Changes in the landscape in a protected area in the Peruvian rainforest and the impact on the local population: case of the Mishana community




Master's Thesis in Geography

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Executive Summary

This research focuses on the landscape change in a small community (Mishana) located within inside a protected area (Allpahuayo Mishana National Reserve), in the Amazonian rainforest of Peru. The landscape is formed by the tropical rainforest, with high biodiversity. My main theoretical approaches will be from geography and ecology (landscape ecology). One potential threat to this landscape is deforestation, so the aim of my study is to determine the forest cover increase or decrease in Mishana, using satellite images and maps from previous years, and GPS surveying from field work. One special type of forest called *varillal* will be key to my results. In addition, there were made interviews to some members the local population and other informants who were connected to Mishana, in order to know more about their activities, their connection to the forest and their opinion about living in a protected area. The most important discovery is that there has been an increase in the forest cover because of the regulations given as a protected area, and that the local population had to adapt to these circumstances, understanding the importance of their forests for the conservation of biodiversity.

List of Abbreviations

AMNR: Allpahuayo Mishana National Reserve

GPS: Geographic Position System

SERNANP: Servicio Nacional de Áreas Naturales Protegidas (National Service of Protected Areas)

INRENA: Instituto Nacional de Recursos Naturales

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Chapter One: Introduction

1.1 Research Problem and Justification of the study

The Amazon basin, the largest basin of the world, is located in South America, which spreads through 9 countries, and covers for more than 750 million hectares, mainly covered by tropical forests (Eden, 1990). This is the largest tropical forest of the world, and provides an enormous variety and quantity of natural resources for the local population.

Peru, second country in South America after Brazil regarding tropical forest area, is covered by the very large Amazon rainforest in more than a half of its territory. Unfortunately, when there are plenty of resources on a certain place, especially in poor countries, there is usually some kind of overexploitation, which affects all the natural ecosystem, in this case the large forest cover of the Amazonian rainforest.

This overexploitation basically consists in deforestation, which can lead to a variety of environmental problems, such as degradation of soils, biodiversity loss, ecological disturbance, water and soil pollution, etc. According to the Map of Deforestation in Peru (2009), over 53% of the Peruvian territory is covered by the Amazonian rainforest (69 million of hectares), but by 2000 the deforested area of this kind of ecosystem was of 9.5% (over 7 million haa).

In the following tables I will show you some statistics regarding the forest cover in Peru collected by FAO with additional information.

Table 1: Peru: forest cover by year

Year	Area (x1000 ha)	Percentage of Land Area
1990	77921	60.6
2000	76147	59.2
2005	75528	58.7
2010	74811	58.2
2015	73973	57.6

Source: FAO, 2015

As we can see, forest cover in Peru has been decreasing steadily since 1990, with a loss of almost 4 million ha in the period 1990-2015 (at a rate of 0.2% per year). On the next table is shown the division of forest cover by characteristic (primary, other naturally regenerated and planted). It should be noted that figures are slightly different from the Peruvian authority (in this case Ministry of Environment).

Table 2: Peru: forest characteristics, 2015

Type	Area (x1000 ha)	Percentage of Forest cover
Primary forest	65790	88.9
Other naturally regenerated	7026	9.5
Planted	1157	1.6

Source: FAO, 2015

Almost 90% of the total forest cover belongs to the primary forests, which is practically all the Amazonian rainforest cover. On the table 3 we can see the evolution of the primary forest cover since 1990.

Table 3: Peru: Primary forest cover by year

Year	Area (x1000 ha)	Percentage of Land Area
1990	69632	60.6
2000	67684	59.2
2005	67148	58.7
2010	66524	58.2
2015	65790	57.6

Source: FAO, 2015

Similarly to the total forest cover, primary forests have been decreasing at a same rate per year (0.2% in the period 1990-2015).

Comparing the situation among the other Amazonian countries, we can see the annual change rate in the period 1990-2015 in the table 4.

Table 4: Annual change rate for the period 1990-2015 in the Amazonian countries

Country	**Annual change rate 1990-2015 (%)**
Brazil	-0.4
Bolivia	-0.5
Colombia	-0.4
Ecuador	-0.6
French Guiana	0
Guyana	0
Peru	**-0.2**
Suriname	0
Venezuela	-0.4

Source: FAO, 2015

With the exception of Guyana, Suriname and French Guiana, all the other countries have a significant decrease in forest cover for the period 1990-2015 (between -0.4 and -0.6%), higher than in Peru. Therefore, deforestation is clearly a pattern in the largest and most populated Amazonian countries, mostly due to human activity.

In Peru, the largest department with forest cover is Loreto, located in the north-eastern part of the country. It covers more than a quarter of the total area of the country, with an extension of 36.9 million haa. Because of its location, it was very little populated in the period of Spanish colonization, and it was not until the last half of the XIX Century that migration processes started to dominate the dynamic of the population.

Loreto's population has increased significantly in the last 40 or 50 years due to new migrators from different parts from Peru. Iquitos, the capital of Loreto, which is located in the left margin of the Amazon River, and is the most important city in the Peruvian side of the Amazonia, has over 430 000 inhabitants as of today. 56 years ago, according to the National census of 1961, Iquitos only had 57772 inhabitants, so it has increased its population by 750% in this period of time.

In Loreto there are very few highways, due to the forest cover and the presence of wetlands in the area. Due to this reason, Iquitos can only be reached by river or by air. But there is one very important highway that comes from Iquitos and follows for almost 100 kilometres until reaching the town of Nauta, which is located in the left margin of the Marañón river, very close to the confluence with the Ucayali river to form the Amazon river. This highway has no connections, so it is completely isolated from any other highway.

It is in both sides of this highway that new migrants have come to settle down and dedicate to different economic activities, such as agriculture, forestal production, livestock and tourism. But, while doing this, they have been affecting the ecosystem of the rainforest, so there has been continuous processes of deforestation through both sides of the highway that has been assessed in the last 30 years.

Situated 25 km southwest of Iquitos is located the Allpahuayo Mishana National Reserve (AMNR). It got its status of protected area in 2004, because it was an area which features very interesting and important ecosystems, such as the *varillal* forests.

Biodiversity is very high within the limits of the protected area. In the AMNR are found over 1800 plant species, 145 mammal species (2 endemic from the area), 120 reptile species (5 endemic), 83 amphibian species (4 endemic), 155 fish species (5 endemic) and 496 bird species (9 endemic) (INRENA, 2005, Alvarez Alonso et al., 2012).

However, this protected area is under continuous threat. The local population, who live in the surrounding area usually practice what is called a “nomadic and subsistence agriculture”, which affects the forest cover and produce the impoverishment of soils (Dancé Caballero, 1981).

My specific study area is the Mishana community, located inside the AMNR, which will be an interesting example of the landscape dynamics and the local population’s actions.

1.2. - Research questions:

For the present study, my research questions are the following:

- How has the landscape of the Mishana community changed in the last 12 years? Has the area of *varillal* forest increased or decreased?
- What are the driving forces that produced this change in the landscape? What kind of disturbances have affected the area? Have these disturbances led to fragmentation within the Protected Area?
- What effects have these changes produced in the activities of the local population? What effects has this brought to the conservation of the Protected Area?

Chapter 2: Theoretical Framework and Literature Review

I will develop three main themes in the theoretical part: landscape ecology, deforestation and protected natural areas. The first topic will give a general idea about what landscape means from geography and ecology approaches, giving more insight to landscape ecology approach: which concepts are used and what kind of application you can give it for environmental studies. In the second topic I will present some concepts and ideas about deforestation, some causes and effects related and challenges. Finally I will give a brief introduction of protected natural areas and their importance in ecology and conservation. For all three concepts I will discuss how I intend to use them in my study.

2.1. - Landscape and Landscape Ecology

First, before giving some concepts about landscape ecology, we must define the term "landscape". As a concept, landscape can have many approximations from different points of view, and I will present two main approaches: from geography and from ecology.

From geography, Sporrong states that landscape "is the entirety of the physical and cultural components, a combination of cultural preferences and potentials and physical conditions developed in a specific society" (Sporrong, 1993, cited in Tunón et al., 2014: 53). Olwig claims that "landscape needs not to be understood as either territory or scenery; it can also be conceived as a nexus of community, justice, nature and environment" (Olwig, 1996: 630-631). According to Jones (1991), there are three main approaches to study the landscape: scientific, applied and human, which produce different kinds of landscapes. In this sense, it is clear that the role of humans is fundamental in how the landscape evolves through space and time.

From ecology, Forman and Godron define landscape as "a heterogeneous land area composed of a cluster of interactive ecosystems that is repeated in similar form throughout (Forman & Godron, 1986, p.11). Haber (2004, cited in Farina, 2006) has a more broad definition and says that landscape is "a piece of land which we perceive comprehensively around us, without looking closely at single components, and which looks familiar to us" (Farina, 2006:5).

Taking into account these conceptualization, landscape ecology considers four main approximations (Turner, 1989:5):

- Development and dynamic of spatial heterogeneity.
- Interaction and exchanges across heterogeneous landscapes.
- Influences of spatial heterogeneity on biotic and abiotic processes.
- Management of spatial heterogeneity.

Farina (2006) presents an interesting epistemological approach to the landscape, where he considers three different levels:

- The nature of landscape, which can be material (e.g. organisms) or un-material (e.g. information related)
- The role of landscape, including three perspectives: landscape as a domain (hierarchized through subdomains), landscape as system (connected through networks, creating a system) and landscape as a unit.
- The description of landscape, which can be from the "ecological" context or from the "cognitive" context. The former refers basically to the description of the landscape considering the abiotic and biotic elements in relation with their habitat, while the latter refers to a most subjective description, from the perception of the organism of their surroundings.

Through these approximations and approaches, landscape ecology focuses on the following characteristics of the landscape (Forman & Godron, 1986):

- Structure: refers to the spatial relationships between distinctive ecosystems.
- Function: refers to the interactions between the spatial elements.
- Change: refers to the alteration of the structure and function of the ecological mosaic over time.

There are some basic terms in landscape ecology that are important to know in order to understand landscape structure, which are:

- Patch: refers to the "non-linear surface area differing in appearance from its surroundings" (Forman & Godron, 1986, p.83). Patches have their own ecological characteristics (De Pablo et al., 2012).
- Matrix: there are three criteria described by Forman & Godron (1986) which can help us to understand it: relative area (when one type of element in a landscape is

considerably more extensive than the others, this element type would be the matrix), connectivity (the matrix is more connected than any other element present in the landscape) and control over dynamics (the matrix influences a greater degree of control over landscape dynamics than any other element type present).

