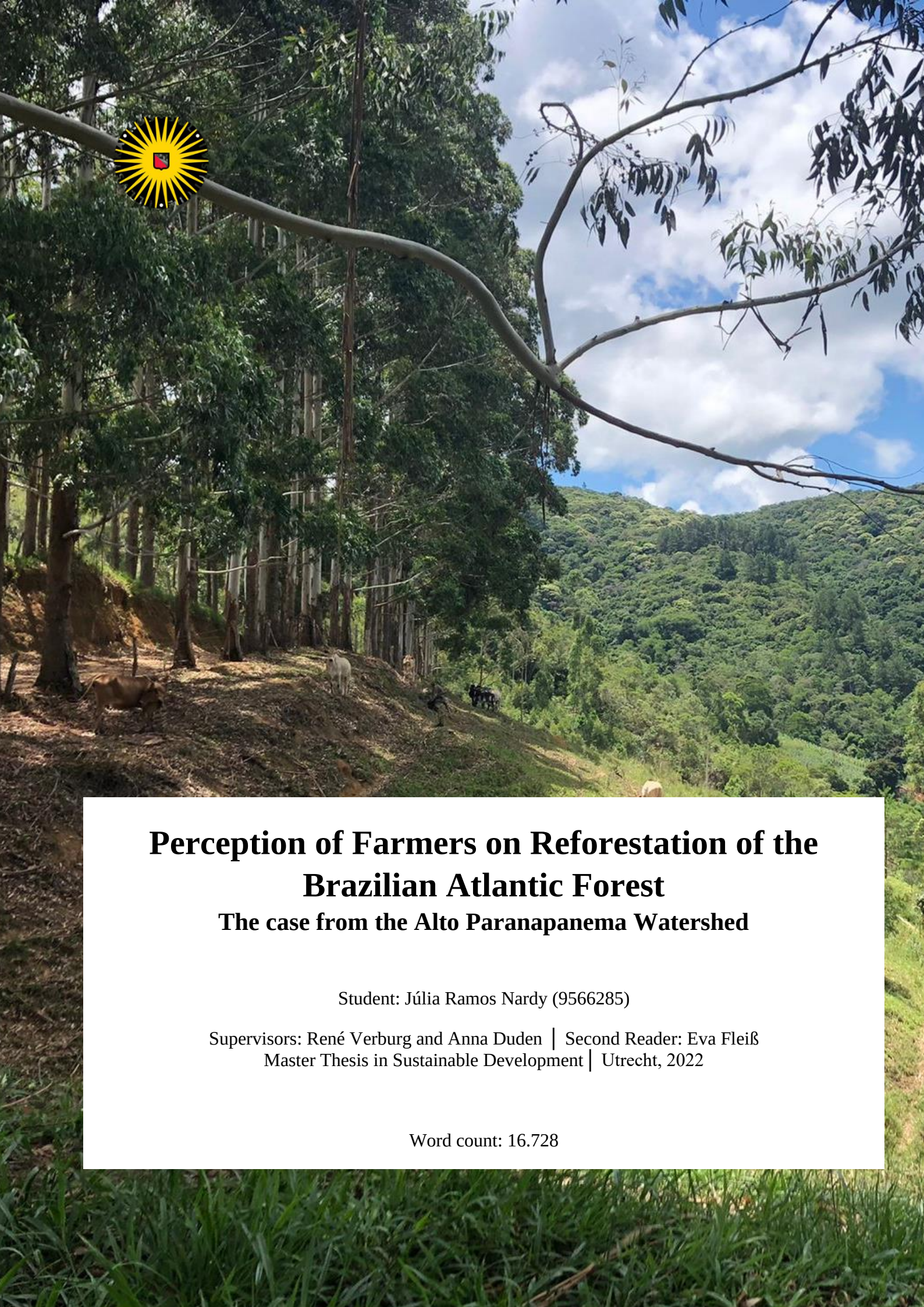

Perception of Farmers on Reforestation of the Brazilian Atlantic Forest

The case from the Alto Paranapanema Watershed

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"*Ecologia sem luta de classes é jardinagem*"

*"*Ecology without social justice is gardening*"*

– Chico Mendes

Nhe'éry

– Atlantic Forest for the guaranis. It means "where spirits bathe"

Abstract

The Brazilian Atlantic Forest (BAF) is an ecological hotspot, and nowadays only 11,4% to 16% of the native vegetation is left, in which most of its remaining forest patches are small and disconnected from each other. Of the native vegetation left, 64% is within rural private properties, that are mainly used for agriculture – a key economic sector for Brazil's GDP. This entails that rural property owners are key actors to ensuring the connectivity of the remaining forest patches of the BAF through forest conservation, preservation, and restoration – necessary measures to ensure that the extinction threshold of this forest is not surpassed. To further understand what the possible drivers and barriers for these actors to ensure the forest perpetuity are, it is important to assess what are their perceptions (shaped by socio-economic factors) on reforestation. To assess this, this study focused on the Alto Paranapanema watershed, located in the southeast of the state of São Paulo, in the southeast of Brazil. This watershed is a multi-functional landscape with forests, agriculture, industries, and people. 381 farmers from the watershed participated on a survey developed by the author, in which the answers were assessed by means of a quantitative analysis. Findings suggest that the watershed accounts for three different clusters of farmers, in which they differ due to their different socio-economic characteristics and perceptions. Nonetheless, they also have common perceptions and characteristics and overall, they understand the benefits of having forests – both for their personal lives, and for their farming practices. Nevertheless, they would be more willing to reforest and maintain forests within their properties if they were to be compensated by market strategies, or if they were to receive the benefits entailed in the Forest Act.

To my dear parents, Gabriella and André.

Acknowledgments

To everyone that works for the resilience of Brazilians forests. You are amazing! Thank you for keeping our forests, our biodiversity, our home alive!

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List of Abbreviations

APA – Environmental Preservation Area, Portuguese Acronym
BAF – Brazilian Atlantic Forest
CAR – Rural Environmental Registry, Portuguese Acronym
CEPEA – Center for Advanced Studies in Applied Economics, Portuguese Acronym
CBH-ALPA – Alto Paranapanema Watershed Committee, Portuguese Acronym
CCA – Canonical Correspondence Analysis
CLT – Consolidation of Labor Laws, Portuguese Acronym
CNS – National Health Board, Portuguese Acronym
CV – Coefficient of Variation
EE – Ecological Station, Portuguese Acronym
EMBRAPA – Brazilian Agricultural Research Corporation, Portuguese Acronym
FAO – Food and Agriculture Organization of the United Nations
FE – State Forest, Portuguese Acronym
FM – Fiscal Module
FN – National Forest, Portuguese Acronym
GDP – Gross Domestic Product
IBGE – Institute of Geography and Statistics, Portuguese Acronym
INCRA – National Institute of Colonization and Agrarian Reform, Portuguese Acronym
LR – Legal Reserve
MEA – Millennium Ecosystem Assessment
MMA – Environmental Ministry of Brazil, Portuguse Acronym
N/A – Not Available
NEEDS – Center of Studies in Spatial Ecology and Sustainable Development
NGO – Non-Governmental Organization
NWO – Dutch Research Council
PAST – Paleontological Statistics
PE – State Park, Portuguese Acronym
PES – Payment for Ecosystem Services
PLANAVEG - National Plan for the Recovery of Native Vegetation, Portuguese Acronym
PPA – Permanent Protection Area
PRA – Environmental Regularization Program, Portuguese Acronym
PRONAF - National Program of Strengthening Family Agriculture
RPPN – Private Reserve of Natural Heritage, Portuguese Acronym
SICAR – System for the Rural Environmental Registry, Portuguese Acronym
SIGRH – Integrated Water Resources Management System for the State of São Paulo, Portuguese Acronym
SNIF – National System of Forest Information, Portuguese Acronym
SNUC – National System of Conservation Units, Portuguese Acronym
UFSCAR – Federal University of São Carlos
URGHI – Hydrographic Units for Water Resources Management, Portuguese Acronym

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1. Introduction

Brazil has the world's second-largest natural forest area, yet it also has the world's largest annual deforestation rate (FAO, 2015). The Atlantic Forest is an ecoregion present throughout 27 degrees of longitude along the east coast of Brazil, and parts of Paraguay and Argentina, with high degrees of biodiversity not only for its longitudinal extent but also for the different altitude gradients (varying from zero to 2.700m from sea level) within its extent (Pinto & Hirota, 2022). It is a known ecological hotspot, which means it features high concentration of endemic species, but it is also a place that experiences major loss of habitat (Myers et al., 2000). This ecoregion used to occupy 150 Mha along Brazil and small parts of Paraguay and Argentina, and nowadays, in Brazil only 11,4% to 16% of its native vegetation is left (Ribeiro et al., 2009). This ecoregion is fundamental for its ecosystem services, its biodiversity (Myers et al., 2000; Ribeiro et al., 2009; Pires et al., 2021), and for hosting about 70% of the Brazilian population (Varjabedian, 2010), and 70% of Brazil's Gross Domestic Product (GDP) (Rezende et al., 2018).

Furthermore, Brazil is one of the biggest commodity producers in the world, being the biggest producer of products such as soybeans, sugar cane and orange (FAO[1], 2019), and is also the biggest exporter in the world of soybeans, beef and veal meat, chicken meat, and maize (FAO[2], 2019). Brazil's GDP has around 24,7%[1] of its total value related to agribusiness – an industry that relies partly on ecosystem services for its existence, for instance through the maintenance of soil structure and fertility (Power, 2010).

Besides that, in Brazil, 90,55% of the farms are smaller than 100 hectares (ha) (Cosme, 2020). Nevertheless, this represents only 20,44% of the total agricultural land being used (Cosme, 2020). Additionally, big, and medium land area[2] farms have grown to 351 million hectares (5% more in extension - if comparing the Census of Agriculture[3] from 2006 to 2017). Hence, 79,56% of the land is owned by only 9,45% of the producers (Cosme, 2020).

In the Brazilian Atlantic Forest (BAF) ecoregion, 78% of the territory is occupied by private rural properties, 6,3% is owned by the government, 9,8% is not specified or registered with the government, and 5,9% is occupied by cities, roads, and water (de Faria et al., 2021). 64% of the remaining native vegetation of the ecoregion is within those rural private properties (de Faria et al., 2021). The properties that host the vegetation are heterogeneous. For instance, 94% of the properties registered in federal systems for land tenure management belong to small producers[4], whilst they occupy only 44% of the total area of this ecoregion (de Faria et al., 2021). In contrast, 1% of the properties belongs to large producers, whilst they occupy 32% of the total area (de Faria et al., 2021). Regarding the remaining forest patches, most of them (83,4%) cover less than 50 ha and are usually isolated from each other (mean distance between fragments is around 1400m) (Ribeiro et al., 2009) – almost half of the forest patches are less than 100m from open areas (such as roads), which shows the vulnerability of this forest, since the biodiversity within it can be sensitive to edge effects (Ribeiro et al., 2009). In contrast, most of the big forest patches are in areas where the terrain is steeper, which are harder to produce agricultural goods, and therefore have smaller human occupation (Silva et al., 2007).

Furthermore, the extinction threshold of the BAF is 30% of native vegetation coverage, which means that the area of forest needs to be increased in order for the biodiversity to persist in the long term (Joly

[1] when considering primary production, production of inputs for agriculture, and all other activities that process and distribute the products to their destination (CEPEA,2021).

[2] According to the Brazilian legislation, extra small, small, medium, and large properties are defined accordingly to their area. The unit of measurement used is the fiscal module (ha). It varies accordingly to the municipality, and it is defined by the National Institute of Colonization and Agrarian Reform (INCRA). This matter will be further explained in the Theoretical Framework (Section 2).

[3] Held by the Brazilian Institute of Geography and Statistics (IBGE)

[4] Land size classification is further explained in the Theoretical Framework (Section 2).

et al., 2014). Since native vegetation coverage is less than 30% (Ribeiro et al., 2009), there are many efforts still to be done about forest restoration (Ribeiro et al., 2009). In line with this need for forest restoration, several initiatives have been developed, such as the Pact for the Restoration of the Atlantic Forest, which is an initiative that was created in 2009 with the goal of restoring 15 million hectares (Mha) of forest cover in private lands by 2050 (Holl, 2017). The Pact consists of multiple stakeholders from private companies, research institutes, NGOs, and governmental institutions (Holl, 2017). They believe that having a multi-stakeholder management of forest restoration programs, and with diverse bottom-up governance and solutions (such as through the development of funding mechanism for restoration), then this goal can be achieved (Holl, 2017; Crouzeilles et al., 2019). There are also different public policies that shape forest restoration in private properties in Brazil such as the New Brazilian Forest Act, the Plan for Vegetation Recovery (PLANAVEG, Portuguese Acronym), and the Payment of Environmental Services law (Pinto & Voivodic, 2021), and specific for the BAF, such as the Lei da Mata Atlântica (Atlantic Forest Law). Nevertheless, even if the goal of the Pact is reached, and landowners comply to the New Brazilian Forest Act (approximately 3 to 5 Mhas of Permanent Preservation Areas restored and 2Mhas of Legal Reserves restored[5]), the restoration will still not be enough to ensure that the BAF does not cross its extinction threshold (de Faria et al., 2021).

There are some particularities regarding the Atlantic Forest in the State of São Paulo. Since the 1960s, São Paulo state passed through a transition from a mainly agricultural State to an agro-industrial one, especially due to public policies that enhanced the mechanization of practices within the farms, enhanced policies for exportation of commodities, and increased the use of chemical pesticides and fertilizers (Calaboni et al., 2018). These policies benefited mostly large-scale farmers, leading to the exodus of small and medium farmers that produced staple food from rural areas to urban areas, in search of work (Calaboni et al., 2018). The percentage of the GDP related to agribusiness in the state is around 14%[6] (80% related to cropland and 20% related to rangeland) (CEPEA, 2021).

Since the 1980s, São Paulo has a net reforestation rate, with more areas being reforested rather than being deforested, given that in many areas where the soil could not retain a lot of water (mainly in slopes and with native forests close by), agricultural lands were abandoned, and restoration of forests occurred naturally (Calaboni et al., 2018). These areas are and were too costly to be used for agriculture, and regeneration mainly occurred naturally given the nearby forests (Calaboni et al., 2018; São Paulo, 2018).

This context shows that agriculture is a key economic sector for Brazil and the state of São Paulo, and it is heterogeneous from a social and agrobiodiversity perspective. Nevertheless, it is also a sector that has had a major impact on the deforestation of the BAF, and nowadays farmers have a great responsibility in reforesting, since the remaining patches are small, disconnected, and within private properties (Ribeiro et al., 2009; de Faria et al., 2021). Additionally, the reasoning behind farmers' willingness to reforest the BAF relates to policies (in which farmers only have an obligation to reforest if they don't meet legal requirements), knowledge, and financial incentives, in which deforestation or reforestation are not necessarily related to farmer's values (Melo et al., 2013; Watanabe & Sant'Ana, 2014; Klein et al., 2015; Trevisan et al., 2016; Toledo & Zonin, 2020).

Within this line, Zubair (2006) argues that perceptions should be accounted for the understanding of farmers' engagement in reforestation programs and policies, and the Millennium Ecosystem Assessment (MEA, 2005) proposes that it is likely that the restoration of landscapes will depend on cultural perception, and political and economic interests.

[5] mechanisms of forest restoration envisioned in the New Brazilian Forest Act that will be further explored in Analytical Framework (Section 3).

[6] when considering primary production, production of inputs for agriculture, and all other activities that process and distribute the products to their destination (CEPEA, 2021).

