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Escola Superior de Agricultura "Luiz de Queiroz"

Investments in timberland: investors' strategies and economic perspective in Brazil

Bruno Kanieski da Silva

Dissertação apresentada para obtenção do título de Mestre em Ciências, Programa: Recursos Florestais. Opção em: Silvicultura e Manejo Florestal

Piracicaba
2013

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“ No que diz respeito ao empenho, ao compromisso, ao esforço, à dedicação não existe meio termo. Ou você faz uma coisa bem feita ou não faz”

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ABSTRACT

Investments in timberland: investors' strategies and economic perspectives in Brazil

Forest plantations provide essential services for human beings. More recently, population and economic growth has increasingly intensified the demand for forest products. Forest activities are expanding to new areas due to low land prices and governmental incentives in Brazil. Among others; Timberland Investment Management Organizations (TIMOs) are the type of invertors that have significantly increased their participation in the timberland market. The purpose of this thesis is to investigate investor's strategies and the mains aspects related to forest investments in Brazil. The thesis is divided into two chapters. The first chapter investigates the strategies used by TIMOs in Brazil and their declared expectations on returns. The second chapter offers a comprehensive analysis of the level and variability of the return rate for three different regions in Brazil.

Keywords: Forest asset analysis; Project assessment; Timberland prices; TIMO; Investment analysis; Risk; Return rate.

RESUMO

Investimentos em ativos florestais no Brasil: estratégias dos investidores e perpectivas econômicas

As plantações florestais fornecem serviços vitais para os seres humanos. Devido ao crescimento populacional e econômico, a demanda por produtos oriundos de florestas plantadas cresceu rapidamente nos últimos anos.Entre os países que possuem uma forte base florestal, Brasil ocupa um papel essencial como produtor de florestas plantadas. A disponibilidade de terra e a alta produtividade atraíram diversos tipos de investidores para o país. As *Timberland Investment Management Organization* (TIMOs) estão entre os tipos de investidores ampliou seus investmentos no mercado florestal brasileiro. Em paralelo, o setor florestal brasileiro tem expandido para novas áreas devido ao menor custo da terra e incentivos governamentais. Essa dissertação tem como principal objetivo investigar as estratégias e espectativas dos investidores estrangeiros e os principais aspectos relacionados a projetos florestais no Brasil. A dissertação está dividida em dois capítulo. O primeiro capítulo investiga as principais estratégias e os retornos esperados das TIMOs em investimentos florestais no país. O segundo capítulo analiza os níveis de atratividade e seus retornos em três diferentes regiões do país.

Palavras chaves: Análise de ativos florestais; Avaliação de projetos; Preço de terra florestal; TIMO; Análise de investimento; Risco; Taxa de retorno.

1 INTRODUCTION

1.1 Planted Forests in the World

A planted forest is defined by the Food and Agricultural Organization of the United Nations (FAO) (2011) as:

"legitimate land use to provide wood, fiber, fuel, and non-wood, forest products, addressing industrial round wood demand and sustainable livelihoods, ensuring food security and contributing to poverty alleviation".

Planted forests, therefore, play an important role in the society by providing basic services to humans. The establishment of planted forests has provided economic and social benefits for communities and countries namely land use optimization and reduction of intervention in natural areas to log wood and nonwood products. Furthermore, according to the Intergovernmental Panel on Climate Change planted forests have proven to be some of the most efficient ways to sequestrate CO_2 due to their high productivity level (NABUURS, et al, 2007)

The total afforested areas worldwide covered approximately 4 billion hectares in 2010 (FAO, 2010) while forest plantations covered 263 million hectares, from which, 200 million hectares are allocated for wood production the other 64 million hectares are used for conservation purposes.

Table 1.1 Planted forest areas distribution by continent

Region	**Area of planted forests**	
	1000 ha	**% of total forest area**
World	264,084.00	6.60
Asia	122,775.00	20.80
Europe	69,318.00	6.90
North and Central America	38,661.00	5.50
Africa	15,409.00	2.30
South America	13,282.00	1.70
Oceania	4,101.00	2.1

Source: FAO, 2010

The planted forests area is expected to expand and occupy new regions in the upcoming years. Abandoned marginal pastures and agricultural lands have been replaced by forest plantations in developing countries (BREMER; FARLEY, 2010). Moreover, the wood market is promising and demand for timber products is likely to increase in the next years (INCE *et al.*, 2012).

1.2 Planted Forests: Future trend

As planted forests derivatives replace products from natural forests and world demand for wood increases, planted forests production tends to grow. According to (FAO, 2009) demand for wood in the society is stimulated by the following factors: (1) population growth, (2) economic growth, (3) the increasing consumption by developing countries, (4) environmental policies for forest preservation and (5) forests as energy source. The combination of these factors has pushed up wood consumption.

Between 1990 and 2005, wood consumption increased 6.5 % (FAO, 2009). This figure does not include consumption for energy, which would have a large significance due to European policies to promote the replacement of nonrenewable to renewable energy sources and the increasing demand for biomass from Asia (DEMIRBAS, 2008; KATSIGRIS *et al.*, 2004).

Forecasts of wood consumption are constantly performed to help government and business leaders' strategies and provide information about the timber production. The outlook of forest plantation has been constantly discussed in the last decade (ABARE, 1999; CARLE; HOLMGREN, 2008 and FAO, 2000).

Carle & Holmgren (2008) published the most recent research about future wood production. The authors modeled the world wood supply from 2005 to 2030 in three scenarios: (1) pessimist: the current increase of planted forests will slow down and the productivity will not increase, (2) business as usual: the current increase of planted forests will continue at the same rate; however and the productivity will increase and (3) optimist: the same as in scenario 2, but the productivity will increase. The authors state that the total planted area is estimated to reach from 302 to 344.6 million hectares. It represents an increase from 15 % to 30 % in relation to the current area or an area approximately as large as Spain (50. 6 million hectares).

In terms of production, until 2030, wood supply may increase from 1,400 million cubic meters to a range between 1,590 to 2,150 million cubic meters, i.e., 13 % to 53 % more than the current production (Carle & Holmgren, 2008). To better visualize the scenarios, the volume of planted forests added in the pessimist scenario (190 million cubic meters) would be enough to supply the Brazilian pulp and paper industry for 5 years[1].

The increase in volume also affects the wood market directly. The global timber market moved 468 billion dollars in 2006, which meant an increase of 10 % in relation to 1990 (424 billion dollars) (FAO, 2009). The wood market has attracted different investors and thereby increasing competition and dynamism.

1.3 Planted Forests as Investment

The first planted forest were funded and supported by government initiatives; large areas were then planted for wood supply and research purposes. Since then, the forest sector have increased significantly worldwide, private funds and direct foreign investments have become as important as the incentives provided by the governments. Consequently, the planted forest sector became a market oriented investments, which the main players are the vertically integrated companies, individuals and institutions , as well as the government (FAO, 2010).

Over the last 30 years a new perspective of forest use has been adopted by the economic structure; timberlands have become part of a portfolio as an asset (SWITZER, 2006; ZHANG *et al.*, 2012). This trend was more noticeable in the U.S., where institutions have purchased large areas of timberland.

Timberland investments became attractive for institutions due to the following characteristics: (i) the inherent inflation hedge, (ii) low or/and negative correlation with other assets in the investor’s portfolio (iii) the historical profits investments in timberland generates and (iv) the low risk involved in the investment (HEALEY *et al.*, 2005; SWITZER, 2006).

Institutional investors started to purchase and manage timberlands to maximize profits and minimize risks. HEALEY et al.(2005) affirmed that if 10 % of their portfolio were composed by timber, the investment returns would rise from 12 % to 14 %, at the same risk level.

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[1] As reported the Brazilian Pulp and Paper Association (BRACELPA), the Pulp and Paper Sector consumed 26 million tons of Eucalyptus and 5 million tons of Pine tree in 2012. The conversion to cubic meter used was 1.04 for Pine tree and 1.15 for Eucalyptus according to SBS,2008.

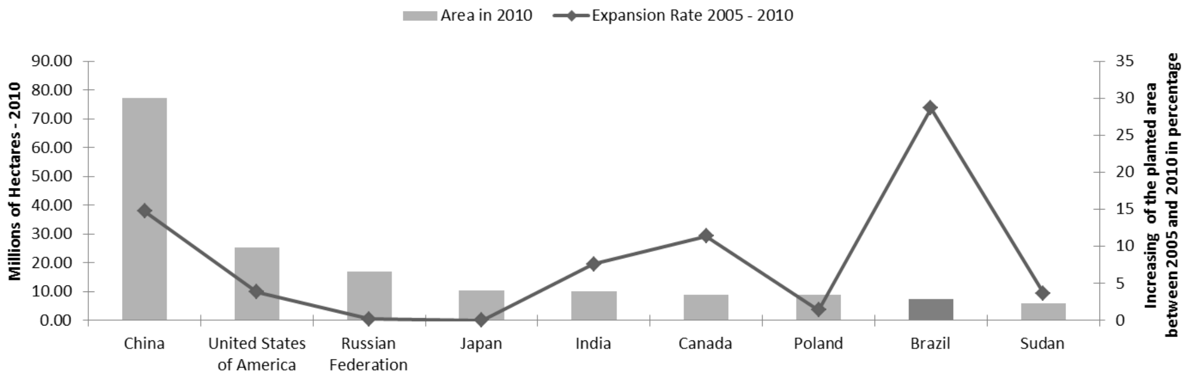
These benefits encouraged institutions to acquire timberlands. While in 2005, they owned approximately 22 billion dollars (SWITZER, 2006), in 2011, the investment achieved 50 billion dollars (FAO, 2012). In order to manage the economic returns from timberland assets, two groups of professional investors were created: (i) Timberland Investment Management Organization (TIMO) and (ii) Real Estate Investment Trust (REIT).