- Corridors: refer to functional structures in a landscape and their presence is very important to mitigate the effect of fragmentation, and can be defined as narrow strips of habitat surrounded by habitat of other types (Farina, 2006).
- Mosaic: it is a collection of patches with similar characteristics (Göyker, 2013).

According to Farina (2000), landscape structure has two qualities: composition and configuration. Landscape composition "describes the quality and quantity of elements (patches) composing a mosaic" (Farina, 2000, p.169), while landscape configuration "describes the physical distribution of patches within the mosaic" (ibid.).

Landscape function, as we already said, involves the interaction of the spatial elements: animals, plants, energy and nutrients (Forman & Gordron, 1986). These interactions are given by the existence of structures such as corridors, matrix and networks (ibid.).

Along with the concepts already shown, there are two important processes to recall when studying the landscape: disturbances and fragmentation. Disturbance: refers to "an event that causes a significant change from the normal pattern in an ecological system or habitat. They can include natural events or human interventions" (Forman & Godron, 1986, pp. 9-10).

Fragmentation refers to the partition and loss of spatial connectivity in a matrix. It is usually an effect of a series of disturbance on a habitat. It is one of the most negative process that threatens biodiversity (Farina, 2006). Three processes occur when fragmentation takes place: reduction in the total amount of the original vegetation, subdivision of the remaining vegetation into patches and introduction of new forms of land use (Bennett & Saunders, 2010).

Once we know the basic elements of landscape structure and landscape function, we can give a brief explanation of landscape change, which is basically the evolution of a landscape over a period of time (Farina, 2000). As it is showed, it has two approximations: geographical (spatial scale) and historical (temporal scale).

There are two types of processes that can potentially change a landscape: natural and human (Göyker, 2013). These changes can be assessed depending of the work scale: large or small spatial scale, in a long or short period of time.

McIntyre & Hobbs (1999) proposed a framework about landscape alterations due to human effects, which can be useful when studying landscape changes. They set four types of landscapes:

a) Intact landscapes: when the degree of destruction of the original habitat is little or none (over 90% is remaining).
b) Variegated landscapes: when the degree of destruction is moderate (60-90% is remaining).
c) Fragmented landscapes: when the degree of destruction is high (10-60% is remaining).
d) Relictual landscapes: when the degree of destruction is extreme (less than 10% is remaining).

We can add that connectivity will be the highest in the intact landscapes and it will be almost none in relictual landscapes.

Landscape change has two components: magnitude (quantitative) and significance (qualitative) (De Pablo et al. 2012). The former refers simply to the measurement of the area change in patches and mosaics, while the latter refers to "the measurement of the differences between the boundary patterns characterizing the former landscape mosaics and those of the new one, regardless of the area involved, which provides information on changes in the ecological interactions" (ibid., p. 572).

When studying habitat fragmentation (which eventually leads to landscape change), it is important to point out the different aspects on landscape change. Bennett & Saunders (2010) describe these aspects categorizing in the following ones:

- Changes in landscape pattern
- Changes to ecosystem processes
- Effects on species
- Effects on communities

Through these aspects, landscape changes can be studied from a spatial, ecological or biological point of view, and of the combination of any of these three components.

Another way to study temporal changes in the landscape is when looking into the stability of a landscape. Stability refers to the measure of its resistance to disturbance and ability to repair and handle these disturbances (Sivertsen & Lundberg, 1996). But as stability cannot be reached in absolute terms, the concept of metastability is useful, which is when the landscape reaches a relative equilibrium (it oscillates around a central position) (Forman & Godron, 1986). When there is a change that forces the system out of this equilibrium, it will get into a level of instability, and a new trajectory appears that leads the system toward a different central position (ibid.). Associated with the idea of metastability is the concept of resilience, which is the capacity of recovering of a landscape due to some type of disturbance to its original state (Malanson et al., 2007). Westman (1978) identified four components of resilience:

- Elasticity: it is the rate of recovery of the landscape.
- Malleability: it is the degree of which the recovered landscape differs from the pre-impact state.
- Amplitude: it is the amount of change that can occur before the landscape cannot recover towards its pre-impact state.
- Hysteresis: it is the degree of which the path of recovery varies from the path of impact change.

Given all the previous concepts and ideas, for my study I intend to use the ecological approach to describe and understand the landscape change that has happened in my study area, including the role of the human activity and its effect on the landscape dynamics. This will also help me in understanding the social impacts of this landscape considering that my study area is located in a protected area.

2.2 Deforestation

Another important topic that can be related to landscape ecology is deforestation. According to FAO, deforestation is “the conversion of forest to other land use, or the tree canopy cover below the minimum 10 percent threshold” (FAO, 2012a, p.5). Therefore, deforestation is the process in which there is a conversion of a forest area to an alternative permanent non-forested land use, such as agriculture (Chakravarty et. al., 2012). Until the early part of the 20th century, deforestation was mostly located in the northern Hemisphere (Europe, Asia, North America), but this pattern changed at around the middle of the 20th

century when it started to be a trend in tropical areas of Southeast Asia, Africa and South America (FAO, 2012b).

Zipperer (1993) identified five patterns of deforestation in the United States due to human activity: internal, indentation, cropping, fragmentation and removal. These can be seen in figure 1:

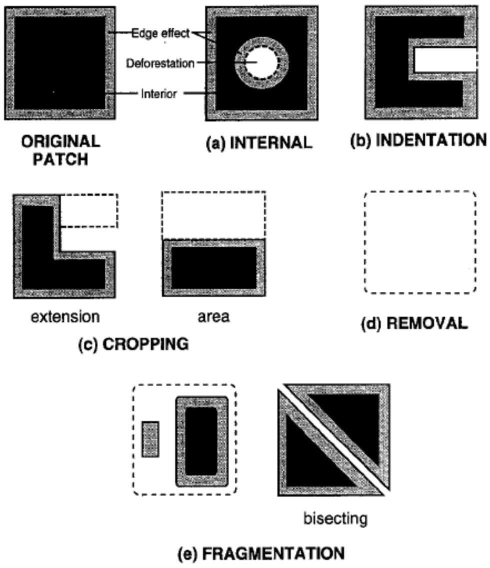

Figure 1: Patterns of deforestation (Zipperer, 1993)

As we can see, patterns usually have a geometric shape of different types, and it will be interesting to see which kind of pattern can be observed in my study area.

The main causes of deforestation can be classified as direct and indirect. Chakravarty et al. list several of these causes:

- Direct causes: expansion of farming land, plantations, logging and fuel wood, overgrazing, fires, mining, urbanization/industrialization, air pollution, wars, tourism.
- Indirect causes: colonialism, exploitation by industrialized countries, overpopulation, poverty, transmigration, land rights and land tenure, undervaluing the forests, corruption and crime.

I will focus more on the direct causes in this research. From the list, probably the expansion of farming land is the most evident in regards of this research project. Numerous cases around the globe (Adu et. al, 2012, Angelsen & Kaimowitz, 2001, Bray et al., 2008) show that agriculture is one of the main human activities that is threatening forest areas in many parts of the world. It will be interesting to see if this applies to my study area.

Chakravarty et al. (2012) give us an insight of the main effects of deforestation, which are the following:

- Climate change
- Water and soil resources loss and flooding
- Decreased biodiversity, habitat loss and conflicts.
- Economic losses
- Social consequences

Regarding the biological and ecological impacts, deforestation changes the spatial pattern of the landscape, and species respond differently to this matter because of their different dispersal abilities (Malanson et al., 2007), and it leads to the decrease of water storage capacity of the soils. (Mawalagedara & Oglesby, 2012). On this research, my aim is to look into the environmental (landscape change) and social issues related with this type of process.

When deforestation happens in an ecosystem (either by natural or human causes), it can either never recover its previous status (no more forest cover again) or it can recover through reforestation. If the process

Deforestation in tropical areas can be studied by a landscape ecology approach, as it has already been the case in the studies by Metzger (2001) and Frohn & Hao (2006), who studied this problem from this approach, giving some interesting insights about deforestation in Brazilian Amazon rainforest with a quantitative analysis of the cases presented.

2.3 Protected areas

Finally, I am going to present a short description of the concept of Protected Area and its importance on conservation for the environment.

A Protected Area is “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (IUCN, 2008: p. 7).

Protected Areas can be classified in 6 categories according to IUCN, depending on their special ecological, geographical and historical characteristics (IUCN, 2008):

- Strict nature reserve (Ia): To protect biodiversity and also possibly geological or geomorphological features, where human intervention, use and impacts are strictly controlled.
- Wilderness area (Ib): Large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation.
- National park (II): Large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area.
- Natural monument or feature (III): To protect a specific natural monument, which can be a landform, sea mount, submarine cavern or any geological feature.
- Habitat/species management area (IV): To protect particular species or habitats and management reflects this priority.
- Protected landscape/seascape (V): Protected area where the interaction of people and nature over time has produced an area of distinctive character with significant ecological, biological, cultural and scenic value.
- Protected area with sustainable use of natural resources (VI): Conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems.

The importance of Protected Areas can be synthetized in the following, according to the Secretariat of the Convention on Biological Diversity (2008, pp. 1-2):

- They are the critical tool to conserve biodiversity in the face of the global crisis of species extinction and the loss of the world's natural capacity to support all life and human existence.
- Provide for life's essentials. They protect natural resources that are critical to many people on earth. Within these areas, genetic diversity is permitted to evolve in response to natural selection pressures.
- Provide for life's diversity in safeguarding species and habitats. Each species is a product of millions of years of evolution. Each species contributes to the extraordinary variety of living creatures on earth.

- They act as life’s buffers while serving as sanctuaries and strongholds of species in the face of climate change.
- They are economic engines. They provide for life’s jobs and livelihoods as a traditional destination for the global tourism industry.
- They provide the settings for healthy outdoor living and recreation. Exploring a protected area offers not only the opportunity to understand nature but also for exercise and education.