People's perceptions are shaped by their capabilities, which are shaped by personal, societal, cultural, environmental, and economic conditions (de Vries & Petersen, 2009; van Egmond & de Vries, 2011). Capabilities are chosen by individuals depending on their value systems and relate to the belief they have on quality-of-life and resources to achieve them (Van Egmond & de Vries, 2011). The capabilities useful for individuals are defined by Nussbaum & Sen (1993) as "physical life, health, physical integrity, senses, imagination, thinking, emotions, reflection, relations, other species, games as well as political and material control over one's own environment" (apud Van Egmond & de Vries, 2011, p.854). Hence, perceptions are shaped by capabilities, which in turn are shaped by environmental, social, and economic constraints. Zubair (2006) argues that perceptions should be accounted for when shaping programs and policies for reforestation, since they can intensify or encourage latent perceptions that do not have expectations met for lack of opportunities. Thus, understanding people's perceptions, and shaping programs and policies in which their expectations could be met, could enhance their participation in restoration programs and policies (Dawes et al., 2018).

Surveys can be used to further understand people's perceptions towards reforestation programs and policies (Soto et al., 2016; Trevisan et al., 2016), and the analysis of perceptions of different actors can support the improvement of policies, not only for adaptive governance, but also for environmental justice issues, for instance through better ensuring the distribution of resources (Dawes et al., 2018). Furthermore, there is a knowledge gap on understanding how different farmers (in farm sizes, type of production), within one set landscape, perceive reforestation and therefore the possible reasoning behind engaging in reforestation practices.

This study focused on the Alto Paranapanema watershed, located in the southwest of the state of São Paulo (further presented in Methodology Section 4). Agribusiness is the main economic sector of the area characterized mainly by the production of corn, beans, potatoes, sugar cane, and soybeans (CBH-ALPA, 2019), and the industries of paper and cellulose, limestone mining and processing of timber (CBH-ALPA, 2019; CBH-ALPA, n.d.). This part of the state has 20% of native vegetation coverage left, which in comparison to other regions within the same state, has one of the largest percentages of forest cover, only losing to the seaside area (São Paulo, 2018). This gives this area an interesting approach to try to understand the relationship between agriculture and nature preservation from the perspective of people that are managing the landscape.

1.1 Research Question

Multi-functional landscapes are landscapes that account for agriculture and forests, and farmers are key actors for the management of these landscapes (Zuidema & Sayer, 2003). Since farmers manage these landscapes, and the remaining patches of BAF are located mainly within rural properties (de Faria et al., 2021), farmers are key actors for the reforestation of the BAF, and effective restoration plans require solutions considering regional, environmental, and socio-economic reality, multi-stakeholder engagement, and tailor-made solutions within those variables (Holl, 2017).

Furthermore, deforestation and reforestation may depend on landscape manager's perceptions on ecosystem services, and according to the policies and capabilities that support them (MEA, 2005; Zubair, 2006; Trevisan et al., 2016).

Within this scope, this research aims at answering the following research question: "What are the perceptions of producers from the Alto Paranapanema watershed on reforestation?"

To answer this research question, two sub-questions were developed:

(1) What are the perceptions of producers from the Alto Paranapanema watershed on ecosystem services and its policies?
(2) What are the farm and farmer characteristics that might be related to these perceptions?

The research questions will be answered by means of a quantitative analysis supplemented by a survey that was applied with 381 farmers from the Alto Paranapanema watershed.

2. Theoretical Framework

In this section, concepts that are touched upon in this study will be further explained to define the boundaries of the research and for the reader to better understand specific concepts that might be unfamiliar to them, since some of these concepts regard specific Brazilian laws. Hence, the concept of farmer provided in this study will be explained in this section, as well as the terms Fiscal Modules (FM), conservation, preservation, and restoration.

2.1 Farmers

Farmers in this study are defined as property decision makers – as in land managers, or people that have agency regarding land management, since for instance in agro-industrial farms, it is common to have employees managing farms instead of property owners (Cunha & Espíndola, 2016; Ceolin, 2019).

2.2 Fiscal Module (FM)

A Fiscal Module (FM)[7] is a unit of measurement of rural properties defined by the National Institute of Colonization and Agrarian Reform (INCRA, Portuguese Acronym)[8] in which size references of properties differs accordingly to their municipality. This unit was defined to represent the minimum average size of an economic viable rural property (Landau et al., 2012). This value varies in accordance with the production types predominant in the municipality, wages, and the "family production" concept of the area (Embrapa², n.d.). One Fiscal Module varies across Brazil from 5 to 100 hectares (Embrapa², n.d.).

Different land-size classifications are defined accordingly to the FM, in which a very small property is defined as having less than one FM, a small property is defined as having from one to four FMs, a medium property is defined as having from four to fifteen FMs, and a large property is defined as having more than fifteen FMs (Embrapa², n.d.).

Additionally, land-size classification is used in the New Forest Act as the unit that defines the amount of forest each rural property should have for each biome (Landau et al., 2012). For instance, for Permanent Preservation Areas (PPAs) (this regulation will be further explained in the Analytical Framework - Section 3), the area of the forest can vary between 5 to 100 meters from the river course, and it cannot surpass 10% of the total area of the farm if the farm has less than 4 FMs and cannot surpass 20% of the total area of the farm if the farm has more than 4 FMs (Landau et al., 2012).

In the Alto Paranapanema watershed the average FM is of 19,64 hectares.

Hence, in this paper, FM is used as a reference unit to portrait land management and demographic characteristics in the analysis.

2.3 Conservation and Preservation

In this section, conservation and preservation will be explained within the context of forest policies in Brazil. Afterwards, the formats in which these two different forest management policies exist within the Alto Paranapanema watershed will be presented.

Conservation is related to the rational and sustainable use of natural resources, ensuring their existence for future generations (Brasil, 2011). It has a utilitarian perspective of nature, in which nature has a monetary value upon, and can be used for society's benefit (Norton, 1986). In contrast, preservation is related to the action of protecting an ecosystem or a natural resource from damage or degradation, that is, not using it, even if in a rational and planned way (Brasil, 2011).

[7] *Módulo Fiscal*
[8] *Instituto Nacional de Colonização e Reforma Agrária*

Two laws shape conservation and preservation of forests in Brazil. The National System of Conservation Units[9] (SNUC, Portuguese acronym), and the New Forest Act.

The SNUC is a national law that defines and regulates conservation units (areas defined by the government in which the natural resources within it have a specific regime). It defines two main categories of land use, one for conservation - Conservation Units of Sustainable Use, and one for preservation - Full Protection Units (Brasil, 2011). Within the watershed, the first one is present as Environmental Protection Areas (APAs), State Forests (FEs), National Forests (FNs), and Private Reserve of Natural Heritage (RPPNs), and the second is present as Ecological Stations (EEs), and State Parks (PEs) (CBH-ALPA, n.d.). These units are presented below in Table 1.

Table 1: Conservation Units from the Alto Paranapanema

Conservation Units of Sustainable Use	**Full Protection Units**
APA Corumbataí, Botucatu e Tejupá	EE de Angatuba
APA da Serra do Mar	EE de Itaberá
FE de Angatuba	EE de Itapeva
FE de Manduri	EE de Paranapanema
FE de Paranapanema	EE de Xitué
FE de Piraju	PE Carlos Botelho
FN Capão Bonito	PE Intervales
RPPN Fazenda Horii	
RPPN Vale do Corisco.	

Source: CBH-ALPA. (n.d.).

The New Forest Act will shape conservation and preservation in the form of Legal Reserves (for conservation) and Permanent Preservation Areas (for preservation) (Embrapa Forestry, 2018). The Act implies that for small farmers (up to 4 Fiscal Modules), the sustainable use of resources (such as agroforestry systems, and extractivism can occur within the Legal Reserves and Permanent Preservation Areas. Private Protected Areas can only be exploited in case of public utility (for the social development, such as infrastructure projects) or social interest (such as extraction of agroforestry products from the area, if the native vegetation does not lose its character) and with the authorization of the competent body (Brasil, 2012; Faria, 2018; Rezende et al., 2018; Milaré & Milaré, 2020; Lima, 2001).

2.4 Restoration

In this study, the definition of forest restoration, or ecologic reforestation of forest ecosystems will be the one given by Rodrigues et al. (2015), which is defined as "the human intervention on degraded ecosystems with the aim of facilitating, accelerating or allowing for the process of ecological succession" (Rodrigues et al., 2015).

Furthermore, forest restoration is the process of restoring degraded, damaged, and/or destroyed ecosystems with the goal of bringing ecosystem services and biodiversity close to its original conditions, either by natural (ecological succession or passive restoration) or assisted (active restoration or reforestation) processes (Fernandes, 2020; Brasil, 2011; Melo et al., 2013). In this way, restoration is not only about increasing the quality of ecosystem services but doing so accordingly to the former native vegetation, since more mature forests have higher ecological complexity, and therefore are more resilient to disturbances (Rodrigues et al., 2015). Furthermore, restoration is a process, in which the

[9] *Sistema Nacional de Unidades de Conservação*

transition towards the similar original level passes through different states throughout the years (Rodrigues et al., 2015).

Within this scope, in this study, reforestation will be used as an umbrella term for passive (ecological succession) and active (reforestation) restoration practices.

3. Analytical Framework

The research questions will be answered by means of a quantitative analysis supplemented by a survey that was applied with rural property decision makers from the Alto Paranapanema watershed. This section aims to describe the frameworks that were used as building blocks for the construction of the survey and for its analysis afterwards.

The survey was divided into four overarching themes: (i) farm characteristics, (ii) farmer characteristics and access to resources/capabilities, (iii) farmers' perception on the New Forest Act regulations, (iv) farmers' perception on ecosystem services, Payment of Ecosystem Services (PES), and their willingness to reforest. All survey questions were based in scientific literature, and insights from a fieldwork held in January 2022 in the Alto Paranapanema watershed, together with project colleagues from the *Universidade Federal de São Carlos* (UFSCAR).

3.1 Farm, Farmer Characteristics and Access to Resources and Capabilities

The understanding of the demographic characteristics of the farmers, as well as the resources available to them, can give a perspective of who are the people that are managing the landscape, and what economic and environmental resources, and capabilities they have available. Therefore, it can give a broader perspective on how their perceptions were built. This section shaped the questions of the two first overarching themes from the survey, as well as its analysis framework.

As mentioned in the Introduction, Brazil's agricultural scenario is very heterogeneous (Landau et al., 2012; Cosme, 2020), which also depicts different resources, and capabilities – which in turn will shape perceptions (de Vries & Petersen, 2009). Basic capabilities, such as access to clean water, basic sanitation, and security are indicators of capabilities within countries that are not industrialized (Ballon, 2013). Even though Brazil is an industrialized country, given its social injustices – rooted also within its colonization history, with land concentration, and agriculture based on the exportation of goods – many people still suffer from the lack of these basic capabilities (Pochmann & Silva, 2020).

Socioeconomic factors can also play a role in defining farmer's perceptions on reforestation, for instance different income and educational levels can indicate different preferences for reforestation practices (Dawes et al., 2018), or religions can play a significant role in defining people's perceptions on community building, and nature (Teixeira et al., 2018), or the economic dependence on the production can also influence on the perception on reforestation (Fernandes, 2021).

Furthermore, as mentioned in the introduction, the topography of the farm can also play a major role in reforestation practices, since higher slopes tend to be more expensive for farming practices, and therefore are more likely to have forests (Calaboni et al., 2018).

The aging of farmers, and the possibilities of rural exodus, that can influence in increased labor costs for farming practices, and the type of production, that can influence on the gross production margin and opportunities costs can also influence on farmer's willingness to reforest (Fasiaben et al., 2010).

Farm ownership and compliance with regulations also can impact the jurisdictional situation of the farm, which implies access to public policies, agricultural credits, and insurance, which in turn also impact farmer's willingness and ability to reforest (Santana & Santos, 2020).

Furthermore, literature has shown that gender, capacity building, and suffered natural hazards can also shape perceptions and further enactments upon adaptation strategies for climate change (Diiro et al., 2016), which in turn were used as possible indicators that could influence perception on reforestation. For instance, men and women can act in different ways when partaking in adaptation strategies for climate change, since women could have less access to resources (such as land and labor, capacity building for structured decision making that can rely on the availability of field technical assistance and agricultural credit lines specific for adaptation) for instance to use specific irrigation methods that could be more sustainable, which requires specific knowledge on how to do it, and capital to buy materials for the new system, natural hazards can influence on the perceptions of what producers could be doing to prevent them from happening again (Diiro et al., 2016).

This section portraits different characteristics that influence directly on the capabilities and perceptions of farmers in reforestation.

3.2 The New Brazilian Forest Act and Forest Conservation, Preservation and Restoration in Private Rural Properties

The New Brazilian Forest Act is a Brazilian law that shapes forest preservation, conservation, and restoration of native vegetation in all of the country's biomes (Brancalion et al., 2016; Rezende et al., 2018). This law has national, state, and municipal enforcement, and clear responsibilities assigned to rural property owners (Rezende et al., 2018). In this section this policy will be further explained, since the compliance or non-compliance of it by rural property owners influences directly on native vegetation coverage (Brancalion et al., 2016; Rother et al., 2018; Rezende et al., 2018). Hence, farmers perception on this policy is key to understand farmer's perception on reforestation of the Atlantic Forest.

The Brazilian Forest Act was created in 1934, but the latest version of it was established in 2012 (New Forest Act). The Act accounts for rules on the protection of native vegetation, guiding and regulating the use of land and the conservation of natural resources (Dichoff, 2016). The specificities for this Act for nature conservation within private land are shaped within the Rural Environmental Registry (CAR, Portuguese Acronym) [10], Legal Reserves (LRs)[11], Permanent Protection Areas (PPAs)[12], and the Environmental Regularization Program (PRA, Portuguese Acronym)[13] (Brites, 2020) that will be further explained in this section.

CAR was created to identify private properties (Dichoff, 2016) and its environmental information (SICAR, n.d.). This regulation implies that all rural property owners must register their properties within their municipalities, for which they must inform different variables, such as the georeferences of the property and of the reminiscent patches of native vegetation within the property, and data of the property owner (SICAR, n.d.). This regulation was created to be used as a tool for the state to be able to verify whether rural properties follow the New Forest Act, and to then be able to enforce sanctions if compliance with the rules is not met (SICAR, n.d.). The non-registration of the property will imply in sanctions such as not being able to get amnesty for deforestation that might have occurred before July 2008, nor will the property owner be able to get access to agricultural credit (Embrapa[3], n.d.).

PPAs are described as mandatory patches of forests (native or non-native) located "along rivers or any watercourse; around ponds, lakes or natural or artificial water reservoirs; in the springs; on top of hills, hills, mountains, and mountain ranges; on slopes or parts of them; in sandbanks, as fixators of dunes or stabilizers of mangroves; on the edges of the boards or plateaus; and at an altitude above 1,800 meters. It is not allowed to use forest resources in APP areas" (SNIF, 2019), regardless of them being in private or public properties (da Silva et al., 2016).

[10] *Cadastro Ambiental Rural*
[11] *Reservas Legais*
[12] *Áreas de Preservação Permanente*
[13] *Programa de Regularização Ambiental*

LRs are a percentage of the rural property that should be conserved with native vegetation (in the BAF region this is 20% of the property area) (Brasil, 2012). If the percentage of forest is not enough as in accordance with the law, the LRs should be restored (either passively or actively), unless the property has less than 4 FMs, and has been deforested before the 22nd of July 2008 (Bernardo, 2010; Chiavari & Lopes, 2016). The property owner can also compensate the forest deficit by buying the equivalent necessary forest area in another private or public owned property (Brasil, 2012; Bernardo, 2010).

