, Ribeirinho.sett)

# Direct Migration
Migr_orig <- data %>% group_by(Occupation, `Migration directly`) %>% summarise(Total=
n())

Migr_orig.com <- Migr_orig  %>% filter(Occupation == "Community")
Migr_orig.com <- Migr_orig.com %>% mutate(Percentage = Total / 8 * 100)

Migr_orig.farm <- Migr_orig  %>% filter(Occupation == "Farm")
Migr_orig.farm <- Migr_orig.farm %>% mutate(Percentage = Total / 5 * 100)

Migr_orig.sett <- Migr_orig  %>% filter(Occupation == "Settlement")
Migr_orig.sett <- Migr_orig.sett %>% mutate(Percentage = Total / 35 * 100)

Migr_orig.merg <- rbind(Migr_orig.com, Migr_orig.farm, Migr_orig.sett)

Migration3 <- data %>% group_by(`Migration directly`) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)

# Direct Migration (no separation)
Migr_orig.2 <- data %>% group_by(`Migration directly`) %>% summarise(Total= n()) %>%
mutate(Percentage = Total / 48 * 100)

# Place previous migration
Migration_place <- data %>% group_by(Occupation, Migration_region1) %>% summa-
rise(Total= n())

Migration_place.com <- Migration_place %>% filter(Occupation == "Community")
Migration_place.com <- Migration_place.com %>% mutate(Percentage = Total / 8 *100)
```

```
Migration_place.farm <- Migration_place %>% filter(Occupation == "Farm")
Migration_place.farm <- Migration_place.farm %>% mutate(Percentage = Total / 5 *100)

Migration_place.sett <- Migration_place %>% filter(Occupation == "Settlement")
Migration_place.sett <- Migration_place.sett %>% mutate(Percentage = Total / 35 *100)

Migration_place.merg <- rbind(Migration_place.com, Migration_place.farm, Migra-
tion_place.sett)

# State previous migration
Migration_state <- data %>% group_by(Occupation, Migration_state1) %>% summarise(Total=
n())

Migration_state2 <- data %>% group_by(Migration_state1) %>% summarise(Total= n()) %>%
mutate(Percentage = Total / 48 * 100)
Migration_place2 <- data %>% group_by(Migration_region1) %>% summarise(Total= n())
%>% mutate(Percentage = Total / 48 * 100)

Migration_state.com <- Migration_state %>% filter(Occupation == "Community")
Migration_state.com <- Migration_state.com %>% mutate(Percentage = Total / 8 * 100)

Migration_state.farm <- Migration_state %>% filter(Occupation == "Farm")
Migration_state.farm <- Migration_state.farm %>% mutate(Percentage = Total / 5 * 100)

Migration_state.sett <- Migration_state %>% filter(Occupation == "Settlement")
Migration_state.sett <- Migration_state.sett %>% mutate(Percentage = Total / 35 * 100)

Migration.merg <- rbind(Migration_state.com, Migration_state.farm, Migration_state.sett)

# Previous migration (no separation)
Migration_place2 <- data %>% group_by(Migration_region1) %>% summarise(Total= n())
%>% mutate(Percentage = Total / 48 * 100)
Migration_place3 <- data %>% group_by(Migration_state1) %>% summarise(Total= n()) %>%
mutate(Percentage = Total / 48 * 100)

# Migration Reason
Migration_reason <- data %>% select(Occupation, `Cheap/free land`, `Abundance of resources`,
`Good land quality`, `To have own land`, `To not be employee anymore`, `Rubber bust`, `Job
opp. - NTFP`, `Job opp. - timber`, `Job opp. - agriculture`, `Job opp. - other`, `Business`, `Road
construction`, `Easier production flow`, `Network info`, `Family`, `Return to family's
land`,`Health services`, `School`, `Lack of knowledge` )

Migration_reason <- Migration_reason %>% group_by(Occupation) %>% summa-
rise(`Cheap/free land` = sum(`Cheap/free land`, na.rm = TRUE),  `Abundance of resources` =
sum(`Abundance of resources`, na.rm = TRUE),  `Good land quality` = sum(`Good land quality`,
na.rm = TRUE), `To have own land` = sum(`To have own land`, na.rm = TRUE),   `To not be
employee anymore` = sum(`To not be employee anymore`, na.rm = TRUE), `Rubber bust` =
sum(`Rubber bust`, na.rm = TRUE),   `Job opp. - NTFP` = sum(`Job opp. - NTFP`, na.rm =
TRUE),`Job opp. - timber` = sum(`Job opp. - timber`, na.rm = TRUE),   `Job opp. - agriculture`=
sum(`Job opp. - agriculture`, na.rm = TRUE), `Job opp. - other` = sum(`Job opp. - other`, na.rm =
TRUE),   `Business` =sum(`Business`, na.rm = TRUE), `Road construction` = sum(`Road con-
struction`, na.rm = TRUE),   `Easier production flow` = sum(`Easier production flow`, na.rm =
TRUE), `Network info` = sum(`Network info`, na.rm = TRUE),   Family = sum(Family, na.rm =
TRUE), `Return to family's land` = sum(`Return to family's land`, na.rm = TRUE),   `Health ser-
vices` = sum(`Health services`, na.rm = TRUE), `School` = sum(`School`, na.rm = TRUE),
`Lack of knowledge` = sum(`Lack of knowledge`, na.rm = TRUE))
```

```
Migration_reason <- as_tibble(cbind.data.frame(Migration_reason[,1], Migration_reason[,-1]/
rowSums(Migration_reason[,-1])))

Migration_reason <- Migration_reason %>% mutate(`Cheap/free land`= `Cheap/free land` * 100,
`Abundance of resources` = `Abundance of resources` * 100, `Good land quality` = `Good land
quality`* 100, `To have own land` = `To have own land`*100, `To not be employee anymore` =
`To not be employee anymore` * 100, `Rubber bust` = `Rubber bust`* 100, `Job opp. - NTFP` =
`Job opp. - NTFP` * 100, `Job opp. - timber` = `Job opp. - timber`* 100, `Job opp. - agriculture`=
`Job opp. - agriculture`* 100, `Job opp. - other` = `Job opp. - other`* 100, `Business` = `Busi-
ness`* 100, `Road construction` = `Road construction`* 100, `Easier production flow` = `Easier
production flow`* 100, `Network info` = `Network info`* 100, Family = Family* 100, `Return to
family's land` = Return to family's land`* 100, `Health services` = `Health services`* 100,
`School` = `School`* 100, `Lack of knowledge` = `Lack of knowledge`* 100)

Migration_reason.melt <- melt(Migration_reason)