Chapter 3: Study Area Presentation

3.1 Location:

The Allpahuayo Mishana National Reserve (AMNR) is situated at the Km. 25 of the Iquitos – Nauta highway, which can be located in the map from the figure 3. It covers 58070 hectares of very particular types of forest, and is threatened by deforestation and other kind of degradation processes, as well as other human activities surrounding the area (SERNANP, 2013). This Protected Area was created on January of 2004 as a National Reserve, and is located between the districts of San Juan Bautista and Alto Nanay, which belong to the province of Maynas (Department of Loreto).

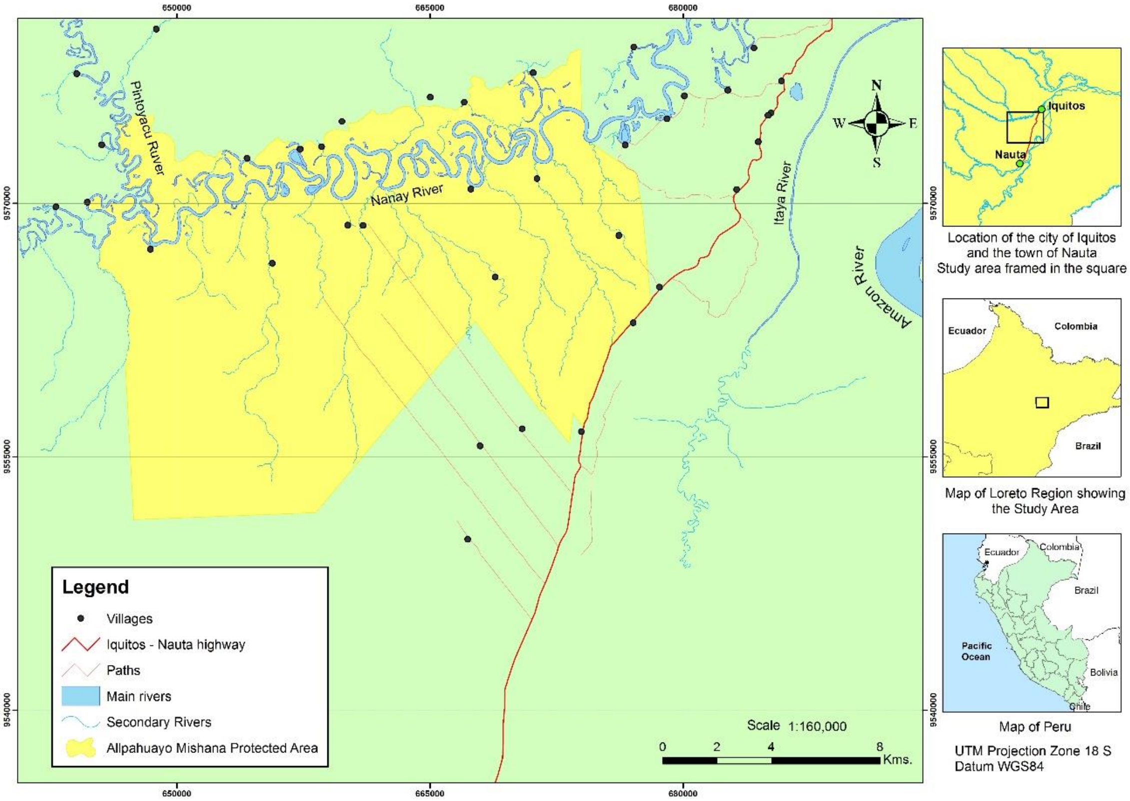

Figure 2: Map of Allpahuayo Mishana National Reserve. Source: SERNANP.

3.2 Objectives of the creation of the AMNR:

According to the first Plan Maestro of the AMNR, the main objective of the creation of the Allpahuayo Mishana National Reserve was “to conserve biodiversity and the habitats of the *varillal* and *chamizal* forests on white sand, which belong to the Napo ecoregion, as well as the swamp forests adjacent to the Nanay river" (INRENA, 2005).

The secondary objectives of the creation of the AMNR are:

- Ensure that the use of resources of wildlife by the local populations established within the "Allpahuayo Mishana National Reserve" is made as to the use of sustainable management techniques.
- Contribute to the conservation of the Nanay River basin, the main source of drinking water for the population of Iquitos.
- Restore habitats degraded by the gradual deforestation of the area in order to minimize the environmental and hydrological effects.
- Serve as natural scenery of the Amazonian biodiversity, where it can demonstrate to students, professionals, and the general public, essential ecological processes of tropical rain forest and the importance of conserving the Nanay River basin.
- Preserve the landscape, aesthetic and cultural values associated with the area, allowing the local population to participate in the provision of recreation, education and tourism.

In the most recent Master Plan, the AMNR is divided in six categories, which can be viewed in the zoning map of the figure 3. This categorization has been done according to the type of ecosystems, species found in the area, current land use, potential uses and threats to the protected area (SERNANP, 2013). The categories are described next with the map showing in the figure 3:

- Strict Protection Zone, areas with certain fragile ecosystems with almost no human intervention.
- Wilderness Zone, areas where there has been almost no human intervention.
- Direct Use Zone, areas where sustainable use of natural resources are allowed but regulated (mainly timber, fruits and fish).
- Special Use Zone, areas where some villages are located and have been in this place prior to the creation of the PA.
- Touristic Use Zone, areas mainly for touristic purposes.
- Recovery Zone, areas where there has been some sort of land degradation so these lands need a special management.

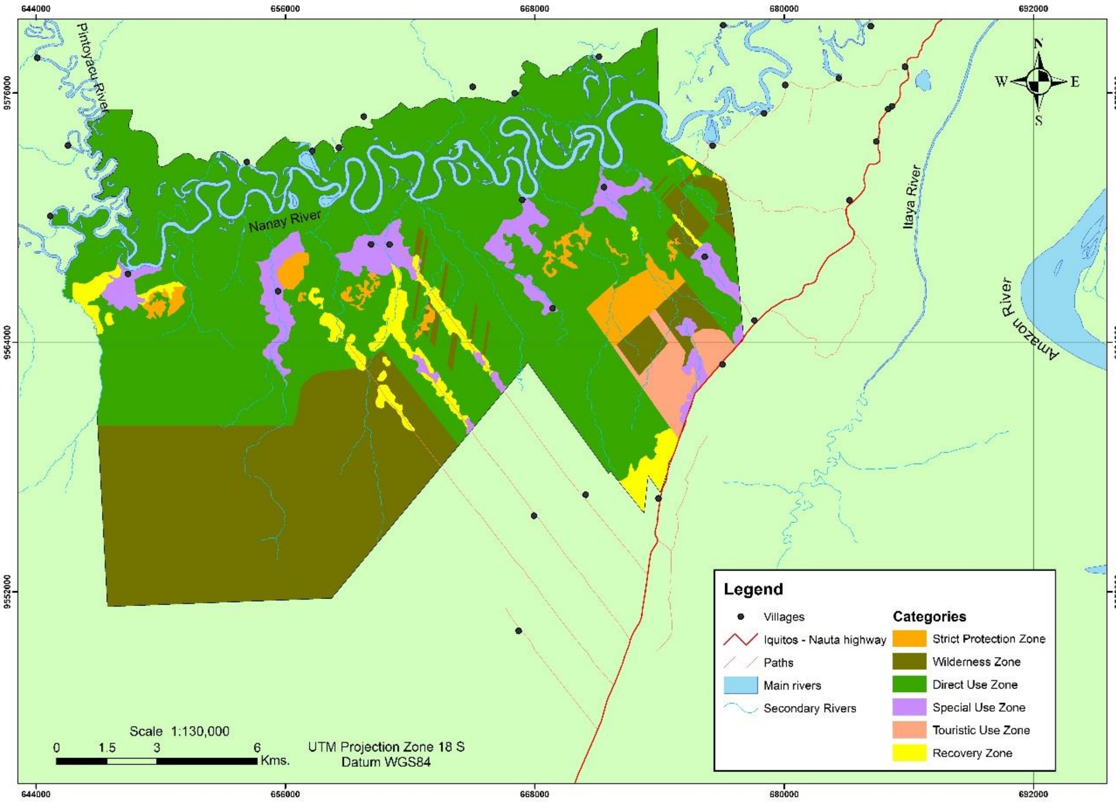

Figure 3: Zoning map of the RNAM. Source: SERNANP.

It is interesting to note that many of these categories for the zoning of the protected area are taken from the IUCN categories, which I have already presented. Nevertheless, according to the Master Plan, it falls in the VI category (Protected area with sustainable use of natural resources).

According to Peruvian legislation (Law of Protected Areas, N° 26834), there are nine categories of Protected Areas (*Áreas Natural Protegidas*), which are the following:

- National Parks (*Parques Nacionales*): Areas that constitute representative samples of the natural diversity of the country and its large ecological units. They are protected by intangible ecological integrity of one or more ecosystems and associations of wild flora and fauna.
- National Sanctuaries (*Santuarios Nacionales*): Protected areas with intangible habitat of a species or community of flora and fauna as well as natural formations of scientific interest.
- Historical Sanctuaries (*Santuarios Históricos*): Areas that constitute the space of sites of special national significance, samples of the monumental and

archaeological heritage or places where outstanding events in the history of the country took place.

- Landscape Reserves (*Reservas Paisajísticas*): Areas whose geographic integrity shows a harmonious relationship between man and nature, sheltering important natural, aesthetic and cultural values.
- Wilderness Refuges (*Refugios de Vida Silvestre)*: Areas that require active intervention for management purposes so as to ensure the maintenance of habitats, as well as to meet the particular needs of certain species.
- National Reserve (*Reservas Nacionales*): Areas for the conservation of biological diversity and the sustainable use of wild flora and fauna, aquatic or terrestrial.
- Communal Reserves (*Reservas Comunales*): Areas for the conservation of flora and fauna for the benefit of the surrounding rural population.
- Protected Forests (*Bosques de Protección*): Areas whose objective is to ensure the protection of the upper watersheds, riverbanks and other water courses, and in general to protect against erosion of fragile lands.
- Game Reserves (*Cotos de Caza*): Areas for the exploitation of wildlife through the regulated practice of sport hunting.

In this sense, for this protected area it was chosen the National Reserve category because it was the most suitable according to the objectives previously mentioned.

3.3 Physical Characterization:

3.3.1 Geology and Geomorphology:

In the AMNR we can find three geological units:

- Neogene Miocene continental – Pebas formation (N-p)
- Quaternary Pleistocene continental – Iquitos formation (Qp-i)
- Quaternary Holocene continental – Alluvial deposits (Qh-al)

To make the description short, the alluvial deposits are due to the Nanay river dynamics in recent times (Holocene), while the other two correspond to more ancient geological formations. The Iquitos formation is constituted mainly by white quartz sandstone, and the Pebas formation is constituted mainly by blue and grey silty clays.