If the requirements of PPAs and LRs are not met, and the policy is enforced, then the property owner is bound to respond legally to this infraction, as depicted by the decree nº6.514/2008 and the law nº 9.605/1998 (de Oliveira et al., 2018), in which fines of R$5.000,00/ha may apply (Brasil, 2008).

The PRA is a program in which producers that have an environmental passive can apply to compensate deforested areas, receive amnesty from fines received from deforestation in PPAs and LRs, amongst other benefits, such as the regularization of agro-silvo-pastoral activities within PPAs (Brancalion et al. 2016; de Faria et al., 2021). This policy gave more power to the states for the creation of policy instruments that were in line with the social, economic, and environmental realities of each state. In the State of São Paulo, the PRA has already been regulated but properties are still not able to adhere (de Faria et al., 2021).

PPAs and LRs are regulations used for the conservation, preservation, and reestablishment of native vegetation areas within rural properties, while the PRA serves as a command-and-control instrument to support and encourage the recovery of degraded or altered areas (Brasil, 2017).

The New Forest Act was used as basis for the public policy questions present in the survey. Therefore, in order to analyse the perception of the farmers regarding the Forest Act, the questions from the survey and analysis afterwards consisted of the possible benefits farmers could have when complying to the policy's instruments such as access to different markets, or agricultural credit (Rode et al., 2015; Bottazzi et al., 2018; de Melo et al., 2021), their overall knowledge and agreement with the policy's instruments (Fernandes, 2021), and the possible social recognition for complying with the policy's instruments (Rode et al., 2015).

3.3 Producers' Perceptions on Ecosystem Services, Payment of Ecosystem Services (PES), and their Willingness to Reforest

The Millennium Ecosystem Assessment (MEA, 2005) proposes that it is likely that restoring landscapes will depend on cultural perception, and political and economic interests. They define ecosystems as dynamic interactions between the nonliving environment, plants, microorganisms, and animals. Ecosystem services are then the services provided by nature that influences human beings (MEA, 2005). Daily (1997) defines ecosystem services as "the conditions and processes through which natural ecosystem, and the species that make them up sustain and fulfil human life". In this study ecosystem services were used as a framework to understand how farmers perceive the benefits of reforestation. Hence, in this section, ecosystem services and the perception of their benefits are further explained.

The MEA defines ecosystem services in four main branches: (1) provisioning services, (2) regulating services, (3) cultural services, and (4) supporting services (MEA, 2005, p.40). (1) Provisioning services are products that can be extracted from ecosystems, such as food, feed, fiber, fuel, genetic resources, natural medicines, animal and plant products, and freshwater. (2) Regulating services are benefits obtained from the functioning of ecosystem processes, such as air quality regulation, climate regulation, water purification and waste treatment, erosion regulation, water regulation, pollination, natural hazard regulation, and disease and pest regulation. (3) Cultural services are nonmaterial benefits from the ecosystem, such as cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetical values, social relations, sense of place, cultural heritage values, recreation, and ecotourism. Finally, the (4) supporting services are the services necessary for the

existence of all other ecosystem services, such as soil formation, photosynthesis, nutrient cycling, primary production, and water cycling. (MEA, 2005, p.40).

To further understand how people might perceive ecosystem services and public policies, the framework developed by Bottazzi et al. (2018) is further explained. They infer that nature, community and money can play a role in defining farmer's motivation to enroll in PES schemes (Bottazzi et al., 2018). Hence, in this study, reforestation through these lenses could be motivated by pro-environmental perceptions, pro-financial perceptions and pro-social perceptions (Bottazzi et al., 2018). Furthermore, it could also be motivated by the lenses that other actors (as the government and markets) have the responsibility of ensuring restoration and nature resilience in the long term (van Egmond & de Vries, 2011; Peter et al., 2021).

Pro-environmental motivations can have two sides, in which one accounts for direct benefits nature can bring to humans (instrumental), and one that accounts for a non-instrumental perspective, in which nature has the right to exist, regardless of the possible added value it might bring to humans (Bottazzi, 2018). In this study, ecosystem services are perceived as instrumental perceptions of nature, given they are perceived as "services" that can sustain human life (Daily, 1997). Non instrumental perceptions were then existence, bequest, and moral commitments perceptions of nature (Bottazzi et al., 2018; Peter et al., 2021). Pro-social motivations that might influence people's perceptions on ecosystem services regard people's relation to the society they are embedded, such as conforming to rules, making alliances, being fair to the community and social capital (Rode et al., 2015; Bottazzi et al., 2018). Finally, financial motivations regard the possible perceptions on how restoration programs could improve the financial performance of farms (Parron & Garcia, 2015; Richards et al., 2020).

These categories are shown in the Categories Definition presented in the Methodology (Section 4).

4. Methodology

4. 1 Area studied

This study will focus on the Alto Paranapanema watershed, an area located in the state of São Paulo, in Brazil, and that has gone through a major agricultural expansion in between 1987 and 2017 (de Melo & Martensen, n.d.), but is also an environmental conservation watershed, especially on the Serra do Paranapiacaba region (CBH-ALPA, 2019).

The Paranapanema river is an affluent river of the Paraná River. This affluent is located in the Southeast of Brazil, in between the Federal states of Paraná and São Paulo. The river's mouth is located in the municipality of Capão Bonito (at the Serra dos Agudos), and the river has an extension of 660 km, moving northeast, towards the Paraná River (Dias, 2003) and its drainage area accounts for 109.000 km² (of which 27.400km² is located within the State of São Paulo) (Sampaio, 1890). It is located within a valley which has an unlevelling of 542 meters (Dias, 2003).

Figure 1. Alto Paranapanema watershed. In the top right of the Figure, the region is highlighted within the state of São Paulo. Source: sigrh.sp.gov.br (n.d.). Legend: boundaries of the URGHI (black line), urban area (in orange), municipal headquarters (small red dot), municipal headquarters (big red dot), rivers and reservoirs (blue line), conservation units (in green), points where superficial water is monitored (yellow dots).

The Alto Paranapanema watershed (shown in Figure 1) was formalized as part of a São Paulo state agreement from 1991 to organize the water resources from the state from an integrated perspective (Cury, 2006) and focusing on quality water supply for future generations (CBH-ALPA, 2019). 22 different Hydrographic Units for Water Resources Management (URGHIs, Portuguese acronym)[14] were formalized, and amongst them is the URGHI 14 – Alto Paranapanema.

The Alto Paranapanema watershed consists of 21,3% of the Paranapanema river watershed, and its main economic activities is agriculture, which includes pulp and paper industries, limestone mining, and planting and processing of reforestation timber, besides rangeland and cropland (CBH-ALPA, 2019). The main products produced in this area are sugar cane, beans, potato, corn, tomato (CBH-ALPA, n.d.), and soybeans (Junior et al., 2021), and in the primary sector, the main economic activity is livestock management. (CBH-ALPA, 2018). Furthermore, many companies that supply inputs, machinery, and technical assistance to produce crops (specially soybeans) have recently been established in the

[14] *Unidades de Gerenciamento de Recursos Hídricos do Estado*

watershed, as well as cooperatives that deal with the drying, storage, and commercialization of these crops (Junior et al., 2021).

The watershed accounts for a big duality in between agro-industries and family agriculture, given that land is mainly concentrated with few people that own large patches of land, producing monoculture crops, but also is an area that accounts for one of the highest concentrations of small, family farms in the state of São Paulo (Kassaoka, 2018; Junior et al., 2021).

The Alto Paranapanema watershed consists of 34 municipalities (totally or partly included in the URGHI-14), which are inhabited by almost 800.000 people, 75% of which live in urban areas (Milani & Oliveira, 2019). The urban population is expected to grow, whilst the rural is expected to decrease within the next decade. In rural areas, the decrease in the population is especially characterized by the exodus of young women and therefore the aging and masculinization of the rural population, that may be a problem specially for family farms, where the succession of the farm activities can be at stake in the longer term (CBH-ALPA, 2018).

As can be seen in the map below (Figure 2), the watershed includes different land uses: native vegetation (BAF and Cerrado), silviculture, rangeland, cropland, urban areas, water basin, and others. The predominant land use is cropland. Nevertheless, this was not always the case. The landscape has changed from 1987 to 2017, with a decrease of almost 70% of rangeland, and an increase of approximately 600% of cropland (de Melo & Martensen, n.d.).

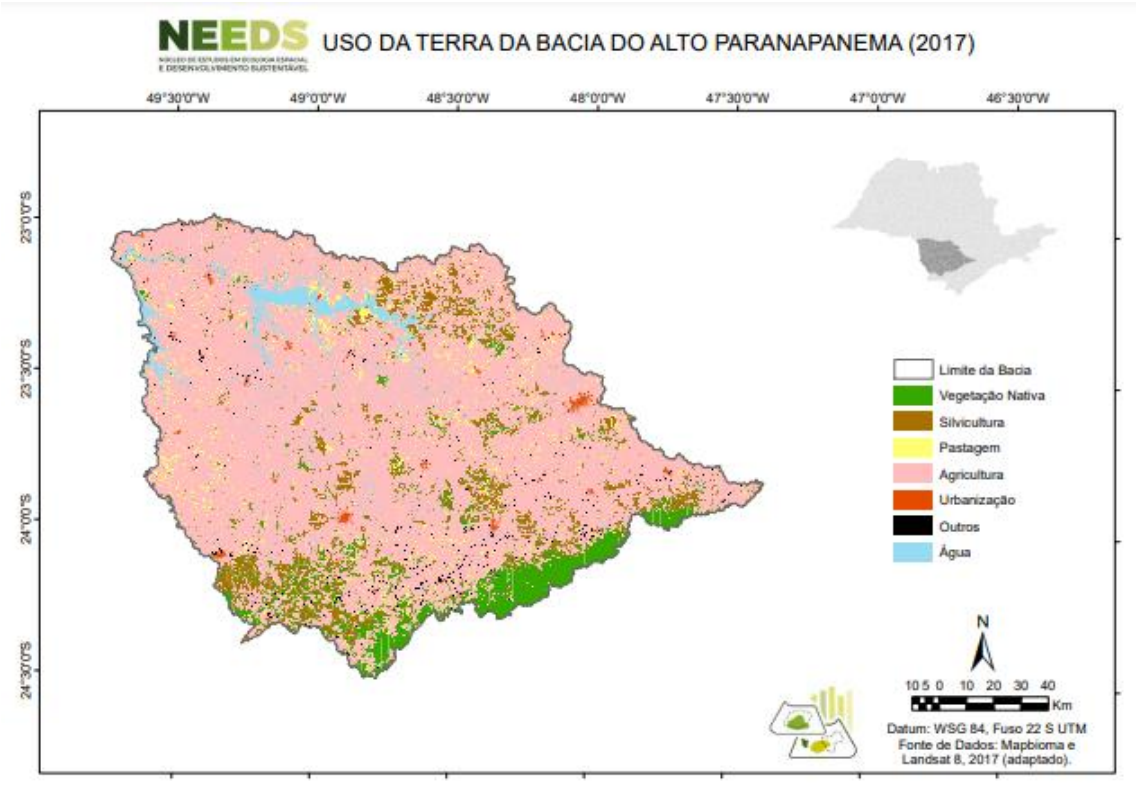

Figure 2. Land Use in 2017in the Alto Paranapanema Watershed. Source: de Melo & Martensen (n.d.). Legend: boundaries of the watershed (white), native vegetation (green), silviculture (brown), cropland (pink), urban areas (red), others (black), water (blue).

Irrigation pivots are used in most of the extent of the URGHI-14. In the municipalities of Itaí, Itapeva, Paranapanema, Buri, Itaberá and Itapetininga, the water demand is approximately 16,85m³/s. This area has a higher demand for water than the total available within the center part of the basin. Furthermore, water crisis has become of greater concern since 2016, since the precipitation has decreased significantly, shifting the hydrological regime of the basin. (CBH-ALPA, 2019).

4.2 Data Collection and Processing

To answer the research questions, a structured survey was conducted with 381 farmers from the Alto Paranapanema watershed. To analyze the answers, a quantitative analysis was made.

4.2.1 Survey

The survey for this study was developed as part of the project "Governing the Atlantic Forest Transition" - a transdisciplinary collaboration between the University of Utrecht (focused on social sciences), and UFSCAR (focused on natural sciences). The project aims to identify opportunities and barriers for the reforestation of the Atlantic Forest.

The survey was developed by the author and the colleague Jaime Alcântara Luz, MSc student of Sustainable Business and Innovation from Utrecht University, in which they were invited to develop a survey to be held with farmers from the Alto Paranapanema watershed, in order to identify key aspects for the project "Governing the Atlantic Forest".

Luz's study focuses on how knowledge was built, and how alliances were created in between farmers and the different stakeholders they engage with. His research questions are: (1) What are the perceived barriers by landowners to engagement in reforestation?, (2) What are the perceived barriers by non-landowner stakeholders to landowner engagement in reforestation?, (3) What socioeconomic and biophysical contextual factors play a role in landowner engagement in reforestation?. In this study, the term "study group" refers to the partnership between the author and Jaime A. Luz.

The survey consisted only of closed questions. They were either of multiple choice (with the option to inform an "other" choice), 7-points Likert scale (ranging from completely agree (7), agree (6), partially agree (5), neutral (4), partially disagree (3), disagree (2), and completely disagree (1)), asking for specific numbers (for instance, size of the farm in hectares), and yes and no questions.

Out of the 178 questions, 96 were used for the analysis of this research.

4.2.2 Sample Definition

As could be seen in the section "Area Studied", the Alto Paranapanema watershed is an area that accounts for a duality in between agro-industries, and family farms. Hence, to answer the Research Questions, farmers in this study are portraited as property decision makers – as in land managers, or people that have agency regarding land management, it is common to have employees managing farms instead of property owners in agro-industrial farms (Cunha & Espíndola, 2016; Ceolin, 2019).

The Alto Paranapanema watershed includes 28.016 farms[15]. For a sample to be representative for the Alto Paranapanema watershed considering a 95% degree of confidence and 5% error margin, the sample must include at least 379 producers.

The sample elements were chosen based on six elements: (1) boundaries of the watershed, (2) CAR boundaries[16], (3) irrigation pivots (2017), (4) Conservation Units, (5) declivity, and (6) hydrography. A map was developed in QGis, in which the cartographic materials of those elements were aggregated (all obtained on the website of the Center of Studies in Spatial Ecology and Sustainable Development (NEEDS)[17] from the UFSCAR.

[15] if considering that the Southeast Paulista region has 13.184 farms (Melo et al., 2021) – and it represents 16 out of the 34 municipalities of the Alto Paranapanema watershed.
[16] Properties with and without CAR boundaries were chosen
[17] Núcleo de Estudos em Ecologia Espacial e Desenvolvimento Sustentável

Figure 3 below shows the Alto Paranapanema watershed. Black lines are properties' boundaries, and dots are properties assessed in the survey.

