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UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ
FACULTADES DE CIENCIAS QUÍMICAS, INGENIERÍA Y MEDICINA
PROGRAMAS MULTIDISCIPLINARIOS DE POSGRADO EN CIENCIAS AMBIENTALES
AND
COLOGNE UNIVERSITY OF APPLIED SCIENCES
INSTITUTE FOR TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS

ASSESSMENT OF SILVOPASTORAL SYSTEMS ESTABLISHMENT IN ITALVA, RIO DE JANEIRO, BRAZIL

THESIS TO OBTAIN THE DEGREE OF:
MAESTRÍA EN CIENCIAS AMBIENTALES
DEGREE AWARDED BY
UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ
AND
MASTER OF SCIENCE
TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS
IN THE SPECIALIZATION: RESOURCES MANAGEMENT
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SAN LUIS POTOSÍ, MÉXICO AUGUST, 2014

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My Beloved Parents
Angelita & Nick
The rest of my Family
To my Old and New Friends
To Felix

Dear Mamacita you will be always in my heart
And I will always be longing to hug you again

You are the inspiration of my life,
my reason to fight,
the word I need to hear,
strength in my solitude,
my unconditional support,
my reason for living.

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ABSTRACT

The Atlantic forest in Brazil is one of the most important and beautiful ecosystem in the world. Nevertheless, it may be the most populous and one with the lowest protected areas of all the biodiversity hotspots. It is endangered and threatened because of the overexploitation, deforestation and fragmentation, caused by the conversion of the forest to agricultural systems, especially pastures and monocultures. The Cologne University of Applied Sciences and the Institute for Technology and Resources Management in the Tropics and Subtropics (ITT), along with other Institutions of Germany and Brazil, have been developing investigations in the Rio de Janeiro State for at least six years. A new project "*Integração de eco-tecnologias e serviços para o desenvolvimento rural sustentável no Rio de Janeiro* – INTECRAL" would contribute to extend the knowledge in this area and it is where this research is framed. The main objective was to assess the establishment of silvopastoral systems (SPS) with an on-farm research in the municipality of Italva in Rio de Janeiro State (Brazil), to contribute for the adoption of these systems using native vegetation for the integral conservation of the ecosystem. A participatory training program for farmers based on the knowledge transfer, the characterization of the actual production systems of selected farms in the municipality, the perception of the farmers for adopting a SPS in their farms were developed. It was also determined in the municipality the promising and multipurpose native trees that could be used in the SPS. Finally, an economical analysis based on the data collected in selected farms was performed to analyze the feasibility of implementation. The results point out the high possibility for the adoption of SPS using native species. A group of 10 producers was the target of this research and the participatory training program, after this, their knowledge and enthusiasm was achieved. A new perception of a new concept they never heard before was created. All the farmers showed an interest for SPS, they have disposition of time and land for the implementation; but they have no the intention to invest money and borrowing is not an option. The use of native species in SPS is one of the most important recommendations of this study; a 40 promising multipurpose native species list was elaborated. In the same manner, the use of leguminous trees is highly recommended. No problems of native species seedlings and saplings location were identified in the study region. The preliminary economical analysis of the actual systems showed an urgent need of sustainable and profitable technologies adoption. For profitability purposes, the use of a successional planting tree system with non-native species is also a viable option. Because these systems are a very versatile technology with optional arrangements and almost infinite combinations possible, it could be attractive for the producers who could plan and design the systems according to their needs and preferences.

RESUMEN

El bosque Atlántico Tropical es uno de los ecosistemas más importantes y hermosos del mundo. Sin embargo, es uno de los ecosistemas clave de diversidad más poblados y con la menor cantidad de áreas protegidas. Está en peligro y amenazado debido a la sobrexplotación, deforestación y fragmentación, causada por la conversión del bosque en sistemas productivos ganaderos y agrícolas (monocultivos). La Universidad de Ciencias Aplicadas de Colonia y el Instituto para el manejo de recursos en el trópico y subtrópico (ITT), junto con otras instituciones de Alemania y Brasil han desarrollado investigaciones en el estado de Rio de Janeiro por al menos seis años. Un nuevo proyecto, "*Integração de eco-tecnologias e serviços para o desenvolvimento rural sustentável no Rio de Janeiro* – INTECRAL" contribuirá con la ampliación de los conocimientos sobre esta área y es dónde el presente estudio se encuentra enmarcado. El objetivo principal de este trabajo fue evaluar el establecimiento de sistemas silvopastoriles (SSP) en una investigación participativa en el municipio de Italva en el estado de Rio de Janeiro (Brasil), para contribuir en la adopción de estos sistemas usando especies nativas para una conservación integral de este ecosistema. Se realizó un programa de entrenamiento participativo para los productores basado en transferencia de conocimiento. Se realizó también la caracterización de los sistemas productivos actuales y se conoció la percepción de los productores para la adopción de SSP. Se determinaron algunas especies nativas multipropósito para sembrar en los SSP. Finalmente, un análisis económico sobre los datos colectados en los sistemas productivos actuales permitió evaluar la posibilidad de efectuar SPP en la región. Los resultados demostraron una alta posibilidad para su adopción usando especies nativas. Un grupo de 10 productores fue el objeto de este trabajo y del programa de entrenamiento participativo, después de éste se logró que ellos adquirieran conocimientos y entusiasmo sobre estos sistemas. Se consiguió crear una nueva percepción en este grupo de productores sobre un concepto del cual nunca habían escuchado. Todos los productores se mostraron interesados en los SPP, y tienen la disposición de dejar tierra y su tiempo para su implementación, sin embargo no tienen ninguna intención en invertir dinero y hacer un préstamo bancario no es una opción. El uso de especies nativas en los SPP, es una de las recomendaciones más importantes de este trabajo, una lista con 40 especies nativas multipropósito promisorias fue elaborada. De la misma forma, el uso de árboles de la familia de las leguminosas es altamente recomendado. En la zona de estudio no se identificaron problemas para la consecución de plántulas o árboles jóvenes de especies nativas. El análisis económico preliminar realizado en este trabajo permitió ver una necesidad urgente para la adopción de tecnologías más sostenibles y rentables. En términos de rentabilidad el uso de un sistema sucesional de plantación de los árboles, que inicie con especies no nativas puede constituirse en una opción viable. Debido a que estos sistemas tienen gran versatilidad de arreglos espaciales y casi que infinitas formas de combinación, pueden ser una alternativa atractiva para los productores quienes puedes planear y diseñar los sistemas de acuerdo a sus necesidades y preferencias.

ACRONYMS AND ABREVIATIONS

R$: Brazil real
AF: Agroforestry
AFS: Agroforestry system(s)
COGEM: *Comitês Gestores da Microbacias Hidrográficas*
Micro-basin management committee
DBH: Diameter at breast height
EMATER: *Empresa de Assistência Técnica e Extensão Rural*
Technical Assitance and Extension Enterprise
EMBRAPA: *Empresa Brasileira de investigación Agropecuária*
Brazilian Enterprise for Agricultural Research
GHG: Greenhouse gases
m a.s.l: Meters above the sea level
PAIS: *Produção Agroecológica Integrada e Sustentavél*
Integrated and sustainable agroecological production
PES: Payment for Ecosystem Services
SEBRAE: *Servicio Brasileño de Apoyo a las Micro y Pequeñas Empresas*
Brasilian service for micro and small companies support
SPS: Silvopastoral System(s)

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1. INTRODUCTION

Intensive cattle systems are one of the most important causes of deforestation and soil degradation in the world, causing among others, fragmentation and habitat loss, a typical phenomenon occurring in all tropical forests of the planet (Altieri, 1995). The Brazilian Atlantic Forest is not an exception, because it's long settlement history, high population density, the conversion to agricultural lands, incorrect management and overexploitation, lead to an intensification of mosaics forest fragments (Barreiro, 2009; Torrico et al., 2009a). Because of the great importance of this ecosystem, but also because the producers now understand the importance, the need of sustainable systems and the introduction of new technologies, that help them to reduce the costs and increase the yield to enhance the profits; national and international institutions have been working in order to develop new alternatives adoptable for household agriculture (small-farming systems) (Barreiro, 2009).

Long time ago, conservation was all about protection of natural areas, but nowadays the discussion focus has changed, therefore the importance of agricultural land in biodiversity conservation switched the type of research, agro-ecology and agro-biodiversity increasing its popularity over the past 30 years, as a way of spread risk and support food security in resource-poor farming systems (Altieri, 1995; Gliessman, 2000). The on-farm conservation is a special form of *in situ* conservation based on the groundwork of traditional farming and gardening methods, focused on management practices that raised the spatial and temporal diversity within fields. As a result, production can be enhanced and the environmental impacts of husbandry systems reduced (Gliessman, 2000).

Agroforestry systems (AFS), silvopastoral systems (SPS), ecological farming systems and related ones, could play a role in helping to maintain higher levels of biodiversity; revegetation in combination with agroforestry practices can promote biodiversity conservation. These systems provide resources and habitat for native plant and animal species that are partially forest-dependent, also positively influencing the presence and dispersal of flora and fauna, ecological processes related with water and nutrient cycles, microclimate, pest, disease and weed control (Torrico et al., 2009a). Although the functions of the systems named before, there is a need to develop land use systems which are economically attractive for farmers, the social aspects must be considered, and it is also important that they understand properly the environmental services brought to the ecosystem (Torrico et al., 2009b). This research was developed towards that aspect. The use of silvopastoral systems in the municipality of Italva, one of the poorest regions of the Rio de Janeiro State (Bastos & Napolao, 2011), it is a great opportunity to train producers and to encourage them into this kind of production systems, especially when in the region there is a lack of other experiences in SPS.

The Cologne University of Applied Sciences and the Institute for Technology and Resources Management in the Tropics and Subtropics (ITT), along with other Institutions of Germany and Brazil, have been developing investigations in the Rio de Janeiro State for at least six years, with a lot of information and publications generated from the project "Climate change, landscape dynamics, land use and natural resources in the Atlantic Forest of Rio de Janerio – DINARIO". This Project allowed and advance in the conservation and sustainable development of this area, that could have continuity with the project "*Integração de eco-tecnologias e serviços para o desenvolvimento rural sustentável no Rio de Janeiro* – INTECRAL" (Integration of eco-technologies and services for the sustainable rural development in Rio de Janeiro) for another four years.

In one of its main objectives (workpackage II) on agriculture best practice management (BPM) and participative planning to fight against the deforestation and land use changes (Schülter y Torrico, 2012) this work is framed, with the implementation of SPS as a suitable alternative. In the study area, the municipality of Italva, where a group of organized household producers were identified as interested in the idea of SPS implementation. Accordingly to the above and from the fact that livestock is the principal activity in the region, the research question of this study is to analyze which is the perception of the livestock farmers for the adoption of the SPS, its suitability in the area and which are the most appropriate multipurpose native trees that could be used in the system depending on the local area conditions. The elaboration of an economic analysis will help in this assessment too. Last but not least, the results obtained in this thesis, will contribute with data needed for the elaboration and implementation of a simulator on SPS that will provide the producers forecasted information about the economic feasibility of the systems.

1.1 PROBLEM APPROACH

The Atlantic forest in Brazil is one of the most important and a beautiful ecosystem in the world, because of its high endemic biodiversity (species, genetical, vertical, horizontal, structural, functional, and temporal (Gliessman, 2000)). It is considered one of the 34 biodiversity hotspots of vascular plant conservation and one of the five existing in Latin America, which is maybe the most populous and the one with lowest protected areas; nowadays, it has one of the biggest conurbations and a lot of agricultural systems of Brazil inside it (Torrico et al., 2009a). It is divided into two major floristic sets: the sciophilous forest, which is dense and characterized by a non climatic seasonality, and the seasonal semi-deciduous forest in regions with periods of water shortage throughout the year (Mallea et al., 2011). By the above, it is endangered and threatened because of the overexploitation, deforestation and fragmentation, caused by the conversion of the forest to agricultural systems, especially pastures and monocultures, since colonization times (C. XVI). It has been reported that during the last centuries the forest area is reduced to 5 – 12% and that the remaining areas are small and partially protected (Figure 1), so its conservation perspectives are complex (Mallea et al., 2011; Ribeiro et al., 2009; Torrico et al., 2009a).

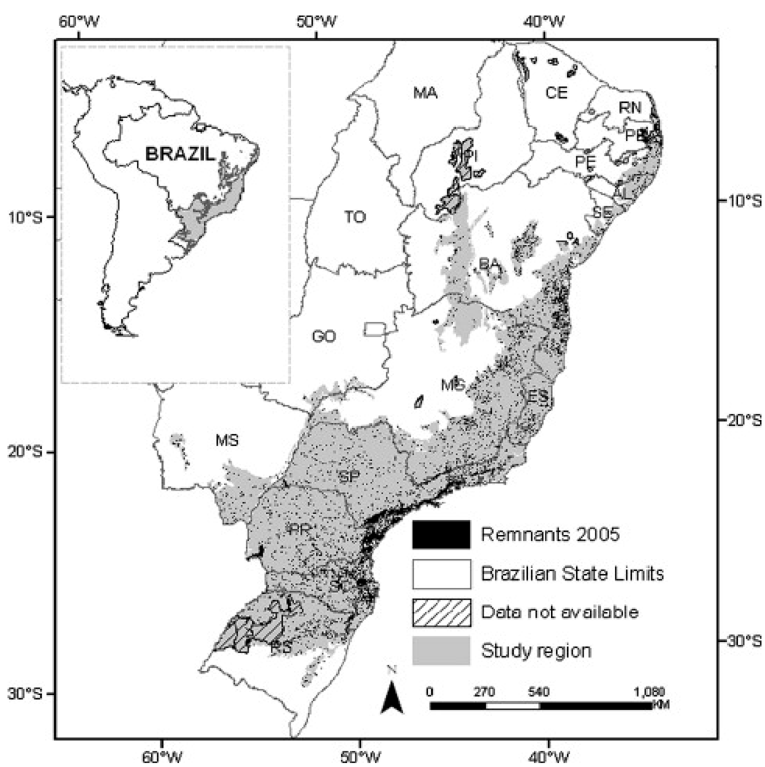

FIGURE 1. REMAINING AREAS OF ATLANTIC FOREST IN 2005.
Souce: Ribeiro et al., 2009

The habitat reduction and the change in the vegetation structure and dynamics of the forest results in species loss, promotion and establishment of invasive species, limitation on regenerative capacity of the species and the ecosystem, shrinking of home range populations and interruptions of migration routes for animals; the sum of all these factors cause the dynamics of the ecosystem to change (Ribeiro et al., 2009; Torrico et al., 2009a). The colonization of humans and unsustainable land use practices, also have a high impact on the physical and chemical qualities of the soils making erosion and landslides intensified, the air quality deteriorates and the surface and groundwater availability is modified. The conservation of the Atlantic forest is now a necessity but it is also a great challenge for modern nature conservation (Torrico et al., 2009a).

In Rio de Janeiro state all land use systems compete with natural forest vegetation. Animal husbandry systems were designed and established on slopes, extending over large extensions of land and over hills. Pastures compete with economic forestry activities, which are dominated by *Eucalyptus,* non-native specie. At valley bottoms there is forage production, with species like elephant grass and sugar cane. It is partly competing with horticultural systems, which mostly occupies the water logged vicinities of rivers (Barreiro, 2009; Schlüter & Pedroso, 2009). It is very difficult to characterize animal husbandry systems, because too often, there are not managed according to economic standards. In addition, the systems between producers are so variable, for example in terms of total numbers of animals, which suggest a large variance in the economic performance of farms (Schlüter & Pedroso, 2009). In this region, it is well-known the importance of pastures and cattle production for the social communities and the local economy. Thus, cattle production has to be turned into a sustainable system for the long term, as well as improve the related agribusiness in the region (Barreiro, 2009). SPS are an alternative, because the actual process of pasture deterioration has to be reverted and more efficient allocation of the existing resources has to be implemented (Barreiro, 2009; Torrico et al., 2009a).

It is reported that actually 74% of the total agricultural surface of the basin is represented by raising cattle; horticultural systems represented a 24%, where leafy vegetables are the most important (14%). In contrast, sustainable systems as silvopastoral only occupies 2% and ecological and organic crops less than 0,4% (Figure 2). These data evidence the great necessity to educate the inhabitants of the region in the lately discussed systems, the advantages for them and for the ecosystems resources and interactions (Torrico et al., 2009b).

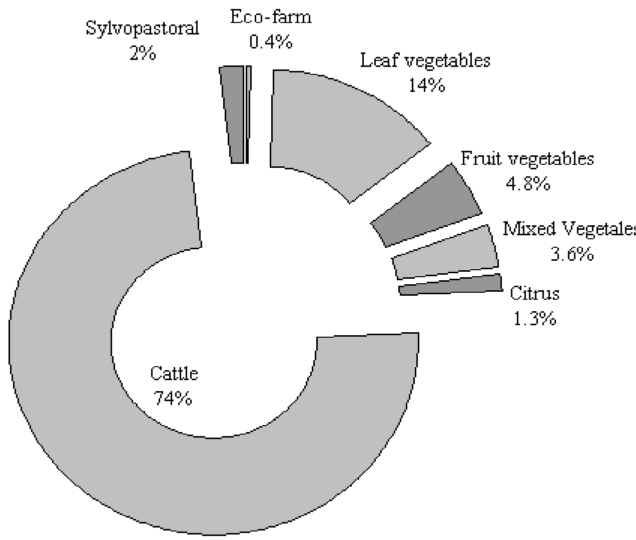

FIGURE 2. RELATIVENESS CLASSIFICATION OF THE AGRICULTURAL SYSTEMS IN THE REGION.

Source: Torrico et al., 2009b

As it was written above, there is a complex problem in the region, and it is not an easy task to solve; most of the land in the Atlantic forest is private property and there are people (families) using that land for living, so there is also a huge social issue (Torrico et al., 2009a). It is impossible to clear the area and let nature act. Because of that, reforestations and the establishment of silvopastoral and agroforestry systems are a way to make nature and humans interact, causing the less impact as possible (Altieri, 1995; Gliessman, 2000). The establishment of these systems has to be accompanied by researchers and other professionals in order to show the population of the region, that they will function and open alternative income sources, instead of damaging the forest with monocultures and pastures.

1.2 STATE OF THE ART

As it was superficially mentioned above, the SPS are a branch of agroforestry (AF) and a very old practice, which had been renamed; is a new science based on an ancient art, based on some age-old land-use systems, all involving trees, developed especially in the tropics and subtropics, where there is a long tradition of raising food crops, trees, and animals together, as well as exploiting a multiple range of products from natural woodlots in an integrated agricultural system. There is a great variety of systems, each with special characteristics, potential yields, benefits and output possibilities. In England in 1988, the 'Bellagio II' Conference on Tropical Forestry Research identified agroforestry as the first of the five major areas of research in tropical forestry. Since then, several international meetings have been held around the world on different aspects of this subject (Nair, 1991).

Just to mention some history, in the period of 1978-1987, the World Bank invested US$ 750 million for agroforestry projects that represent a rise from 6% to 37% of total forestry investment, and the trend keeps on, with the incorporation of other international and bilateral development-assistance institutions worldwide in large scale projects, in which agroforestry forms the main or a significant component in order to contribute with results in areas like soil productivity improvement, reclamation of degraded lands, environmental protection, firewood production, silvopastoral systems and exploitation of indigenous tree species, especially fruit trees (Nair, 1991; Nair et al., 2008). Yearly a great amount of information and articles are generated in this particular area and in international specialized journals in AF or in forestry (table 1), local, national and international ones; and others specialized in related topics like agroecology.

TABLE 1. SPECIALIZED JOURNALS IN AGROFORESTRY AND FORESTRY.

Source: Own elaboration based on web pages of the journals.

Journal Name	Impact Factor (2012)
Forestry	1,677
Annals of Forest Science	1,630
Agroforestry Systems	1,373
Journal of Forest Research	0,838
Journal of Tropical Forest Science	0,537
Journal of Sustainable Forestry	Not Ranked
Agroforestry Today	Not Ranked
International Journal of Agroforestry and Silviculture	Not Ranked

Nevertheless, there is still a lot of work to do and some of this research presents huge failures. The major technical impediments to undertaking quality research in agroforestry are lack of trained personnel for doing research in agroforestry, and lack of appropriate research methodologies. Great possibilities of improving these are mainly based on the possibility of many disciplinary experts of different fields to work on AF research (Nair, 1991). In the case of Latin American and Caribbean countries, different incentives have been applied to promote friendlier production models (SPS and AFS). However, this transformation of Latin American cattle production requires enormous effort and long cultural and technological transitions, demanding economic instruments to promote the fast and reliable adaptation. In Latin America and Caribbean countries there are a lot of public and private projects and international cooperation programs for incentive mechanisms, for the adoption of agroecological practices and SPS (like donation of trees, fodder shrubs and inputs or subsidies for hand labor, payment for ecosystem services [PES]), with variable results (Murgueitio, 2009).

1.2.1 An Overview in Brazil

For the special case of Brazil, the research in this area is also well developed. The Federal institution "*Empresa Brasileira de investigación Agropecuária* - EMBRAPA" is one of the leader institutions working in this topic; occasionally working with a consortium of different federal and private Universities to develop projects in this area. EMBRAPA has a specialized field in forest research (EMBRAPA – *Florestas*), with specific projects, publications, booklets and extension programs to reach producers. Silvopastoral systems in Brazil are well studied and developed in the southern states (famous for their great extensions of cattle rearing), in the regions of the Atlantic forest and also other experiences in Paraná, Rondônia and Amazonas states, as it will be mentioned below.

Brienza & Gazel (1991) reported in their paper, as a part of an EMBRAPA research, some AFS implemented in the Brazilian Amazon, some of them with forest species and/or fruit trees like cacao and banana. The forestry species were *Bagassa guianensis, Jacaranda copaia, Cordia goeldiana, Swietenia macrophylla* and *Vigna unguiculata* in different systems with great results. SPS, were implemented in the Paragominas region (eastern Pará), and has been carried out using *Eucalyptus tereticornis, B. gmanensis* and *Schizolobium amazonicum* as forestry species, *Branchiaria brizantha. B. humidicola* and *Panicum maximum* as forage, and the crop *Zea mays.* The performance of the system was satisfactory and the corn yield was more than the regional average. The cattle, at a low stocking rate, graze normally without harming the trees. Although the good performance of the systems, the authors reported that AFS are not necessarily an ideal solution for all Amazon conditions, but the idea that these systems constitute a rational land-use strategy was recognized in the inhabitant's minds. The need for government incentive programmes for the small-holders was also reported.

In the western Amazon, SPS with baginha trees (*Stryphnodendron guianense)* were implemented in systems with *Brachiaria decumbens* and *B. brizantha* cv. Marandu with good results. This leguminous tree showed a great role in the SPS, a raise of the nitrogen (N) and organic matter in the soil and in the grass tissues was obtained, and it was not detrimental to the production or the grass development (Soares et al., 2002). De Lucena et al. (2004) performed a study in Rondônia state, where various trees, the majority of them being leguminous, were evaluated in SPS. The animals of these systems were buffaloes, cows and sheep. Different shade percentage was assessed, being better for weight gain in all the animals evaluated under shaded conditions, inclusive over 45%. Good results in the accumulation of nutrients in the forage, the development of the grass and the trees, and the nutrients in the soil were normal or sensibly better in the presence of trees.

In Minas Gerais state, in the region of Paracatu, a study was performed to evaluate different nitrogen (N) and potassium (K) fertilization and forage supplement, the chemical composition and dry matter production of silvopastoral understory and the animal performance. The SPS was constituted by *Eucalyptus* sp. and *Brachiaria brizantha* cv. Marandu. The main results of this study showed the importance of fertilization in SPS, with differences in the dry matter, when there was N and K addition. In higher levels of N combined with K, there is a higher liveweight gain per hectare of the herd. In this study the type of forage offered did not affect the animal's weight, but understory fertilization is necessary and efficient for better results in SPS (Bernardino, 2007).

Also, in Minas Gerais state, SPS were proposed as eligible project-based activities reducing greenhouse gases (GHG) emissions (Dias et al., 2009; Fearnside, 1999). In a mixed SPS with *Eucalyptus grandis* and *Acacia mangium* the study estimated the amount of carbon and biomass storage for inclusion of these systems in the Clean Development Mechanism (CDM). After 10 years, in a system composed by 105 plants per hectare (60 eucalyptus and 45 acacia), the estimative of biomass and carbon for eucalyptus were 24,80 Mg ha^{-1} and 11,17 Mg ha^{-1}; acacia were 6,94 Mg ha^{-1} and 3,12 Mg ha^{-1}, and for the pasture (considering only the residues) were 1,28 Mg ha^{-1} and 0,58 Mg ha^{-1}, respectively. Although this research recommends more studies, it recognized the great potential of the system in this issue (Dias et al., 2009).