TIMOs manage timberland portfolios to maximize their financial returns. They analyze business opportunities and investments in productive timberlands. By the TIMOs, investors become owners of the land and their profit come from real estate speculation and timber production. REITs have the same purpose as TIMOs; however, they have a different structure. REITs have tax advantages that are linked to the real estate trust market in the U.S.A. Besides, REIT works similarly to bound markets, from which any investor can buy shares in a public traded REIT. Therefore, REIT has more liquidity than TIMO.

REITs and TIMOs are on the rise in the U.S. and worldwide. Their structure makes it easier for an investor to get into the forest business. Furthermore, timberland has attracted investors to most productive forest countries in the world, namely Brazil, Chile, Canada, Uruguay, Central America, Australia, New Zealand and Eastern Europe (FAO, 2012). Among these countries, Brazil has shown promising characteristics.

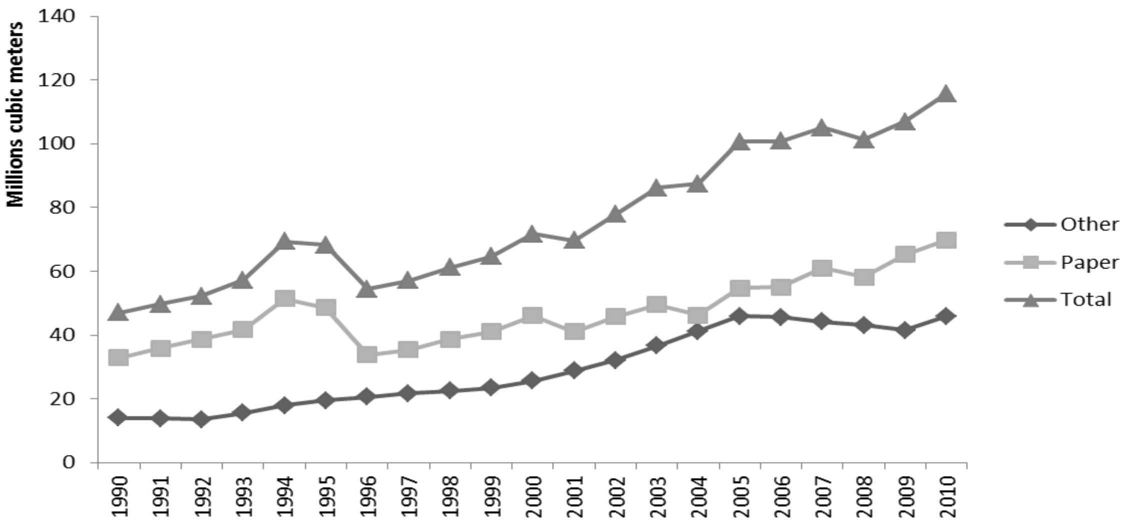
1.4 Brazilian Forest Sector

Although Brazil has only 6.5 million hectares covered with forest plantations (2.8 % of the total planted forest in the world) (ABRAF, 2012), the country has an important role in the forest production sector. High wood productivity, land availability and relative low cost assigned the country among the most promising forest producers. The area covered with forest plantations in Brazil increased 30 % between 2005 and 2010, while China, USA and Russia increased 14 %, 4 % and 0.7 %, respectively, during the same period (Graph 1.1).



Graph 1.1Planted forest in the world. Source: FAOSTAT - FAO, 2010

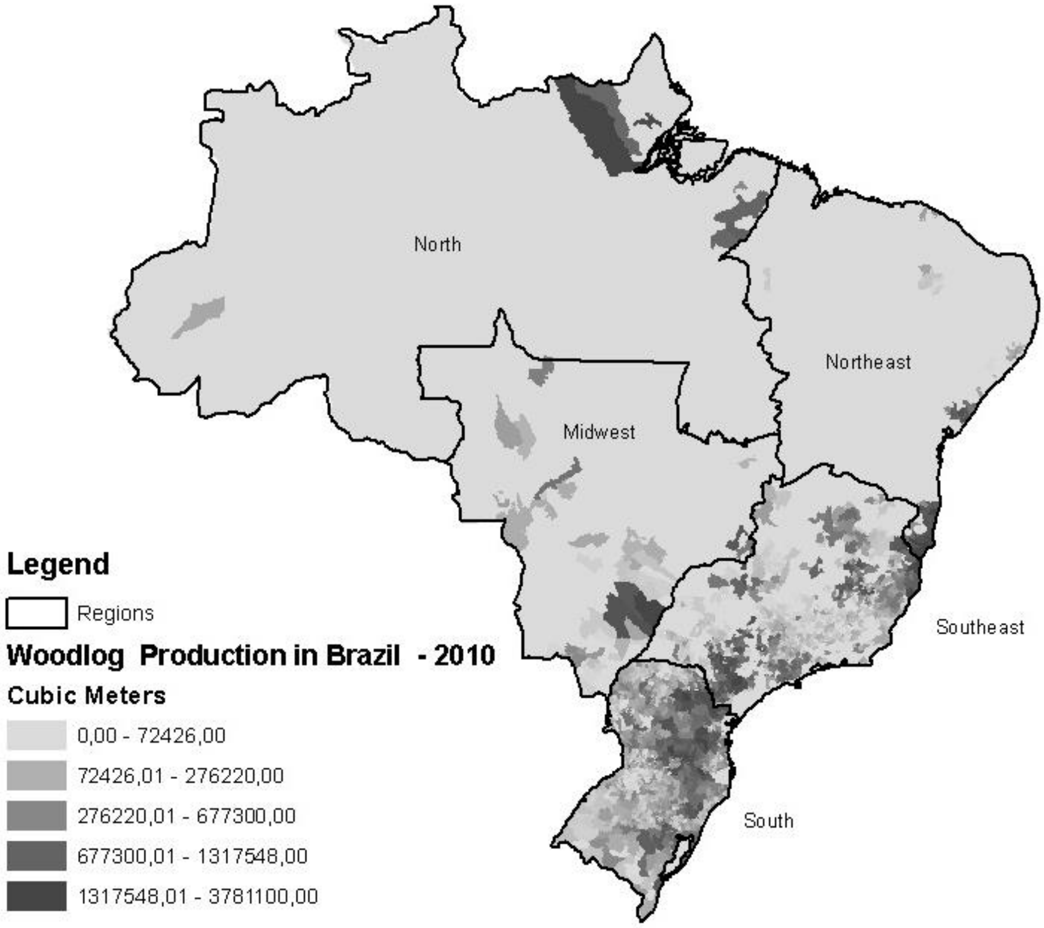
The planted forest production in Brazil increased 145 % (47 million to 115 million cubic meters) between 1990 and 2010 according to the Brazilian Institute of Geography and Statistics (IBGE). The production demonstrates a linear growth with an annual increase of 5.5 % (Graph 1.3).



Graph 1.2 Wood log productions in Brazil. Source: SIDRA - IBGE,2010.

In 2010, wood production from the pulp and paper sector amounted 69 million cubic meters, while, the volume produced for sawmill and chipping industries reached 45 million cubic meters. The difference in volume produced is related to the investment in the sector; once, 10 billion dollars was invested in pulp and paper over the last 10 years, as reported the BRACELPA (2012). Furthermore, demand from the international market increased sharply in recent years, mainly from China. In 2000, 39.5 % of cellulose production in Brazil was exported, while in 2009, exports totaled 62.9 % (MONTEBELLO; BACHA, 2011). Additionally, the international and national demands for fuel wood increased over the last years. Fuel wood production will gain a significant role in the wood production in the next years in Brazil.

Due to the presence of larger markets, forest production is concentrated in the Southern and Southeastern regions of Brazil (Graph 1.3).Altogether, these regions account for 78 % of the total production in the country (91 million cubic meters) (IBGE, 2010).



Graph 1.3 Wood productions in Brazil. Source: SIDRA - IBGE, 2010.

Most success of Brazilian plantations is credited to the biological growth of trees and to a strong internal wood market. On average, the tree growth rate is 41 cubic meters per year for Eucalyptus and 37 cubic meters per year for Pine. Trees in Brazil grow 30 % more than any place in the world (ABRAF, 2012).

The perspectives for new investments in timberland in the country are high. The Brazilian government and investors are exploring new regions and promoting the establishment of new-planted areas. Macroeconomic perspectives and domestic demand for wood products have attracted investors throughout the world to invest in the Brazilian planted forests.