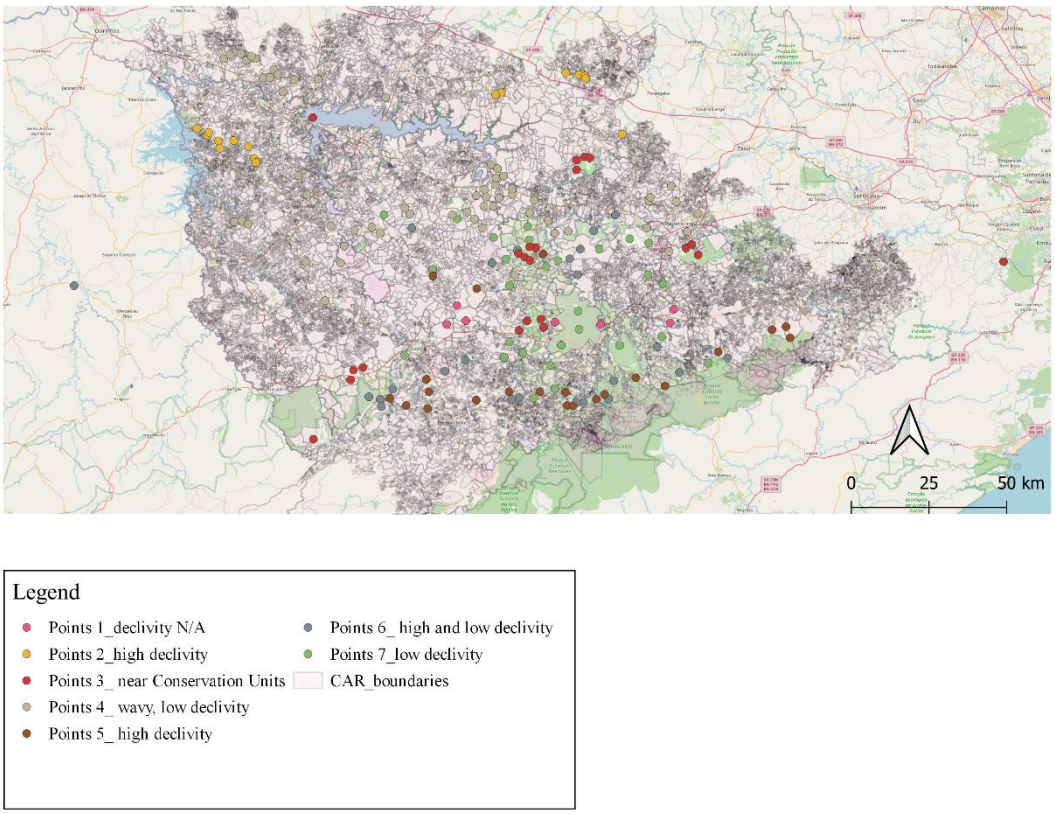

Figure 3: Sample Definition.

4.2.3 Data Collection

To reach the sample elements to carry out the survey, the coordinators of the project "Governing the Atlantic Forest" hired a Brazilian company named Simbiose to do the field work. This company has been doing consultancy with rural extension in Brazil for 10 years, and they were responsible for doing all the face-to-face interviews. This was done in two months (from the 21st of March 2022 to the 11th of May 2022), with three people in the field. They went to 535 different coordinates. 401 of which were defined by the study group, and remaining ones were neighboring properties[18].

Out of the 535 points in which the company Simbiose went to, only 383 farmers were willing to answer the survey. The data analysis was made with these answers. Each conducted survey had a GPS with coordinates and altitude information defined.

Out of the 383 interviews, 2 were disregarded because the land use was not specific for private property farming – one was a forest reserve, and the other was a mining site. Hence, the field work accounted for 381 different farmers.

The interviews were held in 35 municipalities spread across the Alto Paranapanema watershed. Some municipalities are not considered by the CBH-ALPA as part of the Alto Paranapanema watershed. Nevertheless, all points were within its defined boundaries (according to the maps developed by NEEDS-UFSCAR).

[18] if one of the properties presented as sample elements was closed, or the decision maker was not available, or not wanting to respond, the authors of the survey defined that the company should go to neighboring properties for the interview

In order to comply with the ethics committee of Utrecht University, the survey only took place once the interviewer and interviewee had signed a form of consent[19]. This form also follows the guidelines of the national ethics committee of Brazil, through the Free and Clarified Consent Term (CNS[20] Resolution 466/2012). The data was collected anonymously (the data directory does not contain the interviewees' name). All survey data was collected in a software called ODK, and only the interviewers and researchers, have had access to the answers. Free and Clarified Consent Terms were signed on site by each participant, and COVID-19 regulations established by the state of São Paulo - Brazil, such as the use of mask and of hand sanitizer, were duly respected.

4.3 Data Analysis

This section aims to describe how the analysis of the results was made. First, the category definition is explained further, second, the missing data analysis is described, and finally, the statistical analysis is presented.

4.3.1 Categories Definitions

Since the survey is very broad and was developed using scientific literature – as presented in the Analytical Framework, literature was used to define categories, in which answers could be aggregated and representative for a specific theme and could help in analyzing the results.

The analysis was divided into two main categories in order to answer to the research questions: (1) farm and farmers' characteristics, and (2) perceptions.

Table 2: Categories used for survey analysis.

Category	Subcategory (level 1)	Subcategory (level 2)	Subcategory (level 3)
Farm and Farmer Characteristics	Overall Farm and Farmer characteristics	After the gate	
		Demographics	
		Forest characteristics	
		Inside the gate	
		Knowledge	
		Mood	
	Access to Resources		
	Felt Natural Hazards		
Perceptions	Ecosystem Services (ES)	ES - biodiversity	
		Pro-nature instrumental	bequest values
			ES - cultural
			ES - provisioning
			ES - regulating
			ES - practices
		Pro-nature non-instrumental	bequest values
			existence values
			moral values
		Financial incentives and financially driven reforestation rewards	
		Others have responsibility over nature	
		Pro-social motivation	pro-social motivation
			social capital

[19] In the Appendix 1.

[20] *Conselho Nacional de Saúde* – National Health Board

			dutiful citizen
	Public Policies	good for all (social/community)	
		instrumental	
		recognition (by others)	
		overall agreement	
		stricter	

Furthermore, two key categories of farm and farmer characteristics were defined below, in order to simplify the analysis of the survey – "type of production" and "main jobs".

Types of production were defined into umbrella terms according to the Brazilian Agricultural Research Corporation (Embrapa, Portuguese Acronym)[21] (Embrapa[4], n.d.). These categories were defined given the premise that types of production are defined according to a framework of knowledge, resources, and labour, that involves the production, transformation, conservation, and sale of the specific type of product (Dufumier & Couto, 2007).

- Production of grains was defined as any type of production that consisted of grains – such as cotton, beans, corn, soybeans, wheat, sorghum, peanuts, and/or oat.
- Livestock management was defined as any type of production that consisted of beef cattle, and/or the management of other animals such as goats or sheep.
- Livestock products was defined as any type of production that consisted of livestock management to produce milk, and/or cheese.
- Silviculture was any type of production that consisted of pine and/or eucalyptus production. Was also mentioned the production of macadamia.
- Tuber, roots, and bulbs was any type of production that consisted of cassava and/or potato.
- Horticulture was any type of production that consisted of any type of staple food.

The other types of production categories are of aquiculture, coffee, sugar cane, chickens, leasing, grass, or no production.

Farms are not necessarily managed by property owners nor are farms fundamentally managed by someone that has farm management as their main job (Ceolin, 2019). Hence, to identify who was the interviewee in relation to its hierarchical position within the farm structure, they were asked what their main profession was. For the analysis of the responses, main job within the farm were defined according to what was proposed by Simbiose, in which "farmer" is someone that owns the land, and manages it, whilst "manager 1", "manager 2", "machine operator 3", and "general services 4" are people that are hired by the property owner and manage the farm (in a hierarchical position from 1 to 4). In some farms, the structure does not contemplate all four positions, since they may have as the highest hierarchical position a level 3 or 4, but they have this title to be in accordance with the working laws of Brazil (CLT, Portuguese Acronym)[22] regarding working hours and wage. Some other interviewees were the property decision makers but did not consider farming as being their main profession

4.3.2 Missing Values

The questions with the largest amount of missing values, in which the respondents did not wish to answer were (1) "choose your income level" with 45% of not applicable (N/As), followed by (2) define on a Likert scale how much they agreed with the following affirmation "I feel artistically inspired by nature"

[21] *Empresa Brasileira de Pesquisa Agropecuária*
[22] Consolidation of Labor Laws *(Consolidação das Leis do Trabalho)*

with 34% "I do not know", followed by (3) the question in which they had to choose different options on how they wished to be rewarded for reforesting with 30% N/As. When excluding these outliers, the average of missing values (either N/As an “I do not know”) in questions is around 4%.

4.3.3 Statistical Analysis

The statistical analysis was divided in six parts (as can be seen in Figure 4): (1) consisted of testing the reliability of the Likert scale questions in the survey, (2) an overview of the respondents of the survey was made through the cross tabs method, (3) canonical correspondence analysis was made to analyse what are the farm and farmer characteristics that can be associated with perceptions on ecosystem services, policies, and reforestation, (4) correlation matrix was made to identify which were the questions that have high correlation, (5) variation coefficient analysis was made to analyse what are the common perceptions and characteristics between the respondents, (6) where the results from steps (4), (5), and (6) were combined, and (7) the results were combined and discussed (as presented in the Section Discussion of the Results).

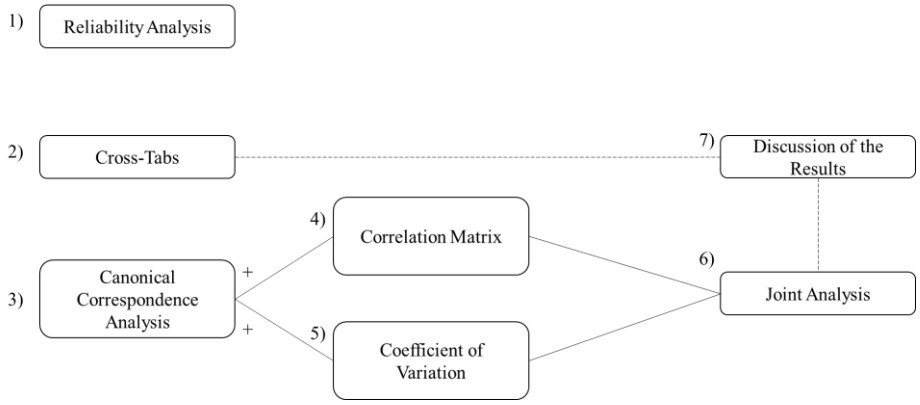

Figure 4: Statistical Analysis Flow Chart

This section will present the methods presented above in more detail, as well as the premises used to analyse their results.

4.3.3.1 Reliability of the Likert Scale

The Cronbach’s Alpha test was used to test the reliability of the Likert scale answers in the survey. Ideally, the Cronbach’s Alpha coefficient of a scale should be above 0,7 (Pallant, 2020).

4.3.3.2 Cross Tabs

The Cross Tabs method was used to cross two different sets of questions, to delineate the profile of the respondents of the survey.

4.3.3.3 Canonical Correspondence Analysis

Canonical Correspondence Analysis (CCA) is a dimension reduction exploratory data technique in which no hypothesis needs to be defined (Doey & Kurta, 2011; Greenacre & Primicerio, 2014). It is a statistical method used mainly by ecological sciences to understand for example the distribution of different plant species dependent on different environmental variables (known as explanatory variables or predictors) (Doey & Kurta, 2011; Greenacre & Primicerio, 2014). CCA measures how much of the variance (inertia) of a data set can be explained by environmental variables (Greenacre & Primicerio, 2014).

In this method the significance of the chi-square test does not provide information on whether the associations are statistically significant or not (Doey & Kutra, 2011). Nevertheless, this method shows the association between variables through the creation of clusters, based on the degree of the correspondence of the variables (Doey & Kurta, 2011). Thus, for social sciences this method has been used for marketing and psychology with the goal of analyzing two sets of categorical, and very diverse

data (Doey & Kurta, 2011). Furthermore, due to its exploratory characteristic, it can be used as a starting point for conducing further research (Doey & Kurta, 2011).

This statistical method was chosen to analyze the results of the survey, through an explorative perspective, in which the different perceptions (on reforestation, ecosystem services and public policies for reforestation of the BAF) farmers may have, were plotted with different farm and farmers characteristics. This allows to test whether different perceptions on ecosystem services and its policies can be explained by different farm and farmer characteristics, with the aim to answer the research questions.

The CCA was made using the software PAST (Paleontological Statistics), in which the results are presented in (1) a scatterplot (that shows the distribution of the answers given by the farmers, and which farm and farmer characteristics and perceptions were mostly associated with those objects), and in two different tables: (2) with each one of the formed Axis' eigenvalues (inertia/variance of the dimension), and % of the explanation of each Axis within the model (relative inertia of the it), and (3) with the scores (x,y) of each variable and object for each one of the formed Axis.

The scores represent the coordinates (x, y, …, n) they are positioned in, in this new dimensional system. The highest the score value of a variable (being it either environmental or biological), the higher the importance the axis had in defining the variance within the cluster (Greenacre & Primicerio, 2014).

The scatterplot shows the results in a graphic way and can suggest different clusters of objects (responses) associated to the answers - since the variables presented in the scatterplot are divided into (1) objects, (2) environmental data, and (3) biological data. The use of the scatterplot can decrease the difficulty in analyzing the model but could not be used as the only tool for interpretation (Chaudhuri et al., 2009).

For this model, all variables need to be homogeneous, discrete, have more than 3 answers, and not have any negative value (Doey & Kutra, 2011). Hence, in total 96 variables (questions) were analysed, of which 25 were within the group farm and farmer characteristics, and 71 were within the group perceptions. All the questions that were not in Likert scale were transformed into dichotomous variables to be analysed, since they accounted for either multiple answers or different categories within a same answer. Hence, for farmer and farmer characteristics, 113 variables were assessed, while for perceptions 99 variables were assessed.

These were the steps taken for the analysis of the CCA: (1) identification of the possible clusters of answers (as in where most farmers – objects – were in the scatterplot), (2) definition of the clusters according to the quadrant they were in, (3) assignment of objects (farmers) and questions (variables) for each defined cluster, (4) assignment of the variables defined for each cluster into categories, (5) definition of which variables were considered representative for each cluster, (6) exclusion of variables not considered strong for each cluster, (7) presentation of the results in a table.

For step (1) and (2) the identification was done only by looking at the scatterplot, step (3) was taken by using the scores (x,y) of each variable and object, and steps (4), (6), and (7) were taken according to the categories defined in the Section Category Definition.

For step (5), two different methods were used. For dichotomous variables, for each cluster, it was counted how many decision makers chose the option or answered yes to a statement. The questions that were excluded for the final analysis were the ones that the difference between the percentage of answers of the cluster in which the question was assigned to and the other clusters was smaller than 25% (for "perceptions"), and 15% (for "farm and farmer characteristics"). For the Likert scale variables, for each cluster, it was given the average and standard deviation of the answers. The questions that were assigned for each cluster were excluded for the final analysis if the range of answers (standard deviation $\pm$ average) of the cluster in which the question was assigned to was contained with both other clusters

and/or if any of the other clusters was equal to the assigned cluster. The level of agreement defined for each cluster was defined as the average of the question for the cluster (e.g., partially agree).

It is important to highlight that being more associated with a question does not mean that the cluster has the highest average in that question, but that the respondents that were associated with the question have the biggest number of similar answers to questions. Furthermore, the characteristics and perceptions that were not present within the results were excluded since they could not be associated with a common sense between respondents, neither could they be associated with specific clusters.

4.3.3.4 Correlation Matrix

Spearman's correlation test was used to identify whether the answers from the respondents of the survey varied in a similar way.

The correlations that were considered for the analysis as common between most respondents, were only those that accounted for a level of significance of less than 0,05, and to classify whether the correlations were strong, and therefore valid for further analysis, the threshold used was: if the correlation coefficient (r) was positive and high (more than 0,7), then the high ranks of one variable coincide with high ranks of the other variable, and correlation coefficients negative and high (less than -0,7) then the high ranks of one variable coincides with low ranks of the other variable.