In the northwest region of Paraná State, SPS are used for the control of erosive process and for land optimization. The objective of this research was to characterize and evaluate the SPS in the region, using visits to farms with already implemented systems. Various arrangements were identified and the most used species were *Grevillea Robusta* (silky oak) and species of the *Eucalyptus* genus. At the moment it was developed, the general conclusion of the study was that the actual systems had not accomplished all of its timber potential, so they were not used economically yet (Nepomuceno & Silva, 2009).

In the midwest of Brazil, mainly in the state of Mato Grosso do Sul, EMBRAPA - *Gado de corte* (beef cattle), developed a study for the implementation of SPS because of its huge potential for sustainable development. Almost 50% of the pastures in the region are degraded or in degradation process, which implies a great need to implement new technologies and sustainable systems, which is a huge socio-economical problem because of the importance of the value chain of milk, meat and leather that this region represents to Brazil. The government, due to this program linked the livestock production with the timber's market, so the producers could be motivated for the implementation, beside the other benefits of a SPS in terms of cash flow for example. Finally, the incentives were created in order to change the actual perception of Brazilian production into a more eco-friendly system (Franceschi et al., 2004).

1.2.2 An Overview in Rio de Janeiro State

For the Rio Janeiro state, there is a tradition of planting Eucalyptus species, because there was a governmental initiative to reforest the region with them, but it should be planted only on hillsides and degraded soils. The project was executed by the state organization EMATER (*Empresa de Assistência Técnica e Extensão Rural*) and was well developed because of a close approach between technicians and farmers. Nevertheless this initiative, exotic species implementation should be more investigated (Torrico et al., 2009b). Carvalho et al. (2003) recommends for the zone, nitrogen-fixing trees for use in SPS, like *Acacia mangium, A. auriculiformis* and *Mimosa artemisiana*, although they are non-native species.

In Rio de Janeiro state, the few existing SPS maintains low indices of diversity but in comparison with normal cattle systems, the species richness increased fourfold. Thirty four timber species were identified in SPS in the Mountain region (*Region Serrana*), near Teresópolis municipality. This shows the high potential of SPS to being implemented with a portion of the original biodiversity of the Atlantic forest, but they also have to be well designed and managed. For farmers with small long term investment capacity, the most used grass species in SPS are *Melinis minutiflor* and *Brachiaria decumbens* and for forestry, species like *Lonchocarpus* sp*., Tibuchina* sp*., Piptadenia gonoacantha, Croton floribundus* y *Machaerium* sp*.* which possess good characteristics for this region. Other diverse native species also possess positive characteristics for SPS but they should be evaluated in the future (Mallea et al., 2011; Quintana, 2012; Torrico et al., 2009b).

Using the region´s agro-biodiversity would be a key in the establishment of environmental friendly production systems. In this context, economic valuable species (native ones as medicinal plants, ornamental, fruits or fiber plants and even more important with multi-purposes) earn a particular attention because they must be the ones used. Mallea et al. (2011) and Quintana (2012) have identified a list of forest species that could be implemented in silvopastoral and agroforestry systems, according to the biodiversity of the region, with different uses. In the implementation of these systems, it is important to show the farmers the options and combinations of species, to obtain greater incomes and greater biodiversity. Quintana (2012) identified that the most common use of native trees in grasslands were to obtain firewood, provide shelter to the herd, food and timber.

Souchie et al. (2006) in the Rio de Janeiro State (Paraty municipality) aimed to evaluate several native and non-native nitrogen-fixing and non-fixing tree species, in relation to their survival rate and growth in pastures for SPS at the Atlantic Forest region. Nitrogen-fixing species like *Enterolobium contortisiliquum, Acacia holosericea, Pseudosamanea guachapelle, Anadenanthera macrocarpa* and *Mimosa caesalpiniaefolia* and other non nitrogen-fixing like *Schinus terebinthifolius, Eucalyptus grandis, Tabebuia chrysotricha, Khaya senegalensis* and *Senna siamea* were evaluated. *M. caesalpiniaefolia*, *E. contortisiliquum*, *A. holosericea* and *E. grandis* were the best performance species for SPS in this study, due to their rapid establishment rate.

In the area of Cachoeiras de Macacu, the research of Quintana (2012), found that the cattle production is an activity with a low profitability and generally is carried out by the producers as a secondary income source. This suggests that the ecosystem is probably overexploited and unbalanced, thereby, some actions must be taken. It was also stated, that some silvopastoral models proposed are economically feasible and represent a highly profitable alternative for the farmers and of course a benefit to the environment. Although, the cattle farmers, show a negative disposition of implementing these kinds of systems, because they thought that the trees might cause a loss of the pasture productivity due to excess of shade and area occupied by them. It was found that the use of *Eucalyptus* spp. mixed with native species is a feasible alternative in the first stages of the cycle, because it generates profits to the producer in a shorter period, which is another cause for the refusal of producers.

As it was described above, it is important to mention that most of the actual implemented SPS in the state is based on non-native species. Torrico et al. (2009b), Mallea et al. (2011) and Quintana (2012) are one of the first authors who write about the inclusion of native species in the systems in Rio de Janeiro. Currently the state is trying to avoid new eucalyptus plantations, and the Rio Rural Institution, is not lending money to the producers if they want to buy seedling of these species. Finally it is important to state that in the study area, or near it, there are no functioning SPS, some of the nearest experiences were abandoned. It is possible that some private initiatives exist, but they are not registered in the official record of the state as a recognized land use in the area.

2. OBJECTIVES

2.1 GENERAL OBJECTIVE

To assess the establishment of silvopastoral systems with an on-farm research in the municipality of Italva in Rio de Janeiro State (Brazil), to contribute for the adoption of these systems using native vegetation for the integral conservation of the ecosystem.

2.2 SPECIFIC OBJECTIVES

- To develop a participatory training program for farmers based on the knowledge transfer of the concept, components, principal benefits and disadvantages of the SPS.
- To characterize the actual production systems of selected farms in the municipality of Italva.
- To determine the perception of the farmers of the municipality of Italva for adopting a silvopastoral system in their farms.
- To determine in the municipality the promising and multipurpose native trees that could be used in the silvopastoral systems.
- To perform an economical analysis based on the data collected in selected farms of the region, to analyze the feasibility of SPS implementation.

3. THEORETICAL FRAMEWORK

Pasture degradation is a major economic and environmental problem in the tropics and, particularly, in Brazil. Among the strategies proposed to reclaim degraded pastures, the introduction of SPS would be appropriate mainly on situations where the intention is to diversify sources of income and to increase biodiversity. Despite their many benefits, the adoption is still very limited, particularly due to their high initial costs (Diaz – Filho, 2006).

Agroforestry systems are agroecosystems, classified as a way of land use and are different from silviculture (Ospina, 2006). The agro-forestry system is defined as an integrated approach of using shrubs and trees, woody and non-woody species, with crops or livestock, combining agricultural and forestry technologies to create a more diverse, productive, profitable, healthy and sustainable land-use system (Gliessman, 2000; Nair et al., 2008). The principal characteristics for the woody species are a life period of at least two years and over five meters of height with a hard stem and canopy. The characteristics of the non-woody species are, statured species and its life cycle might be less or near to one year, in this component, the crops, semi-evergreen species, grasses and herbs are found. When the animals are part of the system, the mostly used is cattle, but there are other animals as sheep, goats, hens, turkeys, even fishes that could be introduced, there are systems specialized in the production of invertebrates as bees or silk worms too (Ospina, 2006).

As Gliessman (2000) describes humans have a lot to learn from nature, and agroecological management must be encouraged in trying to mimic or copy nature and its natural process. The trees role in these systems are so important in terms of canopy interception of light, solar radiation and rain; protection from the wind, raised organic matter content with the litter that falls are important in the nutrient cycling and finally they are the habitat for beneficial organisms and endemic species of the region (figure 3) (Gliessman, 2000, Dias-Filho, 2006; Nair et al., 2008). Ospina (2006) also reported benefits of these kind of systems that the risk of agricultural failure is reduced and they help to improve the economical conditions in rural areas. It is important that the sustainability of these systems could be analyzed in scales, for example local, in the farm or even patches, in a community or town scale, or in a regional or state level (Nair et al., 2008; Ospina, 2006).

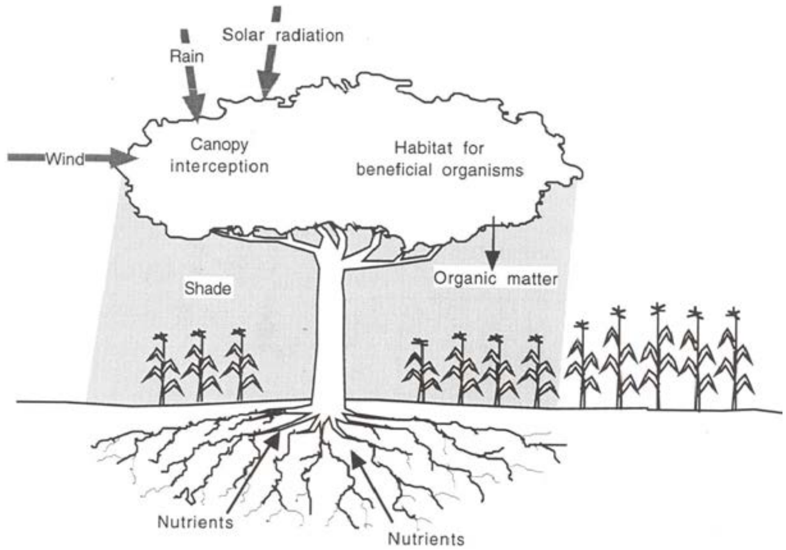

FIGURE 3. EFFECTS OF A TREE ON THE SURROUNDING AGROECOSYSTEM.
Source: Gliessman, 2000

Reported by Janssens et al. (2009), there are systems with high resilience indices (R_i), examples as Coffee in northeast Brazil (0,42), Cocoa Agro-forest in Cameroon (0,22), Coffee in Chiapas México (0,14), and ecological horticulture in the Atlantic forest (0,12), this shows us how those systems are clearly possible and sustainable for nature and humans, and that its establishment could be beneficial for the whole ecosystem. On the other hand, the same authors research reveals that some of the most used agricultural systems in the region of the Atlantic Forest have the lowest indices, for example grass (0,005), citrus (0,006) and vegetables monoculture (0,013). Another research performed by Torrico & Janssens (2010), shows that the potential eco-volume, is greatly reduced and converted to eco-volume loss in systems as grass, citrus, fruit, vegetables, mixed vegetables, leafy vegetables. It is also demonstrated by those authors that SPS and ecological ones, began to increase the bio-volume and decreases considerably the eco-volume loss.

Agroforestry arrangements have a high variety between woody and non-woody species and animals, as its temporal dynamics (Figure 4). Spatially, the components could be combined, mixed or zonal and may have a vertical stratification. In the temporal scale, they could be permanent, simultaneous, combined, sequential, staggered or consecutive (Gliessman, 2000; Ospina, 2006; Nair et al., 2008).

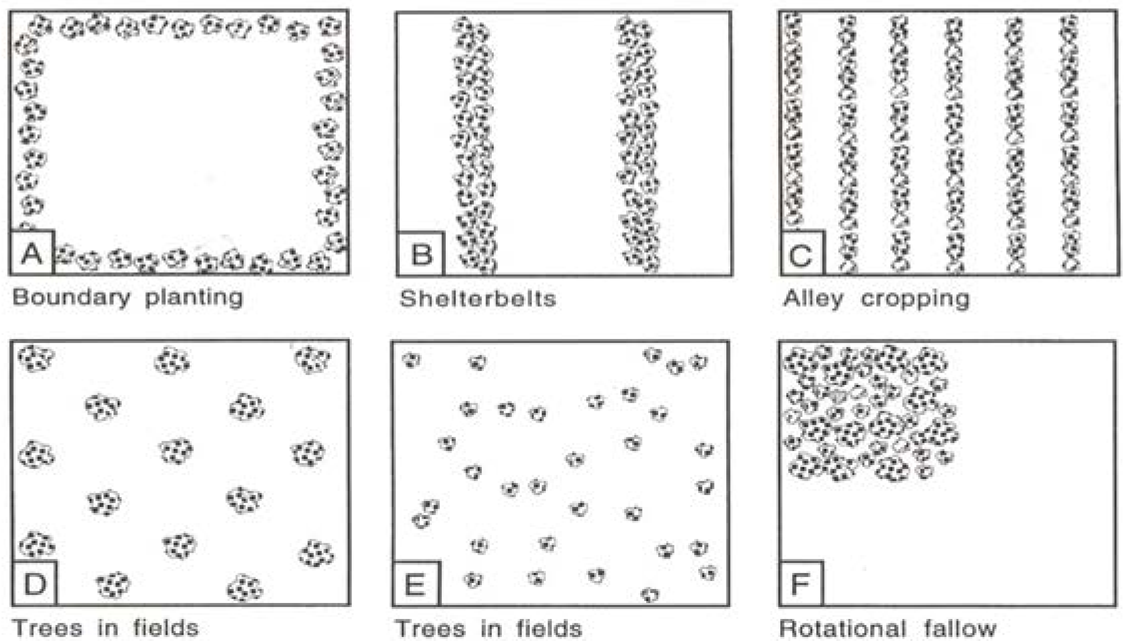

FIGURE 4. MODELS FOR THE ARRANGEMENT OF TREES IN AGROFORESTRY SYSTEMS.
Source: Gliessman, 2000

Ospina (2006) and Diaz-Filho (2006), mention that in tropical lands, an agroforestry system with an agroecological approach must:

- Recognize the ancestral technologies and practices,
- The decisions for its adoption is a part of the family, community or local organizations,
- The local labor and its strengthening might be promoted,
- Simple methologies and tools may be used in productive and conservation labors,
- The teaching and research *in situ* might be strengthed,
- The seeds and breeding of animals might be used and developed from native species with an efficient, simple and economic management,
- The potential use of native biodiversity have to be studied and known,
- The management, composition, structure and temporal dynamics is according to the landscape and region,
- The wild, protected and domesticated biodiversity is conserved as the water, soil and other nature services,
- The system have high biomass, energy accumulation and climatic regulation,

- Variety offer of products and services, therefore the sufficiency of the region with material goods,
- Sense of proudness of being part in conservation of nature project,
- Consumers and traders fair relations (equity and justice).

The SPS are denominated when it is combined livestock grazing (cattle, sheep or goats) in forage crops with shrubs or tree crops (Gliessman, 2000) (Figure 5). Agroecology based systems could facilitate the conservation and restoration of the ecosystems, which helps the rural communities that nowadays live from what they can harvest from the land they use (Altieri, 1995). As the agroecology defines, agro-forestry and silvopastures are a way for raised biodiversity, stability and resilience of the systems, made emergent qualities to appear, raised the total biomass, net productivity, organic matter, conserve the soils and make efficient the nutrient cycling, promote interaction between species and mutualistic interferences that would help to the correct the ecological performance of the ecosystem (Altieri, 1995, Gliessman, 2000).

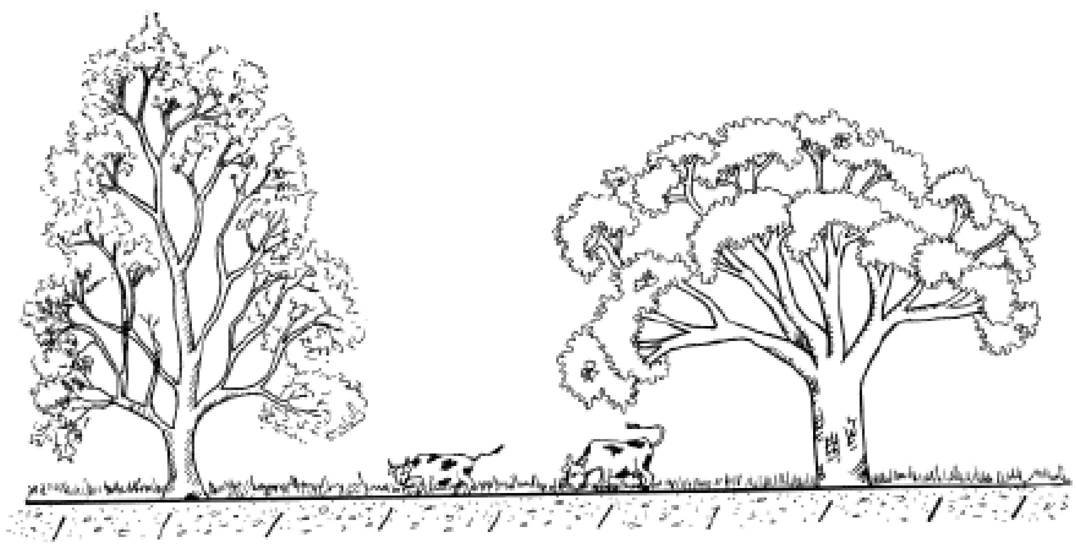

FIGURE 5. SCHEMATICAL REPRESENTATION OF A SILVOPASTORAL SYSTEM.
Source: Ospina, 2006

These types of systems offer the ones who used them new market opportunities. In a livestock system, the only accessible market is the one related to the animal; in contrast, in a silvopastoral system the market could be diversified, because now the animal is not the only component that the system has, the trees are a source of money too because they can produce fruits, fibers or timber; certainly with a lower return rate, but in a well organized system and using the correct arboreal species, this could be reduced (Quintana, 2012). Another important market where producers could earn profits is the carbon forest mitigation. The existence of a carbon market signals the economic importance of protecting forest areas and other environmental services, such as watershed management or biodiversity conservation. It is important to mention that this approach is supported by the World's leading scientific bodies; some like the Intergovernmental Panel on Climate Change (IPPC) or the United Nation's Millennium Ecosystem Assessment are the scientific panel which supports the importance and benefits of adopting new sustainable technologies. A lot of enterprises also have interest in investing in this kind of projects because they have to fulfill the requirements for contamination derived by their production (Boyd et al., 2007).

3.1 TYPE OF ARRAGEMENTS IN SPS

One of the most important decisions in SPS establishment is the definition of the trees spacing and arrangement. This will define the luminous conditions for the grass growth. In bigger spacing more radiation passes to the pasture stratum, which favors the biomass accumulation. Meanwhile, the spacing between the lines cannot be excessive to the point to jeopardize the quantity or quality of the forestry product (in terms of timber) (Ribaski, 2009). A multiplicity of temporal and spatial arrangements and output variations exists in the Neotropics as a result of the research and the farm planners (Figure 4). The systems of main importance used in SPS include scattered trees, live fences, high density trees, cut-and-carry systems; in contrast, others like windbreaks and tree alleys are of lesser importance (Murgueitio, 2004).

- *Scattered trees in pastures:* this arrangement is used mainly for generating income from timber and fruits. The great part of the trees that composed the system grew spontaneously in the pasture. Studies revealed that these trees are generally accepted by the farmers as shade trees, and because of the bird dispersal, there is a high possibility that these trees produce fruits. This system is very appropriate for farmers with low investment capacity. In addition, there is no need to buy seedlings. This arrangement is similar to nature's behavior and the trees are not densely concentrated; therefore the shading effect over the pasture is not so strong. It is perfect for a great raise in biodiversity, because the number of species planted could be huge (Dias-Filho, 2006; Murgueitio, 2004). The management of natural regeneration timber species in SPS is a low cost alternative for the producer (Torrico et al., 2009b).

- *Live fences:* is one of the most typical arrangements in rural landscapes. The trees and shrubs for this arrangement must be adaptable to short planting distances and frequent pruning. It is also used to replace fence posts. The principal objective is to separate properties or lots, but it could also be used by cattle or for a live-corral construction. Studies reveal a 54% of saving costs in fences maintenance and in forest pressure for posts and firewood. Easily, this system becomes a biological corridor depending on the species diversity, width and complexity (Dias-Filho, 2006; Murgueitio, 2004; Ospina, 2006).
- *High tree density or grazing tree plantations:* they are part of the modern intensive SPS, which used over 1000 individuals ha^{-1}. Rotational grazing with electric fence is very common in this kind of systems. The use of fertilizers is also fundamental. These kinds of systems help producers to obtain clean production certificates (Dias-Filho, 2006; Murgueitio, 2004; Ospina, 2006). Because of the high density of the systems the trees could be planted in:
  - *Simple row:* where trees are planted in regular spacing and densities like 3 X 10 m, 5 X 10 m, 10 X 10 m, 5 X 20 m, etc. The choice of the density is directly involved with the specie, because the type of canopy and height. Contour lines are highly recommended in slopes and in plains the rows are to be oriented east-west, to reduce shading effect (Dias-Filho, 2006).
  - *Double and triple row:* the density of trees is higher, so the possibility of shading too. The use of shade tolerant leguminous plants is recommended. The density of the trees will directly depend on the purpose of the plantation. The use of the trees in a kind of succession process is very common in this type of systems (Dias-Filho, 2006).
- *Cut-and-carry systems or protein banks:* is one of the most common and widespread system in developing countries. The most common species implemented in this kind of systems are leguminous and fruits trees and shrubs in polycultures. Its main function is to produce fresh fodder for the animals, so the growth and budding must be very fast. The fodder could be stored and dried and given to the animals as a supplement in their diet. The higher content of protein of the leguminous plants helps in the saving of money in concentrates. High labor and fertilizers could be necessary in this kind of systems (Murgueitio, 2004; Ospina, 2006).
- *Windbreaks and Alley crops:* they are established to protect crops against the wind, cold air or strong currents. The trees are planted in various parallel lines, well distanced (over 10 m) and perpendicular to the wind flow. The trees must have a dense canopy, rapid growth and non fragile. In SPS they could help to protect small animals, for shade and fodder (Murgueitio, 2004; Ospina, 2006).

- *Woodlots:* little patches of trees are created in the pasture which means high density of trees in a little space. The diversity could be very high. The grass growth will be limited because of the shade and the cattle aggregation in that zone. The soil in those areas could be compacted because of the cattle trampling (Dias-Filho, 2006).

3.2 LEGUMINOUS SPECIES ROLE IN SPS

In SPS one important aspect is the quality of the shaded forage, because it influences directly in the animal production, especially in tropical soils where organic matter is very important for the nutrient storage, and a constant input is necessary. Leguminous trees could help to intensify the soil carbon accumulation and the nutrient cycling (Balieiro et al., 2005).

The leguminous trees have the ability, as other members of this botanical family, to establish a symbiosis with diazotrophic bacteria which fix atmospheric nitrogen, making this characteristic a fundamental part for soil management in the tropics, which reflects a partial or total reduction of the nitrogen fertilization, representing an energetic saving of 14.700 kcal kg^{-1} of fertilizer. It is a way to reduce the pollution caused by nitrogen leaching and storage in the soil. It is better to plant species with great root nodulation capacity, of which many species are identified, but plenty information is still missing on this issue. Arboreal species have also shown a great capacity to establish symbiosis with mycorrhizae, which are very important for the phosphorus fixation and availability in the soil (Balieiro et al., 2005).

In the tropical areas there is a large biodiversity of leguminous tree, which makes very easy and almost infinite for the producers to successfully mix different tree species. Just in the *Cerrado* region of Brazil, 527 species in 70 genera were recognized. In a study in the Atlantic forest looking for potential species, 611 species were identified; where the Leguminosae (or Fabaceae) family was the one with the major representation (221 species). These species, the ones selected for working in SPS must be adapted to open spaces and secondary succession stages. There is still a lot of information missing about their impact on the forage and animals in a SPS (Balieiro et al., 2005).

A shade effect to the forage is reported to affect drastically the content of potassium (K), increasing its concentration, so does with phosphorus in a lesser extent. In terms of nitrogen (N), it was less affected than the variable of dry matter. The lignose content also increases in the pasture but digestibility of the grass by the cow was not affected (Balieiro et al., 2005). Leguminous species have great amount of total N, most of them in form of aminoacids and show a greater amount of protein, for example *Thitonia diversifolia* (23,8%), *Gliricidia sepium* (25%), *Leucaena leucocephala* (22,2%) and *Erythina rubrinervia* (22,5%). Studies demonstrate also that feeding of livestock with these plants increase the milk quality, in terms of total solids and protein content (Murgueitio et al., 2010).

These types of plants have a great range of ecological adaptations that make them suitable for SPS. Characteristics like drought tolerance, rapid budding, tolerance to continuous branching and direct harvesting, high forage production and digestibility, deep and large radicular system, makes these trees very suitable for plant associations (Murgueitio et al., 2010). Another study of 16 species of leguminous trees revealed that the growth behavior is affected minimally when they are consumed by the cows, meaning that the survival, canopy development, growth and the DBH are not affected. The study also reveals a high palatability of the species, of course, ones more than others (Dias, 2005). Other studies reveal that some species don't need extra protection to be planted with cattle while they are growing (Dias et al., 2008b). It is also important to mention that these species are well related with the grass species, and in the special case of this study with one of the most used grasses in Rio de Janeiro state, *Brachiaria decumbens* (Dias et al., 2007).