# Initial settlement
Time_arrival <- data %>% group_by(Occupation, Time_migration1) %>% summarise(Total=
n())

Time_arrival.com <- Time_arrival %>% filter(Occupation == "Community")
Time_arrival.com <- Time_arrival.com %>% mutate(Percentage = Total / 8 *100)

Time_arrival.farm <- Time_arrival %>% filter(Occupation == "Farm")
Time_arrival.farm <- Time_arrival.farm %>% mutate(Percentage = Total / 5 *100)

Time_arrival.sett <- Time_arrival %>% filter(Occupation == "Settlement")
Time_arrival.sett <- Time_arrival.sett %>% mutate(Percentage = Total / 35 *100)

Time_arrival.merg <- rbind(Time_arrival.com, Time_arrival.farm, Time_arrival.sett)

Time_arrival.merg %>% mutate(Time_migration1 = factor( Time_migration1, levels =  c("60s",
"70s", "80s", "90s", "00s", "after 2010"))) %>% ggplot(., aes(x= Time_migration1, y= Percent-
age, fill= Occupation)) + geom_col(position = 'dodge') + ylab("% - N° Families") +  xlab("Time
of arrival") + facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(legend.position =
"none")

# Initial settlement (no separation)
Time_arrival2 <- data %>% group_by(Time_migration1) %>% summarise(Total= n()) %>%
mutate(Percentage = Total / 48 * 100)

# Education
Education <- data %>% group_by(Occupation, Education) %>% summarise(Total= n())

Education.com <- Education %>% filter(Occupation == "Community")
Education.com <- Education.com %>% mutate(., Percentage = Total / 8 *100)

Education.farm <- Education %>% filter(Occupation == "Farm")
Education.farm <- Education.farm %>% mutate(., Percentage = Total / 5 *100)

Education.sett <- Education %>% filter(Occupation == "Settlement")
Education.sett <- Education.sett %>% mutate(Percentage = Total / 35 *100)

Education.merg <- rbind(Education.com, Education.farm, Education.sett)
```

```
Education.merg  %>% mutate(Education = factor( Education, levels =  c("Iliterate", "Primary", "Lower secondary", "Upper secondary",   "Tertiary - technical", "Tertiary - bachelor"))) %>% ggplot(., aes(x= Education, y= Percentage, fill= Occupation)) + ylab("% - N° Families") +
  xlab("Education levels") + geom_col(position = 'dodge') + facet_grid(Occupation~.) + theme_light(base_size = 13) +  theme(text = element_text(size=12),axis.text.x = element_text(angle=30, hjust=1)) + theme(legend.position = "none") +   labs(caption = "(Standars by International Standard Classification of Education 2011, UNESCO)")

#Education per region
Education2 <- data %>% group_by(Birth_region, Education) %>% summarise(Total= n())

Education2.N <- Education2 %>% filter(Birth_region == "N")
Education2.N <- Education2.N %>% mutate(., Percentage = Total / 25 *100)

Education2.NE <- Education2 %>% filter(Birth_region == "NE")
Education2.NE <- Education2.NE %>% mutate(., Percentage = Total / 3 *100)

Education2.MW <- Education2 %>% filter(Birth_region == "MW")
Education2.MW <- Education2.MW %>% mutate(Percentage = Total / 2 *100)

Education2.SE <- Education2 %>% filter(Birth_region == "SE")
Education2.SE <- Education2.SE %>% mutate(Percentage = Total / 7 *100)

Education2.S <- Education2 %>% filter(Birth_region == "S")
Education2.S <- Education2.S %>% mutate(Percentage = Total / 11 *100)

Education2.merg <- rbind(Education2.N, Education2.NE, Education2.MW, Education2.SE, Education2.S)

Education2.merg  %>% mutate(Education = factor( Education, levels =  c("Iliterate", "Primary", "Lower secondary",  "Upper secondary", "Tertiary - technical", "Tertiary - bachelor"))) %>% ggplot(., aes(x= Education, y= Percentage, fill= Birth_region)) + ylab("% - N° Families") + xlab("Education levels") + geom_col(position = 'dodge')  + theme_light(base_size = 13) + theme(text = element_text(size=12),axis.text.x = element_text(angle=30, hjust=1)) + theme(legend.position = "right")

#Education (no separation)
Education3  <- data %>% group_by(Education) %>% summarise(Total= n()) %>% mutate(Percentage = Total / 48 * 100)

# Backgroung experiences
BCexp <- data %>% select(Occupation, BC_Agriculture, `BC_Animal husbandry`, BC_Forestry, BC_Fish)

BCexp <- BCexp %>% group_by(Occupation) %>% summarise(Agriculture = sum(BC_Agriculture, na.rm = FALSE),
 `Animal husbandry` = sum(`BC_Animal husbandry`, na.rm = FALSE), Forestry = sum(BC_Forestry, na.rm = FALSE), Fishery = sum(BC_Fish, na.rm = FALSE))

BCexp.com <- BCexp %>% filter(Occupation == "Community")
BCexp.com <- BCexp.com %>% mutate(Agriculture = Agriculture  / 8 *100, `Animal husbandry` = `Animal husbandry` / 8 *100,
   Forestry = Forestry / 8 *100, Fishery = Fishery/ 8*100)

BCexp.farm <- BCexp %>% filter(Occupation == "Farm")
```

```
BCexp.farm <- BCexp.farm %>% mutate(Agriculture = Agriculture  / 5 *100, `Animal husband-
ry` = `Animal husbandry` / 5 *100,
  Forestry = Forestry / 5 *100, Fishery = Fishery/ 5 * 100)

BCexp.sett <- BCexp %>% filter(Occupation == "Settlement")
BCexp.sett <- BCexp.sett %>% mutate(Agriculture = Agriculture  / 35 *100, `Animal husbandry`
= `Animal husbandry` / 35 *100,
  Forestry = Forestry / 35 *100, Fishery = Fishery/ 35 * 100)

BCexp.merg <- rbind(BCexp.com, BCexp.farm, BCexp.sett)

BCexp.melt <- melt(BCexp.merg)

# Backgroung experiences (no separation)
BCEXp2 <- data %>% group_by(BC_Agriculture, `BC_Animal husbandry`, BC_Forestry,
BC_Fish) %>%  summarise(Agriculture = sum(BC_Agriculture, na.rm = FALSE), `Animal hus-
bandry` = sum(`BC_Animal husbandry`, na.rm = FALSE), Forestry = sum(BC_Forestry, na.rm =
FALSE), Fishery = sum(BC_Fish, na.rm = FALSE))
```

Income

```
data <- read_xlsx(path = "/Users/marco/Dropbox/Marcolleta/Thesis/Data Analy-
sis/HH/Database_adapted_2.3_divided.xlsx", sheet = 2)

# N° of families engaged in diferent sources of Income
Income <- data %>% select(Occupation, Farm, Fishery, NTFP, `Job agricult. sector`, `Job other
sector`, Retirement, `Bolsa-familia`, `Gov. support`, Business, Other)