4.3.3.5 Coefficient of Variation

Coefficient of Variation (CV) analysis was used to analyse whether there were farm and farm characteristics and perceptions on ecosystem services, public policies, and reforestation common in between the respondents (Garcia, 1989; Bachmann et al., 2013).

This coefficient was measured for each question of the survey. First, for each question, the average and standard deviation were calculated considering all the 381 responses. After, the standard deviation of each question was divided by the average of each question and multiplied by 100. Hence, each question had its own CV. The formula used is given below.

$$Variation\ Coefficient\ (CV) = \frac{Standard\ Deviation * 100}{Average}$$

Questions that had a CV higher than 40% were considered to have too much variance to be accounted for as common perceptions or characteristics between respondents.

To classify the level of variance for each question that had a CV smaller or equal to 40%, the following rule was used: CV less than 10% was considered low variance, CV less than 20% was considered medium variance, and CV less than 40% was considered of big variance. This level of measurement defined represents the strength of the question, therefore, the lower the variance, more common the answers were between respondents.

Common answers were then classified into small, medium, or big variance, and the average of the answer defined how the affirmation was perceived (for 7-point Likert scale affirmations), for instance Farmers agree with the affirmation "The presence of trees and forests can increase the amount of pollinators such as bees".

4.3.3.6 Joint Analysis

The CCA permitted a broad analysis of how interviewees responded to the questions regarding farm and farmer characteristics and perceptions. Nevertheless, solely interpreting the results of the CCA as depicted in Section 4.3.3.3 leaves the gap of what are then the perceptions that are in the middle of the scatterplot, and therefore, that could be common in between most respondents. Hence, with the aim of understanding further the responses in the middle of the scatterplot, CV analysis and correlation matrix were analyzed together with the results from the CCA.

First, all results (scores and clusters of the answers given by the CCA, CV of each answer, and the significant and high correlation coefficients) were put together into two tables. One specific for perceptions, and one specific for characteristics. Both tables had the same framework as defined in the Category's Definition section.

Each table was divided in (i) common questions (perceptions or characteristics) between respondents, and (ii) specific questions (perceptions or characteristics) for each cluster. For this separation, all questions that were presented in the CV and correlation matrix results section were considered to be common in between respondents (even if they were first assigned to a cluster in the CCA), and then all questions that were in the CCA results as being associated to a cluster, and were not present in the CV or correlation matrix results, were assigned for each cluster they had been assigned to in the CCA results.

5. Results

This section presents and describes the results of the Statistical Analysis.

5.1 Testing the Reliability of the Likert Scale

The Cronbach's Alpha test was used to test the reliability of the Likert scale answers in the survey. Ideally, the Cronbach's Alpha coefficient of a scale should be above 0,7 (Pallant, 2020). The 53 Likert scale questions from the survey that were assessed in the study have a 0,943 Cronbach's Alpha. Hence, there is no need to remove questions as removal will not greatly affect the consistency of the questions (Pallant, 2020).

5.2 Farmer's Characteristics

This section shows the demographic variables accessed to identify who were the interviewed farmers (job, age, gender, and school level), as well as main characteristics of the farm (% of forest, production types, region, topography). This analysis gives a broad perspective of who are the people managing the landscape and depicts its heterogeneity.

As mentioned before, only property decision makers could be interviewed, since this research assesses the perception of farmers as a role of land manager, hence the interviews focused on people that have agency regarding land management. 260 interviewees were the property owners, and their main occupation was to manage the land – as in "farmers", 80 were hired professionals that work and live in the farm, 22 were retired, and 16 were managers of the landscape but also had a different main job outside the farm (2 professors, 2 lawyers, 9 merchants, 2 tenants, and 1 public server). Three interviewees did not respond to this question.

Property sizes were transformed from hectares to FMs classification. The average FM of the Alto Paranapanema watershed, calculated for the 34 municipalities, is 19,64. Hence, Table 3 shows the relation between land-size classification and the size area considered for each of them.

Table 3: Land-size Classification and considered area for each

Land-classification size	Fiscal Modules	Area (in hectares)
very small properties	Less than 1	Less than 19,64
small properties	From 1 to 4	From 19,64 to 78,56
medium properties	From 4 to 15	From 78,56 to 294,6
large properties	More than 15	More than 294,6

Table 4 shows the amount of woman and man interviewed, accordingly to the land size classification of their farm. In total, 78 women, and 303 men were interviewed. Women are minority in all land-sizes,

and almost 50% of the respondents are within very small properties. Furthermore, there are more men in decision making positions in medium and large properties than women (ratio 6,27:1 for large properties, and 7,11:1 for medium properties).

Table 4: Number of Interviewees According to their Gender and Land-size Classification

	very small properties	small properties	medium properties	large properties	Total
woman	38	20	9	11	78
man	88	82	64	69	303
Total	126	102	73	80	381

Table 5 shows the age of the interviewees, accordingly to the age classification defined by the Brazilian government., and the farm size. Most respondents are less than 65 years old, which is the retirement age in Brazil.

Table 5: Number of Interviewees According to their Age Group and Land-size Classification

	very small properties	small properties	medium properties	large properties	Total
under 25 years old	7	3	3	3	16
between 26 and 35 years old	14	7	17	15	53
between 36 and 45 years old	27	24	21	23	95
between 46 and 55 years old	27	17	14	19	77
between 56 and 65 years old	32	24	11	13	80
above 65 years old	19	27	7	7	60
Total	126	102	73	80	381

Table 6 shows the highest achieved school level of the respondents. The results show that most respondents (45%) have only completed their elementary school years, 30% of the respondents completed also high school, and 23% have also higher education completed.

Table 6: Number of Interviewees According to their School Level and Land-size Classification

	very small properties	small properties	medium properties	large properties	Total
Elementary School	72	52	27	20	171
High School	38	25	24	26	113
Bachelors	11	23	21	29	84
Masters	1	0	1	1	3
PhD	0	0	0	1	1
N/A	4	2	0	3	9
Total	126	102	73	80	381

5.3 Farm's Characteristics

In total, the properties assessed account for 94.960,53 has, which represents 4,19% of the total area of the Alto Paranapanema watershed. Of this total, 1% of the land belongs to very small property holders

(less than 1 FM), 4% belongs to small property holders (between 1 and 4 FMs), 13% to medium property holders (between 4 and 15 FMs), and 81% to large property holders (more than 15 FMs). Furthermore, of the 381 interviewees, 125 were very small property holders, 102 small property holders, 74 were medium property holders, and 80 were large property holders. These results are shown in Table 7.

Table 7: Distribution of Land According to the Land-size Classification

	Total Sum of Area Owned (in hectares)	**Number of Properties Assessed**	**Percentage of Land within the Sampled Area**
Very Small Properties	1.070,95	125	1%
Small Properties	4.096,60	102	4%
Medium Properties	12.408,98	74	13%
Large Properties	77.384,00	80	81%
Total	94.960,53	381	100%

The most predominant type of production is of grains (which consist of soybeans, corn, wheat, etc), present in 186 properties, followed by livestock, present in 154 properties, followed by horticulture, present in 61 properties. Grain production and livestock are produced by all different land-size classifications in equivalent proportions, whilst horticulture is mainly produced by very small farms (64%). These results are shown in Table 8.

Table 8: Distribution of Production Type according to the Land-size Classification

	Very Small Properties	**Small Properties**	**Medium Properties**	**Large Properties**	**Total**
Aquiculture	2	1	1	0	**4**
Fruit Growing	12	12	8	6	**38**
Grains	42	47	35	62	**186**
Livestock	38	47	37	32	**154**
Livestock Products	7	8	10	5	**30**
Silviculture	14	14	12	12	**52**
Tubers, Roots, and Bulbs	3	3	2	3	**11**
Horticulture	39	19	3	0	**61**
Coffee	12	16	8	3	**39**
Sugar Cane	6	9	2	5	**22**
Chickens	6	2	2	0	**10**
Leasing	1	6	4	3	**14**
Hay	3	6	6	2	**17**
Nothing	12	3	0	0	**15**
Others	1	1	1	2	**5**
Total	**198**	**194**	**131**	**135**	**658**

Table 9 shows the topography of the farms assessed in the interviews, accordingly to their land size classification. Most farms are within wavy and wavy-plane regions.

Table 9: Land Size-classification and Topography of Farms

	very small property	small property	medium property	large property	Total
plane 0-3	3	0	1	3	7
wavy plane 3-8	41	38	36	52	167
wavy 8-20	63	47	14	17	141
strongly wavy 20-45	19	15	22	7	63
hilly 45-75	0	2	0	1	3
Total	**126**	**102**	**73**	**80**	**381**

Table 10 shows the percentage of forest of the farms assessed in the interviews, accordingly to their land size classification. Most farms (54%) have less than 20% of native vegetation coverage, which is less than what is demanded by the Forest Act (if not considering the amnesty given for those who deforested their lands before July 2008), and 20% has more than what is required.

Table 10: Categories of Percentage of forest in the Property Accoridng to the Land-size Classification

	very small property	small property	medium property	large property	Grand Total
0%	17	6	3	2	28
between 1% and 9%	22	14	21	26	83
between 10% and 19%	23	29	18	26	96
between 20% and 29%	26	32	15	23	96
between 30% and 39%	16	11	10	2	39
between 40% and 49%	11	6	3	-	20
between 50% and 59%	4	2	2	1	9
between 60%¨and 69%	4	2	1	-	7
between 70% and 79%	2	-	-	-	2
NA	1	-	-	-	1
Total	126	102	73	80	381

5.4 Canonical Correspondence Analysis

This section presents the CCA results, in which farmer and farm characteristics were used as explanatory variables.

As mentioned in the methods section, PAST provides three types of results for analysis. (1) a scatterplot, and in two different tables: (2) one with each one of the formed axis' eigenvalues, and % of the explanation of each one of them within the model, and (3) one with the scores (x,y) of each variable and object for each one of the formed Axis.

Figure 5 below was built with the table that presents the formed axis and their eigenvalues and percentages. For this model, 98 axes formed by the model. The first two axis provide the maximum amount of variance of the model - Axis 1 with 27,91% and Axis 2 with 15,86%. Thus, the ones used for this assessment.

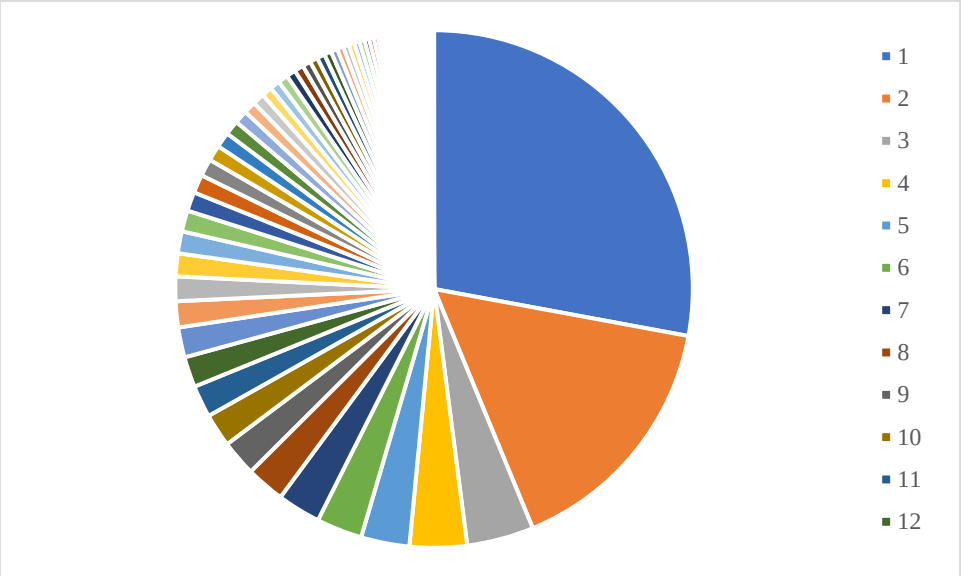

Figure 5: Percentage of Explanation of Each Formed Axis. Each number (from 1 to 98) represents an axis.

Figure 6, 7, 8 and 9 shows how the farmers (black dots with numbers), the answers from the category perceptions (blue dots with numbers), and the answers from the category farm and farmers' characteristics (explanatory variables – green arrows with blue numbers) are associated with and presented around the scatterplot.

When analyzing Figure, 3 different cluster of objects were identified by the author.

Additionally, many perceptions (in blue dots) are scattered around the center of the scatterplot, which can indicate that some of them are common in between clusters. Nevertheless, there are also some perceptions that are closer to clusters than to the center. The results will be further analyzed in this section.

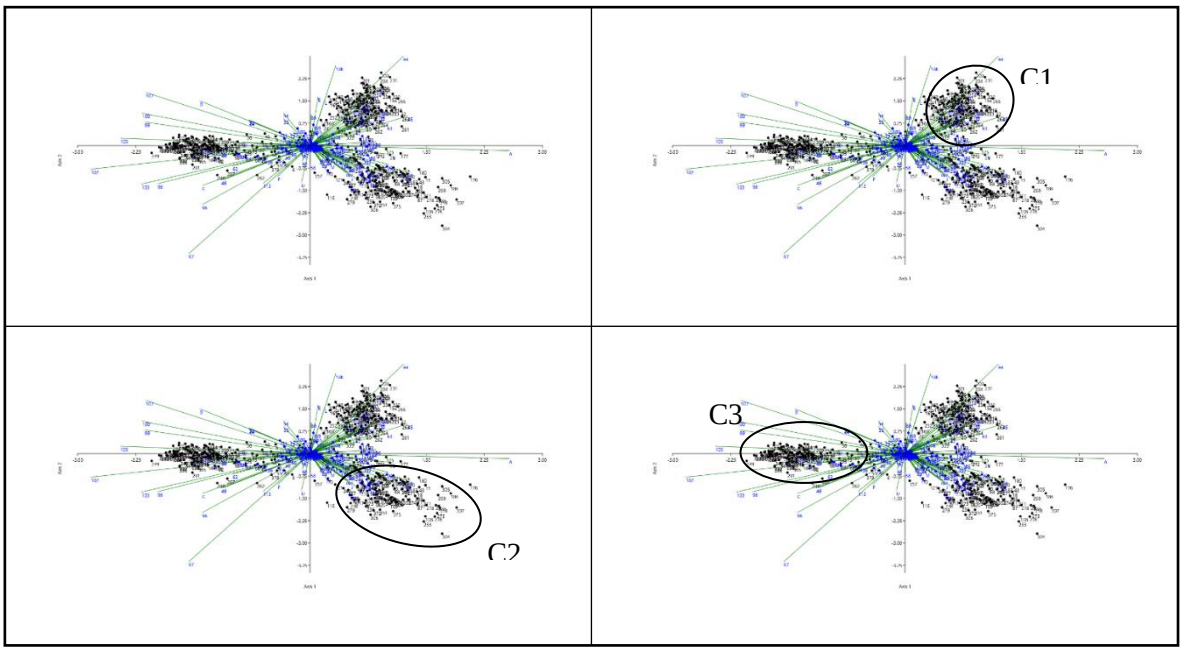

Figure 6: CCA Results and Perceived Clusters. 6.1 (top left), 6.2 (top right), 6.3 (bottom left), 6.4 (bottom right).

Note: For Figures 6.1, 6.2, 6.3 and 6.4, farmers are represented as the black dots with numbers, the answers from the category perceptions are represented as blue dots with numbers, and the answers from

the category farm and farmers' characteristics (explanatory variables) are represented as green arrows with blue numbers. Figures 6.2, 6.3, and 6.4 present where the clusters were defined by the author.