1.5 Thesis purpose and structure

Timberland is one of the most attractive assets in the current economy scenario. The macroeconomic scenario encourages a range of investors to acquire and manage forest assets in order to maximize returns and minimized risks in their portfolio. To achieve success, investors must be aware about factors that influence forest investments. Moreover, the globalization of the forest assets has created new opportunities and made the market more competitive. On the one hand, governments want to attract investors to their country by creating a desirable environment for businesses, and, on the other hand, investors are seeking for more profitable and safe environments for their investments. These combinations have increased the competition among countries and among investors. South America, especially Brazil, is one of the most promising regions to invest in timberland.

The purpose of this research is to analyze the strategies of timberland investors and timberland investment as a whole. To achieve this goal, the thesis is divided into two chapters: (1) Timberland Investment Management Organization (TIMO) strategies for forest plantations investments in Brazil and in the U.S.A. and (2) The economic competitiveness among traditional regions and new agricultural frontiers in forest investments in Brazil.

In the first chapter, we prepared a survey covering the main aspects regarding timberland investments and applied it to the main American TIMOs, which, either current have investments in Brazil or are looking for opportunities in the country.

The second chapter approaches the influence of land price on timberland investment in Brazil. Based on an assessment of production costs, we performed cash flow analyses to understand the factors that are making new agricultural frontiers in Brazil more attractive than others for forest investors.

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2 TIMBERLAND INVESTMENT MANAGEMENT ORGANIZATION (TIMO) STRATEGIES FOR FOREST PLANTATION INVESTMENT IN BRAZIL

Abstract

Timberland investments have become popular among institutional investors in the last decades. The long term, relative low risk and reasonable returns of investments are among the features that have encouraged institutional investors to include timberland asset in their portfolio. Among other investors, Timberland Investment Management Organization (TIMO) has had a meaningful expansion. TIMOs aim to maximize financial returns to their clients (pension funds, insurance and financial institutes) by purchasing and selling timberland and providing their services. They began their business in the U.S.A. and, they are currently investing in all standard forest producing countries. Brazil stands out as one of the most attractive countries for timberland investments in the world. The purpose of this chapter is to analyze TIMOs strategies and preferences regarding new international timberland investments. We elaborated an open-ended survey covering the key aspects that affect the decision-making process of international investor in timberland. We applied the survey to the American TIMOs that current have or intend to have timberland assets in Brazil. Moreover, we performed a cluster analysis to identify different groups macroeconomic, institutional and forest aspects analyzed. The TIMOs presented different strategies in forest asset investments. As expected, the surveys show that returns and risks are the most crucial aspects for investments; however, political risks, land prices and personal security might be crucial to some respondents. The cluster analysis identified two distinguished groups among for aspect proposed. One includes the aspects related to economic perspective and another to institutional perspective. The TIMOs are still willing to invest in Brazil; the country presents several desirable characteristics; nevertheless, the infrastructure and political risks such as the Codigo Florestal and land acquisition from foreign investors delay or inhibit some TIMOs investors.

Keywords: Business strategies; Cluster analysis; International investments, Financial returns, Forest asset investments.

Resumo

O investimento em ativos florestais tornou-se popular entre os investidores institucionais nas últimas décadas.Determinadas caracteristicas como longo de horizonte, baixo risco e razoável retornos econômicos tem incentivado determinados investidores a incluir ativos florestais em seus portifólios. As *Timberland Investment Management Organization* (TIMOs) tiveram um crescimento expressivo nos últimos anos. As TIMOs tem como objetivo maximizar os retornos economicos de seus clientes (fundos de pensão, seguradoras, e outras instituições financeiras) comprando e vendendo terras florestais e comercializando seus produtos. As TIMOs iniciaram suas operações nos Estados Unidos e atualmente estão investindo em todos os países produtores de florestas. Brazil é considerado uma das mais atrativas regiões para se investir em ativos florestais. O objetivo desse capítulo é analizar as estratégias e preferências das TIMOs em investmentos internacionais. Nós elaboramos um questionário para investigar as principais influências na decisão em investimentos internacionais em ativos florestais. Esse questionário foi respondido por TIMOs americanas as quais possuem ou deseja futuramente investir em ativos florestal no Brasil. Além disso, nós utilizamos técnicas de análise de agrupamento para identificar os diferentes grupos entre os principais aspectos analisados. As TIMOs apresentam diferentes estratégias em investimentos em ativos florestais. Como esperado, retorno e risco foram considerados os mais importantes, entretanto, risco político, preço de terra e risco pessoal possuem forte influências na tomada decisão das TIMOs. A análise de cluster identificou dois grupos distintos entre os aspectos estudados, o primeiro é composto principalmente por aspectos economicos e o segundo por aspectos institucionais. As TIMOs tem interesse em investir no Brazil, o país apresenta muitas características atrativas, entretanto, a infra estrutura e o risco político, como a indecisão gerada pelo Código Florestal e a barreira na compra de terras, por capital estrangeiro são alguns dos obstáculos que atrasam ou inibem os investimentos das TIMOs.

Palavras - chaves: Estratégias de negócio; Análises de agrupamento; Investimentos internacionais; Retornos financeiros; Investimentos em ativos florestais.

2.1 Introduction

Investments in forest assets are well known as long-term alternatives with relative low risk and attractive returns. These features have encouraged institutional investors to manage timberland investments and consequently, diversify their portfolio and minimize the risks (CLEMENTS et al., 2011; HAGENSTEIN, 1984; REDMOND; CUBBAGE, F. W., 1988a).

In order to capitalize such investments, specific financial institutions called Timberland Investment Management Organization (TIMOs) were created. TIMOs aim to maximize the value of timberland asset by managing and commercialized their products (BOWYER; HOWER, 2007).

By using a TIMO, the investor becomes the owner of the land and the TIMO specialists guide them to the most profitable management strategy. TIMOs can operate their investments by two primary models: (i) closed-end funds and (ii) separate accounts. The closed-end funds consist of multiple investors who purchase timberland and manage timber for a certain time. Conversely, separate accounts consist of individual investors who purchase the timberland and manage it over an indefinite period.

TIMOs investments were initiated in the United States and have spread their portfolio in countries throughout the world in the last decades. They are looking for new opportunities and places that demonstrate economic potential. Brazil is among the most promising countries in the world in forest production. The country offers a large extension of available land with good potential for planted forests, some of the best plantation growth rates in the world, good access to export markets, and a high level of technology for planted forests and manufacturing.

2.1.1 TIMO motivation

The interest in TIMOs and other types of institutional investments in the United States has been driven by two principal events; (i) the Employee Retirement Income Security Act (ERISA) of 1974 and (ii) the sale of timberland by the forest industry.

One of ERISA’s purpose is to guarantee employees a future amount though pension funds (KEVILLE, 1994). For that purpose, ERISA demands a minimum diversification in the pension fund portfolio and, thus presumably reducing the investment risks.

The second reason was prompted by a major shift in forest ownership, where most industrial timberland was transferred to institutional investors or converted to Real Estate Investment Trust (REITs) (CLUTTER *et al.*, 2005; HAGENSTEIN, 1984). Several factors led to these divestitures: the weak financial performance of the forest products industry; the need of the industry to focus on the manufacturing process; the need to cover debt due to recent acquisitions and mergers in the industry, and the tax policy applied to timberland industry (BLOCK; SAMPLE, 2001). As a result , sales of industrial timberland increased shareholder values and did not impose long-term cost of capital financing (SUN; ZHANG, 2011).

2.1.2 TIMOs and forest investments

In 25 years, the vertically integrated companies of forest products have sold 60 % of their timberland area. In 1980, these companies held 23 million hectares (57 million acres) while, by 2005, their assets decreased to 8.5 million hectares (21 million acres) (LÖNNSTEDT; SEDJO, 2012). The major forest productive lands in the U.S.A. have been sold to either TIMOs or other organizations or converted into REITS.

Among the other players in the timberland market, TIMOs have played an important role. The financial impact of TIMOs on the market has been significant. In 1985, TIMOs invested less than US$ 1 billion, while in 2005, TIMOs investments amounted approximately $ 15 billion (MENDELL, 2006 *apud* LÖNNSTEDT; SEDJO, 2012).

TIMOs purchase and manage forestland depending on how attractive the market is for certain products and services in the region, including the land use either for recreational and hunting purposes or for the traditional management for wood products. Such interests have driven investments at a large spectrum of forestland types.

2.1.3 Foreign investments in Brazil

The rapid increase in demand and competition for acquisitions of the best timberland has pushed land prices upward in the U.S.A., consequently, North American TIMOs started searching for new investments overseas. Many funds have become interested in managing international timberlands. Currently, around 0.6 million hectares are managed by TIMOs overseas, e.g., in Latin America, New Zealand, Australia and Indonesia (MENDELL, B. C. *et al.*, 2011).

Although economic risks and political instability may seem lower in developing countries, the usual uncertainty observed in Latin America and Indonesia has been overcome by the higher return rates in timberland investments observed in this region (CUBBAGE, F. *et al.*, 2007, 2010). Among others, Brazil has shown favorable developments in its domestic markets and shown good economic perspectives, becoming one of the most promising countries for forest investments in the world.