Income <- Income %>% group_by(Occupation) %>% summarise(Farm = sum(Farm, na.rm =
FALSE), Fishery = sum(Fishery, na.rm = FALSE),   NTFP = sum(NTFP, na.rm = FALSE), `Job
agricult. sector` = sum(`Job agricult. sector`, na.rm = FALSE),   `Job other sector` = sum(`Job
other sector`, na.rm = FALSE),  Retirement = sum(Retirement, na.rm = FALSE),   `Bolsa-
familia` = sum( `Bolsa-familia`, na.rm = FALSE), `Gov. support` = sum(`Gov. support`, na.rm =
FALSE), Business = sum(Business, na.rm = FALSE),  Other = sum(Other, na.rm = FALSE))

Income.com <- Income %>% filter(Occupation == "Community")
Income.com <- Income.com %>% mutate(Farm = Farm / 8*100, Fishery = Fishery / 8 * 100,
NTFP = NTFP/ 8 * 100,  `Job agricult. sector`= `Job agricult. sector` / 8 * 100, `Job other sector`
= `Job other sector` / 8 * 100,  Retirement = Retirement / 8 * 100, `Bolsa-familia` = `Bolsa-
familia`/ 8 * 100, `Gov. support` = `Gov. support`/ 8 * 100, Business = Business/ 8 * 100, Other
= Other/ 8 * 100)

Income.farm <- Income %>% filter(Occupation == "Farm")
Income.farm <- Income.farm %>% mutate(Farm = Farm / 5*100, Fishery = Fishery / 5 * 100,
NTFP = NTFP/ 5 * 100,   `Job agricult. sector`= `Job agricult. sector` / 5 * 100, `Job other sector`
= `Job other sector` / 5 * 100,  Retirement = Retirement / 5 * 100,   `Bolsa-familia` = `Bolsa-
familia`/ 5 * 100, `Gov. support` = `Gov. support`/ 5 * 100, Business = Business/ 5 * 100, Other
= Other/ 5 * 100)

Income.sett <- Income %>% filter(Occupation == "Settlement")
Income.sett <- Income.sett %>% mutate(Farm = Farm / 35*100, Fishery = Fishery / 35 * 100,
NTFP = NTFP/ 35 * 100,    `Job agricult. sector`= `Job agricult. sector` / 35 * 100, `Job other
sector` = `Job other sector` / 35 * 100,  Retirement = Retirement / 35 * 100,   `Bolsa-familia` =
`Bolsa-familia`/ 35 * 100, `Gov. support` = `Gov. support`/ 35 * 100, Business = Business/ 35 *
100, Other = Other/ 35 * 100)

Income.merg <- rbind(Income.com, Income.farm, Income.sett)
```

```
Income.melt <- melt(Income.merg)

Income.melt %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + geom_col(position =
'dodge') + ylab("% - N° of families") +
  xlab("Sources of income") + facet_grid(Occupation~.) + theme_light(base_size = 13) +
theme(text = element_text(size=12),
 axis.text.x = element_text(angle=30, hjust=1)) + theme(legend.position = "none")

# Income Participation in Livelihood
Income_Part <- data %>% select(Occupation, SI_Farm, SI_Fishery, SI_NTFP, `SI_Job agricult.
sector`, SI_Retirement, `SI_Bolsa-família`, `SI_Gov. Support`,`SI_Job other sector`,
SI_Business, SI_Other)

Income_Part2 <- Income_Part %>% group_by(Occupation) %>% summarise(SI_Farm =
mean(SI_Farm, na.rm = TRUE), SI_Fishery = mean(SI_Fishery,   na.rm = TRUE), SI_NTFP =
mean(SI_NTFP, na.rm = TRUE), `SI_Job agricult. sector`= mean(`SI_Job agricult. sector`, na.rm
= TRUE),   SI_Retirement = mean(SI_Retirement, na.rm = TRUE), `SI_Bolsa-família` =
mean(`SI_Bolsa-família`, na.rm = TRUE), `SI_Gov. Support`= mean(`SI_Gov. Support`, na.rm =
TRUE), `SI_Job other sector`= mean(`SI_Job other sector`, na.rm = TRUE), SI_Business =
mean(SI_Business, na.rm = TRUE), SI_Other = mean(SI_Other, na.rm = TRUE))

Income_Part.com <- Income_Part2 %>% filter(Occupation == "Community")
Income_Part.com <- Income_Part.com %>% mutate(Total = sum(SI_Farm, SI_Fishery,
SI_NTFP, `SI_Job agricult. sector`, SI_Retirement, `SI_Bolsa-família`, `SI_Gov. Support`,
`SI_Job other sector`, SI_Business, SI_Other, na.rm = TRUE))
Income_Part.com <- Income_Part.com %>% mutate(SI_Farm = SI_Farm / Total * 100,
SI_Fishery = SI_Fishery / Total * 100,
  SI_NTFP = SI_NTFP/ Total * 100, `SI_Job agricult. sector`= `SI_Job agricult. sector` / Total *
100,   `SI_Job other sector` = `SI_Job other sector` / Total * 100,  SI_Retirement = SI_Retirement
/ Total * 100,   `SI_Bolsa-família` = `SI_Bolsa-família`/ Total * 100, `SI_Gov. Support` =
`SI_Gov. Support`/ Total * 100,   SI_Business = SI_Business/ Total * 100, SI_Other = SI_Other/
Total * 100)

Income_Part.farm <- Income_Part2 %>% filter(Occupation == "Farm")

Income_Part.farm <- Income_Part.farm %>% mutate(Total = sum(SI_Farm, SI_Fishery,
SI_NTFP, `SI_Job agricult. sector`, SI_Retirement, `SI_Bolsa-família`,   `SI_Gov. Support`,
`SI_Job other sector`, SI_Business, SI_Other, na.rm = TRUE))

Income_Part.farm <- Income_Part.farm %>% mutate(SI_Farm = SI_Farm / Total*100,
SI_Fishery = SI_Fishery / Total * 100,
  SI_NTFP = SI_NTFP/ Total * 100, `SI_Job agricult. sector`= `SI_Job agricult. sector` / Total *
100,   `SI_Job other sector` = `SI_Job other sector` / Total * 100,  SI_Retirement = SI_Retirement
/ Total * 100,   `SI_Bolsa-família` = `SI_Bolsa-família`/ Total * 100, `SI_Gov. Support` =
`SI_Gov. Support`/ Total * 100,   SI_Business = SI_Business/ Total * 100, SI_Other = SI_Other/
Total * 100)