To further analyze the results of the survey, Cluster 1 (C1) was defined as all objects present in quadrant (+,+), Cluster 2 (C2) as all objects present in quadrant (+,-), and Cluster 3 (C3) as all objects present in quadrants (-,+-).

Furthermore, Axis 1 and Axis 2 represent the strength of the predictions of the model. C3 is clearly separated from C1 and C2 by Axis 1, while C1 and C2 are separated from each other by Axis 2. Since Axis 1 has more explanation strength than Axis 2, it can be inferred that C3 is more distinct to C1 and C2 then C1 and C2 are amongst each other.

Cluster 1 had 124 respondents, Cluster 2, 130, and Cluster 3, 127.

5.4.1 Description of the Results

This section aims to describe the results from the CCA analysis. A table with the results is presented in Appendix 2.

5.4.1.1 Farm and Farmer characteristics

From the results it can be inferred that for Cluster 1 the farms are usually large or medium (more than 78,56 hectares) in wavy plane areas, most respondents are associated with not being the owner of the farm, but a hired employee, with bachelor's degree, and male. They are associated with producing grains and being part of cooperatives and learning their farming practices with cooperatives and technical assistance. They were also the only cluster in which natural hazards were associated with – which were erosion and less fertile soil.

For Cluster 2, properties are usually small (from 19,64 to 78,56 hectares), in which knowledge on farming practices is taught by other local farmers. They are associated with being evangelic and between 46 and 55 years old. They work with livestock, mainly to produce beef, and they are the ones mainly associated with producing feed for their animals, which indicates that some of the respondents must also produce grains to feed their cattle.

For Cluster 3, most of respondents are associated with being in the south of the Alto Paranapanema watershed. Their knowledge on farming practices is associated with being taught by family members and community. Their main occupation is being a farmer, and they consider themselves happy and satisfied.

5.4.1.2 Perceptions

Cluster 1 is associated with enjoying having wild boars, boar-pigs hybrid, tamanduas, and wolfs in the farm. They are associated with agreeing to feel belonging to nature, having a moral responsibility towards nature, and agree with having a role in assuring nature is healthy for their family and for next generations. They were also most associated with reforestation rewards being given in default assignments and public announcements.

Cluster 2 is associated with enjoying having lizards, coatis, and urchins in the farm, and to agreeing that the forest can provide fuel and wood, and that forests are fundamental for the water cycle. Furthermore, they are associated with partially agreeing that governments have responsibility over nature.

Cluster 3 is associated with enjoying having frogs and snakes in the farm and having a broad agreement on the instrumental value nature have through its ecosystem services. Rewards for reforestation are associated with direct financial return (for instance through lowering production costs through agroforestry systems and getting financial compensation for it). They are associated with believing that markets are responsible for nature. Regarding their social motivation for reforestation, they are associated with completely agreeing that nature plays a role in their social life (such as fishing societies), and that if the community was making more effort to reforest, they also would. And agrees that if the

community was asking for them to reforest, they would. They are also associated with believing that complying with forest regulations is the fair thing to do.

Overall, for ecosystem services perception, Cluster 1 is associated with seeing value in biodiversity, with seeing value in nature in a non-instrumental way, but also in seeing value in financial incentives to reforest. Cluster 2 is associated with seeing value in biodiversity, in provisioning and regulating ecosystem services, and they are associated with agreeing that the governments should play a role in assuring nature is healthy. Cluster 3 is also associated with seeing value in biodiversity, with cultural, regulating, and provisioning ecosystem services, with seeing value in nature in a non-instrumental way, but also in seeing value in financial incentives to reforest, and with completely agreeing that the market should play a role in assuring nature is healthy. They also have a pro-social motivation for nature conservation.

Cluster 1 could not be associated with any public policies perceptions. Cluster 2 is associated with having an instrumental perspective of the Forest Act (in which compliance with it can bring benefits), and Cluster 3 is associated with overall agreement with the Forest Act and complying with it for the recognition of others, and with the perception that their own compliance with the Act is beneficial for everyone. Cluster 3 is also associated with being more willing to comply with the Forest Act, if it were to be stricter.

5.5 Correlation Matrix

This section describes the results of the correlations found between all questions from the survey. The table in Appendix 3 shows all the high and significant correlations between all the questions from the survey (n=212). There were only thirteen correlations in which the level of significance (p) was $\leq 0{,}01$ and the correlation coefficient (r) was $\geq 0{,}7$, or $\leq -0{,}7$. It is interesting to notice that most correlations happened in between questions that were made in sequence (such as Q2 and Q3).

Correlation Q2/Q3 shows that farmers that want to take agricultural credits are also interested in acquiring financial products in the bank, correlation Q43/Q44 shows that farmers that agree with the benefits of carbon sequestration, also agree with the ability of the air to clean itself, correlation Q56/Q57 shows that farmers that enjoy having wild-boars also enjoy having boar-pigs hybrid in their farms, Q85/Q86 shows that farmers believe that forests makes the environment healthier, also believe that nature is fundamental for people's well-being, Q87/Q88/Q89/Q90 are all directly, and highly correlated, showing that respondents that believe that nature has long-term benefits for them and their families, also agree that trees provides seeds they can sell, agree that they have a moral commitment to nature, and agree that they feel belonging to nature, correlation, Q100/Q101 shows that people that agree that knowledge about native vegetation is acquired through social relations, also agrees that if their communities were reforesting more they also would do so, the correlation Q103/Q104 shows that interviewees living in the region north did not in the region south, and correlation Q67/Q196 shows that people that agree having full access to food, also enjoy having pacas in their farms.

5.6 Coefficient of Variation

This section presents the analysis of the results from the CV analysis (results are presented in Appendix 4). This analysis was used to measure which were the possible perceptions that were concentrated within the center of the scatterplot in the CCA, and therefore considered common between farmers.

The responses that were most common in between the interviewees were: "The presence of trees and forests can increase the number of pollinators such as bees", "I believe that the presence of trees on the hills helps to prevent soil erosion.", "I believe that forests make the environment healthier.", "I believe that nature is fundamental to the quality of life and well-being.", and "I believe that having trees/forests in my land influences the number of different animals (such as mammals, reptiles, insects) present in it.". All these answers had a CV smaller than 10% which means the variance between the responses between all interviewees was considered low. The average answer for these responses were in between

6,4 and 6,5, which can represent those interviewees either agree, or completely agree with the affirmations.

The “perception” responses that were common in between interviewees but had a CV between 10% and 20% were “I enjoy having birds in my property”, “I believe the natural landscape allows me and my family to have fun - like going to waterfalls or hiking in the forest.”, “I believe this region is important because of its history.”, “I have trees on my property too because I think they are beautiful.”, “In my religion we value the presence of trees, forests, water, biodiversity.”, “I feel that nature has long-term benefits for me and my family.”, “I believe that I have a responsibility to preserve nature and biodiversity so that future generations also have access to nature.”, “I feel belonging to nature.”, “I feel I have a moral commitment to nature conservation.”, “I believe that if people in my community were reforesting more, I would be more willing to do so.”, “Forests provide fresh water for me and my family.”, “I have observed changes in the weather (like rainfall, temperatures) since I have been on this property.”, “The timing and magnitude of water runoff, flooding and aquifer recharge can be strongly influenced by the forest.”, “Trees sequester carbon from the atmosphere.”, “Trees enhance the capacity of the air's ability to clean itself.”, “Forests provide fresh water.”, “Governments have a key role (through regulations, for example) to ensure that nature is healthy.”, “I see positive points in having Legal Reserves and Permanent Preservation Areas.”, and “I agree with the Forest Act.”.

“I enjoy having birds in my property” was the only dichotomous answer in this category. Most answer of this category also accounted for an average of 5,8 and 6,5, which can represent those interviewees either agree, or completely agree with the affirmations. “I agree with the Forest Act.” was the only response in which the average was 5,4 – which can indicate that the respondents either partially agree or agree with the affirmation.

Regarding the “farm and farmer’s characteristics” responses that were common in between interviewees but had a CV between 10% and 20% were “My work environment is safe.”, “I have access to clean water.”, “I feel safe in the environment I live in.”, “No intent to leave the land”. In which the last was the was only dichotomous answer in this category, and the other three had an average in between 6,0 and 6,4 which can represent those interviewees either agree, or completely agree with the affirmations.

The “perception” responses that were common in between interviewees but had a CV between 20% and 40% were “I believe that the climate influences what I can plant on my land.”, “I believe that being able to have agroforestry systems within my Legal Reserves and Permanent Preservation Areas allows me to reduce the costs of regenerating the areas.”, “Forests provide me and my family with natural medicine.”, “Markets play a key role (through internal governance) in ensuring that nature is healthy.”, “I believe that efforts to maintain forests must be rewarded.”, “The presence of forests can decrease the number of human pathogens, and even the number of mosquitoes.”, in which responses range from 5,5 to 6,1, which can represent that interviewees agree with those affirmations. Furthermore, affirmations that had an average of 4,9 to 5,4 (partially agree) within the 20% to 40% CV range were “I believe that the current legislation on land use is fair.”, “I believe that some of my social groups are related to the (natural) landscape of this area - such as fishing societies.”, “The presence of forests is representative of who I am as a resident of this region, for example, because of the fruits that come from native trees (such as cambuci, uvaia, araçá, and others).”, “The presence of trees and forests can help reduce pesticide use.”, “I believe that if I received money for having forests, I would be more willing to have them.”, “The possibility of stricter legislation on reforestation makes me more willing to reforest.”. Finally, the affirmation “I comply with forest rules because it's the right thing to do” had an average of 0,9 (dichotomous variable) and a CV of 29%, which also includes it within the 20% to 40% CV range.

Regarding the “farm and farmer’s characteristics” responses that were common in between interviewees but had a CV between 20% and 40% were “I have financial security.”, in which respondents partially agree with the affirmation, “These (natural hazards) suffered effects made me want to reforest.”, in which respondents are neutral to the affirmation”, and “I own this land” (dichotomous variables).

5.7 Joint Analysis

The overview of the results can be seen in Appendix 5.

All results assigned as common perceptions and farm and farmer's characteristics between most respondents in the CV analysis, and correlation matrix were considered common perceptions in the joint analysis. Hence, this section will only illustrate which characteristics were assigned for each cluster given these two analyses.

Hence, Cluster 1 enjoys having maned wolfs in their land, believes that the rewards for reforesting must be done through default assignments and public announcements.

Cluster 2 enjoys having coatis, lizards, and urchins in their land, agrees that trees provide fuel for their family, and wood that can be sold, and enjoys having CAR because of the possibility of getting amnesty for deforestation previous to 2008.

Finally, Cluster 3 enjoys having snakes and frogs in their land, agrees that trees provide food for the family, seeds, natural medicine, and food that can be sold, and seeds that can be planted by the family, agrees that if it were possible to make money from reforestation through market instruments, they would, and that the possible reward for reforestation should come as financial capital. They are associated with being dutiful citizens, and complying with the Forest Act for social motivations, being them for the benefit and recognition of the community.

Regarding farm and farmer's characteristics, Cluster 1 is mainly associated with being large and medium properties, located in wavy-plane terrains, producing grains. They are associated with being members of cooperatives, which is where they get most of the knowledge acquired for farming practices (also through technical assistance provided by the cooperatives), they are associated with the male gender, with having bachelors, and being employees. They partially agree with having access to basic sanitation and are associated with having perceived soil erosion and less fertile soils in their farms.

Cluster 2 is associated with small livestock farms, where knowledge is acquires with the help of neighboring farmers, and to also produce grains for feeding their own livestock. Furthermore, they are mainly associated with being between 46 and 55 years old and being evangelic.

Cluster 3 is associated with being from the south of the watershed, and with happy and satisfied farmers (that have as their main profession, farming in their own properties). Knowledge is acquired through the help of family members, and community.

6. Discussion

The focus of this study was to analyse what were the perceptions of farmers from the Alto Paranapanema watershed on reforestation, and if there were perceptions that could also be attributed to specific farmers and farm's characteristics. This section will focus on discussing the research results from the final "joint analysis" and how they can answer the research questions.

6.1 Identified Clusters

Within this study, three different clusters of farmers could be identified according to their perceptions on ecosystem services and public policies, and their different farm and farmer characteristics. The CCA results show that Cluster 1 and Cluster 2 are more associated with each other, and Cluster 3 is less associated with both. Nevertheless, there are also perceptions, and farm and farmer characteristics that are common between the three clusters.

Van der Ploeg (2012) describes three different types of farming, (i) the peasant agriculture, which entails a higher connection with ecosystem services, multifunctionality of the land, family labour, production oriented for family consumption and for the market, usually associated with small farms, and understood

as the most different between the three types (ii) the entrepreneurial type of agriculture, which are farms focusing on the enlargement of the production, that rely on policies for the modernization of agriculture, and usually moving from peasant agriculture to the large scale agriculture, and finally (iii) large scale agriculture, in which production is orientated by the market, focusing on profit maximization, and exportation of commodities, with salaried workers, and established in large properties.

These three farming types can also be identified in this study, in which C3 is more related to peasant agriculture, where they rely more on ecosystem services, for instance, since a variety of products are produced within the farm and are available for family consumption, and to be sold in the market, and knowledge practices are learnt with family and community, C2 is more related to entrepreneurial agriculture, where small farmers, that learn their farming practices with neighbouring farmers, are interested in provisioning ecosystem services that relate to the deforestation of the forest, rather than its use in the long-term, with small properties that produce grain production for livestock feed, and livestock production, and C1 representing large scale agriculture, in medium and large properties, where the person managing the farm is an employee, associated with having a bachelor's degree, and most of them are members of cooperatives and receive technical assistance, and they are associated with selling grains – characteristics typical of the agro-industries present in the region (Matheus, 2016). C2 seems to be located closer to farm and farmers' characteristics of C3, but has closer perceptions to C1, and as entrepreneurial agriculture, it is in between the peasantry agriculture and the large scale one.

It is interesting to notice that "Technical Assistance" was mostly associated with respondents of C1, and most of them are also members of cooperatives – finding also associated with large scale agriculture as depicted by Van der Ploeg (2012). In contrast, in the raw data of the survey, other farmers complained about not having technical assistance (for instance, when asked about which natural hazards they had seen on the farm on the last years, fours respondents mentioned they did not have access to technical assistance) – associated with peasantry agriculture (Van der Ploeg, 2012).

The differentiation between clusters and understating of their similarities can help to improve policies and programs for restoration in the region (Teixeira et al, 2018). Hence, within the respondents of the watershed, it was possible to identify three different clusters of farmers, in which they had different characteristics, associated to their resources, and demographic characteristics.

6.2 Perceptions, and Farm and Farmer's Characteristics

In regard to capabilities, that shape perceptions (Nussbaum & Sen, 1993), farmers only agreed on feeling safe in the environment they live and work, having access to clean water and food, and partially agreeing on having financial security.

Farmers partially agreed on having financial security – and respondents perceived different mechanisms that could enhance their financial security thorough having forests in their farms. For instance, most respondents agreed that agroforestry systems could decrease the costs of LRs and PPAs, and that the efforts to maintain forests should be rewarded. Agroforestry systems with exotic and native species could help to offset the costs of the implementation of reforestation practices (Brancalion et al., 2012), and can be implemented within RLs, and in some cases within APPs (depending on the PRA, and size of the property) (Martins & Ranieri, 2014; Lima, 2014). It would also be possible to receive financial compensation for keeping forests and reforesting through Payment of Ecosystem Services (PES) (Richards et al., 2020).