3.3 PLANNING HOW TO PLANT THE TREES IN THE PASTURE

The distribution of the trees is very important for the success of the system. In order to decide the best arrangement to implement, it is important understand the following issues: a) which will be the final purpose of the system (wood, fruits, fuelwood, fences, charcoal, etc.), b) does the distribution interfere with the soil and water conservation, c) which will be the orientation of the trees in the system (De Castro & Paciullo, 2006; Porfirio-da-Silva et al., 2010). If the system will be used for wood production, then the density of trees will be different depending on the final destination of the wood, if it is light or heavy wood. If it is for sawmill, the trees have to be planted with a low density (Table 2). The importance of pruning and trimming is different depending on the market and the number of rows planted, and also it is very important in densely planted systems, because a bad practice could compromise the quality of the forage. The waiting time for the final product in heavy wood systems is longer than in light wood ones. In systems with three rows, for example, there is a way to take advantage of light wood in the first years by cutting some of the trees, thereby leaving less trees for heavy wood at the end; as it is shown in table 2, a system of triple row begins with 1.000 trees ha^{-1}, with trimming and at the end it is transformed to a simple row with 167 trees ha^{-1} (Porfirio-da-Silva et al., 2010).

TABLE 2. EXAMPLE OF SPS PLANTATIONS IN DIFFERENT ARRANGEMENTS AND QUANTITY OF TREES PER HECTARE WHEN THE PURPOSE IS FOR WOOD.

Source: Porfirio-da-Silva et al., 2010

Spatial Arrangement	Light Wood (charcoal, firewood, fences posts)			Heavy wood (sawmill)		
	Spacing (m)	No. trees ha^{-1}	Occupied area by the row of trees (%)	Spacing (m)	No. trees ha^{-1}	Occupied area by the row of trees (%)
Simple line row	14 X 2	357	14,3	14 X 4 or 28 X 4	179 or 89	14,3 or 7,1
Double line row	14 X 2 X 3	417	25	18 X 3 X 1	185	11,1
Triple line row	14 X 3 X 1,5	1.000	40	20 X 3 x 1	167	10

It is recommended for plantations in slopes, to plant in contours, this will help to prevent soil erosion and water losses because of runoff. In general, Brazil´s climatic conditions make the decision easier for the trees orientation. Brazil is characterized by a warm-humid climate, with seasonal rains and a constant luminosity over the year. Hence, the management of pruning is more important than the orientation in almost all the Brazilian regions. It is important to plant in order to shade the cattle but not to affect grass development. The trees selected will depend on the adaptability to the climate and soil conditions, the certainty of a possible market for the products and their requirements. These species must have a rapid growth, which will help to a faster investment return and a diminution of cattle damage to the trees. The slow growth trees could also be selected, but it is important to protect them from the cows, therefore retrieving the cattle for a certain time from the pasture until the tree is big and strong enough. For the forage selection, the most important characteristic is that it has to be shade tolerant, but as it was mentioned before, the pruning practice is one of the key factors for success (Porfirio-da-Silva et al., 2010).

3.4 SPS IMPLEMENTATION IN A RURAL PROPERTIES

Once the system planning, species selection and arrangement has been performed for the property, this phase could commence.

- *Soil and area preparation:* the tree plantation could be performed in a pasture already formed and with cattle on it, or in a renewed one. A well prepared soil stimulates the initial tree development. In the tree plantation zone a deep (40 cm) row is needed for a better root penetration. The preparation minimizes the death of seedlings and the growth of weeds, which at the end, saves money and time. For previously formed pastures, the rows (or spaces) where the trees will be planted must be well prepared; the grass must be cleared at least 1 m wide on each side, to avoid grass competition with the seedlings. It could be done with mechanical weeding or with herbicides (De Castro & Paciullo, 2006; Porfirio-da-Silva et al., 2010).
- *Cutting ants control:* In Brazil these ants represent a severe plague in newly planted tree crops, so its preventative control is necessary and must begin at least one month before the transplanting and continue for at least two months after tree establishment. Granulated bait, is very useful, efficient and less harmful to the environment (Porfirio-da-Silva et al., 2010).
- *Quality and seedlings handling:* for good quality trees it is vital to use guaranteed genetic material (seeds or clones) (De Castro & Paciullo, 2006). The seedling before plating must go through an adaptation process which means to decrease the irrigation and expose them to the sun. Transfer from the nursery to the farm, as well as the final location must be done very carefully. If these instructions are not followed, the number of deaths will increase dramatically *in situ*, which means a loss of money and time. A good quality seedling must have the following:
    - No folding in the roots
    - Good sanity, free from diseases or plagues
    - Good size depending on the specifications of each species.
    - The leaves must have the characteristic coloration of the specie (Porfirio-da-Silva et al., 2010).
- *Plantation techniques and initial fertilization:* it is very important in this stage to check the moisture soil content. Ideally perform the transplanting in the rain or one day after it. It is important to know when it is the rainy season, in order to plant in that moment. If after planting, there is no rain in the first week, it is better to irrigate the seedlings. Planting could

be mechanized (1.000 plants $hour^{-1}$) or manually (800 – 1.000 plants per day with a trained employee). If the seedling is in a plastic bag, it must be removed completely. Some new bags are made in special fabrics, which help to avoid this step. Seedling mortality goes over 5% after transplanting, so 30 days after, the plants must be inspected and replanted. This labor is one of the most expensive activities in the whole process. The soil fertilization must be done based on a soil analysis; it must be at the beginning and 30 days after. Then some periodical fertilization would be needed (De Castro & Paciullo, 2006; Porfirio-da-Silva et al., 2010).

- *Weed control:* At the initial stage of the SPS, the grasses and other spontaneous plants compete strongly with the seedlings, therefore a control is necessary. It could be performed manually and/or chemically (De Castro & Paciullo, 2006; Porfirio-da-Silva et al., 2010).
- *Tree pruning:* this practice consists in the elimination of dead branches, or even live ones, in order to form the tree. The first pruning must be done when the trees are 1,30 m tall and 6 cm of DBH. This part is essential for the plant growth and for its final architecture. In pastures where the cattle are continuously in contact with the trees it is important to isolate them, because in sapling formation it could harm their growth (Porfirio-da-Silva et al., 2010).
- *Tree thinning:* In double or triple rows arrangements, it is important to recognize if the trees are competing. So it is important to mark some trees in the field, measure the DBH and if the development of the trees is decreasing or even stopping, it is necessary to eliminate some, by selecting and cutting them down. At least the 50% of trees are removed in this stage. After this, the trees that remain would be the final constituents of the SPS (De Castro & Paciullo, 2006; Porfirio-da-Silva et al., 2010).

3.5 ADVANTAGES AND DISADVANTAGES OF SPS

Some benefits of these systems were somehow mentioned before. Although, one of the most importat benefit for the farmers is in terms of profit, because of the diversification of the production and a raise in the cattle performance. Primarily because the cattle saves more energy and is comfortable due to the forage offered has a better quality (Baggio, 1983; Daniel & Couto, 1999). Other benefits include the PES for soil conservation, hydrologic regulation, carbon sequestration, biodiversity conservation, landscaping, fire risk reduction, among others (Mallea et al., 2011). The establishment of biological corridors facilitate movement of animals and plant dispersal (Torrico et al., 2009a). The firewood, fence posts and forage bring economical benefits, which could generate an inflow increase over 15 – 35%. Between 60 – 70% of the vegetal biomass could be used in cattle feeding, without causing a competition with human food. There is a decrease in the cinetic energy of the water and its erosive potential, and a reduction in the wind speed because the tree's canopy avoids eolic erosion (Balieiro et al., 2005; Mallea et al., 2011). The deep roots of the trees help in the nutrient availability and/or storage for the grasses that have superficial roots. There is an organic matter adition, which positively impact the nutrient cycle in the soil. Farmers adopt the systems because it is possible to increase the stocking capacity of the paddock and there is a decrease in pasture renewal (Balieiro et al., 2005; Porfirio-da-Silva et al., 2010).

With a SPS it is not necessary to invest in artificial shade for the cattle. The animal performance (productive and reproductive) is optimized because of the shelter provided by the trees to the animals and to the grasses (Porfirio-da-Silva et al., 2010). For the animals, the variation of daily temperature affects their rectal temperature and respiratory frecuency. Furthermore, these variations could be minimized when the animal is in a comfort zone where its body does the less thermoregulatory effort, hence a better conservation of energy, resulting in a stress reduction, less food intake and a positive effect in production. It was reported that thermal discomfort for Holstein cows represents a decrease of 0,10 to 8,40 kg cow^{-1} day^{-1} in the milk production. Other authors report in this same breed, an increase of 0,23 kg day^{-1} more due to the shading effect. In another study, in Holstein cows too, after eight weeks of grazing with access to shade, the mean production of milk increase in 1,45 L cow^{-1} day^{-1}, and also presented a better quality (Balieiro et al., 2005). In general the health of the animals is improved, so there is a saving in medicines. Finally Paciullo & De Castro (2006) mentioned that ethically this kind of systems are better and the cows are "happy".

In spite of the great advantages of the SPS, there are some adoption barriers in Brazil that restrict its use and implementation. There are many inconsistencies between the technical evidence and the practice. At the beginning, the low profitability of the system was due to the high implementation costs, therefore a low return rate, compared with traditional systems, make it unattractive, especially when the producers live from what they produce and are small-farmers (Dias-Filho & Ferreira, 2007). Depending on the spatial arrangement, the use of agriculture machinery could be difficult. Some of the major barriers for the adoption of the systems are the lower profits at the beginning, and the great inversion of time and money in its establishment. Thus, sometimes it is necessary to borrow and some people refuse to do so (Dias – Filho, 2006).

A cultural barrier is also identified, because the producers are used to a way of living – cattle rearing, and it is difficult for them to change their minds, in addition there is a lack of agronomical knowledge and new concepts that farmers do not know or understand. The government has a very important role in the creation of policies and subsidies for the SPS adoption and for education and environmental sensibilization (Dias-Filho, 2006; Dias-Filho & Ferreira, 2007; Mallea et al., 2011). There are important constrains about diseases, weeds and undesirable species too (Torrico et al., 2009a).

Some of the main problems related with SPS are the possibility of competence between the trees and shrubs with the grass because of the shadowing, the competence for water and nutrients and the presence of a high quantity of litter. In some cases the aggregation and continuous movement of the animals beneath the canopy of the trees, can cause the loss of the herbs and consequently soil compaction and erosion because the exposure of bare soil. This aggregation could cause an uneven distribution of the feces and urine, which could impact the nutrient distribution of the plot. It is also reported that the competition may affect the survival of the trees. In fact, one of the reasons of low implementation is the difficulties for planting and establishment of the seedlings (Dias-Filho, 2006).

In the terms of PES, sometimes this is not an attractive way of gaining money for some producers, in some way because the profits are delayed in a long time, while the investment cost is immediate (Dias-Filho & Ferreira, 2007). Because of the above, for the adoption of ecological practices in Rio de Janeiro, it is necessary that the government examines all the communities and stakeholders involved via participation, transparency and democratic criteria (Franco et al., 2001) and create some policies and incentives for the adoption of the systems (Diaz-Filho, 2006). Then all the projects made in this area and the data collected in this project, will be useful for all the stakeholders and for the State Government, in order to make decisions and create new laws. According to Dias-Filho & Ferreira (2007) and Franco et al. (2001), proposals for policy alternatives for the environment in developing countries, Brazil's current category, there is a need to harmonize colonization and land redistribution with conservation objectives, and possible market opportunities. There is a real search underway for innovative economic incentives, better credit access and instruments that may motivate farmers to adopt sustainable land use practices. More rural education and extension is necessary to eliminate the myths producers believe (Dias-Filho & Ferreira, 2010).

One of the first steps in order to achieve these tasks, after a regional plan and a state policy, is the creation of a network of the stakeholders, which might be divided in three levels. The tertiary level is represented by the project investor or the intermediate agents between the investor and the project broker (for examples NGOs); the secondary level is occupied by the implementor or the intermediate agent between the NGO and the municipality or small holders, and finally, in the primary level the community or beneficiaries of the project is found; obviously each level have different interests, but the success of a running project is the efficiency and a pursuit of "almost the same objectives". If some of these strategies are used, as an example, it can be reached to a contingent valuation (willingness to pay and willingness to accept) between the stakeholders of agroforestry networks. In these negotiations, a coherence between agro-economic policies and farmers expectations is very important (Franco et al., 2001).

4. METHODOLOGY

4.1 STUDY AREA

The study area was the municipality of Italva, located in the northwest Fluminense in Rio de Janeiro State (Brazil), where the project INTECRAL has one of the priority zones (Schlüter & Torrico, 2012) (Figure 6). The municipality itself is located at 21° 25’ 15’’ S latitude and 41° 41’ 27’’ W longitude. The municipalities bordering Italva are Campos dos Goytacazes, Cambucí, São Fidélis, Itaperuna and Bom Jesús de Itabapoana. It is 320 km far from the capital of the state, Rio de Janeiro and is intersected by the BR 356 highway and the Muriaé River. The total extension is 341 km^2, from which 64,2 km^2 are arable lands and 224,7 Km^2 are pastures. The total population is 14.027 people, split in 3.799 in the rural area and 10.228 in the urban (EMATER-RIO, 2013).

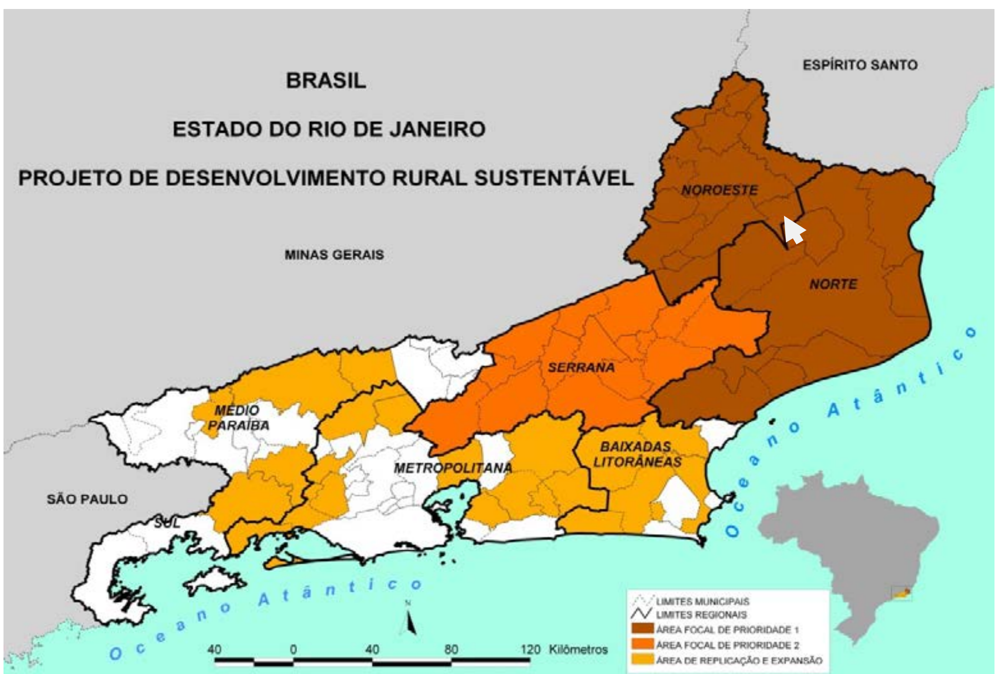

FIGURE 6. STUDY AREA IN RIO DE JANEIRO STATE.
The white arrow shows the location of the study area. Source: Schlüter & Torrico, 2012

The altitude is 42 – 45 m a.s.l. The total mean precipitation is 1.087 mm. During the winter there is a medium hydrological deficit, but in the summer season there are no problems with water availability. The mean temperature is 23,8 °C. The Koppen climate classification is tropical hot-humid. There is just a 7 – 10% of the area covered by forest; there are no conservations units, nor connectivity between fragments. For the state, the conservation priority is low and the restoration is passive, some educational projects have been realized in the zone and there are also some incentives for silviculture. The potential vegetation recognized in this area is seasonal semi-deciduous forest. The soil type is a podzolic haplustox. The topography is represented by 60% hills (no more than 200 m a.s.l.), 30% slopes and 10% floodplains. The zone is highly vulnerable to fires, with one of the highest cases in all the state each year (Bastos & Napolao, 2011; EMATER-RIO, 2013; Prefeitura Municipal de Italva, 2002).

Italva is a very rich area in mineral resources like white marble, calcite, dolomite and quartz. In fact, the etymology name of the municipality in the indigenous language Tupi-Guarani means "Ita"=rock and "alva"= white. The municipality has one of the lowest sanitation levels with a high vulnerability. In terms of health, Italva only has primary attention. The indicator for socio-economic vulnerability is medium, but there is a lot of potential for industries and other economical activities (Bastos & Napolao, 2011; EMATER-RIO, 2013; Prefeitura Municipal de Italva, 2002).

In the fertile lands the production systems are in order of importance: dairy cattle, tomato, sweet pepper and fruits. Italva's farming is the first income activity for the municipality. The milk production is concentrated by small holder farmers, which is characterized by a low productivity and high soil and water degradation indexes. In 2013, in Italva 218 dairy cattle farmers produced 4'936.604 liters of milk, on the other hand, 110 beef cattle produced 154 ton of meat. The great importance of cattle in the municipality, and especially the milk production, allows the government to work with a genetic improvement program and the provision of cooler milk tanks program. The entire northwest Fluminense region is known statewide because of the dairy production. Because of the mineral resources, part of the economy is based in cement, lime, marble and limestone. This attracts big industries like Holcim Brazil S.A. In the region there are no forestry products. In the 80s, Holcim Brazil S.A. planted a million trees of Eucalytus, nowadays only 38% remain of these plantations, but no new silvicultural plantations are registered as official land use in the area (Bastos & Napolao, 2011; EMATER-RIO, 2013; Prefeitura Municipal de Italva, 2002).

The municipality is divided in nine micro-basins (Figure 7) legally recognized and with a management committee named COGEM (*Comitês Gestores da Microbacias Hidrográficas*). The COGEMs are organized by the producers and the inhabitants of each micro-basin. There are bottom-up organizations, self-managed and recognized by the Town Hall and Public Institutions of the area, who is independent and active in community participation, taking part in the decisions of the zone and selecting their inside-government; this organization is very important for problem solving and money resource assignation and is a system used all over Rio de Janeiro State. In Italva there is an EMATER office, the objective of them is to slow or reverse the degradation processes, recover and preserve the Atlantic forest fragments, raise the productivity, diversify the production and intervene in the transition to sustainable practices. EMATER has the mission to impact positively the lives of familiar producers. In addition, the Italva's town council with the Agricultural secretary of the municipality and the *Servicio Brasileño de Apoyo a las Micro y Pequeñas Empresas* (SEBRAE), implement an agroecological program, *Produção Agroecológica Integrada e Sustentavél* (PAIS) at the beginning with 15 units, given its success they are spreading. Finally, RIO RURAL in the last years financed a lot of projects all over the state, for increase economic income and environmental conservation of familiar farmers. In order to access into RIO RURAL Program, the producers must register and make a description of their farms and productive systems with help of an EMATER technician. Then they login into a contest for the approval of up to R$ 7.000. EMATER technicians elaborate a diagnosis, implement and follow all the producers benefited by the money of this program.

4.2 PRODUCERS SELECTION

As it was mentioned before the municipality is divided in nine micro-basins. This study was developed in five of them, trying to cover almost all the area of the municipality. These micro-basins are the most important in milk production (EMATER-RIO, 2013). The selection of the producers was made in a participatory way, using the COGEMs of each micro-basin to select one or two producers each. These committees have a very close relation with EMATER, especially because the execution and assignation of the projects of RIO RURAL.

The COGEMs are the ones who decide the order of sub-project execution and who will be next beneficiary of RIO RURAL's money. Accompanied by EMATER, they follow the actions and the correct investment of the money in the projects financed. Given that RIO RURAL is a partner in the project and the SPS implementation is part of the sub-projects financed, in coordination with EMATER-Italva, they demand to COGEMs to select farmers that meet characteristics like commitment, interest, time and land availability, responsibility, open mind to new technologies, among others, to be object of this study. Therefore the selection was based on a community consensus and they were chosen by their neighbors. It is important to clear up that EMATER office is present in the committees, but they have no power of election in COGEMs.

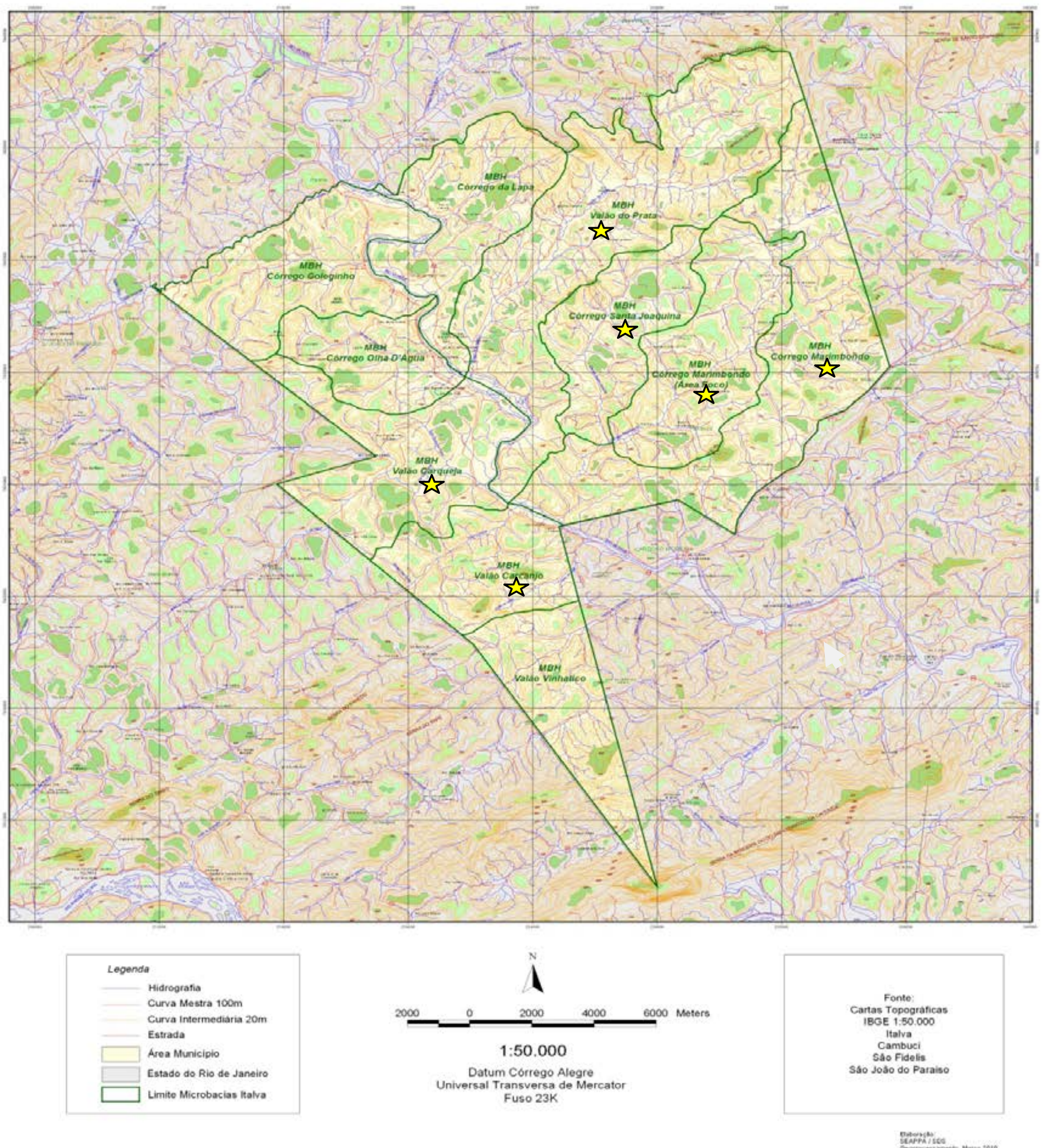

FIGURE 7. MICRO-BASIN DIVISION OF ITALVA, RJ.

The stars represent the micro-basins with interviewed farmers.

Source: SEAPPA/SDS Geoprocessamiento, 2010 in EMATER-RIO, 2013

After the participative selection of the farmers, they were presented to the researcher's team in a first meeting (14th.March.2014). There the researchers explain the objective and their role in this study. The meeting was useful to transfer some concepts about the importance of SPS implementation in terms of money profits. In that meeting they were asked about their interest and commitment with this work, the ones who accept are summarized in Table 3.