Income_Part.sett <- Income_Part2 %>% filter(Occupation == "Settlement")
Income_Part.sett <- Income_Part.sett %>% mutate(Total = sum(SI_Farm, SI_Fishery, SI_NTFP,
`SI_Job agricult. sector`, SI_Retirement, `SI_Bolsa-família`,   `SI_Gov. Support`, `SI_Job other
sector`, SI_Business, SI_Other, na.rm = TRUE))
Income_Part.sett <- Income_Part.sett %>% mutate(SI_Farm = SI_Farm / Total*100, SI_Fishery
= SI_Fishery / Total * 100,   SI_NTFP = SI_NTFP/ Total * 100, `SI_Job agricult. sector`=
`SI_Job agricult. sector` / Total * 100,   `SI_Job other sector` = `SI_Job other sector` / Total *
100, SI_Retirement = SI_Retirement / Total * 100,   `SI_Bolsa-família` = `SI_Bolsa-família`/
```

```
Total * 100, `SI_Gov. Support` = `SI_Gov. Support`/ Total * 100,   SI_Business = SI_Business/
Total * 100, SI_Other = SI_Other/ Total * 100)

Income_Part.merg <- rbind(Income_Part.com, Income_Part.farm, Income_Part.sett)
Income_Part.merg <- Income_Part.merg %>% select(Occupation, SI_Farm, SI_Fishery,
SI_NTFP, `SI_Job agricult. sector`, `SI_Job other sector`, SI_Retirement, `SI_Bolsa-família`,
`SI_Gov. Support`, SI_Business, SI_Other)

Income_Part.melt <- melt(Income_Part.merg)

Income_Part.melt %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + ge-
om_col(position = 'dodge') +  ylab("% - Amount of income per total") +   xlab("Sources of in-
come") + facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(text = ele-
ment_text(size=12),   axis.text.x = element_text(angle=30, hjust=1)) + theme(legend.position =
"none")

# Summary Income - oabsolute values
Income_mean <- data %>% group_by(Occupation) %>% summarise(SI_Farm = mean(SI_Farm,
na.rm = TRUE), SI_Fishery = mean(SI_Fishery,  na.rm = TRUE), SI_NTFP = mean(SI_NTFP,
na.rm = TRUE), `SI_Job agricult. sector`= mean(`SI_Job agricult. sector`, na.rm = TRUE),
 SI_Retirement = mean(SI_Retirement, na.rm = TRUE), `SI_Bolsa-família` = mean(`SI_Bolsa-
família`, na.rm = TRUE), `SI_Gov. Support`= mean(`SI_Gov. Support`, na.rm = TRUE), `SI_Job
other sector`= mean(`SI_Job other sector`, na.rm = TRUE),  SI_Business = mean(SI_Business,
na.rm = TRUE), SI_Other = mean(SI_Other, na.rm = TRUE))

Income_max <- data %>% group_by(Occupation) %>% summarise(SI_Farm = max(SI_Farm,
na.rm = TRUE), SI_Fishery = max(SI_Fishery,  na.rm = TRUE), SI_NTFP = max(SI_NTFP,
na.rm = TRUE), `SI_Job agricult. sector`= max(`SI_Job agricult. sector`, na.rm = TRUE),
SI_Retirement = max(SI_Retirement, na.rm = TRUE), `SI_Bolsa-família` = max(`SI_Bolsa-
família`, na.rm = TRUE), `SI_Gov. Support`= max(`SI_Gov. Support`, na.rm = TRUE), `SI_Job
other sector`= max(`SI_Job other sector`, na.rm = TRUE),  SI_Business = max(SI_Business,
na.rm = TRUE), SI_Other = max(SI_Other, na.rm = TRUE))

Income_SD <- data %>% group_by(Occupation) %>% summarise(SI_Farm = sd(SI_Farm, na.rm
= TRUE), SI_Fishery = sd(SI_Fishery,  na.rm = TRUE), SI_NTFP = sd(SI_NTFP, na.rm =
TRUE), `SI_Job agricult. sector`= sd(`SI_Job agricult. sector`, na.rm = TRUE),  SI_Retirement =
sd(SI_Retirement, na.rm = TRUE), `SI_Bolsa-família` = sd(`SI_Bolsa-família`, na.rm = TRUE),
 `SI_Gov. Support`= sd(`SI_Gov. Support`, na.rm = TRUE), `SI_Job other sector`= sd(`SI_Job
other sector`, na.rm = TRUE),  SI_Business = sd(SI_Business, na.rm = TRUE), SI_Other =
sd(SI_Other, na.rm = TRUE))

Income_min <- data %>% group_by(Occupation) %>% summarise(SI_Farm = min(SI_Farm,
na.rm = TRUE), SI_Fishery = min(SI_Fishery,  na.rm = TRUE), SI_NTFP = min(SI_NTFP,
na.rm = TRUE), `SI_Job agricult. sector`= min(`SI_Job agricult. sector`, na.rm = TRUE),
 SI_Retirement = min(SI_Retirement, na.rm = TRUE), `SI_Bolsa-família` = min(`SI_Bolsa-
família`, na.rm = TRUE), `SI_Gov. Support`= min(`SI_Gov. Support`, na.rm = TRUE), `SI_Job
other sector`= min(`SI_Job other sector`, na.rm = TRUE),  SI_Business = min(SI_Business,
na.rm = TRUE), SI_Other = min(SI_Other, na.rm = TRUE))

# Income grouped
Income_gr <- data %>% select(Occupation, SI_Farm, SI_Extractivism, SI_Gov.Support2,SI_off)
Income_gr2 <- Income_gr %>% group_by(Occupation, na.rm = FALSE )

# Different sources of incomes - FARM
Farm_incomes <- data %>% select(Occupation, `Temporary crops`, `Perennial crops`, `Forest
mgmt.`, `Small animals`, Cattle)
```

```
Farm_incomes <- Farm_incomes %>% group_by(Occupation) %>% summarise(`Temporary
crops` = sum(`Temporary crops`, na.rm = TRUE), `Perennial crops` =
  sum(`Perennial crops`, na.rm = TRUE), `Forest mgmt.` = sum(`Forest mgmt.`, na.rm = TRUE),
`Small animals` = sum(`Small animals`, na.rm = TRUE),
  Cattle= sum(Cattle, na.rm = TRUE))

Farm_incomes.com <- Farm_incomes %>% filter(Occupation == "Community")
Farm_incomes.com <- Farm_incomes.com %>% mutate(`Temporary crops` = `Temporary crops`
/ 7 *100, `Perennial crops` = `Perennial crops`/ 7 *100, `Forest mgmt.`= `Forest mgmt.`/7 *100,
`Small animals` = `Small animals`/ 7 *100, Cattle = Cattle / 7 *100)