With 851 million hectares (2.1 billion acres), Brazil is the largest country in South America and the 5th largest in the world. The country is the 6th economy in the world, with a Gross Domestic Product (GDP) of US$ 3.67 trillion in 2010. Moreover, several credit rating agencies have upgraded Brazil’s risk index. The Emerging Markets Bond Index Global (EMBI +), calculated by the bank J.P. Morgan, measures a country’s risk based on the government debt. In the last 10 years, Brazil’s index decreased 84%. One of the most important indexes, Standard & Poor’s (S&P) upgraded Brazil’s foreign debts from BBB minus to BBB, besides Mexico and South America, which classifies the country with an investment grade as economically stable for business. It is the best position of the country in its entire history.

In this promising economic scenario, forest production has an important contribution to Brazil’s economy. The forest sector accounts for 4% of the Brazilian GDP (SBS, 2008). The country has 516 million hectares (1.2 billion acres) occupied by natural forest, i.e., 56% of the total area. The total area with planted forests covers approximately 7 million hectares (17 million acres), mostly cultivated by Eucalypt and Pine trees; 4.5 and 1.8 million hectares (11.1 and 4.4 million acres) respectively. The areas planted with these species account for 93 % of the total planted area.

Vertically integrated companies forest products companies such as pulp and steel mills own most timberlands. The presence of institutional investors in timberland is relatively new in Brazil. TIMOs started to establish new plantations in 2000 by planting pine in the Southern region of the country. They held approximately 100 thousand hectares (250 thousand acres) in 2005 (MENDES, 2005). According to CONSUFOR (2009), in 2009 TIMOs owned 176,000 hectares (434,000 acres) of the planted area. , an increase of 76% comparing to 2005. .

The interest of international investments in timberland in Brazil is likely to increase in the next few years. I Timberland investments, however, are seen with different criteria and expectations. Planted forests with both Eucalypt and Pine have the highest returns in the world (CUBBAGE, F. *et al.*, 2007, 2010), and timber prices have also risen . Many regions in Brazil have aggressively recruited forest industry and investors, offering large available land areas. These advantages are tempered by some business hindrances and governmental uncertainty.

2.1.4 Research Focus

Despite their recent influence on the timberland market in Brazil, there is no scientific research related to TIMOs activities published in specialized periodicals or journals in the country. Most information available is related to how they operate and the size of their operations (CONSUFOR, 2009; MENDES, 2005; TUOTO, 2007). Furthermore, there is little research on the strategies adopted by TIMOs in any country; in North America or elsewhere.

Information about TIMOs' strategies is essential to understand how they influence the timberland market and to define governmental actions to attract future investors to the country. This chapter aims to redress this lack of studies on TIMOs and initiate new studies and questions about the influence of institutional organizations on the timberland market in Brazil.

The motivation of this research was based on the following hypothesis:

1) There are different strategies and criteria used by TIMOs in the U.S.A. for international investments.

2) Although, there is a large potential market in Brazil, TIMO investments have not achieved their expected size.

3) Macroeconomic, institutional and forest factors have different roles and weight on TIMO's decisions.

We have examined these hypotheses to explain how TIMOs choose their investments overseas and how they build their expectations over new asset acquisitions. This analysis allowed the identification of the main particularities that have affected decisions for forest investments in Brazil.

2.2 Methodology

2.2.2 Research design

This research relied on a mixed qualitative and quantitative survey (Appendix 4.1). The survey was developed in association with Fred Cubbage, professor from the Department of Forestry and Environmental Resources at the North Carolina State University. The survey included questions covering the main strategic aspects about timberland investment in Brazil and in the U.S.A. TIMOs either with current investments or interested to invest in Brazil were invited to participate in the research. The survey was conducted through person-to-person questions or on the phone. Participants were notified by a consent document (Appendix 4.2) about the approximate time required to complete the survey, dataset storage, measures and confidentiality terms. They were not compensated by any source for answering the survey.

As the survey involved interviews and socio-economic dataset analyses, the authors followed standard qualitative research protocols. We developed draft questionnaires, obtained reviews from other colleagues from the forest management sector and professors, and then submitted the questionnaire to the North Carolina State University research review board. The survey was approved by Institutional Review Board (IRB) for the human participants in research at the North Carolina State University and followed all its prescribed principles (Appendix 4.3).

The survey was adapted from the forest investments attractiveness index elaborated by the Inter-American Development Bank (IADB, 2008) and combined with complementary questions formulated by the authors. The survey covered four aspects of forest investment:

1) Background information: this section covers the companies' structure information like current experience in forest asset investments, amount of funds under management, location and size of the forest assets and the approach in new investments oversea.

2) Investment decision: it gathers information about the TIMOs' preferences in forest asset investments; the relevance of macroeconomics; infrastructure; and forest factors on the process of choosing new investments.
3) Investor preferences: it covered investors' expectation in timberland investment and the process to become a timberland investor.
4) Future perspectives for timber investment.

We applied open-closed questions during the interviews. We performed all the interviews orally without any tape recording. This method was chosen to make the individuals interviewed more comfortable, since they were addressing sensitive corporate strategic information. We then digitally stored the tabular closed-end questions, and wrote quotes as reliable as possible to the interview. There still was probably lack of exactness in this method, but it was more likely to garner candid responses and open discussion. Thus, the quotes showed in the following results analysis may not be identical to what the interviewees said. However, they are very close and accurate in their intent, as it will be shown in the results.

The cluster analysis approach was used in the data from the macroeconomic, institutional and forest factors that influence investment decisions. In this approach, a rank system was performed to understand different investors' aspects and perspectives related to the factors that they quoted during the interview. The results obtained were analyzed using multivariate methods known as the Cluster Analysis and some descriptive statistical summaries.

2.2.2 The Cluster analysis

The cluster analysis aims to group objects in similar clusters. This analysis identifies cluster of objects with a strong internal homogeneity and, simultaneously, a strong heterogeneity among the different clusters. Unlike other multivariate methods, the cluster analysis does not estimate a statistical variable. Actually, the purpose of this analysis is to compare different objects based on a statistical variable (the rank system granted by the interviewees).

2.2.3 Dataset

We listed 24 aspects in the questionnaire presumed as possible reasons for TIMO investments in Brazil. They were divided into macroeconomic, institutional and forest factors (Table 2.1) in the survey. The interviewees were asked to grand each aspect from 1 to 5, in which the number 1 was assigned to an unimportant or none influence in the investors decision and 5 to the most important aspect in the investment strategies.

Table 2.1 - Variables used for the ranking questions

Variables	Broad Factor
Investment returns	Forest
Investment risks	Forest
Timber markets	Forest
Environmental laws	Forest
Technical capacity	Forest
Forest certification	Forest
Social/community relation	Forest
Timber growth rates	Forest
Incentives and subsidies	Forest
Land ownership laws	Institutional
Tax complexity	Institutional
Ease of doing business	Institutional
Land price	Institutional
Tax rates	Institutional
Infrastructure	Institutional
Current land use	Institutional
Land location	Institutional
Access to domestic credit	Institutional
Political risk	Macroeconomics
Market size	Macroeconomics
Trade	Macroeconomics
GDP	Macroeconomics
Personal risk	Macroeconomics
GDP Growth	Macroeconomics

2.2.4 The Cluster Method

2.2.4.1 Software R

We used the R statistical software, version 2.1.4.1 for the cluster analysis. The distance analysis was performed by using the *ecodist* package of the software. All the commands used are shown in Appendix 4.4.

2.2.4.2 The Cluster analysis

We used the hierarchical method in the cluster analysis. This method is based on hierarchies of likelihood (or unlikelihood) scores, which the results are expressed as dendrograms and the distances along one axis represent degrees of likelihood (or unlikelihood). This method relies on three characteristics: (1) simplicity, (2) adequacy to the variables selected and (3) mostly, no need to determine parameters (called “seeds”) before the analysis as in non-hierarchical methods (HAIR, et al., 2007).

After selecting the hierarchical method, the similarity index was computed. The correlation coefficient was the most adequate indexes for the present dataset; other indexes, such as Mahalanobis and Euclidean Distance showed less stability. Therefore, we measured the correlation between the variable resulting in a correlation matrix. The correlation is defined by the following formula:

$$\rho_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x}).(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}.\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} = \frac{cov(X,Y)}{\sqrt{var(x).var(Y)}} \qquad (2.1)$$

Where:

$x_1 + x_2 + \ldots x_n$ and $y_1 + y_2 + \ldots y_n$ are the values measured,

$\bar{x}$ and $\bar{y}$ are the means,

Cov means the covariance and,

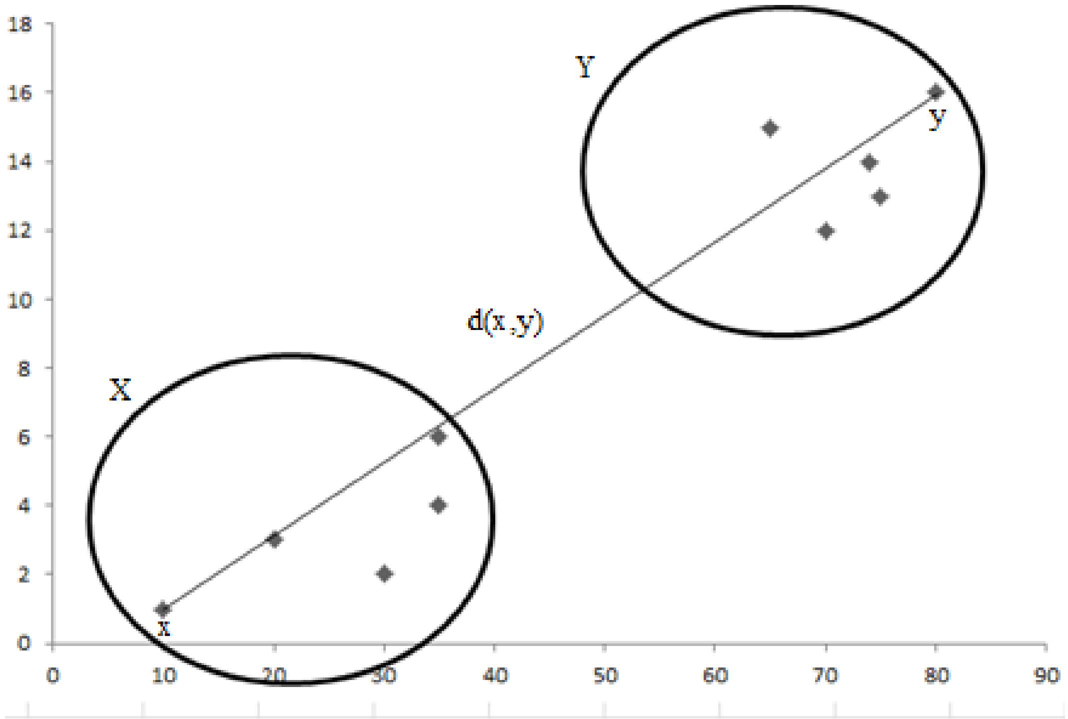
Var means the variance.

The variables were identified and grouped forming different clusters using the correlation measure.

2.2.6 Hierarchical Algorithms

The cluster procedure was performed using Complete linkage algorithm. This method is based on the maximum distance between observations in each cluster. At each stage of the hierarchical procedure, clusters with the shortest maximum distance (most similar) are combined.

In others words, the distance between clusters is computed as the maximum distance between a pair of objects; one in one cluster, and one in the other (HAIR, et al.,2007) (Graph 2.1).



Graph 2.1 Example of Complete – linkage method

The Complete-linkage criterion is expressed mathematically as:

$$D(X,Y) = \max(d(x,y)) \quad (2.2)$$

Where:
D(X,Y) is the distance between clusters,
d(x,y) is the distance between objects and,
x and y ∈ to X and Y.

2.2 Results

In this section, we present the results of the survey and analyses. A general overview of the survey respondents is shown first. Then, aggregated results and results by factor are discussed. Finally, we show the results of the cluster analysis.

2.3.1 Participants

We conducted the interviews in person and by conference calls between April 17 and June 18, 2012. Among the TIMOs with current investments or interested in investing in Brazil, eight participated in the structured interviews.

The number of participants was considered reasonable due to the current numbers of TIMOs effectively investing in Brazil. According to research conducted by CONSUFOR, in 2009, six TIMOs are investing in Brazil (CONSUFOR *apud* AMATA, 2009). Mendell et al (2011) considered thirteen participants in their analysis of investors' perspectives of timberland investments in Colombia.

2.3.2 Background Information

The TIMOs have 15 years of experience on average. The oldest has 40 years and the youngest has less than 3 years. The number of years in existence, though, does not reflect managers' experience in managing forest assets. Almost all interviewed experts worked either for another TIMO or in the forest products industry before starting their current business. "The market demanded new TIMOs, we saw an opportunity to found your own", noted one of the experts about the creation of new

TIMOs in the last decades. Staffs of experts that either used to work for others TIMOs or had experience on other forest companies compose the TIMOs . TIMOs have been operating in the U.S.A. since 1983, while American TIMOs started their business in Brazil in 2000.

The location of the TIMOs investments varies according to the business opportunities and background. According to the respondents, “knowing the location facilitates the market and risk analysis”. Currently TIMOs are investing in Uruguay, Eastern Europe, Brazil, China, New Zealand, Australia, the U.S.A. and Canada. Most participants interviewed had assets in the Northeastern and Southeastern regions in the U.S.A. In Brazil, most of the forest assets are located in the Southern region.

TIMOs do not demonstrate any specific strategy or preference for specific species. Normally, the selection of species is based on the market demand. However, some TIMOs are specialized in a class of species such as hardwood and pine. “The specialization makes us and our clients more comfortable to invest in some regions”, noted one of the respondents.

Most of TIMOs interviewed (42%) are Limited Liability Corporations. C-Corporation and S-Corporation account for 28% and 14% of the TIMOs in the USA, respectively. This diversity of business type does not exist in Brazil, where 100% of the TIMOs are registered as Limited Liability (*Limitada*) companies.

Even though for legal and commercial purposes they were registered under the same business category in Brazil, TIMOs adopted different strategies to start their business. The most used strategies involved acquiring an existing company, developing a partnership with a local company and establishing their own branch. The participants stated that the legal arrangements in Brazil are a very bureaucratic process; “It is by far the most arduous process among our forest assets” said one of the interviewees. This obstacle to do business is corroborated in other studies. Brazil is among the most difficult countries to do business in the world (THE WORLD BANK, in 2012). The country is the 126th place of 183 countries ranked by the financial institution. Among the Latin America and the Caribbean countries, Brazil takes the 28th position of 32 countries. Chile is in the first position among the countries of Latin America and the Caribbean and by far the most promising in this aspect occupying the 35th position in the world.

2.3.3 General Analysis

For the ranking of the broad factors that affect investments, the forest features were more relevant in the investment decision (Table 2.2). However, this result should be seen with caution because the standard deviation was greater for this aspect. The macroeconomic factors followed by the institutional factors showed a lower standard deviation. Therefore, the TIMOs tended to have common opinions about these two aspects.

Table 2.2 Investment decision factors

	Macroeconomic	**Institutional**	**Forest**
Average	3.64	3.54	3.89
Standard Deviatioı	0.64	0.84	0.96

For individual investment decision factors, investment returns and risks were the most important aspects in an investment decision (Table 2.3).

Table 2.3 Rank of the investment factors

Aspect	Sector	Grade	Rank
Investment returns	Forest	5.00	1
Investment risks	Forest	4.71	2
Political risk	Macroeconomics	4.50	3
Timber markets	Forest	4.43	4
Land ownership laws	Institutional	4.43	4
Market size	Macroeconomics	4.33	5
Environmental laws	Forest	4.29	6
Tax complexity	Institutional	4.00	7
Technical capacity	Forest	3.86	8
Forest certification	Forest	3.86	8
Ease of doing business	Institutional	3.86	8
Social/community relation	Forest	3.71	9
Land price	Institutional	3.71	9
Tax rates	Institutional	3.71	9
Trade	Macroeconomics	3.67	10
Infrastructure	Institutional	3.57	11
Current land use	Institutional	3.57	11
Land location	Institutional	3.57	11
Timber growth rates	Forest	3.43	12
GDP	Macroeconomics	3.17	13
Personal risk	Macroeconomics	3.17	13
GDP – Growth	Macroeconomics	3.00	14
Incentives and subsidies	Forest	1.71	15
Access to domestic credit	Institutional	1.43	16

The top 5 elements are composed by 50 % of Forest, 33% of macroeconomic and 17% of institutional factors, while, the last 5 elements are composed by 22 % of Forest, 33% of macroeconomic and 44% institutional. These individual elements are discussed later in this section.

The views differed in terms of the importance of the criteria studied. One participant had similar opinions as the average results, which showed that macroeconomics and forest had 40% each and institutional 20% of importance in decision for timberland investment. Another participant claimed that the institutional is the most important factor. He states that a weakness in institutional factors could make the investment unviable in the first analysis. “There must have an institutional support from the government to make all kinds of investment viable”, concluded one of the participants.

Other TIMOs preferred to discuss specific factors, such as return, risk diversification, land price and the timber market. “The factors complement each other; however, some clients would like to see a few numbers, mainly the investment returns” observed one of the participant. In general, they agree that, all factors are relevant and some of them demand more attention than others, depending on the objective and strategies adopted by each TIMO.

2.3.4 Broad Factor Analysis

Our respondents indicated that, the decision for an investment is based on a balanced and meticulous analysis of a broad range of macroeconomic, institutional and forest factors. Nevertheless, when participants were asked about how they decide on a new timberland investment, the influence of macroeconomic factors such as, cash flow analysis, political stability, timber markets, and land liquidity were mostly cited.

American TIMOs are still looking for opportunities in the U.S.A.; however, land scarcity, higher prices and the current international experience led them to invest overseas. They claim that the current moment is favorable for international investments. The tradeoff between risk and return is adequate with their expectation. Furthermore, the access to different market minimizes the risk by diversifying their portfolio (FU, 2012; BLOCK; SAMPLE, 2001; MILLS; HOOVER, 1982; REDMOND; CUBBAGE, F. W., 1988b)

The process of investing internationally is driven by two initiatives: organization seek buyers willing to invest in forest assets. Most TIMOs are currently conducting diligent analysis of investments overseas and demonstrating their potential returns and risk to their clients. On the other hand, some TIMOs analysis initiative comes from the client as cited by one of the respondents: “We invest wherever the clients say so”; “We manage land according to the client’s choice”.