TABLE 3. FARMER'S NAME AND LOCATION OF THE STUDY AREA

Source: Own elaboration

No.	Name	Micro-basin	Coordinates	
			S	O
1	Ezio García da Silva	Valão da Prata	21°23'25.56''	41°38'55,21''
2	Marciano Soares Pessanha	Valão da Prata	21°22'07.11''	41°38'37,66''
3	Walbiane Almeida Rosa	Córrego Santa Joaquina	21°23'51.67''	41°37'39,38''
4	Jose Correa Filho	Córrego do Marimbondo	21°25'37.58''	41°37'21,57''
5	Jubelton Valentin da Silva	Córrego Santa Joaquina	21°25'30.43''	41°38'48,44''
6	Deildo de Campos Lima	Córrego do Marimbondo	21°23'7.22''	41°35'13,04''
7	Josue Gómez Moreira	Córrego do Marimbondo	21°24'46.16''	41°35'34,75''
8	Licerio Guimarães da Rocha	Valão Carcanjo	21°29'23.5	41°40'47,7''
9	Nilton de Souza Fernandes	Valão Carqueja	21°27'34.60''	41°43'49,49''
10	Almerindo Correa da Silva	Valão Carqueja	21°27'03.11''	41°44'28,12''

4.3 PARTICIPATIVE TRAINING PROGRAM FOR PRODUCERS

Two workshops and one field visit were made during this study in order to train the producers in SPS. After the first meeting, some elements about the producers and their knowledge about the systems were recognized. The first participative workshop was performed on 10th.April.2014. It was divided into three parts:

a) A brain storming (Geilfus, 2002) about SPS, where the producers were asked about the concept of SPS, the characteristics of the trees in these systems, advantages and disadvantages, implementation problems and proposed solutions.
b) A presentation made by the research group was performed in order to summarize the ideas proposed in the first part, to clarify concepts and perceptions, and to show the producers pictures of mature systems in other parts of the world.
c) In the last part, the farmers were asked to perform a field map of their properties (Geilfus, 2002) in order to identify their actual productive areas and the spatial distribution of their

farms. Finally they were asked to point an area where future SPS could or want to be established.

With all the results collected in this first workshop, modifications and new ideas were performed and improved in the following meetings with the producers. The importance of a field visit with them was identified. In the on – farm interviews (section 4.4), the section III assessed the learning concepts in the workshop.

On 16th.May.2014, a field visit to an SPS of two years, double row Eucalyptus was made. A farm was visited in the municipality of Itaperuna, Microbacia Raposso, a neighbor municipality of Italva and in the boundary with Minas Gerais state. It was the nearest SPS system identified, although now it is abandoned because of health problems of the owners.

A second workshop, on 21st.May.2014 was performed. The main objective was to identify the concepts and ideas the producers had learnt of the systems and to clarify doubts. The methodology used in this activity was a presentation composed of SPS images, in order to let them analyze the pictures and have them talk about what they observe. Main conclusions, doubts clarification, their main concerns, the appropriation of new knowledge and the farmer's perception was expected.

4.4 ON-FARM PARTICIPATORY RESEARCH

With the ten producers selected, on-farm, semi-structured interviews (Geilfus, 2002) were performed (Annex 1). The characterization of the production plot, animal production, their knowledge about SPS and the arboreal component of their farm were asked. All the interviews were made in the farmer´s properties, with the participation of the family members present at the moment of the visit. An average of 3 – 4 hours was needed to complete the interview in each farm.

4.5 ON-SITE ARBOREAL COMPONENT EVALUATION

The arboreal component was evaluated in two ways:

a. The forest component of each farm was evaluated in the visits. Farmers were asked about the native trees they have in their pastures, its uses and their reason for leaving them.
b. Five nurseries in the vicinity were visited. Information about availability of seedlings, production capacity and costs were consulted.

With the species identified in this first stage, a literature review of Brazil native species was performed in order to build a 40 species list; leguminous trees were privileged in this approach (Akinnifesi et al., 2010; Lorenzi, 1998a; Lorenzi, 1998b; Mallea et al., 2011; Souto et al., 2003; Trindade et al., 2013a; Trindade et al., 2013b; Trindade et al., 2013c). Almost 80 species were reviewed. Modified for Mallea et al. (2011) the criteria for the selection of the species presented, in order of priority were:

- Availability of seedlings in the nurseries of the region
- Distribution in Rio de Janeiro state
- Nitrification capacity (Leguminosae Family)
- Fast growth
- Canopy structure of the tree (shade capacity)
- Human consumption
- Ornamental flowers
- Wildlife feeding
- Budding capacity
- Wood Density
- Pioneer in secondary succession stages
- Growing capacity in open spaces
- Heliophytic
- Xerophyte
- Selective hygrophyte
- Heterogeneous foresting
- Recommended for degraded areas recuperation

Some non-native species were identified in the farms or in the nurseries of the study zone (Dias et al., 2008a; Murgueitio et al., 2010; Porfirio-da-Silva et al., 2010).

4.6 ECONOMICAL ANALYSIS

An economic analysis was performed, based on the data from the interviews. The gross margin ratio was calculated in order to know the profitability of the actual systems. This value measures the proportion of revenue converted into gross profit or cash flow (revenue minus costs). The higher the value the more money is earned per revenue, so more profit will be available to cover non-production costs (Farris et al., 2010; Xiromeriti, 2009). It is calculated as:

$$\text{Gross Margin} = \frac{\text{Revenue} - \text{Cost of Goods Sold}}{\text{Revenue}}$$

(Farris et al., 2010)

All the numbers presented in this calculation were converted into annual values. In some variables due to the lack of monthly information, like production, an equal value per month was assumed. The calculation was performed per farm and per cow; in the latter, the total cost was divided by the total number of cows in the herd, but the revenue was only between the dairy cows, because these are responsible of this value. The value of revenue assumed in this analysis was only from the cattle rearing (milk or sale of by-products and calves); other profitable activities of the producers were not taken into account. In the Gross Margin estimate per farm, two scenarios were used, one using an assumed familiar labor and other without it. For this analysis an Excel spreadsheet was used.

5. RESULTS

5.1 PARTICIPATIVE TRAINING PROGRAM

During the first meeting on 14th.March.2014, with the INTECRAL researcher's team, the producers, RIO RURAL representatives and EMATER crew, it was possible to identify ten producers committed with this study, as it was explained before (table 3). In this reunion, it was acknowledged that the producers have no background or idea of what SPS were. Because of that, some important concepts about the systems, especially their economical advantages were discussed. This step was very important because it was the first stage in order to motivate, build a trust environment and recognize the actors of this study (Boyd et al., 2007; Franco et al., 2001; Petheram & Campbell, 2010). After knowing the farmers, the next step was to coordinate the first workshop, which was based on participative methodologies (Geilfus, 2002), allowing the farmers to feel comfortable, confident and free to contribute. It was also very important to break down the scientific – producer barrier, so a friendly environment was prepared along this study. It was performed on 10th.April.2014.

At the very beginning, with the first question of the brain storming activity, the producers were reluctant and sustained that they have no idea of what was asked. But with a little help and kind of ice-breaking, the construction of the concept was possible and the initial participation of some of them made in this first activity a success. Even though, some troubles with the language were identified. The summary of the ideas exposed in the activity in response to the questions were:

- What are the SPS?
    - The first idea mentioned was that they didn't know about the systems, and the only productive system for dairy cattle they knew was continuous in a plot or rotational grazing.
    - Then when they felt comfortable, they mentioned the components of the system (pasture, trees and animals).
    - The idea of shade from the trees to the animals.
    - The idea that it was a new production system (innovation) and they asked if it exists in Brazil.

    - Finally, confusion between the rotational grazing and the SPS was evidenced.
- Which characteristics may the trees implemented in SPS have?
    - The composition of the tree´s parts might not affect the quality of the milk (especially they talked about acidity, and how guava trees have this effect in milk).
    - The trees must provide shelter to the animals. But the shade should not be excessive because of the pasture health.
    - The trees might have fruits for human consumption or for the birds.
    - The species selected must be helpful for the soil protection.
    - They might have great budding capacity and fast growth.
    - It might provide wood for the farm, for example for fences.
    - The species should be easy to plant and care.
- Which are the advantages of SPS?
    - Shelter for the animals, they said "the cows like the shade".
    - They found the wood as other benefit.
    - New products to sell in the market.
    - Birds are attracted.
    - Some of the products from the trees could be used by the farm owner and family.
    - Is a new source of income, thereby more money.
    - There is an improvement in the landscape.
- Which are the disadvantages of SPS?
    - The benefits are perceived in a long term.
    - The shade of the trees affects the pastures.
    - Irrigation is needed.
    - The pasture area is reduced.
    - Possible negative effects on milk quality, example with guava.
    - The cows could eat the trees when are young.
    - The implementation is highly costly.
- Which are the principal problematics that they recognized for the implementation?
    - Lack of money
    - Seedlings availability
    - Lack of technical assistance
    - A soil analysis is needed (implies an extra cost)
    - Area availability

All the ideas collected in the first activity were, summarized, better explained and clarified during the researcher's team presentation of the systems. It was the first time for the producers to see an SPS, and one of their main concerns, the pasture growth below the trees was initially clear-up. The participation in this part was also active from the producer's side, but the importance of a field visit was evidenced. Finally, with the farm-map design, all the producers participated actively and the maps were helpful in the on-farm interviews for identification of farms and possible areas for SPS establishment. Some pictures of the activities summarized in this section are presented in Annex 2.

During the visit of the farm in the municipality of Itaperuna (Micro-bacia Raposso) on 16th.May.2014, although the system was abandoned and there were no cattle at the moment of the visit, it was a really important experience with the farmers because they could evidence:

- They familiarize with one system, stand up near the trees and understand the concept.
- Realized that other people in Brazil have implemented the systems, so they feel the technology near them.
- If the trees are planted in correct orientation, the pasture will have enough sun for well development.
- They actually liked it and were more motivated about the implementation.
- For example, they realized that they annually spend a lot of money buying posts for fences maintenance, especially treated eucalyptus posts, so they understand that in a two years period, for example, they will have enough wood to cut and replace their fences, therefore it won't be necessary to buy and a saving money is possible.
- Because the system was planted with eucalyptus, they were excited with this specie, and some of them want to plant it; but it was explained that there are a lot of native plants that could also be planted or options of combining non-native and native trees.

During the second workshop on 21st.May.2014, an amazing response of the producers was obtained. The activity of this day, was focused on the projection of pictures of SPS and they were able to identify concepts, talk about the advantages and the possible money savings, and even to criticize some of the systems showed. After this activity, it was concluded that the objective of concepts transfer was successfully accomplished and it was very satisfactory for the researcher's group.

5.2 ON-FARM PARTICIPATORY RESEARCH

Ten interviews were made, and a lot of information was collected from this part. The interview was divided into four parts so the main results will be summarized in the same manner.

5.2.1 Characterization of the farms

In this study all the selected producers were small-holders, with a household agriculture (more details could be consulted in Annex 5). In average the family members were 3 persons per house (a maximum of 5 and a minimum of 1). The averaged total area of the farms was 23,6 ha. The biggest farm was 42 ha and the smallest 4,84 ha. The areas with pastures dedicated to dairy cattle rearing in average were 17,2 ha, with a maximum of 37 ha and a minimum of 3,3 ha. Six of the ten farmers were owners of the property; nine of them have as principal income activity as dairy cattle. Two farmers have no secondary sources of income and are totally dependent of the milk production, while three of them are retired and the rest have olericulture as a diversified income. This income in almost all of them is new, with the project PAIS (explained before), where they produce in the same unit: herbs, vegetables, eggs and hens. The monthly average familiar income is partitioned as follows: two producers with a range of R$ 501 – 1.000, six with R$ 1.001 – 2.000, one with R$ 2.001 – 3.000, and one with more than R$ 3.000 (but this value is because the producer's wife works and have a wage).

Six farmers hired external labor, with the principal objective of fence maintenance or grass chop or mow, labor is paid daily (R$ 60 day^{-1}) and in a year is not over 30 days or a maximum or 90 days. One farmer hired a worker all year round, for the grass mowing and cane harvesting for the cattle, and he pays the basic monthly salary (R$ 724 – 2014). One farmer uses labor exchange with his neighbors. All the technical assistance that the producers receive is from EMATER office.

Nine are part of an association of producers, partly because the milk commercialization is through it. Each micro-basin has their own association and all the producers sell their milk to it. For the buyers it is better to have the milk production centralized in the Association, and each has milk cooling tanks for quality preservation. The Association also fights for a fair price of the milk. This is something advantageous for the farmers, almost all talk that there are no problems with the commercialization of the product, although they talk about a low price of the milk.

5.2.2 Characterization of the livestock system

The grazing system used by the producers is continuous in almost all the cases, only two farmers use rotational grazing. All the grass species are introduced; just one producer has native pastures in a small area (more details could be consulted in Annex 5). The grasses used in the area in order of importance are: Braquiária (*Brachiaria decumbens*); Braquiarão or Marandú (*Brachiaria brizantha*); Colonião, tanzânia or mombaça (*Panicum maximum*); Pangola (*Digitaria decumbens*) and Estrela (*Cynodon nlemfuensis*). The cultivated pastures in the farms are located on top of the hills, slopes and plains depending on the farm topography. In average, the majority of the pastures are located firstly in plain areas and then in slopes. All the farms have all the types of topography. As a part of the environmental RIO RURAL projects, six farmers have on the top of the hills protected secondary forest areas for watershed and spring conservation or protection. These areas ranged from 2,5 to 5 ha. The practice of burning pasture is forbidden, therefore no one practices it.

The entire cattle race is Girolanda, a Brazilian hybrid. The average of total cows in a herd is 34, the maximum is 64 cows and the minimum is 12. The average for dairy cows is 14 (a maximum of 22 a minimum of 6); in terms of non-productive or dry cows the maximum number is 12, with an average of 6 and there is a farm where there are no dry cows. The average stocking rate is 2,4 cows ha^{-1}. The sales and purchases of cows depend on the actual herd, the food availability, production and income. Five farmers buy cows, all in the category of dairy, and some of them buy certified productive animals (18 L day^{-1}) which are expensive. In the region they also use the exchange of animals. In terms of reproduction, three producers used artificial insemination (one with sex pre-determination), four controlled reproduction methods, and the other three used natural reproduction with their own bull.

The dairy production in average is 84,7 L day^{-1} (maximum 220, minimum 37 L day^{-1}). All the producers, with two exceptions, sell all the milk produced. The price of one liter is around R$ 0,96 and 1,20. The average production per cow is 6,4 L day^{-1} (with a maximum of 13,7 and minimum of 2,3 L day^{-1}). The milking of the animals, in almost all the farms is once daily, just one twice. One of the farmers makes milk by-products, the wife weekly produces an average 4,5 kg of cheese and is sold in the town bakeries, at an average price of R$ 10 kg^{-1}.

In terms of animal nutrition, the principal source is grass. Although six of the farmers give additional concentrates. These are mainly composed of milled corn (*Fubá*) and soy in 2:1 or 3:1 mixtures. Another source is wheat flour. Five farmers also cultivate sugar cane and/or corn, in order to supplement the animal's diet. Others buy the sugar cane for the animals in dry season when the pasture yield is very low. All the producers give the cows mineral and common salt. In terms of animal sanitation, all the producers vaccinate against aphthous fever, rabies, brucellosis and carbuncle at least once a year. In terms of parasites they control ticks, worms and horn flies. Four producers presented cases of mastitis that had to control. The money invested in parasite control is high. It was interesting to discover that one producer didn't spend money in parasite control since 2002, using a product based on garlic, vitamins and sulfates that is added to the mineral salt, it is an expensive product but it seems to compensate the cost because the cows are not using chemical control. There is no necessary labor in this activity and it is a cleaner way to treat the animals.

The technification of livestock production between the farmers, objects of this study, is low. Just one of them is partially technified, because he is the only one who owns a milk cooler tank and mechanical milking among other infrastructure. In the other farms there are few things for production like fodder chopper, sprayers, pumps, animal cart and weed eater. The ones who work with rotational systems had an electrifier (for electric fencing) and its entire infrastructure for this grazing system. The maintenance cost of cattle rearing (in addition to labor) is just for fence maintenance, which means the costs of the posts, staples and wire. The posts are always from treated eucalyptus. In the production systems there is a little cost of oil/diesel, almost always, the cost for moving the milk from the farm to the Association headquarters. There is not a great cost in energy, some just use it in the production system to start the pumps and for the cooler tank (one producer). Annually they have to pay a tax for the land that is directly proportional to the zone and the property size, the range is from R$ 15 to 90. The water in the region is for free. Some of them also pay an annual fee to the Associations.

5.2.3 Silvopastoral Systems component

During the interviews the farmers were asked about the concepts learnt in the first workshop. Just one farmer missed this activity. It was perceived that the producers got some of the ideas in the first activity, but they have a lot of doubts. Even though they mentioned important details that they learnt like the components of a SPS and advantages like shade for the animals and its importance for the animal well-being; a raise in productivity and the use of the trees which could increase the income, the high implementation cost and some arrangements like the live fences. Some mentioned its importance for the environment and sustainability of the livestock system. Another idea mentioned was that the trees and the pastures could co-exist. Some of them also mentioned few ideas they have after the workshop for the implementation, where and which trees to use.

They were asked about the trees they actually have in their properties, why they leave them and if they are used. The majority answered that they like the trees and that they were there, they didn't plant them. The principal use of these trees is for shade, observed in warm days that the cattle always look for the trees for shelter. Some producers also mentioned about the existing laws in the state, if a tree over 15 cm of DHB is cut, a very expensive fine must be paid. Some of them used their trees for obtaining posts.

The farmers were also asked if they would like to increase the amount of trees in their pastures, and all of them gave a positive answer because they recognized the benefits of a tree for the cattle, environment and economic income. Some mentioned that the trees will make their properties more beautiful and its importance for the wildlife, especially birds. About propagation issues, four producers knew how to propagate plants asexually, while six (not excluding) knew how to do it sexually. Just three of them did not know where to buy seedlings. Theoretically talking about a possible implementation, farmers were willing to leave 1 to 3 ha for a SPS. They weren't willing to invest money or borrow from a bank or institution. If an SPS is implemented in their farms they will give labor and the land, this is the contribution they want and are committed to give. It is also important to mark that in the on-farm recognition of the area, almost all of them are degraded areas they want to recover.

These results also help to plan the next two activities mentioned in section 5.1. Another important thing identified with the farmers was a barrier because of the language, not just because the researcher's team was non-native Portuguese speakers, but because the language spoken by the farmers has also some particularities. It was important to identify this, in order to design the next participatory activities with them.

5.2.4 Forestry Component

The producers were asked about this component in their farms, to determine in the municipality the promising and multipurpose native trees. The producers mentioned 25 species in total of native trees; all of them at least, recognized one or two uses of the tree, being shade the most common. The main common species mentioned were (common names are in Portuguese) Angico-vermelho, different Ipê species, Tajuva, Monjolo, Biribá and Genipapo. The producers also have a confusion about some species, because they think that species like eucalyptus, mango, bamboo or guava are native, just because all their lives they are familiarized with them. This part of the questionnaire was also important and analyzed in detail in the next section.

5.3 ON-SITE ARBOREAL COMPONENT EVALUATION

Besides the on-farm recognition of species, five nurseries were also visited. The first one CitroRio (8th.April.2014) located in Stº Antônio de Pádua municipality, has no native trees production, but the owner told us that if there is an agreement, they could produce all the necessary seedlings, because for them it is possible to find the seeds. A second one was the Horto of Italva (9th.April.2014) this place is the nearest place where farmers of Italva could buy seedlings. Actually this place is dedicated to tomato and other olericulture species, but in the next year, the town hall is going to run a project of native trees production. On 14th.May.2014, the nursery GeoPrime, in the municipality of Cardozo Moreira, 20 minutes away from Italva, was visited. This place is dedicated to sell species for reforestation, especially to mining enterprises. They have great availability of native and non-native species, about 30 species are propagated there. During the visit a concern about the seedlings quality aroused, because some of the plants have nutrient deficiencies. The price range goes from R$ 5 to 10 each.

Finally on 15th.May.2014, two nurseries were visited in the Municipality of Bom Jesus de Itapaobana, 40 minutes far away from Italva. The first nursery Itamudas, is very well structured and have seedlings and saplings (2 – 3 years, 1,5 – 2 m tall) of native species. There is also a very good place to get non-native species like Mogno africano, Cedro australiano and Eucalipto (Portuguese names). This place is great for buying saplings of native species, which is great for adaptation success and low death rate after transplanting. Of course, the saplings are more expensive (average of R$ 20 each) but it is safer to buy them. With seedlings, the death rate could be high, and their cost plus the replanting labor (if necessary) could balance the costs of purchasing a sapling. This is a great place, but it has a problem and is that the owner is not interested in native trees production anymore, so after he finishes its stock, it wouldn't be an option. Finally the nursery of the Instituto Federal Fluminense, a technical school of the municipality was visited. With less technification than Itamudas, they also have a great variety of native and non-native species. The quality of the seedlings was good and they also have some saplings of native species. The cost of any seedling of native species is R$ 3, and for fruit trees R$ 5.

After the evaluation of the species named by the producers and the species available in the nurseries visited, a list of species was built. Complemented with literature review (Akinnifesi et al., 2010; Lorenzi, 1998a; Lorenzi, 1998b; Mallea et al., 2011; Souto et al., 2003; Trindade et al., 2013a; Trindade et al., 2013b; Trindade et al., 2013c) a list of 40 promising species is reported in Table 4 and Annex 3. Due to the common non-native species present in the nurseries and mentioned in the interviews, and because they are an option of implementation in the first stages of the SPS, in table 5, a list was constructed based on literature review too (Dias et al., 2008a; Murgueitio et al., 2010; Porfirio-da-Silva et al., 2010). Although these species are reported, it is important to point out that the main objective of this study is to achieve the SPS implementation with native species mainly. The final assess was the determination of the most feasible arrangements that could be used in the farms mainly according with the topography and the farms characteristics, which are live fences, scattered trees and simple or double row tree grazing plantations..

5.4 ECONOMICAL ANALYSIS

This analysis was performed after the conversion of all the data collected in the farms into annual information. The details for the calculation could be consulted in Annex 4. In table 6, the calculation of the annual cash flow and gross margin value per farm demonstrates that the productivity of the actual systems could be improved. Cases like producer's 1 and 8 are serious because the value shows that they are not earning enough money from this activity, and this being their principal way of living, they spend all their earnings in maintaining the system. For the case of producers 3, 5 and 9 this value is below 0,50. The farmers 2, 4, 6, 7 and 10 have better values, but nobody have a number over 0,80.

TABLE 4. POTENTIAL NATIVE TREES TO BE IMPLEMENTED IN SPS IN ITALVA, RJ ORGANIZED BY THEIR MAIN USES

C= Construction; E= Furniture Elaboration; H= Handcraft or Accesories, W= Fuel Wood; F= Food, L= Landscaping, R= Environmental Restoration; X= Exudates, M= Medicinal; A= Wildlife feeding, O= Others; X=just for indoor.* Source: Own elaboration based on: Akinnifesi et al., 2010; Lorenzi, 1998(a); Lorenzi, 1998(b); Mallea et al. 2011; Trindade et al., 2013(a); Trindade et al., 2013(b); Trindade et al., 2013(c).