Farm_incomes.farm <- Farm_incomes %>% filter(Occupation == "Farm")
Farm_incomes.farm <- Farm_incomes.farm %>% mutate(`Temporary crops` = `Temporary
crops` / 4 *100, `Perennial crops` = `Perennial crops`/ 4 *100, `Forest mgmt.`= `Forest mgmt.`/4
*100, `Small animals` = `Small animals`/ 4 *100, Cattle = Cattle / 4 *100)

Farm_incomes.sett <- Farm_incomes %>% filter(Occupation == "Settlement")
Farm_incomes.sett <- Farm_incomes.sett %>% mutate(`Temporary crops` = `Temporary crops` /
12 *100, `Perennial crops` = `Perennial crops`/ 12 *100, `Forest mgmt.`= `Forest mgmt.`/12
*100, `Small animals` = `Small animals`/ 12 *100, Cattle = Cattle / 12 *100)

Farm_incomes.merg <- rbind(Farm_incomes.com, Farm_incomes.farm, Farm_incomes.sett)

Farm_incomes.melt <- melt(Farm_incomes.merg)

Farm_incomes.melt %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + ge-
om_col(position = 'dodge') + ylab("% - N° of families") +   xlab("Farm sources of income") +
facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(text = element_text(size=12)) +
  theme(text = element_text(size=12),         axis.text.x = element_text(angle=30, hjust=1)) +
theme(legend.position = "none") #bar plot))

# Income Participation in Livelihood - FARM
Farm_incomes.part <- data %>% select(Occupation, `SI_Temporary crops`, `SI_Perennial crops`,
`SI_Forest products`, `SI_Small animals`, SI_Cattle)

Farm_incomes.part <- Farm_incomes.part  %>% group_by(Occupation) %>% summa-
rise_all(funs(mean(., na.rm= TRUE)))

Farm_incomes.part <- as_tibble(cbind.data.frame(Farm_incomes.part[,1], Farm_incomes.part[,-
1]/ rowSums(Farm_incomes.part[,-1], na.rm = TRUE)))

Farm_incomes.part <- Farm_incomes.part %>% mutate( `SI_Temporary crops` = `SI_Temporary
crops` * 100, `SI_Perennial crops` = `SI_Perennial crops` * 100, `SI_Forest products` =
`SI_Forest products` * 100, `SI_Small animals` = `SI_Small animals` * 100, SI_Cattle =
SI_Cattle * 100)

Farm_incomes.part <- melt(Farm_incomes.part)

Farm_incomes.part %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + ge-
om_col(position = 'dodge') + ylab("% - Amount of income per total") +   xlab("Farm sources of
income") + facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(text = ele-
ment_text(size=12),   axis.text.x = element_text(angle=30, hjust=1)) + theme(legend.position =
"none") #bar plot

# Modern inputs
```

```
Inputs <- data %>% select(Occupation, Machinery, `Motor-manual`, Pesticides, Fertilizers)

Inputs <- Inputs %>% group_by(Occupation) %>% summarise(Machinery = sum(Machinery,
na.rm = TRUE), `Motor-manual` = sum(`Motor-manual`, na.rm =  TRUE), Pesticides =
sum(Pesticides, na.rm = TRUE), Fertilizers = sum(Fertilizers, na.rm = TRUE))

Inputs.com <- Inputs %>% filter(Occupation == "Community")
Inputs.com <- Inputs.com %>% mutate(Machinery = Machinery  / 7 *100, `Motor-manual` =
`Motor-manual` / 7 *100,
 Pesticides = Pesticides / 7 *100, Fertilizers = Fertilizers/ 7 * 100)

Inputs.farm <- Inputs %>% filter(Occupation == "Farm")
Inputs.farm <- Inputs.farm %>% mutate(Machinery = Machinery  / 4 *100, `Motor-manual` =
`Motor-manual` / 4 *100,   Pesticides = Pesticides / 4 *100, Fertilizers = Fertilizers/ 4 * 100)

Inputs.sett <- Inputs %>% filter(Occupation == "Settlement")
Inputs.sett <- Inputs.sett %>% mutate(Machinery = Machinery  / 13 *100, `Motor-manual` =
`Motor-manual` / 13 * 100, Pesticides = Pesticides / 13 *100, Fertilizers = Fertilizers/ 13 * 100)

Inputs.merg <- rbind(Inputs.com, Inputs.farm, Inputs.sett)

Inputs.melt <- melt(Inputs.merg)

# Hires extra labour
Labour <- data %>% group_by(Occupation, `Hires labor force`) %>% summarise(Total = n())

Labour <- Labour %>% filter(!is.na(`Hires labor force`))

Labour.com <- Labour %>% filter(Occupation == "Community")
Labour.com <- Labour.com %>% mutate(Total = Total  / 7 *100)

Labour.farm <- Labour %>% filter(Occupation == "Farm")
Labour.farm <- Labour.farm %>% mutate(Total = Total  / 4 *100)

Labour.sett <- Labour %>% filter(Occupation == "Settlement")
Labour.sett <- Labour.sett %>% mutate(Total = Total  / 17 *100)

Labour.merg <- rbind(Labour.com, Labour.farm, Labour.sett)

# Outflow production via BR-319
Outflow.BR <- data %>% group_by(Occupation, `Outflow via BR-319` ) %>% summarise(Total
= n())

Outflow.BR <- Outflow.BR %>% filter(!is.na(`Outflow via BR-319`))

Outflow.BR.com <- Outflow.BR %>% filter(Occupation == "Community")
Outflow.BR.com <- Outflow.BR.com %>% mutate(Total = Total  / 7 *100)

Outflow.BR.farm <- Outflow.BR %>% filter(Occupation == "Farm")
Outflow.BR.farm <- Outflow.BR.farm %>% mutate(Total = Total  / 4 *100)

Outflow.BR.sett <- Outflow.BR %>% filter(Occupation == "Settlement")
Outflow.BR.sett <- Outflow.BR.sett %>% mutate(Total = Total  / 17 *100)

Outflow.BR.merg <- rbind(Outflow.BR.com, Outflow.BR.farm, Outflow.BR.sett)
```

Land characteristics

```
data <- read_xlsx(path = "/Users/marco/Dropbox/Marcolleta/Thesis/Data Analysis/HH/Database_adapted_2.3_divided.xlsx", sheet = 3)

# Land accumulation
More <- data %>% group_by(Occupation, `More then one land`) %>% summarise(Total = n())

More.com <- More %>% filter(Occupation == "Community")
More.com <- More.com %>% mutate(Percentage = Total / 8 * 100)

More.farm <- More %>% filter(Occupation == "Farm")
More.farm <- More.farm %>% mutate(Percentage = Total / 5 * 100)

More.sett <- More %>% filter(Occupation == "Settlement")
More.sett <- More.sett %>% mutate(Percentage = Total / 35 * 100)