For Cluster 1, the financial reward could be through default assignments (such as eco-certification soy programmes) (van Wey & Richards, 2014) or public announcements (a methodology that can increase investor's capital) (Rothenstein et al., 2011). And Cluster 3 preferred that this reward should be in cash, not specifying how this could be done. This can imply that they have a broad approach on what types of monetary benefits they could have from the forests, not necessarily being one solution that they already see, as for instance the perception Cluster 1 seems to have.

Most interviewed property decision makers informed that they have no intent to leave the farm. Nevertheless, most of them (312) were more than 35 years old (not considered to be young people) (Council of Europe, 2018). This pattern is supported by literature, that depicts the aging of people living in the rural areas of the watershed, whilst young people, that used to live in rural areas, tend to go to urban areas with the aim of finding better employment and education opportunities, and better quality of life, which can in turn affect the succession of rural properties (CBH-ALPA, 2018).

From the interviewees' answers, quality of life, is correlated to healthy environments and the role that nature has on providing well-being. Which can represent that interviewees perceive the benefits that forests have on health and well-being. Regarding non-instrumental values of nature, most respondents seem to have a consensus also that they feel belonging and that they have a moral commitment to nature, for them, their families, and future generations. Adams & Adger (2013) suggest in their study that heath, well-being, and belonging are factors important for creating utility and commitment to the land, and if they are no longer perceived by farmers (for instance, because of nature degradation, given the effects of climate change), farmers will no longer feel attached to the place they are in, and therefore, they should be used in public policies to create adaptation mechanisms to climate change that farmers could comply to. Within this framework, these three citated factors also seem to be of relevance within this study, which can suggest that farmers' perception on reforestation can be of increasing livelihoods.

Furthermore, Camarano & Abramovay (1999) question whether the prevalence of young people in rural areas regard what is perceived as quality of life and the opportunities of rural areas. Nevertheless, Martignoni & Corona (2011) also affirm that quality of life could be a factor influencing new, and young people to come to rural areas – they are looking for a healthier lifestyle. Literature has shown that overall, lack of opportunities in the rural areas regard the land concentration within the hands of few landowners, and lack of policies that support the prevalence of family farmers in the rural areas (such as PRONAF[23]) (Martignoni & Corona, 2011; da Silva et al., 2019). Hence, if there were more opportunities in the rural areas, also aligned with the possibility of living in a healthier environment, probably more young people would stay or come to them (Camarano & Abramovay, 1999; Martignoni & Corona, 2011; da Silva et al., 2019).

Furthermore, most interviewees seem to have a neutral opinion on whether natural hazards influence their willingness to reforest. Cluster 1 was the only cluster associated with natural hazards, which were erosion and less fertile soil in the last years, and they had a neutral perception on these natural hazards influencing their aim to reforest. Perhaps they see other potential solutions to these problems, for instance through technology provided by technical assistance – which is also associated to this cluster, or through expensive technological packages that can be purchased, such as central pivots for irrigation of grain systems, which can reduce the risks of changes in the rainfall patterns, and of which is common within the region (CBH-ALPA, 2019; Ribeiro & Franco, 2017).

Results suggests that respondents from the three clusters understand the benefits of regulating ecosystem services that forests can provide to society overall, and for agricultural practices, such as increase in the number of pollinators. Furthermore, most respondents also seem to perceive as beneficial cultural ecosystem services provided by forests.

Nevertheless, provisioning ecosystem services, and how they could influence farmer's livelihood were main associated with Cluster 3 – which can present a need of the farmer from forests, hypothesis corroborated by literature that assigns producers that rely on ecosystem services for farming (Van der Ploeg, 2012; Teixeira et al., 2018), and by the biodiversity indicators of the cluster, frogs and snakes – animals that have a role of pest control (Oliveira, 2016; Oliveira, 2020). Cluster 2, on the contrary sees in forest a provisioning service that regards the forest being cut down, as in the use of fuel, and being

[23] *Programa Nacional de Fortalecimento da Agricultura Familiar* – National Program of Strengthening Family Agriculture

able to sell wood – activities that can bring positive return rates if integrated with livestock management (characteristic to the cluster) (Oliveira et al., 2000), and are possible to being done within small farms (Bernardo, 2010; Chiavari & Lopes, 2016) but can increase deforestation if the Forest Act is not enforced (Soares-filho et al., 2014).

Interviewees responded that they believed that markets, and specially governments must also assume a role on ensuring that nature is healthy. There are several mechanisms that the Brazilian government has assumed such as the SNUC, or the Forest Code to ensure the perpetuity of forests. Additionally, markets also can play a role through PES, and environmental, social, and governance (ESGs), but the effectiveness of these programs also rely on the people managing the landscape (Page & Bellotti, 2015), and the ability of these institutions to measure the impacts of more sustainable practices (Thompson, 2018).

Going on a different direction of what was observed by Trevisan et al. (2016)[24], in this research, most interviewed farmers agreed with the Forest Act and perceived benefits in its instruments, such as agricultural credit, the possibility of financing products with the bank, (benefits available only to farmers that have been registered at the CAR) (de Melo et al., 2021), and also perceived positive points in having LRs, and PPAs. Furthermore, Trevisan et al. (2016) argues that the negative perception on the policy instruments could be related to the lack of awareness of farmers on different ecosystem services, such as soil erosion control, which is also not the case within the interviewed farmers of this study, given that most interviewees understand all different regulating ecosystem services provided by forests.

Furthermore, Trevisan et al. (2016) argues that the lack of enforcement of the Forest Act can stimulate its lack of compliance. The CAR instrument was created to ensure this compliance, but still does not seem to be enforced in the region[25] (de Oliveira et al., 2018). Hence, studies suggest that the CAR should be enforced in order for farmers to comply more with the Forest Act (de Araújo et al., 2021).

Cluster 3 was the cluster mostly associated with community driven policy compliance, in which compliance to the Forest Act is related to guilt (a moral responsibility with others, and with enforced Institutions) (Rodriguez-Sickert, 2008; Rode et al., 2015), a sense of cooperation, share of civic values, and social approval appears as ways to enhance or hamper the engagement for conservation (Fehr & Falk, 2002; d'Adda, 2011; Rode et al., 2015).

Pacas (*Cuniculus paca*) was highly correlated to having access to food. Pacas, native to the region, are animals used to be hunted and then eaten (Sparovek, 2020). Furthermore, birds are knowingly animals that are appreciated for its beauty (de Morais et al., 2021) and for being fundamental to the maintenance of the forests, such as through the dispersion of seeds (Oliveira, 2018). Wild boars and boar-pigs hybrids are animals that are exotic to the BAF and are allowed to be hunted since 2013, since these animals can cause different social and environmental problems – such as attacks in farmers' gardens, and to their pets (da Rosa et al., 2018). All these animals were "enjoyed" by most farmers. It may present an instrumental perspective on nature, since pacas, wildboards, and boar-pigs hybrids are used to be either hunted, and birds have cultural, and regulating value engrained.

[24] Trevisan's et al. (2016) interviews were held before 2012, when the New Forest Act came into force, which means also before the CAR system existed, which could explain why most respondents of Trevisan's et al. study did not perceive positive points in the Forest Act.

[25] as observed by Araújo et al., (2021) in which there are still difficulties to regularize properties in the CAR system, and therefore, ensure its compliance

7. Conclusions

Perception about reforestation in this study was defined as the combination of perceptions on ecosystem services, perceptions on institutions that regulate forest conservancy and preservation, and available resources that shape these perceptions.

The presence of forests within the properties interviewed is heterogeneous, and there was not a specific cluster assigned to a certain percentage of forests within the land, which can indicate that the reasoning behind people having forests within their farms does not depend solely on perceptions on ecosystem services and the New Forest Act, and farm and farmer's characteristics.

What then could be drivers of change for farmers to reforest – given not only the necessity of farmers to have the minimum area of forests within farms as depicted in the Forest Act, but also to voluntarily have more forests in their land – given that even if the regulations of the Forest Act are complied to, the extinction threshold of the BAF will still be surpassed? (de Faria et al., 2021). The analysis made in this study can provide ideas of what could be tackled to increase the area of forests within farms, supported by how they perceive ecosystem services and public policies, and the possible benefits those can entail.

This study shows that most farmers within the Alto Paranapanema watershed have similar perceptions on the ecosystem services, and the Forest Act. Nevertheless, they are different amongst each other (as shown by the framework proposed by Van der Ploeg (2012)), in the way they relate to the landscape they manage, and the resources and capabilities they have, are different. And these differences are also associated with specific perceptions. Hence, different characteristics can be associated with the way people perceive reforestation, but there is also a common ground where these different characteristics do not seem to influence their perceptions.

Three different clusters of farmers were found, and of which all perceive the benefits of the regulating services forests have, perceive that efforts to maintain forests within their farms should be rewarded, perceive that nature brings health, well-being, quality of life, and they feel belonging to nature.

Their different perceptions consist on: C3 relying on ecosystem services for their production and livelihood, specially from non-timber products, and that they perceive a possibility of increasing their income through financial rewards for maintaining forests, C2 using timber products from the forests for their benefit, and C3, with its large-scale agriculture characteristics, and all the resources, and support this entail, in which they see in forests a possibility of increasing their income through certifications, and investments.

Most farmers agreed with the Forest Act, and to perceive different benefits from it. Nevertheless, if the Forest Act is not enforced (through the mechanisms of CAR and PRA), the farmers will not be able to enjoy of the benefits they entail, for instance agricultural credit and financing products with banks for their production (de Melo et al., 2021).

Perceptions attributed to guilt of non-compliance with social norms, recognition, and cooperation in between the community enhances the farmers from C3 to comply with legal norms. Nevertheless, the lack of enforcement of these norms can be a barrier to their compliance (Trevisan et al., 2016).

Furthermore, when asked if felt natural hazards (such as erosion, too little water) made them more willing to reforest, they responded "Neutral". This shows an inconsistency, since they perceive regulating services forest have, but the lack of these services also does not imply in a higher willingness to reforest.

Overall, this study shows that forests are perceived as beneficial for farmers from the Alto Paranapanema watershed – both for their personal lives, as for their farming practices. But either way, they perceive

that the maintenance of forests should be compensated by market strategies, or through the benefits entailed through the Forest Act.

7.1 Relevance of the Study

This study can be used to further understand who are the people that are actively managing the multi-functional landscape of the Alto Paranapanema watershed – what do they see in the forest, what do they need from the forest. Therefore, it can also be used as a tool to better shape policies and programs for reforestation.

7.2 Limitations of the Research and Further Studies

The developed survey could be used to assess other different topics that could be of interest of the construction or adaptation of current public policies in the area. For instance, using organic agriculture in the CCA model (as predictor variable) to understand better who the organic producers are, and what are their perceptions on ecosystem services and restoration public policies, or using the percentage of forest within the land in the CCA model (as predictor variable) to understand better if perceptions of ecosystem services are different according to the percentage of forests farmers might have in their farms.

The perceived limitations of this research regard: its quantitative aspect with closed questions in which perceptions of the farmers could be assessed from the perspective of the researcher – that has created and analysed the answers from the survey, for questions that might have been answered untruthfully, and for the limited time in developing the survey.

Furthermore, it was understood after all the analysis were made that the variance of coefficient analysis should have been done prior to the canonical correspondence analysis. This way, questions that were common between respondents could have been left out of the CCA model.

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Appendix 1 - Form of Free and Clarified Consent

UNIVERSITY OF UTRECHT

DEPARTMENT OF GEOSCIENCES

GRADUATE PROGRAM IN SUSTAINABLE DEVELOPMENT AND GRADUATE PROGRAM IN SUSTAINABLE BUSINESS AND INNOVATION

FREE AND CLARIFIED CONSENT TERM

(CNS Resolution 466/2012)

PERCEPTION OF ALTO PARANAPANEMA PRODUCERS ABOUT REFORESTATION IN THE BRAZILIAN ATLANTIC FOREST

You are being invited to participate in the research "Perception of Producers from Alto Paranapanema on Reforestation in the Brazilian Atlantic Forest".

The objective of this study is to understand the relationship of producers with their land, with their partners (such as neighbours, NGOs and city halls), and with the Atlantic Forest preservation laws. We are also trying to understand how techniques applied in animal farming and/or agriculture are learned and put into practice. Your participation is voluntary, that is, at any time you can withdraw from participating and withdraw your consent. Your refusal will not affect your relationship with the researcher or the institution that provided the data.

Data collection will consist of a questionnaire. We will ask yes or no questions, or questions where the answer must be between 1 and 7, or questions where we only want values, or multiple-choice questions. The time used for data collection will be approximately 40 minutes.

Your answers will be treated anonymously and confidentially, that is, at no time will your name be disclosed at any stage of the study. When it is necessary to exemplify a certain situation, your privacy will be ensured. The data collected may have their results published in events, journals and/or scientific papers.

Completing these questionnaires does not pose an immediate risk to you, however, the possibility of a subjective risk is considered, as some questions may refer to some discomfort, evoke unpleasant feelings or memories or lead to a slight tiredness after answering. the questionnaires. If any of these possibilities occur, you may choose to immediately suspend the interview.

This research won't bring you direct benefit. Nevertheless, the purpose of the research is to create public policies to help producers, thus being able to indirectly contribute to you.

You will receive a copy of this term, signed on all pages by you and the researcher, containing the telephone number and address of the main researchers with whom you can ask your questions about the research and your participation now or any time.

Address of the Research Team to contact (24 hours a day, seven days a week):

Responsible Researcher: Júlia Ramos Nardy

Address: Cornelis Mertenssstraat, 41B, 3553JP, Utrecht, Netherlands

Phone: +31645180215 Email: j.ramosnardy@students.uu.nl

Responsible Researcher: Jaime Alcântara Luz

Address: Van Heuven Goedheartplein 15C, 3527DK, Utrecht, Netherlands

Phone: +351935894287 E-mail: j.dealcantaraluz@students.uu.nl

I confirm that:

• I am satisfied with the received information about the research;

• I have been given opportunity to ask questions about the research and that any questions that have been risen have been answered satisfactorily;

• I had the opportunity to think carefully about participating in the study;

• I will give an honest answer to the questions asked.

I agree that:

• the data to be collected will be obtained and stored for scientific purposes;

• the collected, completely anonymous, research data can be shared and re-used by scientists to answer other research questions;

• video and/or audio recordings may also be used for scientific purposes.

I understand that:

• I have the right to withdraw my consent to use the data;

• I have the right to see the research report afterwards.

I declare that I understand the objectives, risks and benefits of my participation in the research and I agree to participate.

Place and date:

_____ _____

Name of the Interviewer Name of the Interviewee

Appendix 2 – CCA Results

Table 11: Demographic characteristics, resources and natural hazards mostly associated with each cluster

	C1	C2	C3
Region			South
Topography	Wavy plane		
Size	Large & Medium	Small	
Main Actors that influence in Knowledge construction	Cooperatives and Technical Assistance	Local Farmers	Family members and community
Type of Production	Grains	Livestock	
After the gate (sales)		Feed for animals	
Gender	Man		
Level of Education	Bachelors		
Profession	Manager-2		Farmer
Religion		Evangelic	
Age		Between 46 and 55 years old	
Mood			Feels happy & satisfied
Resources			Disagree (grade 2 out of 7) on having access to basic sanitation
Natural Hazards	Farm has suffered from erosion and less fertile soil in the last years		

Table 12 below shows the ecosystem services perceptions assigned for each cluster and Table 13 below shows the public policies perceptions for each cluster.