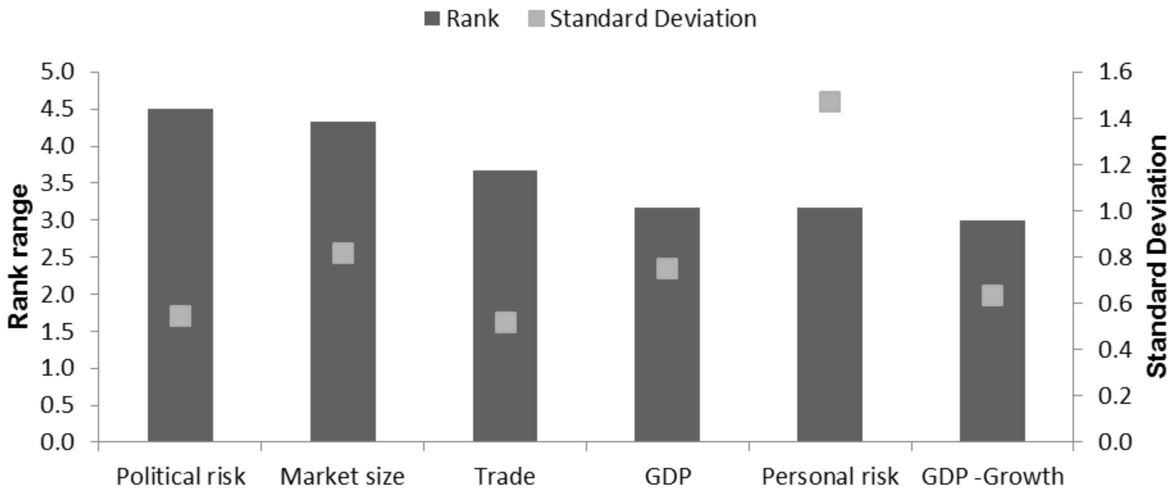
Investments in tree plantations are the most popular among the TIMOs. The property location is the decisive reason in the process of choosing between plantation and natural forest management. In the U.S.A., investments in the Southern region are mainly in forest plantation due to the local market conditions and favorable forest characteristics. Investments in natural forests are made in a few regions in the U.S.A. and in Europe. TIMOs state that the legal and political risks are too high compared to the return of investments in tropical forests.

2.2.5 Investment decision

As mentioned before, the decision on a timberland investment is a careful process. Each TIMO has its own strategy and investment preferences. This reflects directly on the way they analyze the assets returns and risks. The following topics discuss the impact and the different perspectives of macroeconomic, institutional and forest factors on TIMOs' decisions.

2.3.5.1 Macroeconomics

Political risk and market size are the most important factors in the macroeconomic analysis (Graph 2.2). According to TIMOs, investors considered the political situation crucial in an investment analysis. Moreover, political issues are largely reported in different means of communication such as television and the Internet. One of the respondents mentioned as example the nationalization of a Spanish oil company (Repsol) in Argentina recently: "Nowadays, Argentina is not an interesting place to invest and it will take a long time to become interesting again".



Graph 2.2 Rank of the macroeconomic factors of timberland investment

Large markets guarantee large wood consumption level and thus, a safe market in the long term. Personal risk and GDP growth rates were considered less important compared to other macroeconomic factors. Most participants considered the GDP more important than the GDP growth. “GDP is a better indicator of the actual consuming power”, noted one respondent .Most TIMOs’ assets are in countries with high GDP levels and with growth rates either stable or constantly increasing, e.g., the U.S.A., Brazil and China. However, when considering the potential demand for wood products, the countries with high growth rates become markets that are more attractive in a short-term.

Personal risks are taken into account, but not as much as other factors in the investment decision. However, few participants considered this aspect essential as we can observe in the standard deviation of 1.51 (Graph 2.2). “We will not invest in a country where our employees might be exposed to some danger”, said one of the respondents.

Besides the macroeconomic aspects already incorporated to the questionnaire, TIMOs reported other four important aspects: (i) corruption, (ii) land availability, (iii) currency exchange and (iv) legal risk.

Corruption levels are based on the Corruption Perception Index (CPI),(TI, 2010) elaborated by the non-governmental organization called Transparency International, since 1995. CPI ranks corruption levels from 1 (high level) to 10 (lower level). As corruption is correlated with other investments risks, higher levels discourage investments in certain regions, e.g., most African continent and Middle Eastern countries have CPI below 2, while the U.S.A., Brazil and China have 7.1, 3.8 and 3.6

respectively. “However, if it does not harm the business, some level of corruption is acceptable”, noted one of the respondents.

Land availability was an interesting aspect cited during the interviews. “Some places have everything we require to invest, but finding available land demands patience and hard work”, explained one of the interviewees. In other words, some regions are very attractive, but do not have land available with desirable characteristics, even if the TIMOs are willing to pay higher prices. In a competitive land market, most large and attractive timberlands are scarce or inexistent. Among other reasons, land availability is driving TIMOs to new unexplored forest regions.

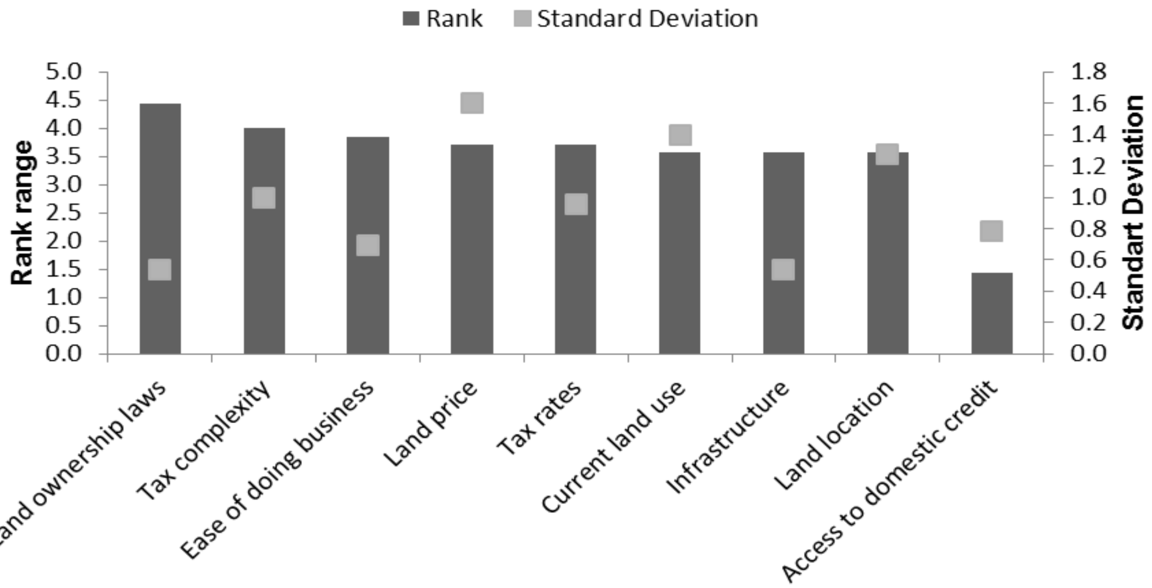
Exchange rates were mentioned as an important aspect regarding the international investments. The acquisition power of American TIMOs is higher when the dollar is stronger than the local currency as one of the respondents quoted: “In the end, we have to convert everything to dollars; so, the current exchange rate can make a huge difference”. In Brazil, for example, the exchange rate between dollar and real affects land acquisition regarding competitiveness of timber products for exports .Therefore, the entire timber production chain is affected by the exchange rate level.

Concerns with the legal risk are correlated with political risks, according to interviewees. TIMO feels more comfortable to invest in a country where the legal system demonstrates stability. The changing on the *Código Florestal* in Brazil is good example of legal risk as a TIMO stated: “We would like to be certain we are working legally. This uncertainty is not good for the business”. As the assets are appraised annually, the change in the land use laws would compromise the value as well as future acquisition decisions.

The lack of a land title was another concern mentioned by the TIMOs. In the acquisition process, all of the TIMOs complained about the difficulty to find a trusted land title. As they reported, this process should be the easiest part in the negotiation; however, it is a critical decision. In Brazil, according to the Brazilian Colonization and Land Reform (INCRA), 70% of the territory or 605 million hectares (1.5 billion acres) were registered legally in 2012. It does not mean that these properties are regulated according to the environmental laws. The absence of a land title or the presence of the illegal ones can be found more frequently in regions with less social and economic development. Even Brazilian investors hire specialists to verify the legitimacy of the title, thereby increasing the cost and time of negotiation. “The high risk to buy an illegal or nonexistent property has delayed or cancelled some TIMOs' acquisitions", concluded one respondent.

2.3.5.2 Institutional

According to the rank elaborated with the institutional aspects, landownership laws and tax complexity are the most important factors for timberland investment (Graph 2.3).