More.merg <- rbind(More.com, More.farm, More.sett)

More.merg  %>% ggplot(., aes(x= `More then one land`, y= Percentage, fill= Occupation))+ geom_col(position = 'dodge') + ylab("% - N° Families") +
  xlab("Family owns more than one land") + facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(legend.position = "none")

# Land tenure
Tenure <- data %>% group_by(Occupation, Tenure) %>% summarise(Total = n())

Tenure.com <- Tenure %>% filter(Occupation == "Community")
Tenure.com <- Tenure.com %>% mutate(Percentage = Total / 8 * 100)

Tenure.farm <- Tenure %>% filter(Occupation == "Farm")
Tenure.farm <- Tenure.farm %>% mutate(Percentage = Total / 5 * 100)

Tenure.sett <- Tenure %>% filter(Occupation == "Settlement")
Tenure.sett <- Tenure.sett %>% mutate(Percentage = Total / 35 * 100)

Tenure.merg <- rbind(Tenure.com, Tenure.farm, Tenure.sett)

#Tenure (no separation)
Tenure2 <- data %>% group_by(Tenure) %>% summarise(Total= n()) %>% mutate(Percentage = Total / 48 * 100)

# Size
Size <- data %>% group_by(Occupation, category_size) %>% summarise(Total = n())

Size.com <- Size %>% filter(Occupation == "Community")
Size.com <- Size.com %>% mutate(Percentage = Total / 8 *100)

Size.farm <- Size %>% filter(Occupation == "Farm")
Size.farm <- Size.farm %>% mutate(Percentage = Total / 5 *100)

Size.sett <- Size %>% filter(Occupation == "Settlement")
Size.sett <- Size.sett %>% mutate(Percentage = Total / 35 *100)

Size.merg <- rbind(Size.com, Size.farm, Size.sett)
```

```
Size.merg  %>% mutate(category_size = factor( category_size, levels =  c("<100", "100 - 600",
">600"))) %>%
  ggplot(., aes(x= category_size, y= Percentage, fill= Occupation)) + geom_col(position =
'dodge') + ylab("% - N° Families") + xlab("Land size") +
  facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(legend.position = "none") +
theme(text = element_text(size=12), axis.text.x = element_text(angle=35, hjust=1))

# Size (no separation)
Size2 <- data %>% group_by(category_size) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)

#2 Year of establishment
Time_Establishment <- data %>% group_by(Occupation, Time_establishment) %>% summa-
rise(Total = n())

Time_Establishment.com <- Time_Establishment %>% filter(Occupation == "Community")
Time_Establishment.com <- Time_Establishment.com %>% mutate(Percentage = Total / 8 *100)

Time_Establishment.farm <- Time_Establishment %>% filter(Occupation == "Farm")
Time_Establishment.farm <- Time_Establishment.farm %>% mutate(Percentage = Total / 5
*100)

Time_Establishment.sett <- Time_Establishment %>% filter(Occupation == "Settlement")
Time_Establishment.sett <- Time_Establishment.sett %>% filter(!is.na(Time_establishment))
Time_Establishment.sett <- Time_Establishment.sett %>% mutate(Percentage = Total / 34 *100)

Time_Establishment.merg <- rbind(Time_Establishment.com, Time_Establishment.farm,
Time_Establishment.sett)

Time_Establishment.merg %>% mutate(Time_establishment = factor( Time_establishment, lev-
els =  c("40s", "60s", "70s", "80s", "90s", "00s", "after 2010"))) %>%  ggplot(., aes(x=
Time_establishment, y= Percentage, fill= Occupation)) + geom_col(position = 'dodge') + ylab("%
- N° Families") +  xlab("Property - Time of establishment") + facet_grid(Occupation~.) +
theme_light(base_size = 13) + theme(legend.position = "none")

# Land use - Per family
Land_use <- data %>% select(Occupation, Pasture, `Temporary crops`, `Perennial crops`, `Sec-
ondary forest - young`, `Secondary forest - old`, Agroforestry, `Primary forest`, Waterbody)
Land_use <- Land_use %>% group_by(Occupation) %>% summarise(Pasture = sum(Pasture,
na.rm = TRUE), `Temporary crops`= sum(`Temporary crops`, na.rm = TRUE), `Perennial crops`
= sum(`Perennial crops`, na.rm = TRUE),   `Secondary forest - young` = sum(`Secondary forest -
young`, na.rm = TRUE), `Secondary forest - old` = sum(`Secondary forest - old`, na.rm =
TRUE),   Agroforestry = sum(Agroforestry, na.rm = TRUE), `Primary forest` = sum(`Primary
forest`, na.rm = TRUE), Waterbody = sum(Waterbody, na.rm = TRUE))

Land_use <- as_tibble(cbind.data.frame(Land_use[,1], Land_use[,-1]/ rowSums(Land_use[,-1])))

Land_use <- Land_use %>% mutate(Pasture = Pasture * 100, `Temporary crops`= `Temporary
crops`*100, `Perennial crops`=  `Perennial crops` * 100, `Secondary forest - young` = `Secondary
forest - young` * 100, `Secondary forest - old` = `Secondary forest - old` * 100,  Agroforestry =
Agroforestry * 100, `Primary forest` = `Primary forest` * 100, Waterbody = Waterbody * 100)

Land_use.melt <- melt(Land_use)

Land_use.melt %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + geom_col(position
= 'dodge') + ylab("% - N° Families") +   xlab("Land use categories") + facet_grid(Occupation~.)
```

```
+ theme_light(base_size = 13) + theme(text = element_text(size=12),   axis.text.x = element_text(angle=35, hjust=1)) + theme(legend.position = "none")

# Land use - Area
Land_use.ar <- data %>% select(Occupation, Sz_Pasture, `Sz_Temporary crops`, Sz_Agroforestry, `Sz_Perennial crops`, `Sz_Secondary forest - young`, `Sz_Secondary forest - old`, `Sz_Primary forest`)

Land_use.ar.mean  <- Land_use.ar  %>% group_by(Occupation) %>% summarise(Sz_Pasture = mean(Sz_Pasture, na.rm = TRUE), `Sz_Temporary crops`= mean(`Sz_Temporary crops`, na.rm = TRUE), `Sz_Perennial crops` = mean(`Sz_Perennial crops`, na.rm = TRUE),   Sz_Agroforestry = mean(Sz_Agroforestry, na.rm = TRUE),`Sz_Secondary forest - young` = mean(`Sz_Secondary forest - young`, na.rm = TRUE), `Sz_Secondary forest - old` = mean(`Sz_Secondary forest - old`, na.rm = TRUE),   `Sz_Primary forest` = mean(`Sz_Primary forest`, na.rm = TRUE))

Land_use.ar.mean.melt <- melt(Land_use.ar.mean)