Table 12: Ecosystem Services Perceptions mostly associated with each cluster

			C1	C2	C3
Ecosystem Services	**ES - biodiversity**		wild boar, boar-pig hybrid, tamandua, wolf	lizard, coati, urchin	frogs, snakes
	Pro-nature instrumental	**bequest values**	agrees that nature has long term benefits for themselves and their family		
		ES - cultural			completely agrees with nature being representative of who they are, and that nature is beautiful
		ES - provisioning		partially agrees that trees provide wood and fuel for the family	completely agrees that trees provide food and natural medicine that can be consumed by the family and seeds that can be planted, and agrees that trees provide food, seeds and natural medicine that can be sold
		ES - regulating		agrees that timing and magnitude of water runoff, flooding and aquifer recharge can be strongly influenced by the forest.	completely agrees that the presence of forests can decrease the number of human pathogens, and pests
	Pro-nature non-instrumental	**bequest values**	responsibility towards next generations to have access to nature		
		existence values	agrees that feels belonging to nature		
		moral values	agrees that has a moral responsibility towards nature		
	Financial incentives & financially driven reforestation reward		default assignments, public announcements		efforts to maintain the forest must be rewarded, reward for reforestation must be in cash, receiving money to have forests increases the willingness to having them, and agroforestry systems in LR and APPs can decrease production costs

	Others have responsibility over nature			partially agrees that governments have responsibility over nature	completely agrees that markets have responsibility over nature
	pro-social motivation	**pro-social motivation**			completely agrees that nature plays a role in their social life (such as fishing societies), and that if the community was making more effort to reforest, they also would. And agrees that if the community was asking for them to reforest, they would.
		dutiful citizen			compliance with the forest rules regard thinking it is only fair

Table 13: Perceptions mostly associated with each cluster

		C1	C2	C3
Public Policies	**good for all (social/community)**			compliance with the forest rules regard guilt and understanding that if all do it, it will be good for all
	instrumental		has CAR because wants to have amnesty	
	recognition (by others)			compliance with the forest rules regard to social approval, being recognized as altruistic, and feeling selfless
	overall agreement			with the forest act
	stricter			stricter regulations would make them more willing to reforest

Appendix 3 - Correlation Matrix

Table 14: Correlations between Surveys' Questions

	Q2	Q3	Q43	Q44	Q56	Q57	Q67	Q85	Q86	Q87	Q88	Q89	Q90	Q100	Q101	Q103	Q104	Q196
Q2 - I have a CAR because I want to take Agricole credit	1	+																
Q3 - I have a CAR because I want to take financing products with the bank		1																
Q43 - Trees enhance the capacity of the air's ability to clean itself.			1	+														
Q44 - Trees sequester carbon from the atmosphere.				1														
Q56 - I enjoy having wildboars in my farm					1	+												
Q57 - I enjoy having boar-pigs hybrid in my farm						1												
Q67 - I enjoy having pacas in my farm							1											+
Q85 - I believe that forests make the environment healthier.								1	+ +									
Q86 - I believe that nature is fundamental to the quality of life and well-being.									1									
Q87 - Trees provide me and my family with seeds that we can plant.										1	+ +	+	+					
Q88 - Trees provide seeds that I can sell.											1	+ +	+					
Q89 - I feel I have a moral commitment to nature conservation.												1	+					
Q90 - I feel belonging to nature.													1					
Q100 - I believe that knowledge about native vegetation is passed on from generation to generation and among friends and community.														1	+			
Q101 - I believe that if people in my community asked me to reforest more, I would.															1			
Q103 - region north																1	-	
Q104 - region center																	1	
Q196 - I have full access to food																		1

Note: $+ = 0{,}7 \leq r \leq 0{,}8;\ ++= 0{,}8 \leq r \leq 0{,}9;\ -- = -0{,}7 \geq r \geq -0{,}8$

Appendix 4 – Coefficient of Variation

This appendix presents the results from the CV analysis.

Table 15 shows that the questions that had the biggest amount of consensus between interviewees. Interesting to notice that there was no farm and farmer characteristic that had a CV≤10%.

Table 15: Low variance (CV <=10%)

Category	Perception	Average	CV
ES - regulating	The presence of trees and forests can increase the number of pollinators such as bees.	6,5	8,7%
ES - regulating	I believe that the presence of trees on the hills helps to prevent soil erosion.	6,4	8,7%
ES - regulating	I believe that forests make the environment healthier.	6,4	8,9%
ES - Non-instrumental existence values	I believe that nature is fundamental to the quality of life and well-being.	6,4	9,0%
ES - biodiversity	I believe that having trees/forests in my land influences the number of different animals (such as mammals, reptiles, insects) present in it.	6,5	9,2%

Table 16 and Table 17 shows the questions that had the medium consensus between interviewees.

Table 16: Medium variance in perceptions (10%< CV<=20%)

Category	Perception	Average	CV
ES - biodiversity	birds	1,0	18,8%
ES - cultural	I believe the natural landscape allows me and my family to have fun - like going to waterfalls or hiking in the forest.	6,4	11,2%
ES - cultural	I believe this region is important because of its history.	6,5	13,0%
ES - cultural	I have trees on my property too because I think they are beautiful.	5,9	18,7%
ES - cultural	In my religion we value the presence of trees, forests, water, biodiversity.	6,0	19,0%
ES - Instrumental - bequest	I feel that nature has long-term benefits for me and my family.	6,3	12,5%
ES - non-instrumental - bequest	I believe that I have a responsibility to preserve nature and biodiversity so that future generations also have access to nature.	6,3	14,8%
ES - non-instrumental - existence	I feel belonging to nature.	6,1	16,6%
ES - non-instrumental - moral	I feel I have a moral commitment to nature conservation.	6,2	15,3%
ES - pro-social motivation	I believe that if people in my community were reforesting more, I would be more willing to do so.	6,2	12,6%
ES - provisioning	Forests provide fresh water for me and my family.	6,3	15,9%
ES - regulating	I have observed changes in the weather (like rainfall, temperatures) since I have been on this property.	6,5	10,1%
ES - regulating	The timing and magnitude of water runoff, flooding and aquifer recharge can be strongly influenced by the forest.	6,4	10,4%
ES - regulating	Trees sequester carbon from the atmosphere.	6,5	11,1%

ES - regulating	Trees enhance the capacity of the air's ability to clean itself.	6,4	11,1%
ES - regulating	Forests provide fresh water.	6,5	13,6%
ES - others/goverment	Governments have a key role (through regulations, for example) to ensure that nature is healthy.	5,8	19,6%
PP - overall agreement	I see positive points in having Legal Reserves and Permanent Preservation Areas.	6,2	13,9%
PP - overall agreement	I agree with the Forest Act.	5,4	20,0%

Table 17: Medium variance in farm and farmer characteristics (10%< CV<=20%)

Category	**Farm & Farmer characteristics**	**Average**	**CV**
Resources	My work environment is safe.	6,1	12,3%
Resources	I have access to clean water.	6,4	13,0%
Resources	I feel safe in the environment I live in.	6,0	16,0%
Demographics	No intent to leave the land	1,0	19,4%

Table 18 and Table 19 shows the questions that had the big consensus between interviewees.

Table 18: Big variance in perceptions (20%< CV<=40%)

Big variance in perceptions (20%< CV<=40%)			
Category	**Perception**	**Average**	**CV**
ES - financially driven	I believe that being able to have agroforestry systems within my Legal Reserves and Permanent Preservation Areas allows me to reduce the costs of regenerating the areas.	5,7	22,7%
PP - overall agreement	I believe that the current legislation on land use is fair.	5,4	22,7%
ES - regulating	I believe that the climate influences what I can plant on my land.	6,1	22,8%
market	Markets play a key role (through internal governance) in ensuring that nature is healthy.	5,5	26,8%
PP - dutiful citizen	I comply with forest rules because it's the right thing to do	0,9	29,3%
ES - regulating	The presence of forests can decrease the number of human pathogens, and even the number of mosquitoes.	5,5	29,7%
ES - cultural	The presence of forests is representative of who I am as a resident of this region, for example, because of the fruits that come from native trees (such as cambuci, uvaia, araçá, and others).	5,2	30,2%
ES - provisioning	Forests provide me and my family with natural medicine.	5,6	32,0%
ES - pro-social motivation	I believe that some of my social groups are related to the (natural) landscape of this area - such as fishing societies.	5,3	32,3%
ES - financially driven	I believe that efforts to maintain forests must be rewarded.	5,5	33,1%
ES - regulating	The presence of trees and forests can help reduce pesticide use.	5,2	34,4%
PP - stricter	The possibility of stricter legislation on reforestation makes me more willing to reforest.	4,9	38,2%
ES - financially driven	I believe that if I received money for having forests, I would be more willing to have them.	4,9	40,0%

Table 19: Big variance in farm and farmer characteristics (20%< CV<=40%)

Big variance in farm and farmer characteristics (20%< CV<=40%)			
Category	**Perception**	**Average**	**CV**
Resources	I have financial security.	5,3	27,4%
Natural Hazards	These (natural hazards) suffered effects made me want to reforest.	4,1	38,2%
Demographics	What kind of ownership do you have over this land/ What is the legal status of this property?	0,9	39,4%

Appendix 5 – Joint Analysis Results

Table 20: Joint Analysis - Perceptions

			Common				C1	C2	C3
			CV			Correlation			
			Strenght of the CV	Average	Question	Question			
Ecosystem Services	ES - biodiversity		+ + +	6,5	I believe that having trees/forests in my land influences the amount of different animals (such as mammals, reptiles, insects) present in it.	I enjoy having wildboars in my land	I enjoy having maned wolfs in my land	I enjoy having coatis in my land	I enjoy having snakes in my land
			+ +	1	I enjoy having birds in my land	I enjoy having boar-pig hybrids in my land		I enjoy having lizzards in my land	I enjoy having frogs in my land
						I enjoy having pacas in my property		I enjoy having urchins in my land	
	Pro-nature instrumental	bequest values	+ +	6,3	I feel that nature has long-term benefits for me and my family.				
		ES - cultural	+	5,2	The presence of forests is representative of who I am as a resident of this region, for example, because of the fruits that come from native trees (such as cambuci, uvaia, araçá, and others).				
			+ +	6,5	I believe this region is important because of its history.				
			+ +	5,9	I have trees on my property too because I think they are beautiful.				
			+ +	6	In my religion we value the presence of trees, forests, water, biodiversity.				

			+ +	6,4	I believe the natural landscape allows me and my family to have fun - like going to waterfalls or hiking in the forest.				
		ES - provisioning	+ +	6,3	Forests provide fresh water for me and my family.			Trees provide fuel for me and my family.	Trees provide food for me and my family.
			+	5,6	Forests provide me and my family with natural medicine.			Trees provide wood that I can sell.	Trees provide me and my family with seeds that we can plant.
									Trees provide seeds that I can sell.
									Forests provide natural remedies that I can sell.
									Trees provide food that I can sell.
		ES - regulating	+ + +	6,4	I believe that forests make the environment healthier.				
			+ + +	6,5	The presence of trees and forests can increase the amount of pollinators such as bees.				
			+ + +	6,4	I believe that the presence of trees on the hills helps to prevent soil erosion.				
			+ +	6,5	I have observed changes in the weather (like rainfall, temperatures) since I have been on this property.				
			+ +	6,4	The timing and magnitude of water runoff, flooding and aquifer recharge can be strongly influenced by the forest.				
			+ +	6,5	Trees sequester carbon from the atmosphere.				
			+ +	6,4	Trees enhance the capacity of the air's ability to clean itself.				
			+ +	6,5	Forests provide fresh water.				

			+	6,1	I believe that the climate influences what I can plant on my land.				
			+	5,5	The presence of forests can decrease the number of human pathogens, and even the number of mosquitoes.				
			+	5,2	The presence of trees and forests can help reduce pesticide use.				
	Pro-nature non-instrumental	**bequest values**	+ +	6,3	I believe that I have a responsibility to preserve nature and biodiversity so that future generations also have access to nature.				
		existence values	+ + +	6,4	I believe that nature is fundamental to the quality of life and well-being.				
			+ +	6,1	I feel belonging to nature.				
		moral values	+ +	6,2	I feel I have a moral commitment to nature conservation.				
	Financial incentives & financially driven reforestation reward		+	5,7	I believe that being able to have agroforestry systems within my Legal Reserves and Permanent Preservation Areas allows me to reduce the costs of regenerating the areas.		The reward for reforesting must be in default assignments		If there were ways to make money from reforestation via the market, would you do it? Yes
			+	5,5	I believe that efforts to maintain forests must be rewarded.		The reward for reforesting must be in Public Announcements		The reward for reforesting must be in cash
			+	4,9	I believe that if I received money for having forests, I would be more willing to have them.				
	Others have responsibility over nature		+ +	5,8	Governments have a key role (through regulations, for example) to ensure that nature is healthy.				
			+	5,5	Markets play a key role (through internal governance) in ensuring that nature is healthy.				

	pro-social motivation	**pro-social motivation**	+ +	6,2	I believe that if people in my community were reforesting more, I would be more willing to do so.				
			+	5,3	I believe that some of my social groups are related to the (natural) landscape of this area - such as fishing societies.				
						I believe that if people in my community asked me to reforest more, I would.			
		social capital				I believe that knowledge about native vegetation is passed on from generation to generation and among friends and community.			
		dutiful citizen	+	0,9	I comply with forest rules because it's the right thing to do				I comply with forest rules because I think it's fair to do this
Public Policies	**good for all (social/community)**								I comply with forest rules because if me and my peers do it, it will be good for all of us
									I comply with forest rules because I would feel guilty if I didn't
	instrumental					I have a CAR because I want to take agricultural credit		I have a CAR because I want to have amnesty	
						I have a CAR because I want to take financing products with the bank			
	recognition (by others)								I comply with forest rules because I feel like I'm selfless if I'm doing this.
									I comply with forest rules becauseI feel like people recognize me as altruistic if I do this

								I comply with forest rules because I can get social approval if I do this, and if I don't, I won't be socially approved
	overall agreement	+ +	6,2	I see positive points in having Legal Reserves and Permanent Preservation Areas.				
		+ +	5,4	I agree with the Forest Act.				
		+	5,4	I believe that the current legislation on land use is fair.				
	stricter	+	4,9	The possibility of stricter legislation on reforestation makes me more willing to reforest.				

Table 21: Joint Analysis - Farmer and Farmer's Characteristics

	Common				**C1**	**C2**	**C3**
	CV			**Correlation**			
	Strenght of the CV	**Average**	**Question**	**Question**			
Region							South
Topography					Wavy-plane		
Size					Large & Medium	Small	
Knowledge					Cooperatives and Technical Assistance	Local Farmers	Family members and community
Type of Production					Grains	Livestock	
Inteded time in the land	+++	**1,0**	No intent to leave the land				
Ownership	+	**0,9**	Own the farm				
After the gate						Feed for animals	
Gender					Man		

Level of Education					Bachelors		
Profession					Manager-2		Farmer
Religion						Evangelic	
Age						Between 46 and 55 years old	
Mood							Feels happy & satisfied
Resources	+ + +	**6,1**	My work environment is safe.				
	+ + +	**6,4**	I have access to clean water.				
	+ + +	**6,0**	I feel safe in the environment I live in.				
	+ +	**5,3**	I have financial security.				
				I have full access to food			
					Partially Agrees that has access to basic sanitation		
Natural Hazards	+	**4,1**	These (natural hazards) suffered effects made me want to reforest.		Farm has suffered from erosion and less fertile soil in the last years		

In order to facilitate the analysis, CV related questions were put into one column of the final table with the strength of the variation, and considered average for each question, correlation matrix related questions were put into specific columns, and correlations were highlighted in same colors. Questions that were present in CV and correlation matrix results were merged into one cell of the table, being them contained in two columns.