The geomorphological units found in the Mishana community are:

- Flood plains, located in the right margin of the Nanay river
- Low hills with very little erosion, where topographical variation is low.
- Swamps and *aguajales*, which are seasonally or permanently flooded

The information about geology and geomorphology units, as well as the descriptions comes from INGEMMET (1999).

3.3.2 Climatology and Hydrology:

In the northern Amazonian rainforest of Peru, climate is tropical: hot and rainy all year long. In the city of Iquitos, located 25 km northeast of the Mishana community, averages highs of 30°C and lows of 22°C (Kalliola & Flores Paitán, 1998). Mean annual precipitation is 3087 mm with no dry season (ibid.).

The main river that goes through the AMNR is the Nanay River, which flows in west – east direction, turning to the northeast when it approaches to the Amazon River, where it discharges. This river is navigable during all year.

3.3.3 Ecological characteristics:

The AMNR is covered by many types of forests, but the main ones are: v*arillal* (also called white sand), a*guajal* and t*ahuampa* (also called black swamp) forests.

- *Varillal* forests:

Within the limits of the Mishana community we can find many types of forests, from which the most important are the white sand forests, locally known as *varillal* forests, which are very rare in Peru (Alvarez Alonso et al., 2012). There are up to 5 subtypes of these forests, which have been classified according to the height of the canopy forest and the kind of drainage of the soils, represented by the thickness of the organic matter (thin layer: good drainage, thick layer: bad drainage) (García et al., 2003):

- Forest canopy height less than 5 m: very low
- Forest canopy height between 5 – 15 m: low
- Forest canopy height more than 15 m: high
- Organic matter less than 11 cm in the soil: dry
- Organic matter more than 11 cm in the soil: humid

According to this classification there are up to 5 types of varillal forest: high dry varillal, high humid varillal, low dry varillal, low humid varillal and very low humid varillal, also called *chamizal.* (INRENA, 2005).

Most tree species in the *varillal* forests have a short canopy, a brighter understory, and a thick layer of organic material compared to other types of ecosystem in the Amazon tropical forest (Fine et al., 2010). Certain level of edaphic specialization occurs in the varillal forests, which contains many edaphic endemic plants (Gentry, 1986, quoted in Fine et al., 2010). These specialization is due to the poor nutrient availability in the soils. (Fine et al, 2010). With no forest cover, these soils would degrade quite fast.

The main species of trees that can found in the varillal forests are:

Table 5: Main species of *varillal* forests

Common Name	**Scientific name**	**Family**
Aguaje de varillal	*Mauritia carana*	Palmae
Aguajillo	*Mauritiella aculeata*	Palmae
Andiroba	*Carapa guianensis*	Meliaceae
Azúcar huayo	*Hymenaea sp.*	Leguminosae
Balata	*Manilkara bidentata*	Sapotaceae
Boa caspi	*Haploclathra cordata*	Guttiferae
Brea caspi	*Caraipa densifolia*	Guttiferae
Canela moena	*Ocotea aciphylla*	Lauraceae
Carahuasca	*Guatteria sp.*	Annonaceae
Cumala	*Virola decorticans*	Myristivaceae
Espintana negra	*Oxandra xylopioides*	Annonaceae
Guariuba	*Clarisia racemosa*	Moraceae
Lagarto caspi	*Calophyllum brasiliense*	Calophyllaceae
Mari mari	*Vatairea guianensis*	Leguminosae
Marupá	*Simarouba amara*	Simaroubaceae
Moena amarilla	*Ocotea costulata*	Lauraceae
Moena negra	*Ocotea marmiensis*	Lauraceae
Palta moena	*Beilschmiedia tovarensis*	Lauraceae
Panguana	*Brosimun sp.*	Moraceae
Pinsha caspi	*Eugenia percincta*	Myrtaceae
Quillobordón	*Aspidosperma parvifolium*	Apocynaceae
Remo caspi	*Aspidosperma rigidum*	Apocynaceae
Tangarana	*Tachigali poeppigiana*	Leguminosae

Source: Gentry (1993)

- *Aguajal* forest:

Another type of forest that we can find in the Mishana community is the *aguajal,* which is constituted basically by palm trees, among other species. These forests are located in permanently flooded depressions, usually very close to the banks of the rivers between ridges (Kahn & Mejia, 1990). The soils (histosol) are usually composed of accumulation of slightly decomposed organic matter in acidic water (pH of 3.5). Usually, the density of palms is very high, with around 130-250 adult plans per ha (Kahn, 1991).

The main tree species that can be found in the Aguajal forests are the following:

Table 6: Main species of *Aguajal* forests

Common Name	**Scientific name**	**Family**
Aguaje	*Mauritia flexuosa*	Palmae
Brea caspi	*Caraipa densifolia*	Guttiferae
Canela moena	*Ocotea aciphylla*	Lauraceae
Cumala	*Virola decorticans*	Myristivaceae
Huasaí	*Euterpe oleracea*	Palmae
Huayruro	*Ormosia coccinea*	Leguminosae
Lagarto caspi	*Calophyllum brasiliense*	Calophyllaceae
María buena	*Pterocarpus sp.*	Leguminosae
Quillosisa	*Vochysia venulosa*	Vochysiaceae
Shiringa	*Hevea brasiliensis*	Euphorbiaceae
Shiringarana	*Sapium sp.*	Euphorbiaceae
Ungurahui	*Oenocarpus bataua*	Palmae

Source: Gentry (1993)

- *Tahuampa* forests:

Another type of forest that we can find in the AMNR is the black-water swamp forest, also known as *igapó* or *tahuampas de agua negra* (INRENA, 2005). This type of forest can only be found within Peru in the Allpahuayo Mishana National Reserve and is located in the margins of the Nanay River only. They are usually swamped between the months of December to June, and the soils are usually poor in nutrients (IIAP, 2007). Within the Protected Area, it covers around 30% of the total extension. Forest canopy height of these forests is usually shorter than the average swamp forests (ibid.).

The most common species found in the tahuampa forests are *Astrocarium jauari*, *Bactris concinna* and *Bactric maraja,* which usually constitute dense and monospecific patches on small areas (Kahn & Mejia, 1990).

3.4 Population:

In the AMNR we find seven communities, which live mainly close to the Nanay River. The communities are the following:

- Anguilla
- El Porvenir
- 15 de Abril
- San Juan de Yuto
- Mishana
- San Martín
- Nueva Esperanza

In addition, there are another 22 communities and villages located in the Buffer zone of the protected area (The buffer zone was considered 5 km from the outer limits from the protected area). Considering these communities located in the buffer zone, the total population was 6288 inhabitants by year 2007 (INEI). Population only from the seven communities within the limits of the AMNR was 523 for the same year, which was only 8.3% from the total.

Mishana was chosen as the community where I conducted my study, whose location can be seen in the figure 4.

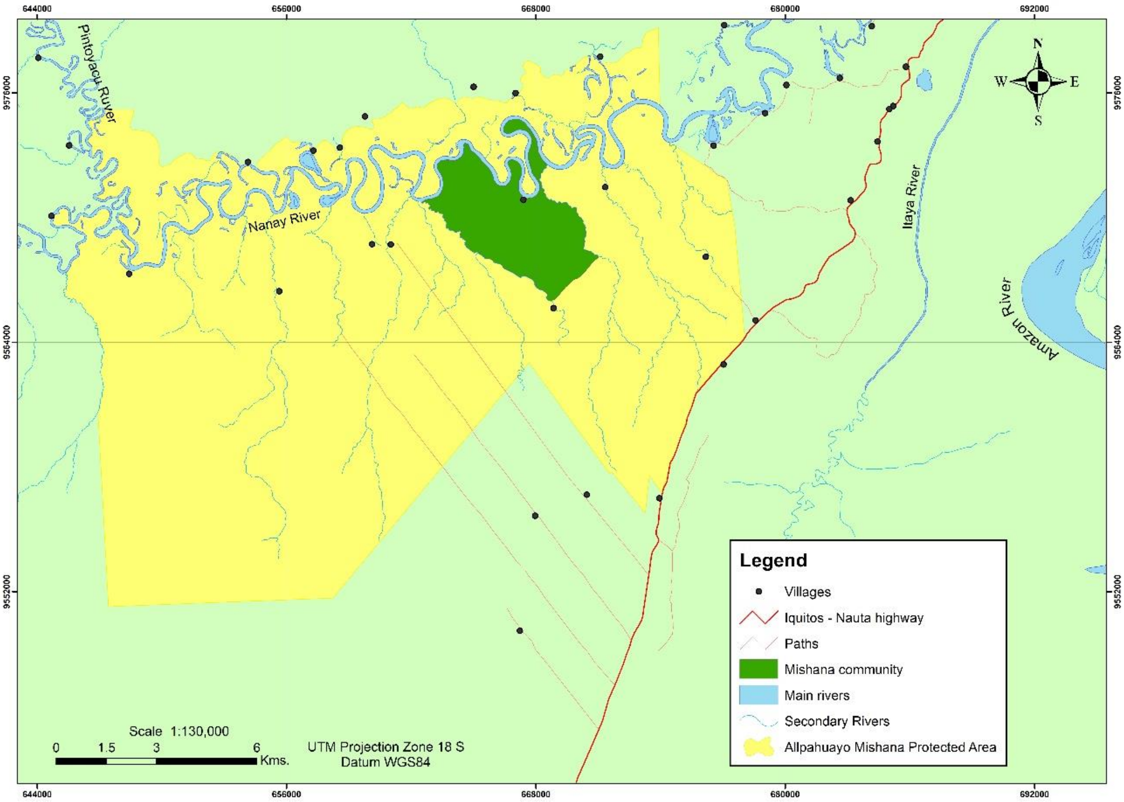

Figure 4: Location of the Mishana community within the Allpahuayo Mishana National Reserve. Source: SERNANP.

It has a total area of 3085 ha, which covers 5.31% of the whole National Reserve. The population of Mishana community by 2007 was of only 70 inhabitants, but by 2016 it increased to 90 (information collected on the field work). It is important to note that this village was founded in the 1920s, but as a community exists since 2004 (more information in the results chapter).