No	Family	Scientific name	Common names	Uses										
				C	E	H	W	F	L	R	X	M	A	O
1	Lauraceae	*Mazilaurus crassiramea* (Meissn.) Taub. Ex Mez	Tapinhoã, canela-tapinhoã	**X**	X				X				X	
2	Lecythidaceae	*Lecythis lanceolata* Poir	Sapucaia-mirim, sapucaida-miúda, sapucaia, sapucaiai-branca, sapucaiú	**X**				X	X	X			X	
3	Leguminosae - Caesalpinoideae	*Caesalpinia ferrea* Mart. Ex Tul. Var. *ferrea*	Jucá, pau-ferro, ibirá-obi, imirá-itá	**X**					X	X				X
4	Leguminosae - Caesalpinoideae	*Caesalpinia peltophoroides* Benth.	Sibipiruna, sebipira, sepipiruna, coração-de-negro, pau-brasil	**X**	X				X	X				
5	Leguminosae - Caesalpinoideae	*Swartzia langsdorfii* Raddi	Pacová-de-macaco, jacarandá-banana, jacarandá-de-sangue, banana-de-papagaio	**X**					X	X			X	
6	Leguminosae - Mimosoideae	*Anadenanthera colubrina* (Vell.) Brenan	Angico-branco, cambuí-angico	**X**			X		X				X	
7	Leguminosae - Mimosoideae	*Anadenanthera macrocarpa* (Benth.) Brenan	Angico, angico-vermelho, angico-preto, angico-do-campo, arapiraca, curupaí, angico-de-casa	**X**					X	X	X		X	
8	Leguminosae - Mimosoideae	*Parapiptadenia rigida* (Benth.) Brenan	Angico-vermelho, angico, angico-da-mata, angico-verdadeiro, angico-amarelo , angico-cedro, angico-rosa, angico-de-curtume, angico-dos-montes, angico-de-banhado, angico-sujo, guarucaia, angico-branco, brincos-de-saguim, brincos-de-sauí, paricá	**X**			X		X	X		X	X	
9	Leguminosae - Mimosoideae	*Plathymenia reticulata* Benth.	Vinhático-do-campo, vinhático, amarelinho, vinhático-testa-de-boi, candeia, pau-de-candeia, oiteira, vinhático-castanho, pau-amarelo, amarelo, acende-candeia, vinhático-branco, vinhático-rajado	**X***					X	X			X	
10	Leguminosae - Mimosoideae	*Mimosa caesalpiniaefolia* Benth.	Sabiá, cebiá, sansão-do-campo	**X**			X		X	X			X	X
11	Rhamnanceae	*Rhamnidium elaeocarpus* Reiss.	Tarumaí, saguaraji, saguaraji.amarelo, cafezinho, cabrito, azeitona, pau-brasil	**X**						X			X	
12	Anacardiaceae	*Astronium concinnum* Schott.	Gurubu, guaribu-preto, guaribu-rajado, mucuri, aroeria-mucuri, gibata-preto, gibatão-preto, gonçalo-alves, aderno-preto	X	**X**	X			X					X

No	Family	Scientific name	Common names	Uses										
				C	E	H	W	F	L	R	X	M	A	O
13	Aquifoliaceae	*Ilex theezans* Mart.	Congonha, Caúna.margosa, orelha-de-mico, caúna, carvalho-branco, miqueira, caúna-de-folha-grande		**X**							X		
14	Meliaceae	*Cedrela fissilis* Vell.	Cedro, cedro-rosa, cedro-vermelho, cedro-branco, cedro-batata, cedro-amarelo, cedro-cetim, cedro-da-várzea	X	**X**	X			X	X				
15	Annonaceae	*Guatteria nigrescens* Mart.	Pindaíba-preta			**X**			X	X		X	X	
16	Annonaceae	*Porcelia macrocarpa* (Warm.) R.E. Fries	Louro-branco, banana-de-macaco, pindaíva-do-mato			**X**		X	X	X			X	
17	Aquifoliaceae	*Ilex cerasifolia* Reiss.	Congonha			**X**	X		X	X			X	
18	Araliaceae	*Oreopanax fulvum* E. March.	Figueira-do-mato, tamanqueira, mandioqueira			**X**			X	X			X	
19	Bixaceae	*Bixa arborea* Benth.	Urucu-arbóreo, urucu-da-mata, urucurana-da-mata			**X**			X	X		X		
20	Bombacaceae	*Eriotheca pentaphylla* (Vell.) A. Robyns	Imbiruçu, imbiruçu-branco, paineira			**X**			X					
21	Euphorbiaceae	*Alchornea glandulosa* Poepp. & Endl.	Tapiá, tanheiro-de-folha-redonda, tanheiro, maria-mole, iricurana, boleiro, araibá, bugé, tamanqueiro, tapiá-guaçu, tapiá-mirim, caixeta, canela-raposa			X	**X**		X	X				
22	Leguminosae - Caesalpinoideae	*Bauhinia longifolia* (Bong.) Steud.	Unha-de-vaca, pata-de-vaca, unha-de-boi, unha-de-vaca-do-campo	X*			**X**		X			X		
23	Leguminosae - Mimosoideae	*Piptadenia gonoacantha* (Mart.) Macbr.	Pau-jacaré, jacaré, angico-branco, monjoleiro, monjolo, icarapé, casco-dejacaré		X	X	**X**			X			X	
24	Annonaceae	*Rollinia mucosa* (Jacquin) Baill.	Biribá, araticum,condessa, fruta-da-condessa, fruta-de-conde, graviola-brava			X		**X**				X	X	
25	Annonaceae	*Rollinia sericea* (R.E.Fries) R.E Fries	Cortiça, curtiça, araticum-pecanine, araticum, cortiça-ouriça, curtiçao, pinha-da-mata			X		**X**	X	X			X	
26	Bombacaceae	*Bombacopsis glabra* (Pasq.) A. Rob	Castanha-do-maranhtão, castanha-da-praia, castanha, cacau-do-maranhão, mamorana, cacau-selvagem			X		**X**	X	X				X
27	Caparidaceae	*Crataeva tapia* L.	Tapiá, cabaceira, cabeceira, cabaceira-do-pantanal, trapiá, pau-d'alho	X*				**X**	X	X		X	X	
28	Rubiaceae	*Genipa americana* L.	Jenipapeiro, jenipapo, jenipá, jenipapinho, janipaba, janapabeiro, janipapo, janipapeiro	X	X			**X**		X	X		X	
29	Bignoniaceae	*Tabebuia impetiginosa* (Mart.) Standl.	Ipê-roxo, pau-d'arco-roxo, ipê-roxo-de-bola, ipê-una, pau-cachorro, ipê-de-minas, ipê-roxo-do-grande, piúna, piúna-roxa	X		X			**X**	X				

No	Family	Scientific name	Common names	Uses										
				C	E	H	W	F	L	R	X	M	A	O
30	Bignoniaceae	*Tabebuia vellosoi* Tol.	Ipê-amarelo, ipê-tabaco, cavatã, ipê-cascudo, ipê-preto, ipê-una, pau-d'arco, ipê-amarelo-da-casaca-lisa, ipê-comum, piúva, quiarapaíba.	X					**X**				X	
31	Bombacaceae	*Chorisia speciosa* St. Hil.	Paineira-rosa, paineira, árvore-de-paina, paineira-branca, paina-de-seda, barriguda, árvore-de-lã, paineira-fêmea			X			**X**	X				
32	Leguminosae - Mimosoideae	*Albizia polycephala* (Benth.) Killip	Angico-branco, albízia	X*					**X**	X				X
33	Leguminosae - Mimosoideae	*Albizia hasslerii* (Chodat) Burr.	Farinha-seca, frango-assado			X			**X**	X				
34	Leguminosae - Papilionoideae	*Platypodium elegans* Vog.	Amendoim-do-campo, faveiro, jacarandá-bana, jacarandá-branco, amendoim-bravo, jacarandá-tã, jacarandazinho, secupiruna, uruvalheira	X*					**X**	X				
35	Apocynaceae	*Malouetia cestroides* (Nees) M. Arg.	Leiteira, paina			X				**X**			X	
36	Cecropiaceae	*Cecropia pachystachya* Trec.	Embaúva, embaúba, imbaúba, umbaúba, umbaubeira, umbaúba-do-brejo, ambaíba, árvore-da-preguiça, caixeta-do-campo			X			X	**X**			X	X
37	Leguminosae - Caesalpinoideae	*Schizolobium parahyba* (Vell.) Blake	Guapuruvu, guapurubu, ficheira, bacurubu, guapiruvu, garapivu, guarapuvu, pataqueira, pau-de-vintém, bacuruva, birosca, bandarra, faveira	X*		X	X		X	**X**				
38	Leguminosae - Caesalpinoideae	*Caesalpinia echinata* Lam.	Pau-brasil, ibirapitanga, orabutã, brasileto, ibirapiranga, ibirapita, ibirapitã, muirapiranga, pau-rosado	X	X				X		**X**			
39	Leguminosae - Caesalpinoideae	*Copaifera lagsdorffii* Desf.	Copaíba, óleo-de-coaíba, copaíba-vermelha, bálsamo, oleiro, copaíba-da-várzea, copaibeira-de-minas, capaúba, cupiúva, óleo-vermelho, pau-de-óleo, podoi	X	X				X	X	**X**	X		X
40	Moraceae	*Maclura tinctoria* (L.) D. Don ex Steud.	Taiúva, tajuva, amora-branca, tatajuva, tatajuba, tatajiba, amarelinho, amoreira, jataíba, moreira, limãorana, tatané, pau-amarelo, taúba, pau-de-fogo	X	X					X	**X**		X	X

TABLA 5. NON-NATIVE SPECIES IDENTIFIED

Source: Own elaboration based on: Dias et al., 2008(a); Murgueitio et al., 2010; Porfirio-da-Silva et al., 2010

Family	Scientific name	Common names *(Portuguese)*
Anacardiaceae	*Mangifera indica*	Manga
Lamiaceae	*Tectona grandis*	Teca
Leguminosae – Papilionoideae	*Gliricidia sepium*	Gliricídia
Leguminosae – Papilionoideae	*Erytrina poeppigiana*	Mulungu do Alto
Leguminosae – Mimosoideae	*Pseudosamanea guachapele*	Albízia
Leguminosae – Mimosoideae	*Acacia holosericea*	Oloserícia
Leguminosae – Mimosoideae	*Acacia auriculiformis*	Acácia auriculada
Leguminosae – Mimosoideae	*Leucaena leucocephala*	Leucena
Meliaceae	*Kaya ivorensis*	Mogno africano
Meliaceae	*Toona ciliata*	Cedro australiano
Meliaceae	*Cedrela odorata*	Cedro
Moringaceae	*Moringa oleifera*	Moringa
Myrtaceae	*Eucaliptus* spp.	Eucalipto
Myrtaceae	*Psidium guajaba*	Goiaba
Pinaceae	*Pinus* spp.	Pínus
Proteaceae	*Grevillea robusta*	Grevilea
Rutaceae	*Citrus* spp.	Cítrico

TABLE 6. ANNUAL CASH FLOW AND GROSS MARGIN VALUE PER FARM

Source: Own elaboration

No.	Total Fixed Cost (R$)	Total Variable Cost (R$)	Total Costs (R$)	Total Revenue (R$)	Annual Cash Flow (R$)	Gross Margin Value
1	78.089,90	600,00	78.689,90	78.694,00	4,10	0,00
2	5.332,49	11.800,00	17.132,49	43.700,00	26.567,51	0,61
3	15.789,93	18.600,00	34.389,93	51.092,00	16.702,07	0,33
4	6.042,53	410,00	6.452,53	21.900,00	15.447,47	0,71
5	6.106,30	4.800,00	10.906,30	17.520,00	6.613,70	0,38
6	4.119,00	360,00	4.479,00	17.100,00	12.621,00	0,74
7	2.899,24	3.900,00	6.799,24	20.516,00	13.716,76	0,67
8	6.227,98	5.400,00	11.627,98	13.983,50	2.355,52	0,17
9	12.509,90	7.722,00	20.231,90	48.680,00	28.448,10	0,58
10	8.238,00	0,00	8.238,00	25.440,40	17.202,40	0,68

In the table 7, the calculation per dairy cow was performed and the values for all the producers are between 0,60 and 0,88. This calculation suggest that the dairy cows are producing enough revenue to cover their cost, but in relation with the low values of the general profit in the farm, the revenue produced is not enough to bear the maintenance of the other part of the herd that is not producing milk.

TABLE 7. ANNUAL GROSS MARGIN VALUE PER COW

Source: Own elaboration

No.	Total Costs (R$)	Total Revenue (R$)	Gross Margin Value
1	1.967,25	4.918,38	0,60
2	503,90	2.913,33	0,83
3	1.273,70	3.406,13	0,63
4	184,36	1.825,00	0,90
5	320,77	1.460,00	0,78
6	373,25	2.442,86	0,85
7	174,34	1.465,43	0,88
8	283,61	873,97	0,68
9	316,12	2.212,73	0,86
10	633,69	4.240,07	0,85

In this way the actual systems seem to be profitable in Italva, but when the familiar agriculture labor is included as a fixed cost, a value that the producer never takes into account, the systems profitability change drastically and the values showed before as well (Table 8). The familiar labor assumed for this analysis equals to the minimum wage in Brazil for 2014 (R$ 724) by the number of family members dedicated to the production. In this new scenario, negative numbers appear, as in the case of producers 1, 5, 7 and 8; the best number is reflected in farmer 9, while in the other cases the value is not greater than 0,33. The data presented was based on estimated numbers from the farmer's interviews, which may or not include additional costs that influence even more the values presented. In addition, farmers do not carry a detailed production record.

TABLE 8. ANNUAL GROSS MARGIN VALUE INCLUDING FAMILIAR LABOR

Based on the same raw data of table 6. Source: Own elaboration

No.	Assumed Familiar labor	Gross Margin Value
1	8.688	-0,11
2	17.376	0,21
3	8.688	0,16
4	8.688	0,31
5	8.688	-0,12
6	8.688	0,23
7	17.376	-0,18
8	17.376	-1,07
9	8.688	0,41
10	8.688	0,33

6. DISCUSSION

During this study, a very good response from the group of producers was obtained. The activities developed were successfully carried out and the objective was achieved. At the end a group of producers were trained in SPS, as a result they understood and seem enthusiastic with the systems, so they could act as knowledge broadcasters in their communities. The change in their minds of pre-conceptions and the concept appropriation of something they had never heard before was very motivating for the researcher's team. These results were possible because the participative methodologies used (Geilfus, 2002). A confident environment was built and therefore the importance of it in community research was recognized for good results (Holguín et al., 2007). This trust allowed the scientific barrier to be broken and it was possible to work in a friendly environment. Also, this made the producers feel comfortable, confident and free in this study, therefore they were not afraid to talk with the truth, and thereby a reflection of the reality of their farms was drawn. These two interactions, during the workshops and in their farms, were important to achieve the objectives of this study between the researchers and the farmers.

Although, the particularity of the language spoken by the producers was a possible problem in the knowledge transfer, the help of EMATER-Italva crew during all the process was very important. Their cooperation in all the activities related with this study was also crucial for the confident environment mentioned before. This issue correlates the importance of an integral access to the producer, and how the stakeholders' integration pursuing the same objective at the end brings good results (Holguín et al., 2007). Because they have never heard about the concept, one significant step in the knowledge appropriation was the field visit performed to a SPS; despite it was abandoned, it was very important for them in comprehending the final concept. The reaction of farmers after the visit made them more enthusiastic. Another new experience was improved during this study, because after the meetings, producers of different micro-basins had the opportunity to share with others their experiences and problems, which was great for know-how exchange. For example the recommendations of some products, ways of efficient production and others were shared, and helped in some way the improvement of the actual systems.

As Geilfus (2002) mention, in participatory strategies of knowledge appropriation, it is very important to advance slowly and to transfer clear ideas or messages to the community. So the definition of these ideas was planned and the design of all the activities was performed in such a way. It is not necessary to give the producers a lot of information and scientific-based details, it is better to insist in simple concepts and the appropriation of the knowledge will be easy and effective. Because the motivation, attitude and commitment of the farmers on all the activities proposed in this study could be successfully achieved. It was a very important factor for the success of this work. The participatory way they were selected by COGEM gives them an additional recognition and now they could be replicator agents in their communities (Holguín et al., 2007; Murgueitio et al., 2010). Little attention has been given to research based on local people perspectives and their potential roles as ecological service providers, therefore understanding the farmer's perspectives with the participatory tools facilitating the open dialogue and co-learning by researchers and producers. This experience could be extended to the municipality and other parts of the State (Franco et al., 2001; Holguín et al., 2007; Murgueitio et al., 2010).

The on-farm characterization of the producing systems show that the group of producers in this study was diverse, although all of them were small familiar producers with low technified systems, that needs an improvement in their production, are facing problems of land degradation and production diminution; thereby, new technologies for a sustainable production are necessary and SPS is a good alternative because of the economical and productive benefits (Baggio, 1983; Betancourt et al., 2005; Dias-Filho, 2006; EMBRAPA Florestas 2002a; Fearnside, 1999; Hernández & Ponce, 2004; Murgueitio et al., 2010; Porfirio-da-Silva, 2006; Ramírez & Enríquez, 2003; Ribaski, 2009). Different market possibilities, including PES are options for income increase in this production system (Boyd et al., 2007).

Regardless their enthusiasm and understanding of the systems, the willingness to establish SPS and to increase the trees in the pastures was evidenced; but there are still a lot of barriers and fears (Dias-Filho & Ferreira, 2007). Also, producers will not risk and change their traditional production system to a new technology if they are not 100% sure about the benefits (Mallea et al., 2011). Because of this, all of them manifested no disposition to invest money or to borrow for the SPS implementation in their farms, because they don´t have the economic solvency for this investment. Their contribution is with their land (1 – 3 ha) and with family labor. The importance of governmental incentives or external investment are essential for the adoption of these technologies (Murgueitio, 2009), and the policy makers should consider designing hybridized schemes in order to integrate conservation and development (Petheram & Campbell, 2010), if this is not achieved all the work with this farmers will be thrown away.

This research was enough to recognize that the SPS implementation would be helpful in the region and will improve the quality of life of the farmers and the animals. The economical analysis performed shows that the actual systems need to be modified, so more money income would be perceived in the family farmers. A first overview of the systems profitability shows that all of them (except producer 1 and 8), are earning profits with the dairy production in Italva (Table 6 and 7); in fact, this region of the Rio de Janeiro state is recognized as dairy producer (Bastos & Napolao, 2011). Even though there is a great variance in the type and herd composition in the farms analyzed, there is also a large variance in the economic performance of the productive units, as it was reported by other studies in the state (Schlüter & Pedroso, 2009).

In the case of the producer 1 and 8, whose profit is very low, during the analysis of the raw data of farmer 1, the payment of an all year wage of external labor, an excessive frequent ticks control, its infrastructure (the only one who owns a milk cooling tank) and the service payment (electricity for the tank) are factors that are hindering its profit margins. It may seem that he is the most technified producer, with the higher number of cows, but this apparently is counterproductive. In the case of this producer, the technical assistance is very important to change his production habits and then earn more money. In the case of producer 8, weaknesses in this analysis are focused on a low milk production, in comparison with other producers with the same or less number of cows even in less pasture land. His average production of milk per cow is the lowest, 2,3 L day^{-1}, which is very low compared with other production systems in Italva and Latin America (Murgueitio, 2010).

In spite of the profits presented, the great variability shows how these numbers are not reliable enough, and the values of the productivity per cow must be analyzed more carefully. In table 9, the head stocking and its production is related to the revenue per hectare, which in various cases where more land is dedicated to the production are not performing to its optimum. At the end, this affects the profitability, well demonstrated in the case of producer 8, compared with producer 2, for example. There is also important to mention that the lack of comparable information according to the values presented, was a limitation in order to compare the profitability of the actual systems evaluated, most of the literature present values for more technified systems.

TABLE 9. RELATION OF PRODUCTION AND LAND VALUE

Source: Own elaboration

No.	Dairy cows	Pastures area (ha)	Average milk production day $^{-1}$ dairy cow^{-1}	Land Price (R$ ha^{-1})	Cows ha^{-1}	Average Revenue ha^{-1} (R$ ha^{-1})
1	16	9,6	13,8	10.000	0,60	3.011,25
2	15	14,5	6,7	10.000	0,97	2.355,47
3	15	39,8	8,7	9.500	2,65	8.389,16
4	12	37,0	5,0	9.000	3,08	5.627,08
5	12	24,0	4,2	8.500	2,00	3.041,67
6	7	3,3	5,7	9.500	0,47	983,27
7	14	6,8	2,9	10.300	0,49	506,53
8	16	24,0	2,3	10.300	1,50	1.266,09
9	22	22,0	5,0	10.700	1,00	1.825,00
10	6	6,5	10,0	10.300	1,08	3.954,17

Table 9 is also helpful to explain a very important thing in the discussion of the profitability of these systems, because in this economical analysis, there are some important costs that are not taken into account. In table 8, the inclusion of the family labor as a fixed cost (a cost not included in the costs of the production), shows how the profitability of the systems observed in table 6 was drastically reduced. In the case of table 9, if the cost of land is included, and it is related with the cow productivity, it is demonstrated that the profitability of the systems is even lower. Tables 8 and 9 are very important demonstrations of how SPS implementation could be an alternative to income diversification and increase in profit; among the environmental and animal standards improvement explained before. For example in the special case of land cost, it would be higher with the trees implementation, and of course it will be an important factor in new economical analysis.

Another important issue found in this study was the lack of records in the farms. Continuous and consistent record keeping, is a very important tool that would be very effective for further research, more data provisioning and less assumption; but especially for the farmers, because they would be able to evaluate the real benefits or losses in their husbandry system.

With all the information gathered in this research, the feasibility of implementation of SPS in ten farms of Italva municipality is high; the main problem is external investment. The actual systems in the farms used as grasses Braquiária (*Brachiaria decumbens*); Braquiarão or Marandú (*Brachiaria brizantha*); Colonião, tanzânia or mombaça (*Panicum maximum*); Pangola (*Digitaria decumbens*) and Estrela (*Cynodon nlemfuensis*), which are reported as principal grasses used in Brazil with potential for SPS implementation because their shade tolerance capacity (Dias et al., 2008a; Porfirio-da-Silva et al., 2010). This is an advantage because no new grass species with particular management requirements have to be introduced, and the farmers just need to learn and focus in the trees´ management. It is also important to mention that studies in Brazil state that 40 – 70% of light transmission is necessary for the optimum growth and development of shade tolerant grasses without an effect in nutritional value. The correct density, pruning and architecture formation of trees is a fundamental issue in the success of SPS (Carvalho et al., 2002; Dias et al., 2009; EMBRAPA Florestas, 2002b; Paciullo & De Castro, 2006).

Almost all the SPS successful experiences in Brazil are using eucalyptus species (Bernardino, 2007; Daniel & Couto, 1999; EMBRAPA Florestas, 2002b; Franceshi et al., 2004; Nepomuceno & Silva, 2009; Radomski & Ribaski, 2009; Xiromeriti, 2009) or pine species (Baggio, 1983) both non-native. The approach of this study was to diversify the options of SPS, and especially to use the native biodiversity for the establishment. It is true that eucalyptus species are profitable due to the fast growth they have (Cacho, 2001; Quintana, 2012); but the use of leguminous trees as well as other fast growing native species could be possible and an important input of this research. In addition to the above, the state is trying to reduce the eucalyptus plantations, and RIO RURAL is not financing the purchase of seedlings of these species.

During this study the importance of implementing SPS with native species is recommended. Brazil has a great biodiversity, enough species were identified (Table 4 and Annex 3) and there is a lot of seedlings and saplings available in the area. Other studies (Torrico et al., 2009b, Mallea et al., 2011; Quintana, 2012) also proposed the importance of the native species, especially for recuperation of fragments connectivity, biological corridors improvement and biodiversity conservation in the Atlantic forest. Likewise it is a goal to achieve for the Rio de Janeiro state. In addition, native species are better for soil conservation and recuperation, as well for water (Carvalho et al., 2003). It is useful to use the experiences of RIO RURAL environmental projects and EMATER technician's knowledge, because they know the development of native species in the area and its implementation.

The use of leguminous trees (natives if it is possible) is another well supported recommendation of this study. The advantages and benefits for the soil, pasture and animals are well studied. The use of these species will be especially useful for money saving in fertilization and concentrates, because of the better quality and protein content of the forage of these species (Balieiro et al., 2005; Calle & Piedrahita, 2007; De Lucena et al., 2004; Dias, 2005; Dias et al., 2007; Dias et al., 2008a; Dias et al., 2008b; Murgueitio et al., 2010; Soares et al., 2002). In the region, the use of a non-native tree named gliricídia (*Gliricidia sepium*) is well distributed, which is easily accessible and its propagation is very easy. Even one producer, has observed good results with some trees in his farm. This specie is reported to have a 22% protein content in the tissues (Murgueitio et al., 2010), so its implementation in a mixture with other trees could be viable.

One of the major concerns of the farmers for the system adoption is the long term return of the investment (Diaz-Filho & Ferreira, 2007; Quintana, 2012). With this study, it was possible to conclude that using fast growth species in 2 – 4 years the system could be completely installed. All depends of the purpose of the system; of course, if it is planted for timber use, the complete return would be 15 – 20 years later (Nepomuceno & Silva, 2009). But it was observed that when the trees are big enough, for cattle not to harm them, and its use as shelter is possible, some intrinsic economical benefits could be achieved. These benefits sometimes are not taken into account but are very important. With the SPS, the well being of the cattle is improved and in relation to health as well; therefore, some savings in terms of medications for disease and parasite control are possible. The other important thing is that the quality and quantity of the milk is improved in 15 – 30%, which also implies more money. Producers could also request a better price of the milk, not only because of the quality, but because of an environmental friendly practice as well. The leguminous trees used as forage for the cattle, could represent a saving in dietary supplements like soy (the most expensive reported by the farmers). Finally, they could also use the trimmed trees for fence posts, which is a great saving; the annual purchase of posts was one of the most expensive cost in the analysis (Barreiro, 2009; Cacho, 2001; Hernández & Ponce, 2004; Hernández, 2005; Murgueitio, 2004; Murgueitio et al., 2010).