Graph 2.3 Rank of the institutional factors for timberland investment

Land ownership laws affect the acquisition process. Most TIMOs are concerned with restrictions in Latin America for foreign landownership; Brazil and Uruguay were the most quoted examples. Both countries claim national security and sovereignty to justify such restrictions. TIMOs understand that this law should be reconsidered for large territories such as Brazil. However, they still feel motivated to invest in the country even with this obstacle; "It made the acquisition harder, but not impossible" affirmed one of the interviewees. On the other hand, it drives investors to search for other regions. "These restrictions are affecting the decision whether or not to invest in the country for some clients", as noted by one of the TIMOs. The Brazilian Association of the Planted Forest Producers (ABRAF) claims that, since the adoption of land purchase restriction to foreign investors in 2010, many projects in the forest sector were cancelled or suspended involving a total value of US$ 20 billion dollars (ABRAF, 2011).

Tax complexity was mentioned due to its influence on the cash flow analysis. In a complex system, it is necessary to hire an experienced accountant in order to decide the best tax strategy. This factor was more relevant in timberland investments overseas as noted by one of the survey participants “We understand the tax system here, the problem is the tax complexity overseas.”

Business viability affects investments according to the country. It was considered an important factor in general, TIMOs showed more patience with new markets. The slow acquisition process is attributed to the need for diligence studies. After the studies are concluded, the bureaucratic process does not take longer than required. In Brazil, investors expected a maximum period of 6 months after the due diligence analyses. This time is six-fold longer than in the USA, where all the transaction can be done in a few days (THE WORLD BANK, 2012).

However, the attractiveness of Brazil to the forest business seems to overcome difficulties to start a business, as noted by one of the participants: “Brazil is among the countries where we have to be most patient.” Surprisingly, land price was ranked in the 4th place among the institutional factors. The high land price could compromise the investment; on the other hand, for some TIMOs land price is less relevant for long-term investments. They argue that land price is more important after the acquisition, during the asset management. The land price is compensated by the real estate market: “If we can make money selling the property, we will purchase it”, “our business is the timber as well as the land market”, noted by one of the interviewees.

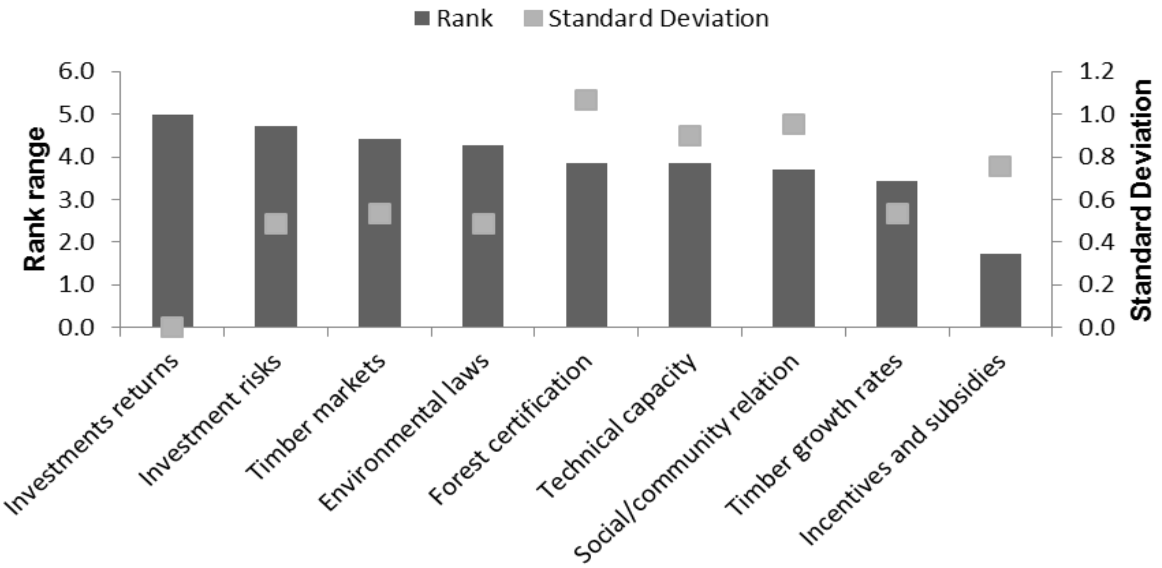
The standard deviation of the land price aspect was the highest in the ranking. This result demonstrates the significant caution of some TIMOs regarding this aspect while others do not consider it essential. “We look for investments worldwide, if we see the land price as a barrier in a determined country, we will look for other opportunities elsewhere”, concluded one participant.

Land location was pertinent for all TIMOs except one; “the market will show where the good land is”. This factor might not have influence in a country with access to good transportation systems, infrastructure and a mature market, such as the U.S.A. On the other hand, in developing countries with a poor infrastructure system, the choice of a property near or with easy access to the road means the tradeoff between success and failure. The difficulty to transport the wood would be so high that, it would demand investment in infrastructure beyond the property limits. “There would be a high cost effect on timberland located in regions with precarious infrastructure", noted one of the TIMOs. On the other hand, the vertically integrated companies in Brazil invest in infrastructure like roads and even in harbors to transport their products. TIMOs do not seem to make such external investment. According to them, the production chain is one of reasons that places infrastructure as important as the land location for timberland investment.

Access to local credit was considered little or irrelevant by the respondents for investments in timberland, as can be observed in the following quote: "A timberland investment cannot be based on local credit; the investment must be profitable by itself."

2.3.5.3 Forest

As expected, investment returns and risks are the most important among the forest aspects (Graph 2.4). "Risk and investment returns are the reason for every investment", "Ultimately, these two aspects decide the present and future investments" and "These variables included all the other aspects for the investment" are some examples of the definition of investment returns and risks by the participants. Additionally, investment returns were considered even more important than the risks. According to TIMOs, return of investments is easier to figure out with numbers, while, some risks are impossible to predict.



Graph 2.4 Forest factors on timberland investments

The timber growth rates were not very relevant in the investment analysis reported by the TIMOs; the investment is closely correlated with the market. In other words, the price paid by the market converts the timber growth rate automatically to monetary value, subsequently, integrated to a cash flow models. “The timber price must correspond with the timber growth”, affirmed one of the interviewees. Another TIMO noted that, “In some markets, the timber will not pay a premium price for slower growth or higher quality wood, therefore, fast growth is important and financially advantageous”.

TIMOs are open to the process of timberland certification, according to one of the respondents. Fifteen per cent of the TIMOs interviewed prioritize forest certification. However, according to them, this process will be done if the market or the clients demand such regulation. “The timber certification is driven according to the timber market demand, if there is a payback of the process, we will certify our forest”, quoted one of the TIMOs. Some specific export markets and European clients have the highest concern with forest certification.

The technical capacity is an essential factor discussed during the interviews. The communication between the TIMOs and the company that manage the forest is the main aspect in international investments. As reported by a TIMO: “In Brazil for example, forest management is heavily based on volume increment models. The economic aspect is much more relevant to us”.

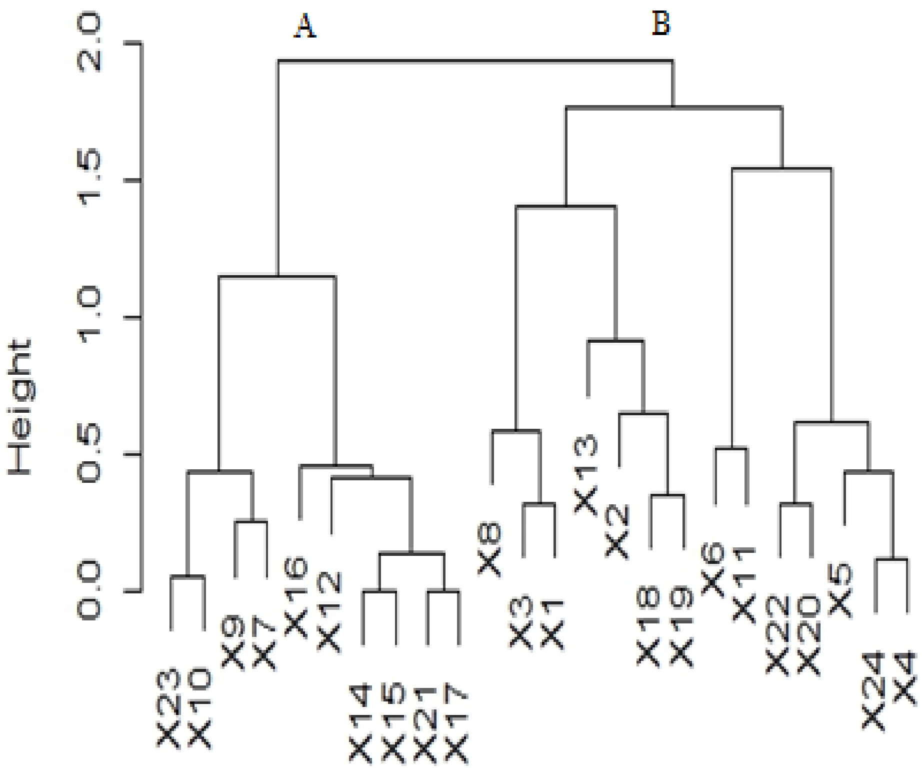
Incentives and subsidies were not as important as the other factors studied in timberland investment. The reason is the same as the access to local credit “the business cannot rely on these bonuses”, as reported the TIMOs.