From a landscape ecology point of view, we can consider the rainforest (in general) as the matrix of this landscape. The types of forests such as *varillal* and *aguajal* would count as patches in the landscape, while deforestation would be a type of disturbance in the study area. Deforestation processes would turn into a fragmentation of the landscape. If the disturbance increases, then it would create patches of deforestation, making the matrix smaller, with the possibility of losing connectivity in the landscape.

Figure 5: View from Mishana

Figure 6: Nanay River

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Chapter 4: Methodology

4.1 Introduction: Research Design

Given the research questions in the first chapter, I used both quantitative and qualitative methods for this research. Quantitative methods in order to assess the change of the forest cover and deforestation in our study area, and qualitative methods to give us an insight of the population of Mishana in relation with their activities, with their habitat and the use of natural resources. Field work was conducted to employ these methods mentioned.

4.2 Quantitative and Qualitative methods:

4.2.1 Quantitative methods:

The main quantitative method used was the GPS (Geographic Position System) surveying in the forests of the Mishana community. My objective was to survey the *varillal* and *aguajal* forests by tracking the edges of the patches found on the way. From a cluster of points I would be able to size a polygon (patch) of the forest I had found and in this way I could calculate the patch area. This was possible only for the *varillal* forest patches, but I managed to gather some information about the *aguajal* forest. I will give a further explanation of this problem on the field on 4.6.

4.2.2 Qualitative methods:

There were two main qualitative methods that I used for this study: interviews and observation. Observation is one simple main tool that is always helpful in most of researches, either in social or natural studies.

Interviews were chosen as a way of approximation to the local population because it let me to understand the reality of this community, their activities and relationship with their habitat: the forest.

For both qualitative methods, I will give a further explanation on 4.4.2.

4.3 Selection of case study:

The Allpahuayo Mishana Natural Reserve (AMNR) was chosen as the general study area because it is a protected area that is located close to a large city (Iquitos) and which has special features regarding biodiversity and ecological aspects as we have already seen.

Due to its area (over 58000 ha) I had to select one sector of the AMNR to conduct my research, and with the help of the personal of SERNAMP (entity in charge of protected areas in Peru) I finally chose the Mishana community (5300 ha), which lies in the northern part of the protected area. Because of its very low population (only 90 inhabitants) I considered it would be interesting to know about the forest cover in this place, and also about the local population that currently live there.

Personally, I had already been in this protected area before as a tourist, so I had some basic information about the area, so I felt that it could be interesting to do research in this place.

4.4 Data collection and sources

4.4.1 Forest observation and description:

For this part I carried out an observation and subsequent description of the forests object of my study, which were *varillal*, *aguajal* and t*ahuampa* forests. This was performed while going through the forest, searching for the best places to get the GPS points.

The observation consisted in looking at the forest cover, how dense the forest was, average canopy height and state of the soil (if possible).

4.4.2 GPS Surveying:

As I have previously said on 4.2.1, the GPS surveying consisted on tracking down the forest patches found in the study area. Surveying points were collected in the edges of the forests, so my goal was, with the help of a satellite image (from Google Earth), to delimit the boundaries of the forest patches.

The collected points were entered into a GIS (Geographic Information System) on which I had the following spatial data:

- Allpahuayo Mishana National Reserve
- Rivers
- Villages
- Mishana community
- Map of vegetation (2004)

The map of vegetation, from 2004, is very important because it gives us a detailed information about the cover of the main forest types I am considering for my study. It was made by INRENA (today SERNANP) for the first Master Plan of the AMNR, so it comes from an official document from the National entity in charge of the protected areas in Peru. This map will help me to compare the *varillal* forest cover change between 2004 and 2016, as well as the deforested area.

4.4.3 Interviews:

Interviews were conducted with nine different people, which I will call them informants. The list can be seen in the following table:

Table 7: List of informants interviewed

Informant	**Work/status**	**Place of Residence**
Informant 1	Local guide	Mishana
Informant 2	Forest keeper	Mishana
Informant 3	Boat driver	Libertad*
Informant 4	Lieutenant Governor**	Mishana
Informant 5	Housewife	Mishana
Informant 6	Farmer	Mishana
Informant 7	President of the Mishana community	Mishana
Informant 8	SERNANP worker	Iquitos
Informant 9	SERNANP worker	Iquitos

*Libertad is a village located in the Buffer zone of the AMNR. ** Lieutenant Governor (Teniente Gobernador) is the main authority in a village in Peru.

My main focus in choosing the informants was to include people with different roles inside the community (internal informants), as well as some other informants that do not live there but has some special connections with Mishana due to their work (external informants).

I decided to perform semi-structured interviews for my study. A semi-structured interview is the type of interview that has some degree of predetermined order but there can exist some flexibility regarding the formulation of questions and the topics mentioned by the informant (Clifford et al, 2010). Therefore, the interviews were conducted in an informal way, but maintaining the objectives clear. On average, the interviews lasted for about 30 minutes.

My informant number 1 (local guide) was a key informant, not only because he accepted to be interviewed, but also because he helped me in exploring the forest. Accessibility was a big issue that will explain more in 4.5.

The topics involved in the interviews were:

- Activity/work in which the person was involved
- Perception/knowledge of the possible change in the landscape (forest cover)
- Natural resources management of the local population
- Status of the protected area: advantages and disadvantages.

The questionnaire model is attached in the Annex 1. I considered two versions: one for the internal informants, and other for the external informants.

The answers of the informants were not recorded by any audiovisual device, but just by taking notes in the field. It took place at the informants' home in most cases, except for the SERNANP workers and the boat driver, which were made at their work.

4.4.4 Secondary data sources:

For the spatio – temporal analysis, I used two satellite images from Google Earth with the following specifications:

Table 8: Specifications of the images used

Image source	**Original source**	**Year**	**Type of image**	**Resolution**	**Cloud cover**
Google Earth	CNES	2016	SPOT	1.5 m	Less than 10%
Google Earth	USGS	1970*	Landsat*	30 m*	Less than 5%

Both images helped a lot in assessing the deforested cover in my study area, and the SPOT image also helped me in defining the edges of the varillal forest patches. The asterisk (*) on the 1970 image from USGS means that, although Google Earth says that image is from 1970, it is not clear which type of image is it. One of the oldest satellite imagery belongs to the Landsat project (images with resolution of 30 metres), but it started operating in 1972, so there might be a chance that this image comes from another project different to Landsat or the date shown is wrong.

4.5. Field work experience and challenges:

4.5.1 Planning and development of field work

Field work for this study took 27 days in total (Staying between Iquitos and Mishana) and, while it was very interesting and exciting, it was quite challenging as well. I went with a friend who helped me both in the GPS surveying and in the conduction of the interviews. In addition, as I said in 4.4.3, the key informant, who was a local guide of the community, helped me in the GPS surveying, guiding me and my friend through the forest.

Before going to the field, there was some planning needed. For this planning phase, I was able to finish preparing the questionnaire for the interviews, and had a base map ready. Besides, all necessary equipment (GPS devices, photo cameras, notebooks) was prepared and the necessary arrangements were made to go to the study area. Finally, I had to arrange transport to the study area, which was not an easy task.

Data collection took 10 days when we were in the Mishana community. From Iquitos it took us between 2.5 – 3 hours (by car and then by boat) to get to Mishana. In Mishana, field work in the forest usually took place from 8 am to 3 or 4 pm, depending on the route followed and how much farther we were going through the forest. Interviews in Mishana were usually conducted after being in the forest, previous arrangement with the informant.

4.5.2 Challenges in the field

As the field work was going to be conducted in a remote area in the Peruvian rainforest, I had to face several challenges along the way, which I will explain in the following lines.

First, choosing the specific study area (as addressed in 3.4) turned to be the first challenge because I had come with the idea of conducting my field work in a different sector, which was originally located on the southern part of the protected area, close to the Iquitos – Nauta highway (which was easy to reach by land). However, when discussing this issue with one of the SERNANP workers (which turned to be informant 8), he told me that the area I had chosen was actually private property, so I couldn't enter in that sector. He recommended me to go to Mishana, in the northeast part of the AMNR, which turned to be a great choice for ecological reasons (important *varillal* forest cover in this community). But this choice would lead to the next point.

Getting to the Mishana was not an easy task, because it implied both land and river journey. In order not to have problems about getting there, informant 8 from SERNANP told me some important information about how I should get there, time and cost, who to contact, etc. So I and my friend went from Iquitos to a village called Ninarumi by *motorcar* (sort of informal taxi that can go through roads in bad condition) that took us almost 1 hour, and from Ninarumi we needed to hire someone who can take us to Mishana by boat through the Nanay River. Fortunately I managed to find one person who did this service, and he took us from Ninarumi to Mishana by boat, in a 2-hour journey. This person turned to be informant 3.

Once I was in Mishana, I had to make the daily plans about how to cover the forest area in order to survey the forests that I could find. Being a rainforest, this place was very difficult to go through, so our guide (informant 1) helped me a lot in finding paths on which we could walk safely through the forest. In occasions there was no real path, so he had to cut some tree branches in order to open space for us. Because of this, I did not go exactly where I would have wanted to go, but only where it was possible to go. Accessibility in the forest was probably the most challenging issue

It has to be noted that I (and my friend) were bitten in many places of our bodies by mosquitoes, plus weather conditions were very tough (temperature easily reached 30 degrees, plus high humidity), so hydration was fundamental when walking in these difficult conditions.

Finally, on technical issues I did not have too much trouble with the GPS devices, only that I had to wait a bit long to receive the satellite information (because of the forest cover), so in each point it took me around 3-5 minutes to collect correctly each point.

Chapter 5: Data Analysis

In this chapter, I will present all data results collected in the field, as well as the analysis secondary data that was used in the data processing. It is divided in three parts:

- The state of the forests found in the study area.
- Spatio-temporal analysis of the forest cover and deforestation in the study area.
- Interviews analysis

5.1. Forests found in the field: State and description

Before presenting the results of the GPS surveying, I am going to make a general description and assessment of the forests object of my study.

5.1.1 *Varillal* forests

Varillal (or white sand) forests, probably the most important type of ecosystem in the study area (because of being rare in the Peruvian rainforest), was found in several patches in the Mishana community. There were five patches on indistinctive size that I was able to track.

This type of forest was easy to recognise in the field, due to two main characteristics: the high density of trunks (up to 4 trees per square meter) and the thinness of these trunks. Obviously this pattern was not always observed but one could identify when entering into *varillal* forest.