Other non-quantifiable benefits, rapidly perceived in SPS are the ones for soil recuperation, biodiversity increase and landscape beautification (Cacho, 2001; Calle & Piedrahita, 2007). Another alternative for the return rate concern is proposed. Using a model of successional planting of trees (Gliessman, 2000) in SPS, in order to achieve the economical but also the conservation goals with the native species, could be followed. The use of fast growth native and/or leguminous trees, and even some eucalyptus (although the state is not willing to implement them), will be valuable for the milk yield increase, firewood, forage and a light wood utilization after the system trimming; this could help to enhance the familiar income in the first 2 – 4 years. Then, the slow growth species in a long term would produce wood, fruits, exudates, among others. The income diversification is one of the key successes in risk diminution and better farm profitability (Schlüter & Pedroso, 2009; Torrico et al. 2009b). After 2 – 4 years of SPS implementation there is also an increment in the land cost, which grows proportionally with the years and maturity of the trees plantation. PES is also an alternative for income (Gliessman, 2000; Murgueitio, 2004; Murgueitio et al., 2010; Nair et al., 2008; Ospina, 2006).

One advantageous feature of the SPS technology is its versatility. The numbers of arrangements, species used and purposes are almost infinite. The most important thing is to find a functional trees association that does not compete with the pastures, the animal health and other trees. So the family farmer, with technical assistance, could plan and design the system according with their necessities and preferences. For the ten farms visited, according to the topography and other characterisitics, and supported by the literature review the recommended arrangements are live fences, scattered trees and simple or double row tree grazing plantations (Gliessman, 2000; (De Castro & Paciullo, 2006; Porfirio-da-Silva et al., 2010).

Finally, the importance of understanding that the SPS are an integral system is fundamental. The correct management of all the components, the trees, pasture and cattle, is essential for the success. The farmers in Italva, actually "dominate the management of the grass and the animals properly", so the trees introducted have to be balanced and an appropriate technical assistance during the whole process is necessary. All the stages during implementation (Porfirio-da-Silva et al., 2010; De Castro & Paciullo, 2006) have to be carefully monitored. The importance of the good quality of seedlings or saplings is also essential (Porfirio-da-Silva, 2006; Porfirio-da-Silva et al., 2010).

7. CONCLUSIONS AND RECOMMENDATIONS

An assessment for the establishment of silvopastoral systems in the municipality of Italva, Rio de Janeiro State (Brazil), was performed using an on-farm participation methodology. The results point out the high possibility for the adoption of these systems using native species.

A group of 10 producers was the target of this research and a participatory training program. After participatory activities their knowledge and enthusiasm about SPS technology was achieved. A new perception of a new concept they never heard before was created.

All the farmers showed an interest for SPS, they are ready to begin and dispose time and land for the implementation; but they have no the intention to invest money, because they don't have economic solvency and borrowing is not an option. In order to reach the implementation objectives, some governmental or external financing sources must be found. If it is not possible, the enthusiasm achieved in these farmers and this study itself would be useless.

The use of native species in SPS is one of the most important recommendations of this study; a 40 promising multipurpose native species list was elaborated. In the same manner, the use of leguminous trees will highly and rapidly impact the production systems. No problems of native species seedlings and saplings location were identified in the study region, but the quality of the materials must be very carefully selected.

This preliminary economical analysis of the actual systems showed an urgent need of sustainable and profitable technologies adoption. The economical, environmental and social potential benefits of SPS implementation in ten producers of Italva municipality were recognized.

For profitability purposes, the use of a successional planting tree system is also a viable option for SPS adoption in this region.

The SPS is a very versatile technology with optional arrangements and almost infinite combinations possible. This is very attractive for the producers who could plan and design the systems according to their needs and preferences. For the ten farms visited, according with the topography, the recommended arrangements are live fences, scattered trees and simple or double row tree grazing plantations.

The SPS is an integrated system, so the correct management of all the components is in part responsible for its success.

The results of this research could be applied for other farmers of this municipality and the Rio de Janeiro state, but some funds and technical assistance must be designated for SPS implementation.

As a next step for this study, more economical variables, monthly evaluations and cost/profit projects have to be performed. The BIOSS model tool development by the Institute for Technology and Resources Management in the Tropics and Subtropics is very important.

More participatory activities and knowledge transfer must be carried out to keep these producers motivated with SPS implementation.

Further investigation must be carried out, for a longer period of time in order to prove the economical benefits of implementation in Italva. It is necessary to begin a monitoring of economical variables before and after if the implementation is possible.

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ANNEX 1. QUESTIONNAIRE FOR ON-FARM PARTICIPATORY CHARACTERIZATION OF CATTLE PRODUCTION IN ITAVA, RJ

No. Questionário: ______________
Nome:____ Sexo: Masculino _____ Feminino _____
Municipalidade: ____________________________ Microbacia: _______________________________
Coordenadas GPS: N: _______________________________ W: _______________________________
Data: _________________________________

I. Caracterização geral da unidade de produção

1. Número de membros da família: Total: _______ Homens: _______ Mulheres: _______
2. Área total da fazenda: ________________________________
3. Área com pastagem: ________________________________
4. Mandato:
   a. Meeiro
   b. Arrendatario
   c. Parceiro
   d. Diarista
   e. Assalariado
   f. Proprietário
   g. Outro: ____________________

5. ¿Qual é a sua atividade principal e atividade complementar realizada?

   a. Produção agrícola
   b. Produção pecuária (leite)
   c. Produção pecuária (corte)
   d. Produção pecuária (duplo proposito)
   e. Produção florestal
   f. Dona de casa
   g. Empregado

   Actividade complementar: ____________________________

6. ¿Qual é a principal fonte de renda?
   a. A venda de produtos agrícolas.
   b. A venda de produtos de origem animal.
   c. A venda de produtos florestais (carvão, madeira, lenha, só da floresta, etc.)
   d. A transformação dos produtos animais e subprodutos (pão, queijo, etc).
   e. Outra atividade que não é produção agrícola.

7. ¿Qual é sua renda familiar mensal média (R$) ?

0 – 500		501 – 1000		1001 – 2000		2001 – 3000		Mais de 3000	

8. Utiliza Mão de obra externa?

Sim		Não	

Objetivo	Temporalidad	Unidade	Quantidade	Custo unidade

9. Recebe assessoría técnica?

Sim		Não	

De quem? ____

10. Pertenece a alguma associação pecuária?

Sim		Não	

Qual? ____

II. Caracterização da produção pecuária

1. Área utilizada para a produção pecuária

Uso	Localização e Área		
	Topo de morro	Encosta	Baixada
Pastagem nativa			
Pastagem induzido			
Capoeira			

2. ¿Quantos piquetes tem a sua fazenda? ____

3. ¿Que sistema de pastejo utiliza?

Contínuo		Rotacionado	

4. Nome da pastagem: ____
5. Lotação na pastagem (cabeça/hectare): ____
6. ¿Qual é a raça dos animais? ____
7. Composição do rebanho
   a. Número total de cabeças: _____________________________

b. Pecuaria de leite

Categoria	Vacas em lactação	Vacas secas	Bezerras (meses)			Novilhas (meses)		Touros
			0 a 2	2 a 6	6 a 12	12 a 18	18 a 24	
Quantidade								
Peso medio (kg)								
Precio de venta								

c. Dados de produção de leite

Litros/día	Quantidade vendida	R$ / L	Total R$

d. Pecuaria de corte

Categoria	Matrizes	Touros	Bezerras	Bezerros	Novilhas (anos)		Garrotes (anos)			Bois gordo
					1 a 3	2 a 3	1 a 2	2 a 3	>3	
Quantidade										
Quantidade vendida										
Peso medio (kg)										
Precio de venta (R$/kg)										
Total (R$)										

8. O Senhor comercializa seus produtos? | Sim | | Não | |

9. Onde comercializa seus produtos? ____

____

10. O Senhor elabora Subprodutos pecuários?
    a. Queijo
    b. Creme
    c. Manteiga
    d. Outros: ________________________

11. Vende os produtos que o Senhor faz? | Sim | | Não | |

    A quem? ____

12. Quanto recebe pelos produtos? ____

13. Quales são os problemas que o Sehnor percebe pela comercialização dos seus produtos?
____
____
____

14. ¿Quantos animais compra por ano?

Categoría	Quantidade	Custo R$	Total R$

15. Ração

Tipo	Quando	Unidade (kg)	Marca	Quantidade	R$ Unidade	Total R$
Milho						
Silagem						
Cana						
Suplementação à base de concentrados						
Sal mineral						
Sal comum						
Vitaminas						
Outros						

16. O que Sistema de reprodução é usado?
   a. Inseminação artificial
   b. Inseminação com touro de repasse
   c. Natural controlada
   d. Natural não controlada

   Custo da inseminação por animal: __________________________
   Quantos animais insemina? _______________________________

17. Vacinações

Vacina	Aplica	Quando	Dose/Cabeça	Quant.	Marca	R$ Dose	Total R$
Febre Aftosa							
Brucelose							
Carbúnculo sintomático							
Carbúnculo hemático							
Botulismo ou doença da vaca caída							
Paratifo							
Raiva bovina							
Leptospirose							
Outros							

18. Controle de parásitos

Parásito	Controla	Quando	Unidade	Quant.	Marca	R$ Unidade	Total R$
Externos (ectoparasitos)							
Carrapato							
Berne							
Mosca de chifres							
Outros							
Internos (endoparasitos)							
Verminose							
Mamite							
Outros							

19. Infra-estrutura

Categoria	Unidad	Quantidade	R$ Unidad	Total R$
Trator				
Picadeira de forragems				
Pulverizador				
Tanque de leite				
Botijão de semen				
Ordenhadeira mecânica				
Arado				
Equipamentos de irrigacão				
Balança para pesar animais				
Veículo utilizado para transportas o gado				
Outros				

20. Manejo da pastagem

Categoria	Unidade	Quantidade	Marca	R$ Unidade	Total R$
Urea					
Calcáreo					
Adubos					
Outros					
Herbicidas					
Arame					
Grampos					
Postes					

21. ¿ Você pratica a queima de pastagem?

Sim		Não	

22. Outros

Categoría	Unidade	R$/mes	Total R$
Gasolina / diesel			
Energía			
Taxas			
Gas			
Água			
Outros			

III. Sistemas silvopastoles

Sim		Não	

1. O senhor estiviste em o workshop de pasado 10 de Abril?
2. O senhor que lembra que são os sistemas silvipastoriles?

____

____

____

____

____

____

____

____

3. Por que o Senhor tem interesse en os sistemas?

____

____

____

____

____

IV. Componente florestal

1. Tem floresta na sua propiedade?

Sim		Não	

Área: ____________________

2. Ten árvores nas áreas de pastagem?

Sim		Não	

Por que? ____

____

____

3. ¿Quais são os nomes das árvores e quais são seus usos?

Nome comum	Uso

4. Gostaría de ter mais árvores na sua pastagem?

Sim		Não	

Por qué? ____

____

____

5. Voce sabe propagar mudas de especies nativas?

Sim		Não	

6. O sehnor sabe onde comprar mudas de especies nativas?

Sim		Não	

Lugar: ____

____

7. Que área o Senhor estaria disposto a convertir a sistemas silvipastoril?

____

8. Quanto o Senhor estaria disposto a investir para a conversão?

   Dinheiro? (R$) ____________________________________

   Mão de obra? (Tempo) _____________________________

9. Conhece instituções que possan otrogar creditos o apoios para a inversão

____

____

____

____

____

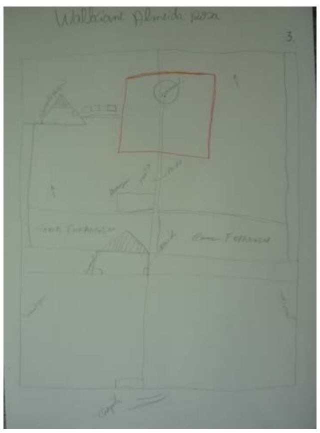
____

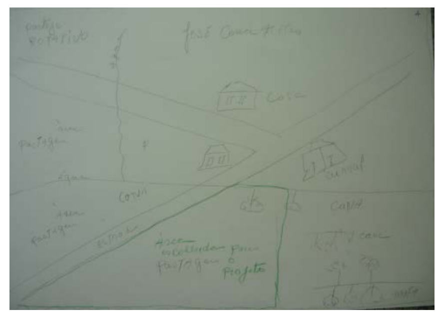
____

ANNEX 2. PICTURES OF THE WORKSHOPS, FIELD VISIT TO A SILVOPASTORAL SYSTEM AND INTERVIEWS WITH THE SELECTED PRODUCERS OF ITALVA, RJ.

First meeting (14th.March.2014)

First Workshop (10th.April.2014)





Field Visit to a SPS (16th.May.2014)


Second Workshop (21st.May.2014)






On-farm semi-structured interviews (11th.April.2014 to 17th.April.2014)

ANNEX 3. BOTANICAL AND MORPHOLOGICAL CHARACTERIZATION OF NATIVE TREES TO BE IMPLEMENTED IN SPS IN ITALVA, RIO DE JANEIRO, BRAZIL

TABLE A. MAIN MORPHOLOGICAL CHARACTERISTICS OF NATIVE TREES TO BE IMPLEMENTED IN SPS IN ITALVA, RJ

Source: Own elaboration based on: Lorenzi, 1998(a); Lorenzi, 1998(b)

No.	Scientific name	Morphology						
		Height (m)	Diameter (cm)	Canopy	Leaves	Flowers	Fruits	Other features
1	*Mazilaurus crassiramea* (Meissn.) Taub. Ex Mez	6-12	40-60	Elongated or pyramidal	Simple, fasciculate	Axillar and terminal raceme planicle	Berry	
2	*Lecythis lanceolata* Poir	12-28	50-70	Rounded & dense	Simple, subcoriaceous	Purple, raceme over the insertion of the leave	Dehiscent woody pyxis	Erect trunk. Each pyxis contains 4-12 seeds with white fleshy aril
3	*Caesalpinia ferrea* Mart. Ex Tul. Var. *ferrea*	10-15	40-60	Rounded, low & sparse	Compound bipinnate	Yellow displayed in a raceme	Legume	
4	*Caesalpinia peltophoroides* Benth.	8-16	30-40	Rounded, low & sparse	Compound bipinnate	Yellow displayed in a raceme	Legume	
5	*Swartzia langsdorfii* Raddi	8-14	40-60	Dense	Compound pinnate	Yellow. Zygomorphic. Simple racemose inflorescence	Drupe like legume. Great fruit with juicy aril	Beautiful flowers used for ornamental purposes in urban greening.
6	*Anadenanthera colubrina* (Vell.) Brenan	12-15	30-50	Branched & Leafy	Compound bipinnate	Cream-Yellow sessil in a axillary cluster	Legume	Trunk and branches thorny when young
7	*Anadenanthera macrocarpa* (Benth.) Brenan	13-20	40-60	Branched & Leafy	Compound bipinnate	Cream-Yellow dense inflorescence. Sessil flowers in a axillary cluster	Legume	
8	*Parapiptadenia rigida* (Benth.) Brenan	20-30	60-110	Corymbiform	Alternate bipinnate	Green-yellowish flowers in a dense axillary inflorescence.	Legume	Dichotomous ramification of the trunk
9	*Plathymenia reticulata* Benth.	6-12	30-50	Globose, branchy & sparse	Compound bipinnate	Hermaphroditic flowers in cymes	Legume	7-12 seeds per pod, each surrounded by a winged papery envelope

No.	Scientific name	Morphology						
		Height (m)	Diameter (cm)	Canopy	Leaves	Flowers	Fruits	Other features
10	*Mimosa caesalpiniaefolia* Benth.	5-8	20-30	Sparse & branchy	Compound bipinnate	White, axillary in terminal panicles	Craspedium	Trunk and branches thorny
11	*Rhamnidium elaeocarpus* Reiss.	8-16	30-50	Dense	Simple		Drupe	
12	*Astronium concinnum* Schott.	30-40	140	Leafy & dense	Compound pinnate			One of the tallest trees in the Atlantic forest. During fructification recognized because an intense rose coloration of the canopy because the fruits calyx.
13	*Ilex theezans* Mart.	12-18	30-50	Orbicular	Simple leathery	Axillary	Berry	From long distance bluish-green foliage. Higly confused and counterfeit with yerba mate.
14	*Cedrela fissilis* Vell.	20-35	60-90	High, dense, corymbiform	Compound parapinnate	Greenish-white unisexual	Dehiscent capsule	When leaves ser detached from the branch exude an odor similar to onion. It is important not to plant in monoculture because the border (coleoptera)
15	*Guatteria nigrescens* Mart.	8-12	30-40	Branched & Leafy	Alternate simple	Solitary, axillary on peduncles	Purple ovate-oblong drupe	One seed per fruit. Usually short trunk, bark almost smooth coated .
16	*Porcelia macrocarpa* (Warm.) R.E. Fries	10-20	60-80	Pyramidal or rounded	Simple alternate	Terminal lone	Berry gathered in a infructescense	The flowers are scented and showy
17	*Ilex cerasifolia* Reiss.	4-7	25-40	Wide & low	Simple alternate	White in axillary fascicles	Berry	Each fruit contains 2-4 seeds. The flowers are gently scented. The trunk is generally short and tortuose.
18	*Oreopanax fulvum* E. March.	6-12	15-30	Rounded	Simple alternate	Capitulum disposed in panicles	Drupaceous berry	Purple freshy pulp fruit with 1-3 seeds.

No.	Scientific name	Morphology						
		Height (m)	Diameter (cm)	Canopy	Leaves	Flowers	Fruits	Other features
19	*Bixa arborea* Benth.	6-11	20-30	Pyramidal & very dense	Simple alternate	Terminal panicles rufous tomentose	Dehiscent capsule	
20	*Eriotheca pentaphylla* (Vell.) A. Robyns	8-14	30-45	Orbicular	Compound digitate	Axillary raceme	Dehiscent capsule	Seeds are covered with a white fiber
21	*Alchornea glandulosa* Poepp. & Endl.	10-20	50-70	High, dense, irregular & wide	Simple alternate	Creme in axillary racemes	Cocarium	Dioecious plant.
22	*Bauhinia longifolia* (Bong.) Steud.	4-7		Rounded & sparse	Simple, alternate	White-yellowterminal raceme	Legume	Devoid of thorns, new branches rufous tomentose, trunk slightly tortuose. Bark thin and rough coated
23	*Piptadenia gonoacantha* (Mart.) Macbr.	10-20	30-40	Irregular & umbelar	Compound bipinnate	Yellow-beige, litte clustered in axillary inflorescence	Legume	Dichotomous ramification of the trunk
24	*Rollinia mucosa* (Jacquin) Baill.	10-20	40-60	Dense	Pubescent, simple	Inflorescence with 1-3 flowers	Syncarp berry shaped	Fleshy fruit, whose weight can reach up to 1.3 kg
25	*Rollinia sericea* (R.E.Fries) R.E Fries	5-15	40-50	Dense	Simple alternate	1-3 flowers in a Inflorescence,	Ovoid berry compound with 100-150 carpels	Flowers covered by brown-withish hairs
26	*Bombacopsis glabra* (Pasq.) A. Rob	4-6	30-40	Dense & Branchy	Compound, alternate, digitate	Perfect, terminal with long peduncle	Smooth green capsule	Large, scented and showy flower. Green trunk and delicate structure.
27	*Crataeva tapia* L.	5-12	20-40	Rounded & dense	Compound trifoliolate	Inflorescence in terminal raceme	Globose berry	Plant with garlic odor. Tortuose trunk. Fruit with fleshy pulp and a great contain of seeds.
28	*Genipa americana* L.	8-14	40-60	Pyramidal & dense	Simple opposite	White, yellow or red in cymes	Globose berry	Monoecious plant.
29	*Tabebuia impetiginosa* (Mart.) Standl.	8-12	60-90	Globose, branchy & dense	Compound opposite	Rose intense tubular panicle	Dehiscent capsule	Seeds surrounded by a winged papery envelope. Showy flowers.

No.	Scientific name	Morphology						
		Height (m)	Diameter (cm)	Canopy	Leaves	Flowers	Fruits	Other features
30	*Tabebuia vellosoi* Tol.	15-25	40-70	Globose, branchy & dense	Simple palmately foliate	Yellow tubular panicle	Dehiscent capsule	the difference with the other pê-amarelo are that this specie had the longest corolla. It was named as the brazilian National tree by Federal decree.
31	*Chorisia speciosa* St. Hil.	15-30	80-120	Globose & wide	Compound digitate	Terminal large white-creamy in the center and rose in the periphery	Dehiscent ovoid capsule	Thorny bottle shaped trunk. Showy flowers.
32	*Albizia polycephala* (Benth.) Killip	8-14	40-60	Branched & Leafy	Compound, bipinnate		Legume	Petiole with glandule & new branches rufous tomentose
33	*Albizia hasslerii* (Chodat) Burr.	10-20	40-60	Rounded, low & sparse	Compound pinnate	Dense Inflorescence. Small flowers in bundles	Legume	Because the stamens are much longer than the petals they are very showy
34	*Platypodium elegans* Vog.	8-12	40-50	Rounded & dense	Compound pinnate	Yellow terminal raceme	Oblong, woody samara	
35	*Malouetia cestroides* (Nees) M. Arg.	4-8	20-35	Rounded, low & sparse	Simple alternate	Inflorescence in axillary fascicles with 5-15 white flowers	Dehiscent follicle	Lactescent plant. Scented flowers. Seeds are provided with white silky fibrouos hairs.
36	*Cecropia pachystachya* Trec.	4-7	15-25	High & umbraculiform	Large, circular, palmately lobed	Blue-purple in solitary axillary spikelet inflorescenses♀: slightly membranous perianth, ♂: sessile and smaller	Achenes enveloped by a fleshy perianths	Dioecious plant.

No.	Scientific name	Morphology						
		Height (m)	Diameter (cm)	Canopy	Leaves	Flowers	Fruits	Other features
37	*Schizolobium parahyba* (Vell.) Blake	20-30	60-80	Wide & umbelar	Compound bipinnate	Yellow, big in terminal raceme	Dehiscent oblong cryptosamara	Showy flowers. Is one of the native tress with the most rapid development.
38	*Caesalpinia echinata* Lam.	8-12	40-70	Rounded, low & sparse	Compound bipinnate	Yellow flowers in raceme	Legume	Spiny tree. Scented flowers.
39	*Copaifera lagsdorffii* Desf.	10-15	50-80	Dense & globose	Compound alternate, parapinnate	With-yellowish to cream-rose, zygomorfic, in terminal panicle	Legume	Seeds with a surrounded aryl
40	*Maclura tinctoria* (L.) D. Don ex Steud.	15-30	50-100	Rounded & dense	Simple alternate	Inflorescenses♀:solitary, ♂: aments	Clustered globose berry	Thorny dioecious plant. All the plant parts exudate latex if injured.

TABLE B. GEOGRAPHIC LOCATION AND MAIN WOOD CHARACTERISTICS OF NATIVE TREES TO BE IMPLEMENTED IN SPS IN ITALVA, RJ

Source: Own elaboration based on: Lorenzi, 1998(a); Lorenzi, 1998(b)

No.	Geographic Location	Wood			
		Hardness	Density (g/cm^3)	Texture	Other characteristics
1	Bahía, Espírito Santo, Minas Gerais e Rio de Janeiro. Atlantic forest.	Hard	0.76	Medium	Highly resistant and durable
2	From Rio de Janeiro to Pernambuco in the Atlantic forest. Less frequent in Goiás and Mato Grosso.	Hard	1.01	Medium	Highly resistant to xylophages organisms. Good resistence.
3	Piauí, Alagoas, Bahia, Espírito Santo, Atlantic forest of Rio de Janeiro	Very hard	1.22	Rough	Natural durability - high
4	Atlantic forest of Río de Janeiro. South of Bahía.	Hard	0.90	Medium	Natural durability - medium. Because its canopy beuty is one of the most used tree in urban greening.
5	Rio de Janeiro, Minas Gerais & São Paulo	Hard	0.75	Medium	Moderately resistant and easy to work. Natural durability medium.
6	Maranhão to Paraná and Goiás. Over 400 m.a.s.l	Hard	0.93	Rough	Natural durability - high
7	Maranhão and Northeast of Brasil until São Paulo, Mato Grosso do Sul.	Very hard	1.05	Rough	Compact, not elastic. Natural durability-high
8	Minas Gerais, Mato Gross do Sul, São Paulo to Río Grande do Sul. In Semi-deciduous forest of Paraná	Hard	0.85	Rough	Compact, low elasticity. Natural durability and resistance-very high. The wood contains tanins.
9	From Amapá to Goiás, Mato Grosso, Minas Gerais, Mato Grosso do Sul and São Paulo. In Cerrado and Campo cerrado.	Soft	0.55	Rough	Highly resistant to xylophages organisms. Easy to work. Sapwood differentiated.
10	From Maranhão and Noreast region of Brazil	Hard	0.86	Rough	Great durability even if it is exposed to moisture and is burried.
11	Pernambuco to Rio Grande do Sul, Atlantic forest, Minas Gerais, Goiás, Mato Grosso do Sul, São Paulo e Paraná, In the semi-deciduous forest in Paraná	Hard	0.98	Medium	Highly resistant to rottening in contact with soil and moisture, highly reccomended for fenceposts
12	South of Bahia, Espiritu Santo, Atlantic forest zone of Minas Gerais.	Very hard	1.07	Medium	Highly resistant to xylophages organisms
13	Bahia, Rio de Janeiro, Minas Gerais to Río Grande do Sul. Mainly in altitude regions but also in the Atlantic forest.	Medium - Hard	0.63	Smooth	Low resistance and durability
14	From Rio Grande do Sul to Minas Gerais. Mainly in the semi-decidous forest and Atlantic forest. Occurs in a low distribution all over the country.	Soft	0.55	Medium	Soft to cut and very durable in dry environment. In contact with water its rottening is fast.