Land_use.ar.mean.melt %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + geom_col(position = 'dodge') + ylab("Average Area - ha") +   xlab("Land use categories") + facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(text = element_text(size=12),
  axis.text.x = element_text(angle=35, hjust=1)) + theme(legend.position = "none")

#Zooming
Land_use.ar2 <- Land_use.ar.mean %>% select(Occupation, Sz_Pasture, `Sz_Temporary crops`, `Sz_Perennial crops`, Sz_Agroforestry, `Sz_Secondary forest - young`, `Sz_Secondary forest - old`)

Land_use.ar2.melt <- melt(Land_use.ar2)

Land_use.ar2.melt %>% ggplot(., aes(x= variable, y= value, fill= Occupation)) + geom_col(position = 'dodge') + ylab("Average Area - ha") +  xlab("Land use categories") + facet_grid(Occupation~.) + theme_light(base_size = 13) + theme(text = element_text(size=12),
  axis.text.x = element_text(angle=35, hjust=1)) + theme(legend.position = "none")
```

Others

```
data <- read_xlsx(path = "/Users/marco/Dropbox/Marcolleta/Thesis/Data Analysis/HH/Database_adapted_2.4.xlsx", sheet = 1)

# Future plans

Future_plans <- data %>% select(Occupation, `Expand agriculture`, `Expand pasture`, `Expand/ change forest`, `Sell and move`, `Sell and stay`, `Fish-farming`, Tourism, `Move to land owned`, `Share land among children`, `Raise cattle`, `Agriculture modernization`, `Expand business`, `Acquire more land`)

Future_plans <- Future_plans %>% group_by(Occupation) %>% summarise( `Expand pasture` = sum(`Expand pasture`, na.rm = TRUE), `Expand agriculture` =  sum(`Expand agriculture`, na.rm = TRUE), `Expand/ change forest` = sum(`Expand/ change forest`, na.rm = TRUE), `Sell and move` = sum(`Sell and move`, na.rm = TRUE), `Sell and stay` = sum(`Sell and stay`, na.rm = TRUE), `Fish-farming` = sum(`Fish-farming`, na.rm = TRUE), Tourism = sum(Tourism, na.rm = TRUE),`Move to land owned` =  sum(`Move to land owned`, na.rm = TRUE), `Share land among children`= sum(`Share land among children`, na.rm = TRUE), `Raise cattle` = sum(`Raise cattle`, na.rm = TRUE), `Agriculture modernization` =sum(`Agriculture modernization`, na.rm = TRUE), `Expand business` = sum(`Expand business`, na.rm = TRUE), `Acquire more land` = sum(`Acquire more land`, na.rm = TRUE))
```

```
Future_plans <- as_tibble(cbind.data.frame(Future_plans[,1], Future_plans[,-1]/ row-
Sums(Future_plans[,-1])))

Future_plans2 <- Future_plans %>% mutate(`Expand pasture`= `Expand pasture` * 100, `Expand
agriculture` = `Expand agriculture` * 100, `Expand/ change forest` =  `Expand/ change forest`*
100, `Sell and move` = `Sell and move`*100, `Sell and stay` = `Sell and stay` * 100, `Fish-
farming` = `Fish-farming` * 100, Tourism = Tourism * 100, `Move to land owned` = `Move to
and owned`* 100, `Share land among children`= `Share land among children` * 100, `Raise cat-
tle` =  `Raise cattle`* 100, `Agriculture modernization` = `Agriculture modernization`* 100, `Ex-
pand business` = `Expand business` * 100, `Acquire more land` = `Acquire more land`* 100)

Future_plans.melt <- melt(Future_plans2)

# Technical Assistance
Tech <- data %>% group_by(Occupation, `Tech Assist`) %>% summarise(Total = n())
Tech <- Tech %>% filter(!is.na(`Tech Assist`))

Tech.com <- Tech %>% filter(Occupation == "Community")
Tech.com <- Tech.com %>% mutate(Total = Total  / 8 *100)

Tech.farm <- Tech %>% filter(Occupation == "Farm")
Tech.farm <- Tech.farm %>% mutate(Total = Total  / 5 *100)

Tech.sett <- Tech %>% filter(Occupation == "Settlement")
Tech.sett <- Tech.sett %>% mutate(Total = Total  / 33 *100)

Tech.merg <- rbind(Tech.com, Tech.farm, Tech.sett)

Tech2 <- data %>% group_by(`Tech Assist`) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)

# Cooperative
Coop <- data %>% group_by(Occupation, Cooperative) %>% summarise(Total = n())

Coop.com <- Coop %>% filter(Occupation == "Community")
Coop.com <- Coop.com %>% mutate(Total = Total  / 8 *100)

Coop.farm <- Coop %>% filter(Occupation == "Farm")
Coop.farm <- Coop.farm %>% mutate(Total = Total  / 5 *100)

Coop.sett <- Coop %>% filter(Occupation == "Settlement")
Coop.sett <- Coop.sett %>% mutate(Total = Total  / 35 *100)

Coop.merg <- rbind(Coop.com, Coop.farm, Coop.sett)

# Consultation about BR-319
BR <- data %>% group_by(Occupation, `Consult BR`) %>% summarise(Total = n())

BR.com <- BR %>% filter(Occupation == "Community")
BR.com <- BR.com %>% mutate(Total = Total  / 8 *100)

BR.farm <- BR %>% filter(Occupation == "Farm")
BR.farm <- BR.farm %>% mutate(Total = Total  / 5 *100)

BR.sett <- BR %>% filter(Occupation == "Settlement")
BR.sett <- BR.sett %>% mutate(Total = Total  / 35 *100)
```

```
BR.merg <- rbind(BR.com, BR.farm, BR.sett)

# Consultation about governamental plans
Plans <- data %>% group_by(Occupation, `Consult plans`) %>% summarise(Total = n())

Plans.com <- Plans %>% filter(Occupation == "Community")
Plans.com <- Plans.com %>% mutate(Total = Total  / 8 *100)

Plans.farm <- Plans %>% filter(Occupation == "Farm")
Plans.farm <- Plans.farm %>% mutate(Total = Total  / 5 *100)

Plans.sett <- Plans %>% filter(Occupation == "Settlement")
Plans.sett <- Plans.sett %>% mutate(Total = Total  / 35 *100)

Plans.merg <- rbind(Plans.com, Plans.farm, Plans.sett)

# Awareness of govvernamentl plans
Awareness <- data %>% group_by(Occupation, `Awarennes plans` ) %>% summarise(Total =
n())

Awareness.com <- Awareness %>% filter(Occupation == "Community")
Awareness.com <- Awareness.com %>% mutate(Total = Total  / 8 *100)