Average canopy height of this forest was between 5-10 metres, but there were some longer and shorter trees as well. One important characteristic of this forest is that in many parts sunlight was poor, so it could get darker when being in the middle of this ecosystem.

We can see some samples of this kind of forest in the following pictures:

Figure 7: ***Varillal*** **forest**

Figure 8: ***Varillal*** **forest**

The varillal forest cover will be shown in 5.2 in two different years: 2016 (from my field work) and 2004 (from the vegetation map mentioned in 4.4.2).

5.1.2 *Aguajal* forests

In the study area one large aguajal forest patch was found. Access to this patch was difficult, because in the lower part (depression) it was flooded, so it was not possible to walk this forest. The only possible way to track the edge was to follow the southern border of the patch, which is located close to the village. In addition, it was not possible to access this forest from the northern side, because the *tahuampa* forest was blocking the access.
Probably the most characteristic aspect of this type of forest is that is mostly covered by palm trees. In the field, these trees could reach as high as 20 metres.
The most important species in the *aguajal* forest is the palm tree from where his name comes from: aguaje (*Mauritia flexuosa*). There were many individuals of this palm tree found on this patch.

In the following pictures we can see this type of forest:

Figure 9: *Aguajal* forest

Figure 10: *Aguajal* forest

5.1.3 *Tahuampa* forests

In the case of the *Tahuampa* (black swamp) forests, I only had a brief access in the northwestern part of the study area, in the shores of the Nanay River. This is due to the fact that this type of forest is usually flooded and that it was covering a very large area. Height of the trees in this ecosystem was variable and in some cases many trunks were inclined.

Figure 11: ***Tahuampa forest***

Figure 12: ***Tahuampa forest***

In the next section I will show the forest cover analysis through time, with special focus on the *varillal* forest.

5.2 Spatio-temporal analysis:

On this section I am going to detail the results of the GPS surveying in the Mishana community and compare with spatial data of previous years.

5.2.1 GPS Surveying and forest mapping:

After the completion of the field work conducted in the Mishana community, there were 35 surveying points collected that correspond to the limits of the forest patches found. These GPS points are shown in the figure 13:

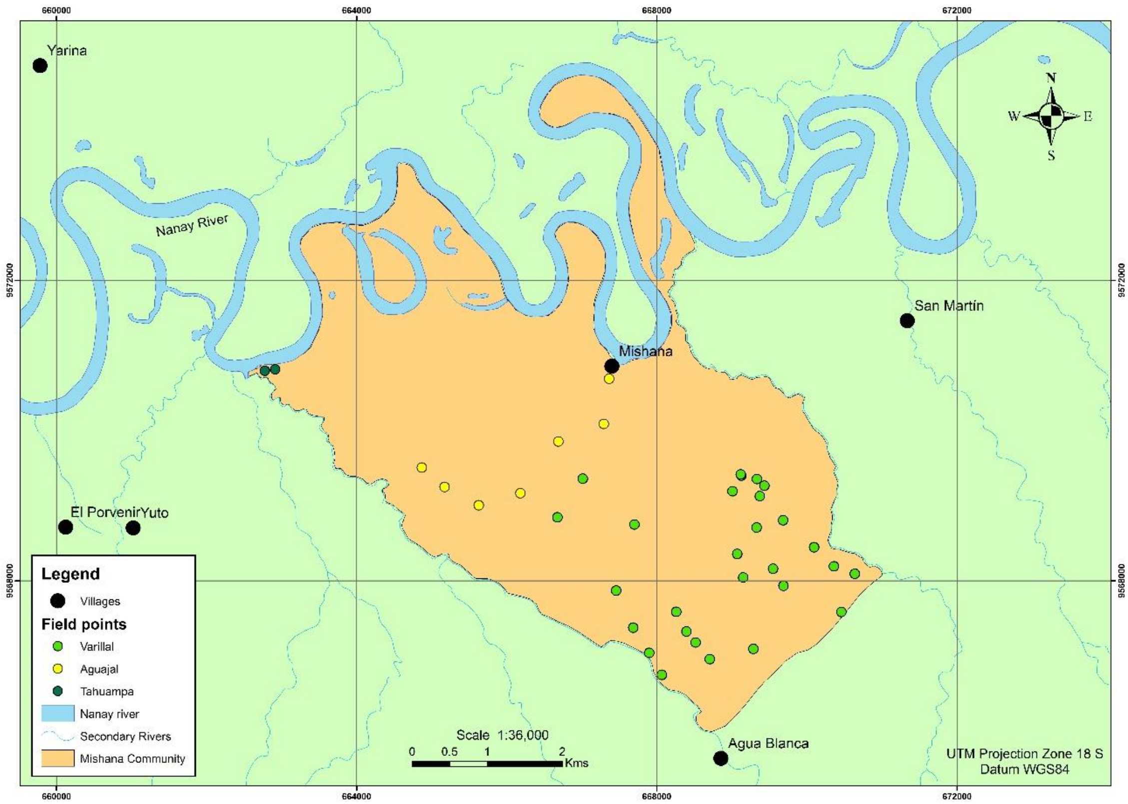

Figure 13: Map of the GPS surveying points in the Mishana community

The points shown in the figure 13 were grouped as a polygon (for *varillal* forest patches) or as a line (for the *aguajal* forest patch) which is displayed in the figure 14 below. Unfortunately, because of the inaccessibility to certain areas, it was not possible to survey the whole *aguajal* forest, so it was reached the southern border only. In the same way, only two points were taken in the *tahuampa* forest as samples because the border in the northern edge was known (Nanay River) but the southern border was inaccessible, so it was not possible to track it where it mostly mattered and was not considered for further analysis. Additionally, deforested areas are shown in the map shown in the figure 14, which were found during the field work and also with the help of Google Earth (for the image of 2016).

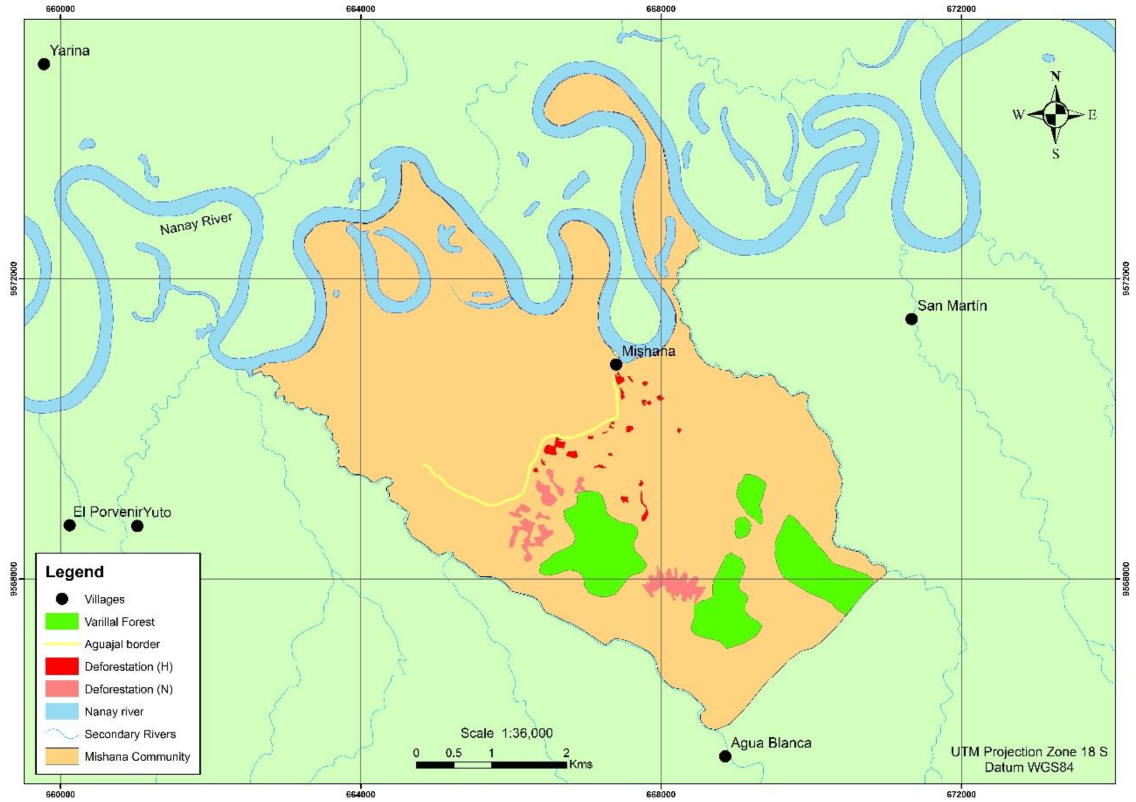

Figure 14: Map of the *Varillal* forest and deforestation cover in Mishana community, 2016

For the map shown we can see 5 patches of *varillal* forest, which are located in the central and SE part of the community. Further, we can see the delineation of the *aguajal* forest, very close to the village of Mishana. In addition, there are represented the deforested areas within the community are represented, and in this case a distinction was made between "natural" and "human" deforestation. This differentiation was possible due to the fact that human deforestation patches had a more polygonal shape, while the natural deforested patches had a more irregular shape, with a different texture (as seen from the Google Earth image). This natural deforestation, as said by our key informant, was due to the strong winds that can happen in the area a few times a year.