No.	Geographic Location	Wood			
		Hardness	Density (g/cm^3)	Texture	Other characteristics
15	Minas Gerais, Rio de Janeiro, São Paulo & Paraná	Soft	0.59	Medium	Easy to work. Susceptible to rottening when is exposed
16	Santa Catarina, Paraná, São Paulo and Minas Gerais. Atlantic and Semi-deciduous forest.	Medium - Hard	0.76	Medium	Low mechanical resistence and greatly subject to rottening
17	São Paulo, Rio de Janeiro, Minas Gerais, Goías, Mato Grosso do Sul. Semi-deciduous forest and Cerrado	Medium - Hard	0.65	Smooth	Mechanical resistence and durability - low
18	Minas Gerais, São Paulo, Paraná e Santa Catarina. Semi-deciduous forest	Medium - Hard	0.56	Smooth	Low resitance and very susceptible to rottening when is exposed
19	South Bahía, Espirirtu Santo, Rio de Janeiro, Minas Gerais. Atlantic forest.	Soft	0.47	Smooth	Easy to work. Low mechanical resistance and durability. Contains dye.
20	From Bahía to São Paulo and Minas Gerais. Atlantic forest.	Soft	0.43	Medium	Low mechanical resistence and durability
21	Rio de Janeiro, from Minas Gerais to Rio Grande do Sul.	Soft	0.40	Smooth	Low natural durability, very porous.
22	São Paulo and Minas Gerais. Semi-deciduous forest and Cerrado	Medium - Hard	0.67	Rough	Mechanical resistence - medium low durability
23	Rio de Janeiro, Minas Gerais, Mato Grosso do Sul until Santa Catarina. Atlantic forest in the slopes.	Medium - Hard	0.75	Rough	Hard to cut but soft to work. Moderately resistant to xylophages organisms.
24	All over the Brasilian territory, with a predomination in the Atlantic & Amazon rainforest.	Soft	0.32	Medium	Low mechanical resistence and greatly subject to rottening
25	Southeast of the country. Mainly in Paraná and Santa Catarina in the Atlantic Forest until 600 m.a.s.l.	Soft	0.47	Medium	Low mechanical resistence and greatly subject to rottening
26	From Pernambuco to Río de Janeiro in the Atalntic forest	Very soft	0.33	Smooth	Low natural durability
27	From Pernambuco to São Paulo and Minas Gerais. In the Atalntic forest and the Matogrossense swampland	Medium - Hard	0.56	Medium	Susceptible to cracking when dried, low durability
28	All over the Brasilian territory in various forest types, in humid floodplains or waterlogged.	Medium	0.68	Smooth	Easy to work, flexible. Long durability when is exposed to humid soil.
29	From Piauí and Ceará to Minas Gerais, Goiás, São Paulo. Mainly in the semi-decidous forest and Atlantic forest. Ocasionally in Cerrado and Catinga.	Very hard	0.96	Medium-soft	Highly resistant to xylophages organisms. Very hard to cut.
30	Rio de Janeiro, Minas Gerais, Goiás, São Paulo, Mato Grosso do Sul. Mainly in the Atlantic forest.	Very Hard	0.99	Rough	Very resistant to environmental conditions
31	Rio de Janeiro, Minas Gerias, São Paulo, Goiás, Mato Grosso do Sul e Norte do Paraná.	Soft	0.28	Rough	Low natural durability
32	São Paulo, Paraná, Mato Grosso do Sul e Sana Catarina. Semi-deciduous forest	Soft	0.50	Rough	Low resistance in natural conditions
33	São Paulo, Mato Grosso do Sul, Minas Gerais & Goiás.	Soft	0.60	Smooth	Low resistant to xylophages organisms

No.	Geographic Location	Wood			
		Hardness	Density (g/cm^3)	Texture	Other characteristics
34	From Piau to São Paulo, Goiás and Mato Grosso do Sul . Mainly in Cerrado	Medium - Hard	0.82	Rough	Moderately durable
35	Espiritu Santo and South Bahia. Atlantic forest. Frequent in the higrophyte forest of south Bahía	Medium - Hard	0.58	Smooth-Medium	Low resistant and low durability
36	Ceará, Bahia, Minas Gerais. From Goiás and Mato Grosso do Sul to Santa Catarina in various forest types.	Soft	0.41	Smooth	Low natural durability
37	From Bahia to Santan Catarina. Atlantic forest in the slope.	Very soft	0.32	Rough	Very low durability in natural conditions. Sapwood and heartwood indistinguishable.
38	From Ceará to Río de Janeiro in the Atlantic forest. Particularly frequent in South Bahia.	Very hard	1.10	Smooth	Very fine wood
39	Minas Gerais, Goiás, Mato Grosso do Sul, São Paulo and Paraná.	Medium - Hard	0.70	Medium	Medium resistant. Very durable in natural conditions. Sapwood differentiated.
40	All over the Brasilian territory in various forest types.	Medium - Hard	0.88	Rough	Highly resistant to xylophages organisms and rotening.

TABLE C. ECOLOGICAL CONSIDERATIONS AND FENOLOGY OF NATIVE TREES TO BE IMPLEMENTED IN SPS IN ITALVA, RJ

Source: Own elaboration based on: Lorenzi, 1998(a); Lorenzi, 1998(b)

No.	Ecological Considerations	Fenology
1	Semi-decidous, heliophytic, selective xerophyte. Endemic from the Atlantic forest. Common in primary and secondary forest.Common in pastures and open secondary patches. Bird dispersion of seeds. Well drained and sandy soil of tops and slopes.	Flowering from april to june . Fruit ripening from august to october.
2	Decidous, heliophytic to shade tolerant, selective xerophyte. Endemic from the Atlantic forest. Common in primary forest. Well drained and fertile lands of slopes.	Intensive flowering from october to february, with emergence of new foliage. Fruit ripening from july to september.
3	Evergreen, heliophytic, selective higrophyte, low population density. For humid lowlands and bottom valleys. In closed forest patches or in open ones.	Flowering from the end of november till january. Fruit ripening from july to august.
4	Medium to rapid growth. Semi-deciduous, heliophytic. Indiferent to soil conditions.	Flowering from final august to november. Fruit ripening from final july until mid september
5	Evergreen plant, shade tolerant, characterisit for primary forest. Low quantity of viable seeds.	Flowering during september to january. Fruit ripening in february to april.
6	Decidous, heliophytic, pioneer. Common in secondary successional stages.	Flowering from novemember to january . Fruit ripening in july and august.
7	Decidous, heliophytic, pioneer, selective xerophyte. Common in secondary and primary successional stages in sandy soil. Well drained soil.	Flowering from september to november. Fruit ripening in august and september
8	Decidous, heliophytic, pioneer, physical soil conditions indifferent. Common in secondary successional stages in sandy soil.	Flowering from mid november to january. Fruit ripening in june and july.
9	Decidous, heliophytic, pioneer, selective xerophyte. In Cerrado and semi-decidous forest. In highlands with sandy soils (well drained). Common in primary and secondary successional stages. Well adapated to poor soils.	Flowering from final september with the new foliage sprouting, until mid november. Fruit ripening in august to september when the plant loose the foliage.
10	Decidous, heliophytic, pioneer, selective xerophyte. In the Catinga. Deep soils. Common in primary successional stages.	Flowering from november to march. Fruit ripening from september to november.
11	Decidous plant, heliophytic, selective higrophyte. Common in secondary successional stage. Seed dispersion by birds.	Flowering from october to novemember. Fruit ripening from december to march.
12	Evergreen plant. Clayey soils in the slopes. Humid conditions for flowering and resprout	Flowering highly dependent on humidity (april to october), followed by fructification (may to november)
13	Evergreen, heliophytic to shade tolerant. Physical soil conditions indifferent.	Flowering from september to december . Fruit ripening from january to may.

No.	Ecological Considerations	Fenology
14	Decidous, heliophytic or shade tolerant. In semi-decidous forest and Atlantic forest. Preferibly humid and deep soils. Common in primary and secondary successional stages.	Flowering from august to september. Fruit ripening in june to august when the plant loose the foliage.
15	Evergreen plant. From understory to heliophytic. Indiferent to soil conditions.	Flowering during september to november. Fruit ripening in january and february.
16	Decidous, shade tolerant to heliophytic, selective xerophyte. Common in secondary successional stages. Fauna dispersion of seeds.	Flowering in august and september. Fruit ripening in november.
17	Decidous, heliophytic to shade tolerant, soil moisture indifferent, deep soils with medium fertility. Bird dispersion of seeds. Common in primary and secondary forest in plains, slopes and tops of the hill.	Flowering in more than one season in the year, predominantly during october and november. Fruit ripening predominantly in june.
18	Semi-decidous, shade tolerant to heliophytic, selective higrophyte. Common in secondary successional stage. Very rare specie. Characteristic in riparian forest. Highly organic matter and soil moisture content. Bird dispersion of seeds.	Predominantly flowering from january to april. Fruit ripening in august and september.
19	Evergreen, shade tolerant to heliophytic, selective higrophyte, pioneer. Exclusive in the Atlantic forest. Common in secondary succesional stage in plains and slopesl, with deep soils. Highly organic matter and soil moisture content. From see level to 200 m.a.s.l.	Flowering from january to februaryl. Fruit ripening in august and september.
20	Evergreen, shade tolerant to heliophytic, soil moisture indifferent. Exclusive in the Atlantic forest. Common in secondary succesional stage in plains and slopes. Clayey and fertile soils.	Flowering from may to june. Fruit ripening in august and september.
21	Evergreen, heliophytic, pioneer, rustic, selective higrophyte. Riparian. Common in secondary successional stages, but also in edges and clearings of primary forest.	Flowering at least twice per year, in may-june and october-november. Fruit ripening in september-october and december-january.
22	Decidous, heliophytic, soil moisture indifferent, pioneer. Common in secondary successional stages. Clayey soils, with high fertility and wavy topography.	Flowering during a long period of the year, with a higher intensisty in december to january . Fruit ripening mainly from july to august.
23	Semi-decidous, heliophytic and selective higrophyte. In Atlantic forest, Cerrado and semi-decidous forest. Common in secondary successional stages. Indifferent to soil fertility.	Flowering from final october to january. Fruit ripening in september and october.
24	Decidous plant, heliophytic, common in secondary successional stage	Flowering during july to september. Fruit ripening in december to april.
25	Semi-decidous, shade tolerant to heliophytic. Common in primary and secondary successional stages. Fauna dispersion of seeds.	Flowering in more than one season in the year, predominantly during sepetember to november. Fruit ripening predominantly in december to february.

No.	Ecological Considerations	Fenology
26	Evergreen, heliophytic, selective higrophyte. Characteristic in the Atlantic forest. Common in secondary successional stages in plains and slopes. Very rare in dense primary forest.	Flowering from september to november. Fruit ripening from january to february.
27	Decidous, heliophytic, selective higrophyte. Exclusive in Atlantic forest and the Matogrossense swampland. Common in secondary successional stages in floodplains or riparian forest. Clay soils with high fertility and a bit saline, or with high potassium. It presence is indicator of soil fertility. Fauna seed dispersion.	Flowering from august to november. Fruit ripening from january to may.
28	Semi-decidous, heliophytic, selective higrophyte. High soil moisture. Common in primary and secondary successional stages.	Flowering from october to december. Fruit ripening from november to december almost at the same time the new foliage sprout.
29	Decidous in winter, heliophytic. Greatly distributed in the semi-decidous forest. Common in primary and secondary successional stages.	Flowering from may to august when the tree loose the foliage. Fruit ripening from mid september to october.
30	Decidous, heliophytic to shade tolerant. Distributed in the Atlantic forest and semi-decidous forest. Common in primary successional stages.	Flowering from july to sepetember, when the tree loose all the foliage. Fruit ripening in october and november.
31	Decidous, heliophytic, selective higrophyte. Common in primary and secondary successional stages. Fertile soils in floodplains and valleys. Wind dispersion of seeds.	Flowering from mid december to april. Fruit ripening from august to september, when the trees loosse all the foliage.
32	Semi-decidous plant, heliophytic, selective higrophyte, pioneer. Common in secondary as well as primary successional stages.	Flowering from novemember to december. Fruit ripening from may to june.
33	Decidous, heliophytic, pioneer, selective xerophyte. Common in primary and secondary successional stages.	Flowering from final october to january. Fruit ripening in september and october when the plant has not foliage.
34	Semi-decidous, heliophytic, pioneer, rustic, selective xerophyte. In Cerrado and semi-decidous forest and highlands in the Atalntic forest. Common in secondary successional stages.	Flowering from mid september to november. Fruit ripening in september and october.
35	Decidous, heliophytic to mesophyte. Soil moisture indifferent. Pionner and rustic. Exclusive in the atlantico forest. Common in secondary successional stages in plains and slopes. Deep soils with good fertility. Wind dispersion of seeds.	Flowering in october and november. Fruit ripening in january and february.
36	Evergreen, heliophytic, pioneer, selective higrophyte. High soil moisture. Riparian. Common in secondary successional stages, rare in primary dense forest . Ants simbiosis.	Flowering from september to october. Fruit ripening in may and june.
37	Decidous, heliophytic, pioneer, selective higrophyte. Exclusive of the Atlantic forest. Frequent in plains or in riparian forest, also in some slopes depressions. Common in secondary successional stages and open forest.	Flowering from final august, with no leaves in the plant, until mid october. Fruit ripening in april to june.
38	Semi-decidous, heliophytic to shade tolerant. Generally occurs in dry soils. Exclusive in Atlantic forest. Common in primary successional stages.	Flowering from the end of september to mid october. Fruit ripening from november to january.

No.	Ecological Considerations	Fenology
39	Decidous or semi-decidous , heliophytic, selective xerophyte. In Cerrado and semi-decidous forest. Common in primary and secondary successional stages. Bird dispersion of the seeds.	Flowering from december to march. Fruit ripening in august to september when the plant loose the foliage.
40	Decidous, heliophytic, selective higrophyte, pioneer. Common in secondary successional stages and clearings, rare in the primary dense forest. Moistured soils of floodplains and slopes.	Flowering from september to october. Fruit ripening in december and january.

TABLE D. PROPAGATION OF NATIVE TREES TO BE IMPLEMENTED IN SPS IN ITALVA, RJ

Source: Own elaboration based on: Lorenzi, 1998(a); Lorenzi, 1998(b)

No.	Seeds Recollection	Seedling Production
1	Directly hand-picked or in the ground when they fall. Leave in a plastic bag while parcial pulp decomposition. Aprox 1 kg. of seeds are 400 units.	Seeds are planted in pots partially shaded with organic-sandy substrate. Germination occurs 5-8 weeks, with a low germination rate. Development in situ is slow.
2	Directly hand-picked when initiating the spontaneous opening or in the ground when they fall. Leave in the sun to produce the fruit opening. Aprox 1 kg. of seeds are 270 seeds.	Seeds are planted in pots with organic-clayey substrate. Cover them with a 1 cm layer of sieved substrate and irrigate twice per day. Germination occurs 5-7 weeks, with a germination rate over 50%. The saplings are ready for planting in situ in 7-8 months. Development in situ is moderate.
3	Directly hand-picked when are ripe (dark coloration and spontaneous pods opening). Also the seed could be picked from the ground. The pods must be sun dried in order to produce the opening. Aprox. 1 kg of seeds are 5.200 units, with a storage viability over to 8 months.	It is needed a mechanical scarification in order to raise germination rate. Seeds are planted in pots partially shaded, with clayey-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs 7 - 15 days. Germination rate over 60%. The plant development in the field is moderate, with 2.5 to 3 m heigth after 2 years.
4	Directly hand-picked when initiating the spontaneous opening of the pods. Leave on the sun for the final pods aperture. Aprox 1 kg. of seeds are 2.850 units, with a storage viability of 1 year.	These seeds do not requiere any previous treatmentt. Planted directly in pots with clayey-sandy substrate and cover with a thin layer of sieved substrated. Irrigate twice per day and leave in a partially shaded environment. Germination occurs 10 - 25 days. germination rate over 60%. The develpement of the seedlings is rapid getting ready for planting in situ in 4-5 months. Development in situ is moderate, reaching 3 m height in 2 years.
5	Directly hand-picked when initiating the fall or directly in the ground. Open the fruit to obtain the seed (1-3 per fruit). Remove the mucilagenous aril. Aprox 1 kg. of seeds without aril are 25 units, with a storage viability of less than 1 month.	Seeds are planted in individual pots with organic-clayey substrate. In a completely shade environment. Cover the seed with a 1.5 cm layer of sieved substrate and irrigate twice per day. Germination occurs 10-20 days with a high germination rate in fresh seeds. The develpement of the seedlings is moderate getting ready for planting in situ in 8-9 months. Development in situ is slow.
6	Directly hand-picked when initiating the spontaneous pods opening. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 15.600 units, with a storage viability less than 4 months.	Seeds are planted in pots partially shaded with organinc-sandy substrate, with non previous treatment. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs 4-8 days. High germination rate, over 80%. The develpement of the seedlings is very rapid getting ready for planting in situ in less than 4 months. Development in situ is very rapid, 4-5 m in 2 years.

No.	Seeds Recollection	Seedling Production
7	Directly hand-picked when spontaneous opening begins. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 7.600 units	Seeds are planted with no previous treatment, in pots partially shaded with organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs in 5-8 days. Germination rate is high for fresh seeds (80%). The development in situ is very rapid, 5-6 m in 2 years.
8	Directly hand-picked when spontaneous opening begins. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 38.600 units. Storage viability over 3 months.	Seeds are planted with no previous treatment, in pots partially shaded with organic-clayey substrate. Germination occurs in 5-10 days. Germination rate is very high. The development in situ is rapid, 3 m in 2 years.
9	Directly hand-picked pods when spontaneous opening begin. The pods must be sun dried in order to produce the opening. It is not necessary to remove the membrane that cover the seeds. Aprox 1 kg. of seeds are 33.200 units.	Seeds are planted with no previous treatment, in pots partially shaded with organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs in 10-30 days. Germination rate lower than 20%. Scarification could improve the rate, but studies are necessary. The development of seedlings is slow, ready for planting in situ in 8-10 months. Development in situ is slow, 2.5 m in 2 years.
10	Directly hand-picked when spontaneous opening begin. They must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 22.000 units. Storage viability over 1 year.	Seeds are planted with no previous treatment in pots, partially shaded with organic-sandy substrate. Cover with a fine layer of sieved substrate and irrigate twice per day. Germination occurs in 5-20 days. The germination rate generally is over 50%. The development of seedlings is very rapid, ready for planting in situ in 4 months. The development of saplings in situ is rapid, 4 m in 2 years.
11	Directly hand-picked when initiating the spontaneous fall from the tree. Leave them somedays to facilitate the pulping in running water. Aprox 1 kg. of seeds are 18.500 units, with a storage viability of 1 year, with a low storage viability, maximum of 90 days.	These seeds do not requiere any previous treatmentt. Planted directly in pots with organic-clayey substrate. Germination occurs 5-15 days. Germination rate 100% for new seeds. Seedlings are ready for planting in situ in 4-5 months. Development in situ is rapid.
12	Directly hand-picked or in the ground when they fall. The calyx is retired and the seeds are separated (3 per fruit). There are planted in a susbtrate. Aprox. 1 kg of seed are 1.300 units.	Seeds are separed in pots, partially shaded, and covered with a sieved substrate. Germination occurs 15 - 25 days. Germination rate over 70%.
13	Directly hand-picked when the fruit is dark red or black, or when the spontaneuos fall begins. Leave in a plastic bag while parcial pulp decomposition. Knead the fruits over a fine sieve with runing water. Aprox 1 kg. of seeds are 140.000 units.	This seeds have a very slow germination. The seeds must be left in piles, buried in contact with moisture to soften the seed coat and facilitate the absorption of water. Then planted in pots, stratified Scarification is needed. Seeds are planted in pots partially shaded with organic-sandy substrate. Germination takes 30-50 days.

No.	Seeds Recollection	Seedling Production
14	Directly hand-picked of capsules when spontaneous opening begin. The capsules must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 21.000 units. Storage viability over 4 months.	Seeds are planted in pots, semi-shaded with clayey substrate. Cover them with a fine layer of sieved substrate and irrigate twice per day. Germination occurs in 12-18 days. The development of seedlings in situ is rapid, 3-4 m in 2 years.
15	Directly hand-picked when are ripe. Leave them in a plastic bag until the pulp is rotten, that would help to obtain the seeds easily with some running water. Dry them in the shadow. Aprox. 1 kg of seeds are 1.600 units, with a storage viability over to 6 months.	Seeds are planted in pots, partially shaded, with organic - sandy substrate. Cover them with a 0.5 cm of sieved substrate and irrigate twice per day. Germination occurs 40 - 60 days. Germination rate low. The germination rate is improved if the seed is mechanically or chemically scarifyed.
16	Directly hand-picked when ripening begins (green-yellowish coloration). Handly opened for the seeds removal. Wash them with running water and dry them in the shade. Aprox 1 kg. of seeds are 950 units.	Seeds are planted in pots partially shaded with organic-sandy substrate. Cover them with a 0.5 cm layer of sieved substrate and irrigate twice per day. Mechanical or chemical escarification is needed for break dormancy. Germination rate over 50% with treatment.
17	Directly hand-picked when the fruit is red or when the spontaneuos fall begins. Leave in a plastic bag while parcial pulp decomposition. Knead the fruits over a fine sieve with runing water. Aprox 1 kg. of seeds are 115.000 units.	Seeds are planted in pots, in full sun with a sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs 2-3 months, with a lower germination rate. Development in situ is slow.
18	Directly hand-picked when the spontaneuos fall begins. Leave in a plastic bag while parcial pulp decomposition. Mechanical, physical or chemical scarification is needed. Aprox 1 kg. of seeds are 35.600 units.	Scarified seeds are planted in pots partially shaded with organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs 6-8 weeks, with a low germination rate.
19	Directly hand-picked when the spontaneuos opening occurs. Leave in the sun for complete opening. Aprox 1 kg. of seeds are 60.000 units.	Seeds are planted in pots partially shaded with organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs 2-3 weeks, with a high germination rate. The saplings are ready for planting in situ in 4-5 months. Development in situ is very rapid, 2 m in 2 years.
20	Directly hand-picked when the spontaneuos opening occurs. Leave in the sun for complete opening and facilitate fiber removal from the seeds. Aprox 1 kg. of seeds are 1.500 units.	Seeds are planted in pots partially shaded with organic-sandy substrate. Cover them with a 0.5 cm layer of sieved substrate and irrigate twice per day. Germination occurs 2-3 weeks, with a germination rate lower than 50%. The saplings are ready for planting in situ in 5-6 months. Development in situ is moderate.
21	Directly hand-picked when spontaneous opening begin (a bright red aril is exposed) . They must be sun dried for complete opening. It is not neccesary to remove the aril, just is needed to be dried. Aprox 1 kg. of seeds are 19.500 units. Storage viability low, no more than 60 days.	Seeds are planted in pots, partially shaded with organic-clayey substrate. Cover them with a fine layer of sieved substrate. Germination occurs in 20-50 days. Germination rate lower than 50%. The seedlings are ready for planting in situ in 4-5 months. The development of saplings in situ is rapid.