Awareness.farm <- Awareness %>% filter(Occupation == "Farm")
Awareness.farm <- Awareness.farm %>% mutate(Total = Total  / 5 *100)

Awareness.sett <- Awareness %>% filter(Occupation == "Settlement")
Awareness.sett <- Awareness.sett %>% mutate(Total = Total  / 35 *100)

Awareness.merg <- rbind(Awareness.com, Awareness.farm, Awareness.sett)

# Distance roads, BR, schools and hospital
Distance <- data %>% select(Occupation, `Distance road`, `Distance BR-319`, `Distance school`,
`Distance hospital`)

Distance.com <- Distance %>% filter(Occupation == "Community")
Distance.com <- Distance.com %>% select(`Distance road`, `Distance BR-319`, `Distance
school`, `Distance hospital`)

Distance2 <- data %>% group_by(`Distance road`) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)
Distance3 <- data %>% group_by(`Distance BR-319`) %>% summarise(Total= n()) %>% mu-
tate(Percentage = Total / 48 * 100)

plot <- Highcharts$new()
plot$chart(polar = TRUE, type = "line", height=500)
plot$xAxis(categories= Distance.com, tickmarkPlacement= 'on', lineWidth= 0)
plot$yAxis(gridLineInterpolation= 'circle', lineWidth= 0, min=
0,max=150,endOnTick=T,tickInterval=10)
plot$series(data = Distance.com[,"Distance road"], name = "Distance road", pointPlace-
ment="on")
plot$series(data = Distance.com[,"Distance BR-319"],name = "Distance BR-319", pointPlace-
ment="on")
plot$series(data = Distance.com[,"Distance hospital"],name = "Distance hospital", pointPlace-
ment="on")
```

```
plot$series(data = Distance.com[,"Distance school"],name = "Distance school", pointPlace-
ment="on")
plot

Distance.farm <- Distance %>% filter(Occupation == "Farm")
Distance.farm  <- Distance.farm %>% select(`Distance road`, `Distance BR-319`, `Distance
school`, `Distance hospital`)

plot2 <- Highcharts$new()
plot2$chart(polar = TRUE, type = "line",height=500)
plot2$xAxis(categories= Distance.farm, tickmarkPlacement= 'on', lineWidth= 0)
plot2$yAxis(gridLineInterpolation= 'circle', lineWidth= 0, min=
0,max=200,endOnTick=T,tickInterval=10)
plot2$series(data = Distance.farm[,"Distance road"], name = "Distance road", pointPlace-
ment="on")
plot2$series(data = Distance.farm[,"Distance BR-319"],name = "Distance BR-319", pointPlace-
ment="on")
plot2$series(data = Distance.farm[,"Distance hospital"],name = "Distance hospital", pointPlace-
ment="on")
plot2$series(data = Distance.farm[,"Distance school"],name = "Distance school", pointPlace-
ment="on")
plot2

Distance.sett <- Distance %>% filter(Occupation == "Settlement")
Distance.sett  <- Distance.sett %>% select(`Distance road`, `Distance BR-319`, `Distance
school`, `Distance hospital`)

plot3 <- Highcharts$new()
plot3$chart(polar = TRUE, type = "line",height=500)
plot3$xAxis(categories= Distance.sett, tickmarkPlacement= 'on', lineWidth= 0)
plot3$yAxis(gridLineInterpolation= 'circle', lineWidth= 0, min=
0,max=200,endOnTick=T,tickInterval=10)
plot3$series(data = Distance.sett[,"Distance road"], name = "Distance road", pointPlace-
ment="on")
plot3$series(data = Distance.sett[,"Distance BR-319"],name = "Distance BR-319", pointPlace-
ment="on")
plot3$series(data = Distance.sett[,"Distance hospital"],name = "Distance hospital", pointPlace-
ment="on")
plot3$series(data = Distance.sett[,"Distance school"],name = "Distance school", pointPlace-
ment="on")
plot3

Distance.gr <- Distance %>% group_by(Occupation) %>% summarise(`Distance road` =
mean(`Distance road`), `Distance BR-319` = mean(`Distance BR-319`), `Distance school` =
mean(`Distance school`), `Distance hospital` = mean(`Distance hospital`))
Distance.gr <- Distance.gr %>% select(`Distance road`, `Distance BR-319`, `Distance school`,
`Distance hospital`)

plot4 <- Highcharts$new()
plot4$chart(polar = TRUE, type = "line",height=500)
plot4$xAxis(categories= Distance.gr, tickmarkPlacement= 'on', lineWidth= 0)
plot4$yAxis(gridLineInterpolation= 'circle', lineWidth= 0, min=
0,max=160,endOnTick=T,tickInterval=10)
plot4$series(data = Distance.gr[,"Distance road"], name = "Distance road", pointPlace-
ment="on")
```

```
plot4$series(data = Distance.gr[,"Distance BR-319"],name = "Distance BR-319", pointPlace-
ment="on")
plot4$series(data = Distance.gr[,"Distance hospital"],name = "Distance hospital", pointPlace-
ment="on")
plot4$series(data = Distance.gr[,"Distance school"],name = "Distance school", pointPlace-
ment="on")
plot4
```

Deforestation

```
my_data <- read.delim(file.choose(), dec = ",")
my_data
colnames(my_data)

sample_n(my_data, 10)
levels(my_data$Deforestation)

group_by(my_data, )
data2<- my_data[,
c("Lot_size","Deforestation","Man","Education","Distance","Lot_year","Income")]
lm.data <- lm(as.formula('Deforestation ~.'), data = data2)
summary(lm.data)

ggscatter(my_data, x = "Deforestation" , y = "Lot_size" , add = "reg.line", conf.int = TRUE,
cor.coef = TRUE, cor.method = "pearson", xlab = "Deforestation (ha)", ylab = "Lot size (ha)")

ggscatter(my_data, x = "Deforestation" , y = "Lot_year" , add = "reg.line", conf.int = TRUE,
cor.coef = TRUE, cor.method = "pearson", xlab = "Deforestation (ha)", ylab = "Lot year (years)")

ggscatter(my_data, x = "Deforestation" , y = "Income" , add = "reg.line", conf.int = TRUE,
cor.coef = TRUE, cor.method = "pearson",xlab = "Deforestation (ha)", ylab = "Income (BRL)")

ggscatter(my_data, x = "Deforestation" , y = "Distance" , add = "reg.line", conf.int = TRUE,
cor.coef = TRUE, cor.method = "pearson",xlab = "Deforestation (ha)", ylab = "Distance (km)")

ggplot(my_data, aes(x = Deforestation, y = Income)) +   geom_point() + stat_smooth()
cor(my_data$Deforestation, my_data$Income)
lm.data2 <- lm(formula = Deforestation ~ Income, data = my_data)
summary(lm.data2)
```