5.2.2 Comparison with past data:

The map of vegetation of the Allpahuayo Mishana National Reserve from 2004 gives us an interesting insight of the state of the vegetation for that year in the Mishana community. This is shown in the figure 15:

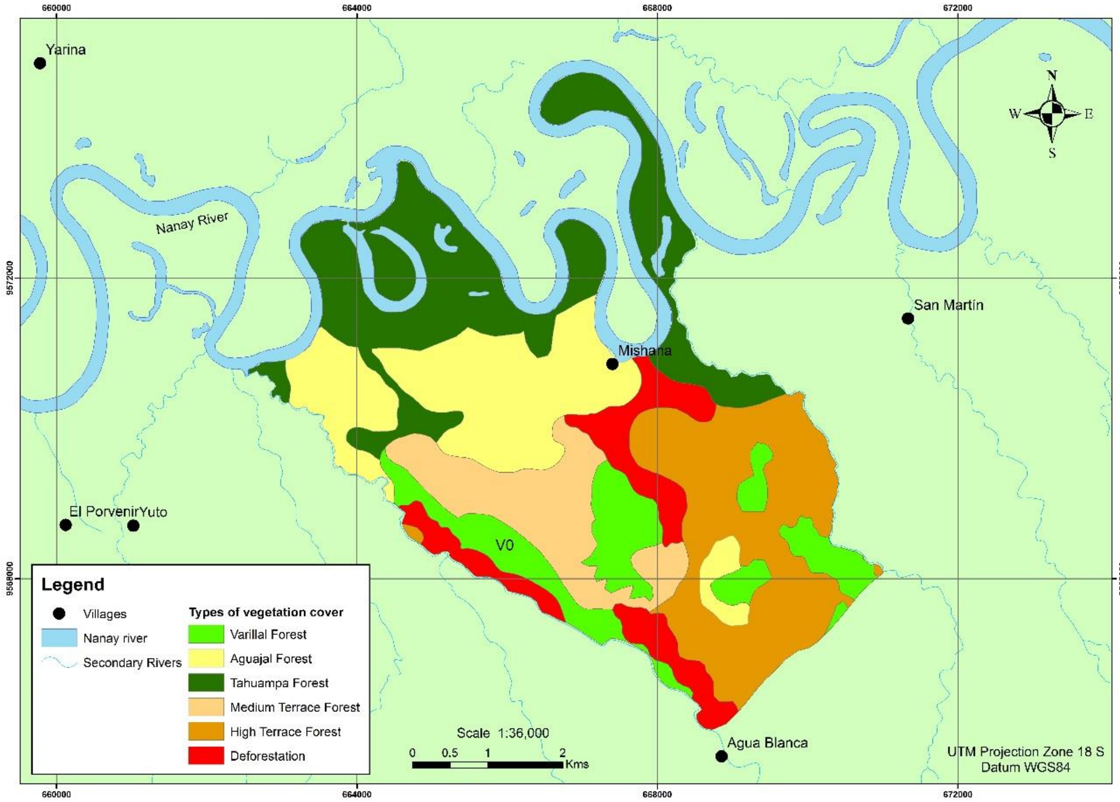

Figure 15: Map of vegetation displaying the *varillal*, *aguajal* and *tahuampa* forests, and deforestation cover in Mishana community, 2004 (Source: INRENA)

From the map shown in the figure 13 we can see there are some large deforested patches within the Mishana community, along with six *varillal* forest patches. In addition, there are three *aguajal* forest patches, two of them located in the northern part and the other one in the southern part. Probably the most interesting pattern that we can obtain from this map is the fact that the deforested area is much larger for the year 2004 compared to 2016.

There is one *varillal* forest patch labelled as V0 on the map. This patch was not covered by the GPS surveying due to the inaccessibility of the forest and its area will not be counted when we calculate changes in the forests cover and deforested area.

Another detail to analyse from this map is the fact that the southern edge of the *aguajal* forest patch from 2016 looks very similar to the one from the patch from 2004, so apparently the area of this forest patch has not changed significantly (along the southern border). It should be noted that the area between the Nanay river and the two large *aguajal* forest patches correspond to the *tahuampa* forest, which is located in both banks of the Nanay river and can only be reached from there and not from inland.

Finally, the medium terrace and high terrace forests are two types of mixed forests that have different characteristics from the *varillal*, *aguajal* and *tahuampa*.

As I decided to study further in the past, from the Google Earth image from 1970 I managed to identify and map the deforested area only for that year. This mapping is shown in the figure 14 below:

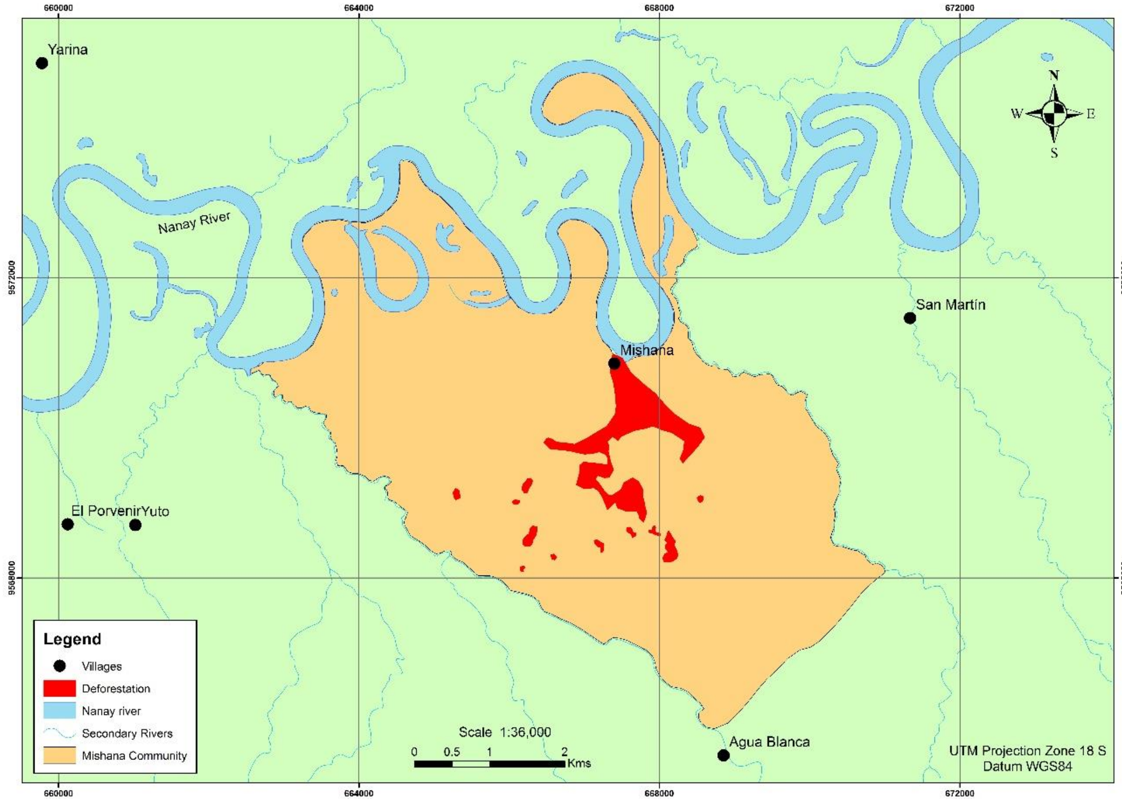

Figure 16: Map of deforestation cover in Mishana community, 1970

As we can see, the deforested area looks smaller for 1970 compared to 2004, with one large patch that extends from the Mishana village towards the south, southwest and southeast, plus some very small patches around. Due to the fact that this information was obtained from Google Earth only, no information about the forest cover of the forests evaluated were obtained for this year.

5.2.3 Area comparison of the varillal forest and deforestation

From the points obtained on the field (2016), the map of vegetation of 2004 and the Google Earth image of 1970, I was able to calculate the deforested area in the Mishana community for those years, as well as the *varillal* forest area (except for 1970). The results can be seen on the Table 5 below:

Table 9: Varillal forest cover and deforestation cover in years 1970, 2004 and 2016

Year	***Varillal* forest cover (ha)**	**Deforestation cover (ha)**
1970	No data	127.71
2004	232.64	277.38
2016	269.65	**49.52**

Source: Own, SERNANP, Google Earth

From the table 9, we can see that the *varillal* forest area has increased from 232.64 to 269.65 haa in the period 2004-2016 (increase of 15.9%). Nevertheless, the most significant change has been the overall reduction of the deforested area, which increased in the period from 1970 to 2004 (increased of 117.2%) but decreased a lot in the next 12 years (decrease of 82.2%). It should be noted that the deforested area for 2016 includes both types of deforestation: natural and human. Natural deforestation (due to strong winds) covers 39.25 haa and human deforestation only 10.27 haa. Therefore, the forest cover in the Mishana community has been increasing since the establishment of the protected area, and the deforested area only covers 1.6% of the total area of the study area. Hence, I can say that landscape has changed considerably in my study area, through natural reforestation.

5.3 Interviews' analysis

As I have previously mentioned, nine people were interviewed for this study. They gave me very valuable information about Mishana, their lives and their forests, as well as how is living in a community located inside a protected area. So in the following sections I will describe and analyse their responses, having in mind my research questions. This part is divided in three parts, which are:

- General questions, regarding the informants' activities, history of Mishana and general comment on how they like it living there.

- Perception on their habitat (forest cover, deforestation and exploitation of natural resources).

- Mishana as part of the AMNR: threats and opportunities.

5.3.1 General questions

Among the internal informants, two of them had an important role within the community: they were authorities (President of the Mishana community and Lieutenant Governor). But they could work in many activities such as farming and fishing, which were the most important activities in Mishana. Other informants, despite having one important activity in which they usually work, still could perform another activities, because, as a community, every member of it was able to help in any important work there were. Another activities that some of the informants (and other people in Mishana) were involved was tourism: there was a lodge in Mishana where tourists (mainly foreigners) went in order to practise shamanism, with the consumption of *ayahuasca* (spiritual beverage) in order to "get purified". Therefore, this lodge need a lot of people for maintenance.

Mishana, as a village, was founded in 1925 (Informant 1), but it was constituted as a community in 2004, because they felt they would have more rights if they were a community, given the creation of the new protected area at that time (Informant 7). In Mishana there are 20 families (90 people) living by 2016.

As for what the informants from Mishana think about their community (positive and negative aspects of living there), most of them said they like living in Mishana because it was far from the big city (Iquitos) and loved to live in a quiet place, surrounded by nature. On the other hand, about the negative aspects of living there, some of the informants said that they feel a bit isolated (it takes at least 3 hours to get to Iquitos) (informant 1), farming was not a very productive activity because of the soils (informant 7), and internal conflicts between the locals (informant 5). Nevertheless, the general consensus from the informants is that they feel happy living in Mishana.

From the point of view of the external informants, they were connected to the Mishana community due to their work, and they enjoyed it because they felt it was their responsibility to help in the protection of the forest and the environment in the AMNR.

5.3.2 Perception of their habitat: forest cover and natural resources exploitation

For the internal informants, all of them agree that the forest cover within the Mishana community has increased in the last 10-15 years. Before the establishment of the protected area (2004), most inhabitants were connected to timber activity and farming without any kind of regulations, but this situation changed and it took some time for them to realise about the importance of the forest (Informant 7). But the timber activity was not only exclusive from the locals: people from other villages and communities used to go to Mishana for wood extraction (Informant 6). Because of the increase in the forest cover, more animal species were seen, and they felt quite happy about it.