No.	Seeds Recollection	Seedling Production
22	Directly hand-picked when initiating the spontaneous pods opening. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 10.600 units.	Seeds are planted in pots, in full sun with a sandy substrate. Cover them with a 0.5 cm layer of sieved substrate and irrigate twice per day. Germination occurs 3-5 weeks, with a germination rate lower than 50%. The saplings are ready for planting in situ in 5-6 months. Development in situ is rapid.
23	Directly hand-picked pods when spontaneous opening begin. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 18.000 units. Storage viability low, less than 60 days.	Seeds are planted with no previous treatment, in pots partially shaded with organic-clayey substrate. Germination occurs in 5-10 days. Germination rate is very high. The development of seedlings is fast, ready for planting in situ in 3-4 months. Development in situ is rapid, 5 m in 2 years.
24	Directly hand-picked when are ripe, the fruit must be green-yellow colored. Hand-opened and washed eith running water. Aprox. 1 kg of seeds are 3.400 units.Highly number of seeds produced per year.	Seeds are planted in pots partially shaded, with organinc-sandy substrate. Cover them with a 0.5 cm of sieved substrate and irrigate twice per day. Higly dormant seeds, the mechanical or chemical scarification is needed to improve germination. Germination rate over 50%.
25	Directly hand-picked when are yellow or in the ground when they fall. Leave in a plastic bag while parcial pulp decomposition and facilitate cleaning with running water . Aprox. 1 kg of seed are 20.000 units, with a low storage viability.	Seeds are planted in pots partially shaded with organic-sandy substrate. Cover them with a 0.5 cm layer of sieved substrate and irrigate twice per day. Germination occurs 30-50 days, with a low germination rate. Scarification could improve the results. Development in situ is rapid.
26	Directly hand-picked the capsules when spontaneous opening begin, or from the ground. They must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 380 units.	Seeds are planted with no previous treatment in pots, with organic-sandy substrate. Germination occurs in 5-10 days. The germination rate is very high, almost 100%. The development of seedlings is very rapid, ready for planting in situ in 4 months. The development of saplings in situ is rapid, 3.5 m in 2 years.
27	Directly hand-picked when spontaneous opening begins or from the ground. Piled until pulp decomposition to facilitate seed recuperation in running water in a sieve. Aprox 1 kg. of seeds are 6.000 units.	Seeds are planted in pots, in full sun with a organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs in 2-3 weeks. Germination rate lower than 50%. The plant development in situ is rapid.
28	Directly hand-picked when spontaneous opening begin, or from the ground. Pulping them manually with running water in a sieve. The seeds must be dried in the shade. Aprox 1 kg. of seeds are 14.280 units. Storage viability is lower than 4 months.	Seeds are planted with no previous treatment in pots, partially shaded with clayey substrate. Germination occurs in 25-45 days. Germination rate generally is over 40%. The seedlings are ready for planting in situ in 7-9 months. The development of saplings in situ is moderate, 3 m in 2 years.
29	Directly hand-picked of capsules when spontaneous opening begin. The capsules must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 8.950 units. Storage viability lower than 3 months.	Seeds are planted in pots, with clayey substrate rich in organic matter. Germination occurs in 10-12 days. The germination rate generally is high. The development of seedlings is rapid, ready for planting in situ in less than 4 months. The development of saplings in situ is rapid, 3.5 m in 2 years.

No.	Seeds Recollection	Seedling Production
30	Directly hand-picked of capsules when spontaneous opening begin. The capsules must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 15.200 units. Storage viability lower than 4 months.	Seeds are planted in pots, with organic-clayey substrate. Cover with a fine layer of sieved substrate and irrigate twice per day. Germination occurs in 6-12 days. The germination rate generally is over 60%. The development of seedlings is slow, ready for planting in situ in 4-6 months. The development of saplings in situ is slow, 2.5 m in 2 years.
31	Directly hand-picked the capsule when spontaneous opening begin, which is easy to recognize becuase the presence of white feather like balls. They must be sun dried in order to produce the opening. The fiber cover of the seeds (white feather like part) must be manually removed . Aprox 1 kg. of seeds are 5.700 units. Storage viability over 5 months.	Seeds are planted with no previous treatment in pots, partially shaded with organic-sandy substrate. Cover with a fine layer of sieved substrate and irrigate twice per day. Germination occurs very rapid (5-8 days) and the germination rate generally is over 80%. The development of seedlings is rapid, ready for planting in situ in 4 months. The development of saplings in situ is very rapid, 5-6 m in 2 years.
32	Directly hand-picked when initiating the spontaneous pods opening. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 25.600 units, with a storage viability less than 6 months.	Seeds are planted in pots partially shaded with organinc-sandy substrate, with non previous treatment. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs 10 - 30 days. Low germination rate. The develpement of the seedlings is rapid getting ready for planting in situ in 5-6 months. Development in situ is moderate.
33	Directly hand-picked when spontaneous opening begins or from the ground. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 36.000 units, with a storage viability over 8 months.	Seeds are planted with no previous treatment, in pots partially shaded with organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs in 10-40 days. Germination rate lower than 30%. The seedlings development is fast, getting ready for planting in situ in 4 months. The development in situ is rapid, 4 m in 2 years.
34	Directly hand-picked of samaras when spontaneous opening begin, or in the ground. Aprox 1 kg. of seeds are 770 units. Storage viability over 8 months.	Seeds are planted with no previous treatment, in pots in full sun with organic-clayey substrate. Cover them with a 0.5 cm layer of sieved substrate and irrigate twice per day. Germination occurs in 15-25 days. Germination rate over 50% for new fruits. Scarification could improve the rate, but studies are necessary. The development of seedlings is slow, ready for planting in situ in 8-9 months. Development in situ is slow.
35	Directly hand-picked when spontaneous opening begins. Leave in the sun for complete opening and facilitate seeds removal. Aprox 1 kg. of seeds (with fibers) are 52.000 units.	Seeds are planted in pots partially shaded with organic-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs in 2-4 weeks. Germination rate over 50%. The saplings are ready for planting in situ in 4-5 months.

No.	Seeds Recollection	Seedling Production
36	Directly hand-picked when the fruits are ripe, which is easy to distinguish because bird bites. Pile them and left for pulp decomposition. Macerate the fruits. The seeds are separated after leaving in water and the pulp is strained. The filtered seeds must be sun dried. Aprox 1 kg. of seeds are 800.000 units.	Seeds are planted in pots, full sun in clayey substrate. Germination occurs in 25-40 days. Germination rate low. The seedlings are ready for planting in situ in 3 months. The development of saplings in situ is rapid.
37	Picked from the ground after spontaneous fall. Manually retrieve the seed. Aprox 1 kg. of seeds are 500 units. Storage viability very long, over years.	Seeds must be scarified, sanding one point or boilin pontsing them in water for 4-10 minutes and leaving them in water for 1 to 2 days. Then plant in pots with clayey substrate. Germination occurs in 5-15 days. Germination rate is very high (over 85%). The development in situ is very rapid, 8-10 m in 2 years.
38	Directly hand-picked pods when spontaneous opening begin. The pods must be sun dried in order to produce the opening. The opening of the legume is a very rapid process, just few days lasting. Aprox 1 kg. of seeds are 3.600 units.	Seeds are planted in pots without any treatment, with a clayey-sandy substrate. Cover them with a thin layer of sieved substrate and irrigate twice per day. Germination occurs in 8-15 days. Germination rate of new seeds is over 60%. The seedlings development is fast, getting ready for planting in situ in 4-5 months. By the other hand, the development in situ is moderate to slow, 2.5 m in 2 years.
39	Directly hand-picked pods when spontaneous opening begin. The pods must be sun dried in order to produce the opening. Aprox 1 kg. of seeds are 1.720 units.	Seeds are planted with no previous treatment, in pots with organic-sandy substrate. Germination occurs in 20-40 days. Germination rate is medium (over 60%). The development in situ is slow, 2 m in 2 years.
40	Directly hand-picked when spontaneous opening begin, or from the ground.Pile them and left for pulp decomposition. Macerate the fruits. The seeds are separated after leaving in water and the pulp is strained. The filtered seeds must be sun dried. Aprox 1 kg. of seeds are 384.000 units.	Seeds are planted in pots, partially shaded with organic-clayey substrate. Germination occurs 10-20 days and the germination rate generally is low. The development of saplings in situ is moderate.

ANNEX 4. DETAILS FOR GROSS MARGIN CALCULATION

TABLE A. GENERAL INFORMATION OF FARMER'S ECONOMIC ACTIVITIES AND HERD

Source: Own elaboration

No.	Total Herd	Dairy cows	Pastures area (ha)	Principal activity	Secundary activity	Principal money income
1	40	16	9,6	Dairy	Retired	Milk
2	34	15	14,5	Dairy	Retired	Milk
3	27	15	39,8	Dairy	None	Milk
4	35	12	37,0	Dairy	Family agriculture	Milk
5	34	12	24,0	Dairy	None	Milk
6	12	7	3,3	Dairy	Mandala (olericulture, chicken and eggs)	Milk
7	39	14	6,8	Dairy	Mandala (olericulture, chicken and eggs)	Milk
8	41	16	24,0	Dairy	Mandala (olericulture, chicken and eggs) & Pensionate	Milk
9	64	22	22,0	Dairy	Olericulture	Milk
10	13	6	6,5	Olericulture	Dairy	Agriculture

TABLE B. ESTIMATED ANNUAL FIXED COST

Source: Own elaboration

No.	External Labor salary (R$)	Alimentation (R$)	Vaccines (R$)	Parasites control (R$)	Infrastructure (depreciated values) (R$)	Oil, Services and Taxes (R$)	Total (R$)
1	8.688	48.336	141,0	15.248,9	1.716,0	3.960,0	78.089,9
2	0	2.080	321,1	404,0	892,3	1.635,0	5.332,5
3	0	14.582	190,9	475,2	337,8	204,0	15.789,9
4	0	3.834	184,0	595,7	413,8	1.015,0	6.042,5
5	0	2.520	229,1	3.027,6	0,4	329,2	6.106,3
6	0	3.482	246,0	206,0	44,0	141,0	4.119,0
7	0	380	407,9	127,0	612,5	1.371,8	2.899,2
8	0	888	544,9	312,5	817,5	3.665,0	6.227,9
9	0	9.874	370,4	277,0	698,5	1.290,0	12.509,9
10	0	6.708	147,6	0,0	367,4	1.015,0	8.238,0

TABLE C. ESTIMATED ANNUAL VARIABLE COSTS

Source: Own elaboration

No.	New Animals (R$)	Reproduction (Artificial insemination) (R$)	External Labor (R$)	Maintenance (fences mostly) (R$)	Total (R$)
1	0	600	0	1.048,0	600
2	10.000	0	1.800	300,0	11.800
3	15.000	1.800	1.800	1.677,5	18.600
4	0	410	0	4.164,6	410
5	3.000	0	1.800	1.952,5	4.800
6	0	0	360	1.260,0	360
7	3.900	0	0	983,0	3.900
8	0	0	5.400	2.960,0	5.400
9	3.402	0	4.320	3.423,0	7.722
10	0	0	0	0,0	0

TABLE D. ESTIMATED ANNUAL REVENUE

Source: Own elaboration

No.	Cow-calves sale (R$)	L day^{-1}	Average dairy cow^{-1}	Total milk day^{-1} (R$)	Total milk production Year^{-1} (R$)	Dairy by-products (R$)	Total (R$)
1	0	220	13,8	215,6	78.694,0	0	78.694,0
2	7.200	100	6,7	100,0	36.500,0	0	43.700,0
3	5.540	130	8,7	124,8	45.552,0	0	51.092,0
4	0	60	5,0	60,0	21.900,0	0	21.900,0
5	0	50	4,2	48,0	17.520,0	0	17.520,0
6	2.500	40	5,7	40,0	14.600,0	0	17.100,0
7	6.500	40	2,9	38,4	14.016,0	0	20.516,0
8	0	37	2,3	31,9	11.643,5	2.340	13.983,5
9	500	110	5,0	132,0	48.180,0	0	48.680,0
10	6.840	60	10,0	51,0	18.600,4	0	25.440,4

ANNEX 5. DETAILS OF THE ON-FARM RESEARCH CHARACTERIZATION

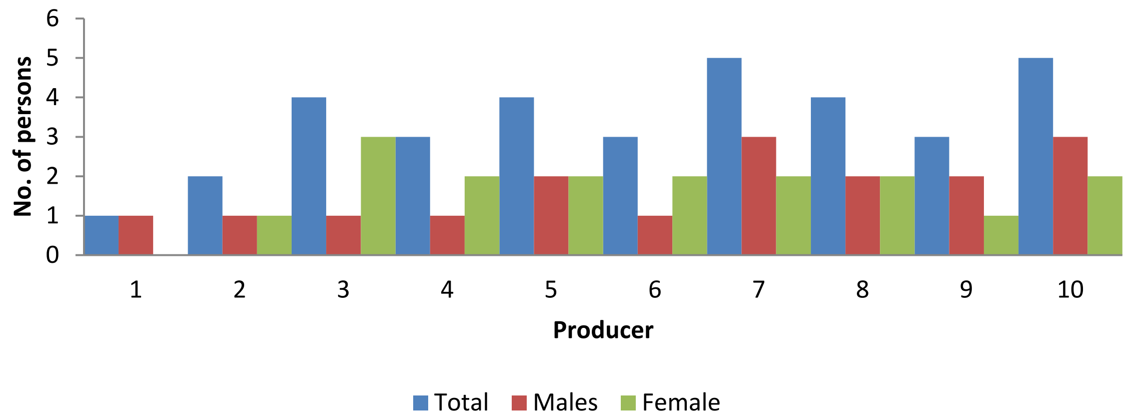


FIGURE A. TOTAL AND GENDER FAMILY MEMBERS DISTRIBUTION
Source: Own elaboration

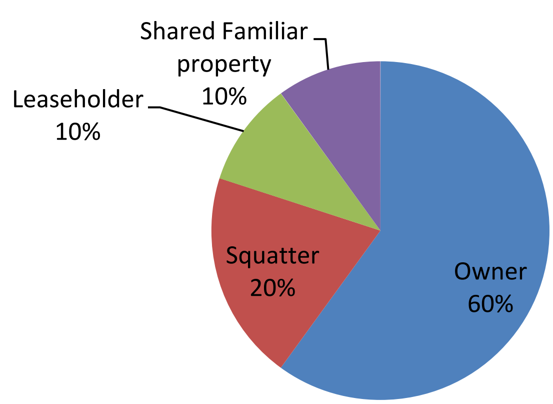


FIGURE B. TYPES OF OWNERSHIP DISTRIBUTION Source: Own elaboration

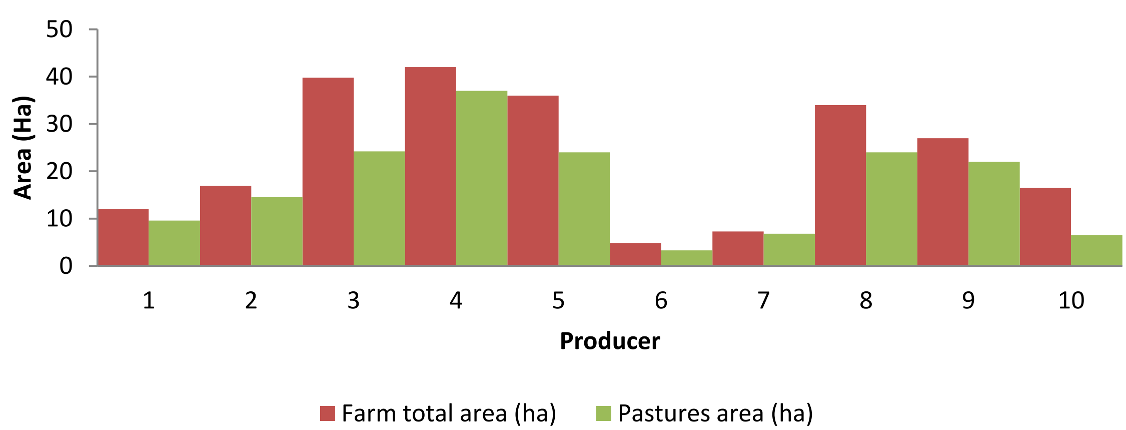


FIGURE C. RATIO BEWTEEN TOTAL AREA AND PASTURES AREA IN THE FARMS
Source: Own elaboration

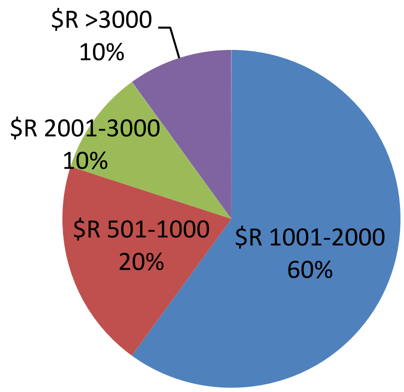


FIGURE D. FAMILIAR MEAN INCOME RANGE
Source: Own elaboration

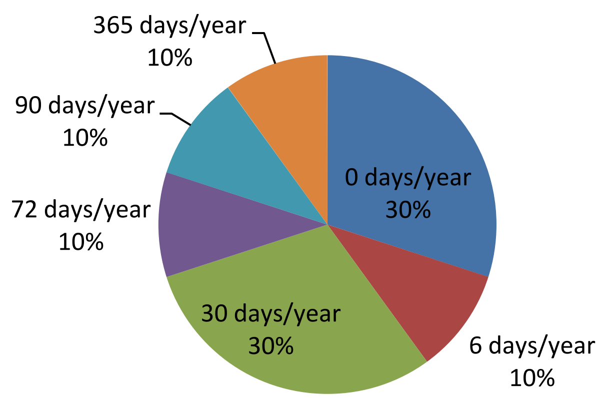


FIGURE E. USE OF EXTERNAL LABOR
Source: Own elaboration

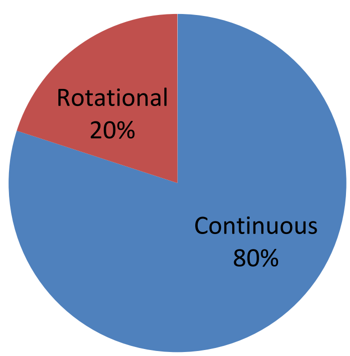


FIGURE F. GRAZING SYSTEMS USED
Source: Own elaboration

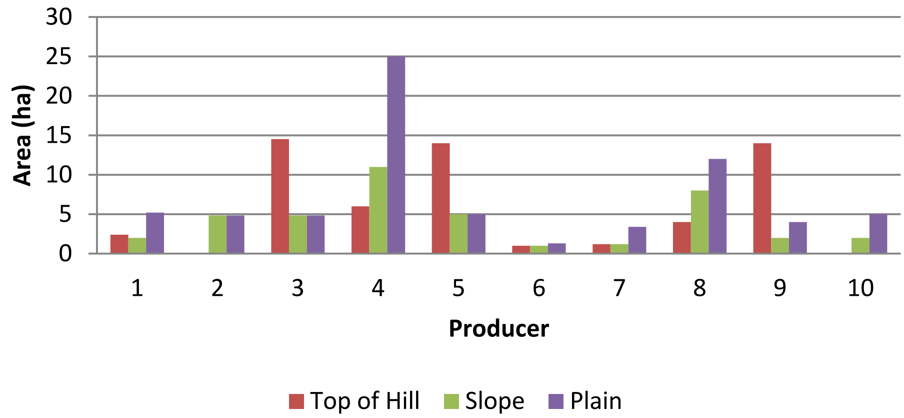


FIGURE G. AREA AND LOCATION OF CULTIVATED PASTURES ON THE FARMS

Source: Own elaboration

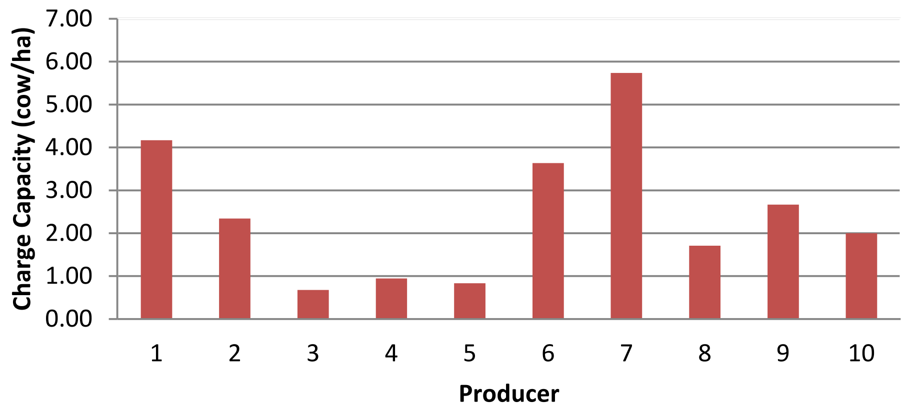


FIGURE H. CHARGE CAPACITY ON THE FARMS

Source: Own elaboration

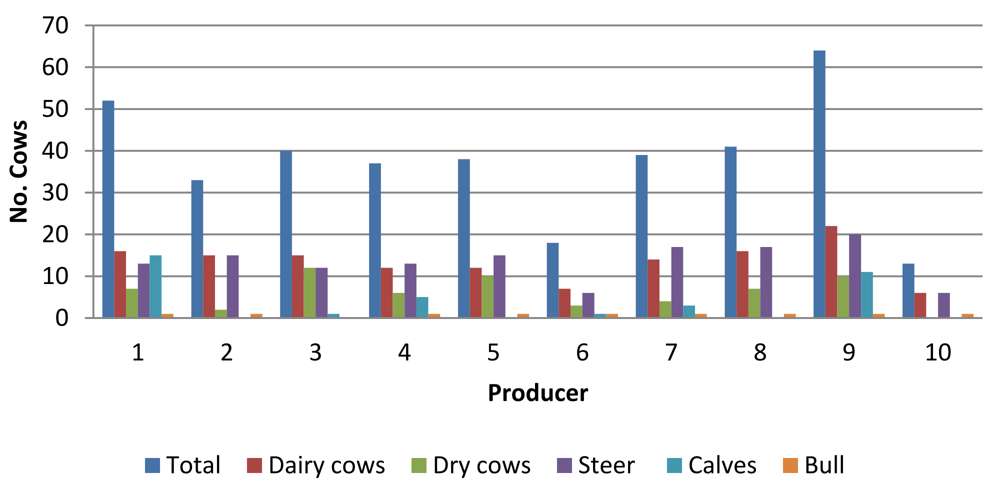


FIGURE I. HERD DISTRIBUTION

Source: Own elaboration

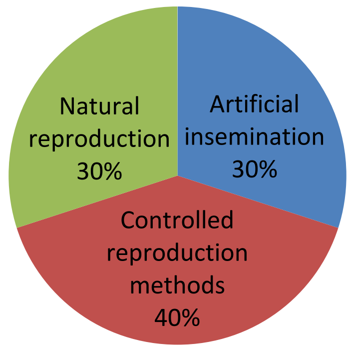


FIGURE J. REPRODUCTION METHODS
Source: Own elaboration

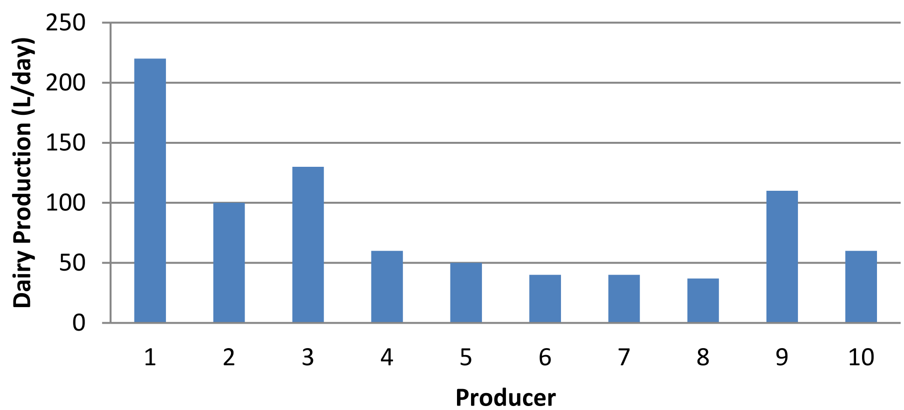


FIGURE K. DAIRY PRODUCTION OF THE FARMS
Source: Own elaboration

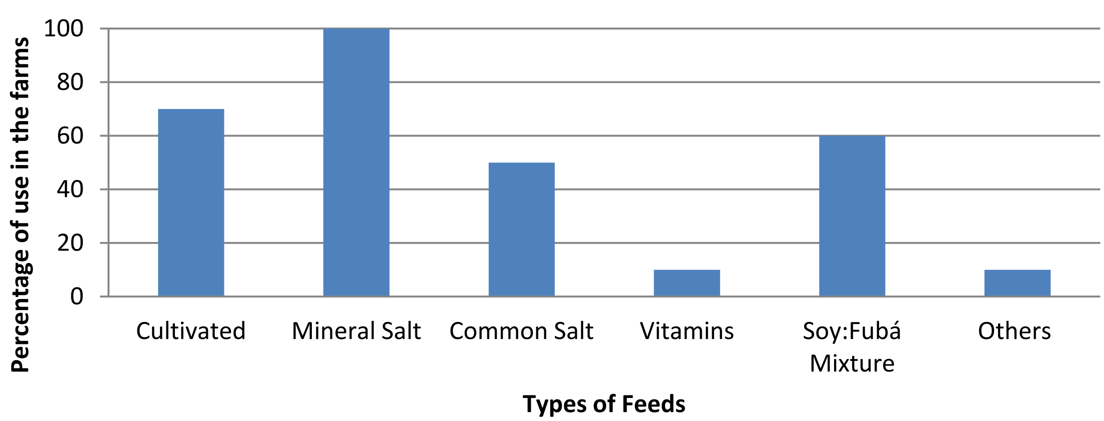


FIGURE L. TYPES OF FEEDS USED IN THE FARMS
Source: Own elaboration