There are specific rules and regulations given by SERNANP for the exploitation of natural resources. These regulations were implemented once the protected area was established, and it has been adjusting frequently in order to give the local population more opportunity to use this resources for their own benefit. The main rule concerning this problem says that the population had free access to all fallen trees, and each family had the chance of cut up to 5 trees per year (for themselves only, not for business) (Informant 7). For this, each family had to fill an application first. Fines were given if it was discovered that a person cut more trees than allowed (informant 5).

In another point, all families have a small land area very close to the village, where they can cultivate some basic products for their own consumption (informant 6).

According to the external informants, they also claimed that the forest cover has been recovering since the establishment of the AMNR, and not only in Mishana but in the whole protected area as well. This was due to the implementation of several rules, regulations and restrictions to the different kinds of natural resources, but without forgetting about the local population's needs. Moreover, SERNANP has been working on developing projects about management of these resources with the population of Mishana as well as with the other communities inside the protected area (Informant 2).

5.3.3 Mishana as part of the AMNR: threats and opportunities

About the condition of Mishana as a community part of the AMNR, most of the internal informants said that currently there were no real threats to the forests in the community. They feel that SERNANP helps them in the conservation of the forests (informants 1, 4, 7). One of the informants, however, points to the strong winds (that can occur a few times a year) as a threat, because it may lead to the falling of trees, which can affect the cultivated land they own (informant 6). In the past (before 2004) however, they agree that there was no control from any state entity authority regarding the timber activity, so deforestation was common to a certain extent.

The external informants, talking about the whole protected area, agree that Mishana, as a community, does not really face any significant threat. However, some communities have had some conflicts with SERNANP because of the regulations in the exploitation of the natural resources (informant 2). Another threat that mostly affects the buffer zone (right outside the boundaries of the protected area) is the exploitation of white sands, which is used for construction of houses and buildings in Iquitos (informant 9). This turns to be a serious problem because it implies the deforestation of forests such as *varillal*. This threat can be seen very close to the Iquitos – Nauta highway, so it is located relatively far from the Mishana community.

Regarding the opportunities and new expectations the local population has about their future, they point on the importance of tourism as an important source of income. As pointed in 5.3.1, the lodge used for shamanism generates work for some people from Mishana, and, at the time I conducted my field work, a new lodge for tourists was being built and implemented, which would be ready for the end of the year 2016. They really see tourism as a really huge opportunity for all the community.

Finally, on the topic of conservation, the internal informants said that they expect more projects from SERNANP and work together in land and forest conservation (informants 6, 7). They also request the presence of more forest keepers in the protected area (informant 4).

Chapter 6: Discussion

After the results shown in the previous chapter, there are a few things that need to be discussed, such as the validity of the data collected and the relation of my results with the theory presented in chapter 2. It is important to address and comment these points in order to explain the possibility of some kind of bias in my results.

Concerning the validity of the data obtained and collected, I have to talk about the GPS surveying. As I already stated in the previous chapters (4 and 5), due to the inaccessibility of the terrain, it was not possible to get the exact points of the edges of the *varillal* or *aguajal* forests. Nevertheless, I made the greatest effort to be as close as possible of these edges.

On to the functioning of the GPS devices used in the field, in almost all cases the error shown was between 5 – 8 metres, so in general the satellite reception was quite well. Fortunately, weather was sunny or mostly sunny on the days when I was doing field work in the forest (only one rainy day), so this also helped in a better reception.

About the secondary data obtained, the map of vegetation for the study area from year 2004 constitutes a very important source because I was able to compare the varillal forest cover and deforested area for both 2004 and 2016. This map, despite coming from an official document, does not say explicitly what the original source was and which techniques were used, so it is not 100% trustworthy. Nevertheless, it is a very important source for my study.

The Google Earth image from (apparently) 1970 was very interesting to analyse because it was an old satellite image, which let me compare three different moments in time. As stated in 4.4.4, I cannot determine with 100% reliability about the exact date of the image shown or the type of image it is. However, this does not affect the validity of my results, because I can see the deforested area at that time. Unfortunately, the spatial resolution of this image is low (around 30 metres), but even with that resolution it was possible to identify the deforested land in my study area. For this reason, area calculations might have a little error, but the trend is still clear.

In 5.2.1, I made a distinction between natural and human deforestation, because I believe it was important to differentiate both types of deforestation (of course if it was possible to do). So, with the help of the 2016 image from Google Earth, I was able to identify the deforested area in my study area, and the deforested patches due to human activity were easy to recognise because of their geometrical form, while deforested patches due to natural causes (strong winds according to the informants) had a very irregular shape, plus texture looked quite different compared to the other one.

About the interviews conducted, I must say that all of them took place on a familiar surrounding (either their home of their place of work), and therefore the informants were always in a good mood to answer the questions given. People from Mishana were very kind and helpful.

Looking carefully at the area calculations about the deforested area and the *varillal* forest cover for 1970 (only deforestation), 2004 and 2016, it is interesting to note that in the first period (1970-2004) we can see an increase of the deforested area. This sounds logical, given the fact that there were no regulations during this period and there was no protected area established yet. Then, from 2004 until 2016, the deforested area has reduced considerably (82%). Certainly, this is quite a big change, and the fact that the forest has recovered so much in 12 years tell us how dynamic can this ecosystem be. Of course, the main reason for this increase in the forest cover was the establishment of the AMNR, but that would not be enough if not for the continuous work of SERNANP in collaboration with the local population. The purpose and objectives for which this protected area was created are being accomplished.

Regarding this increase in the forest cover in Mishana, it is still unclear if this reforestation (secondary succession) is being given by primary or secondary forest. From my results, there is a small information that can gives us some insight, and is the increase in the *varillal* forest cover, of almost 16% in the period 2004-2016. Although it is a significant value, I cannot say with complete certainty if this process of reforestation is due to primary or secondary forest. It would be necessary a deeper research in the ecological succession of this ecosystem to get to know this process more clearly.

From the theory chapter, after analysing these results, we can say that resilience, as explained by Malanson (2007), is quite high in this type of ecosystem. However, from the data collected, it is not possible to know which component(s) of resilience (proposed by Westman (1978)) were keys on this resilience of the forest (elasticity, malleability, amplitude and hysteresis). We can only know that elasticity (rate of recovery) was 6.9%

per year for the period 2004-2016. Further research and methods are needed to understand this event.

According to McIntyre & Hobbs (1999), we can observe that now, this landscape would be intact (only 1.6% deforested). From the three moments in time, it never got into the second category (variegated landscape), although it got very close, with 9% by 2004. Probably if the AMNR had never been established, this would have gone the opposite way (more deforestation).

Fragmentation within the forests of the Mishana community was low. Deforested areas cover less than 2% of the total study area, and it is constituted by very small patches, so in general it is possible to say that there is a high degree of connectivity too.

The most important disturbance in this ecosystem are the strong winds, as already mentioned in 5.3.3. In the past, humans played an important part on this regard, but in recent times this changed in benefit of the conservation of the forest.

Deforestation patters model, proposed by Zipperer (1993) can tell us that in general, the two most common patterns observed are internal and cropping (until 2004). As deforestation caused by human activity has virtually stopped, this framework would not be useful for Mishana from now on (depending on the circumstances and events that could happen in the future).

About the consequences of deforestation addressed by Chakravarty et al. (2012), for the period 1970-2004 the main effects of deforestation were probably a decrease in the biodiversity, habitat loss and social consequences, related to the timber activity (according to my informants). Nowadays, the opposite has been happening for the last 12 years (reforestation), and it will be interesting to know if this good work in conservation is maintained or not.

Chapter 7: Conclusions

The Mishana community is a very interesting place regarding their forest and local population. Twelve years have passed since the establishment of the AMNR and, according to the results presented on this thesis, I can say that the general outcome has been positive, regarding the conservation of the forests, fauna and flora. Before 2004, farming and forestry activity were the driving forces that modified the landscape of Mishana, but once the protected area was established, rules were given to the local population and they learnt to give their forests a special value and work on their conservation. *Varillal* forests are a very good example.

The forest recovery in the Mishana community has been really impressive (given the recovery rate), and gives very good news about future conservation plans in other protected areas. The landscape had a relatively small deforested area by 2004, but it managed to recover almost completely only 12 years later. Nowadays, the only real threat, as a disturbance, are the strong winds that may affect this area. Fragmentation could only be the result of this weather event.

The Allpahuayo Mishana covers over 58000 haa, from which 3000 belong to the Mishana community. It is only a small piece inside this important protected area that has a very high biodiversity, but it can be a very good example of land and forest conservation.

Tourism appears as the potential main activity of the local population in the future, and, if it turns to be that way, it has to go along with plans that involve conservation and care for the environment.

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Appendices

Appendix 1: Questionnaire guide

To:

- Group A: Local population: men/women over 35 years.
- Group B: Rangers of the Protected Area and researchers (internal or external)

Mishana population: 90 inhabitants (2016)

Part I: General Questions (For Groups A & B)

1. - Basics:

   a) Age

   b) Occupation

   c) Place of residence

2. - How long have you been living here?

3. - When was this village created (established)? (If it was known by the person)

4. - If you are originally from another place, why did you move here?

Part II: (For Group A only)

5. - What do you like and dislike the most about living here?

6. - Do you have free access for exploitation of natural resources in your property?

7. - Look back 20 years ago. Do you perceive any significant changes in the forest cover around your village/community?

8. - If yes, how would you describe it? Is it positive or negative?

10. - In your opinion, what are the main threats to the Mishana community as a Protected Area (PA)? Please explain.

11. - What could be done to improve the conservation inside the Mishana community?

12. - What does it mean for you to live inside a PA?

13. - In overall terms, are you happy living here? Why?

Part III: (For Group B only)

14. - How long have you been working in the PA?

15. - When was the first time you came here?

16. - In your opinion and personal experience, do you think there has been a change in the landscape within the PA in the last 10/20 years? (Time lapse could be less according to personal experience). If so, how would you describe it?

17. - In your opinion, what are the main threats and problems that affects the PA?

18. - What can be done to improve the conservation of the PA?

19. - What is the impact of tourism in the PA?

20. - How is the relationship of SERNANP with the Mishana community?