2.2.6 Cluster Analysis

The cluster analyses we performed are described below. We used the cluster approach to identify factors that are related to each other in making an investment as a new means to test the merits of the IADB approach we used initially.

2.2.6.1 Variables Analysis:

The cluster analysis was used to assess the broad factors that affect TIMO forest investments by analyzing the pattern of each individual factor discussed above, without any prior classification into broad factors. The analysis showed that the variables are not allocated to the same broad factors (microeconomics, institutional and forest) as presented at the beginning of this research. Instead, the following cluster analysis dendrograms demonstrate the division of the individual variables in two broad clusters:



Graph 2.5 Cluster Dendrograms

Where:

Table 2.4 Cluster dendrograms results

Code	Variables	Broad Factor	Cluster
X23	Forest certification	Forest	A
X16	Timber growth rates	Forest	
X17	Timber markets	Forest	
X21	Environmental laws	Forest	
X7	Infrastructure	Institutional	
X9	Land ownership laws	Institutional	
X10	Current land use	Institutional	
X12	Land location	Institutional	
X14	Tax rates	Institutional	
X15	Tax complexity	Institutional	
X18	Investment returns	Forest	B
X19	Investment risks	Forest	
X22	Social/community relation	Forest	
X20	Technical capacity	Forest	
X24	Incentives and subsidies	Forest	
X8	Ease of doing business	Institutional	
X13	Access to domestic credit	Institutional	
X11	Land price	Institutional	
X1	GDP	Macroeconomics	
X3	Market size	Macroeconomics	
X2	GDP Growth	Macroeconomics	
X6	Trade	Macroeconomics	
X4	Political risk	Macroeconomics	
X5	Personal risk	Macroeconomics	

The variables in cluster A and cluster B were slightly different from the broad factors suggested at the start of the research. Cluster B has variables that are directly connected with economic factors, except for technical capacity and social/community relation. Cluster A is composed mostly by forest and institutional variables that indirectly affect timber investment. The timber market is the only one directly related with economic issues.

Some of the individual relationships in the dendrograms seem quite logical, which help to support the merits in the cluster analysis. For example, in class A, factors X14 and X15, tax rates and tax complexity were in the same branch (Graph 2.5). Forest certification and current land use were "twinned" in one branch, as well as land ownership laws and infrastructure. Timber growth rates and land location were grouped together at a higher level in the dendrograms. These were all combined to determine most forest and institutional factors in Cluster A.

In Cluster B, the four sets of twins at the lower levels: (1) GDP and market size, (2) investment returns and investment risks; (3) social/community relations and technical capacity; and (4) incentives and subsidies and political risk. All in all, these pairs were moderately to extremely logical; risks and returns of investment for example had the highest grade in the general analysis (Table 2.3) and their relation and importance were also mentioned in open questions (topic 2.3.5.3 Forest).

Another result that also supported the cluster approach was the division of the institutional and forest factors that were divided between factors that have high correlation to the market (X19, X18, X22, X20, and X24 of the forest group and X8, X13, X11 of the institutional group) and high correlation with no parameters for the market (Cluster A).

The results showed therefore, the allocation of these variables in two factors such as institutional and biological factors for cluster A and economic factors for cluster B. Other detailed breakdowns many be conceptually useful; however, the interviews indicated that TIMOs operationalized them somewhat differently in their decisions.

2.2.7 Minimum Acceptable Rate of Return

The investment decision analysis does not differ for countries as noted by 50% of the respondents. One of the TIMOs claimed that only an adjustment between risk and return of investment is required. However, respondents say that more caution on the decision is necessary for investments overseas: "Some factors in Brazil are not as clear as they are in the U.S.A".

These aspects directly affect the financial criteria such as Minimum Acceptable Rate of Return (MARR), also called discount rate. The discount rate that TIMOs use in Brazilian projects is 5 % higher on average than in the projects in the U.S.A. (Table 2.5).

Table 2.5 Discount Rate

Country	**Max**	**Min**	**Average**
Brazil	16	8	11.35
USA	11	5.5	6.11

The value of the discount rate reflects directly the risk of the investment, according to one TIMO. This risk can vary according to the country and the region in the same country. “In remote regions in Brazil the discount rate used are higher than in traditional timberland regions”, reported one of the interviewees. In some cases, the risk in Brazil is even lower than in USA, specifically in the Southern region, due to the strong domestic market and the current economic situation.

The discount rates found in this research showed different results compared to the current literature. In Brazilian investments, LIMA et al., 1997, found the range of 4.5 % to 10.5 % in the linear model analysis. BERGER et al., 2011 used 6 % as a discount rate in an economic analysis of pine plantations in Parana State, Brazil.

The Internal Rate of Return (IRR) demonstrated higher value than the discount rates used by the TIMOs. CUBBAGE, F. et al., 2010 implemented cash flow analysis in timberland investments in Brazil and obtained a range between 16.3 % with *Pinus Eliotti* and 25.5 % with *E. grandis* to sawtimber production without including land cost. With land cost included, this figure decreased to 6 to 8 %. BERGER et al., 2011 has a range between 11.8 % including the land acquisition and 22.1 % without including the land acquisition. In comparison, for timber investments in the U.S.A., CUBBAGE, F. et al., 2010 found the range between 8.5 % in pine investments in the Southern region of the country and 6.5 % in Douglar-Fir, without including land cost.

2.2.8 Investors' Perceptions

Only a few respondents made comments about their investors' perspectives and objectives. The TIMOs that participated in interviews have pension funds, insurance companies, financial institution and universities as clients. Pension funds are the major clients, mentioned by approximately 83 % of all respondents.

Among the main reasons to choose timberland as an investment, portfolio diversification was the most often cited. Investors search for an asset that has the minimal correlation with their portfolio. Thus, any decrease in one asset does not affect other investments. Other characteristics for forest investments mentioned by the interviewees were the merits as inflation hedge and capital preservation.

Most investors expect different returns from forest investments in different countries. They expect more returns from investments in countries with higher risk. "It is correlated with the risk", explained one of the respondents. Therefore, they demand more information for new investments. According to the TIMOs, the main information demanded by investors regards political, liquidity, and physical risks on the forest assets. Certification was cited as one of the requirements from European investors. Social and other types of sustainability indexes are not required by investors.

Investors who want to purchase any forest asset normally contact TIMOs by networking, presentations and/or events. The minimal capital required ranges from US$1 to US$5 million for separate accounts and US$5 to US$10 million for pooled common funds. In practice most investors/investments are much larger, probably US$50 to US$100 million. Also, most TIMOS are often willing to make individual forest investments of US$25 million or more per transaction.

2.3 Future Perspectives

Similarly to the preceding topic, not many respondents opined about future opportunities. There were positive expectations regarding future investments and challenges in the timberland market among the TIMOs. All of the interviewees were very confident and looking for new business opportunities to invest worldwide.

Asia, Latin America and the United States are among the countries that they are always looking for an opportunity. They say Brazil is one of the most attractive countries in the present and future acquisitions. TIMOs that still do not have business in Brazil plan to make acquisitions shortly. Additionally, TIMOs that already have business in the country plan to expand their investments.

The business environment in Brazil could be even more attractive if some obstacles were removed or minimized. The main hindrances refer to the lack of information on *Codigo Florestal,* the complex tax system and the environmental pressure for the plantation of fast-growth species. The recent prohibition for foreign landowners to hold most investments of a company also has been an obstacle for TIMOs since 2011.

2.4 Discussion

The results confirmed that TIMOs have different strategies for the management of current assets and future acquisitions. As any portfolio investment manager, TIMOs follow the basic concepts of Modern Portfolio Theory: the maximization of expected returns and minimization of investment risks (FU, 2012;CARROLL, 2003; REDMOND; CUBBAGE, F. W., 1988b). The more managers diversify their timberland portfolio, the lower the risks and the more balanced expected returns they will have (CAULFIELD, 1998; REDMOND).

Features of forest assets encouraged institutional investors to include them in their portfolio. The impact on the market can be seen by the intense landownership change in the U.S. over the last 30 years (HAGENSTEIN, 1984; ZHANG *et al.*, 2012). and the globalization of the TIMOs investments. Little investment has occurred in other traditional countries with an attractive forest sector, e.g., Sweden (LÖNNSTEDT; SEDJO, 2012), while South America is becoming more promising as shown in our research and in Mendes (2005).

The respondents of the survey affirmed that investments in forest assets have opportunities throughout the world. When invested in the right place and time, forest assets can provide opportunities that are more profitable and reduce the risk in portfolios. In general, TIMOs expect better returns from international investments due to the higher risk and the economic analysis computed this expectation; minimum Acceptable Rate of Return are higher in Brazil than in the U.S.A. as measured in Table 2.4 in topic 2.2.7 (Minimum Acceptable Rate of Return). Although their individual decisions are driven by TIMOs' expertise and risk aversion levels, all TIMOs share many aspects.

Previous researches on investments in Latin America shows that investors' are concern with the macroeconomic, institutional and forest aspects (CUBBAGE et al. 2010,MENDELL, B. C. et al., 2011). Mendell. et al. (2011) interviewed several institutional investors about investment strategies in Colombia. The respondents demonstrated similar concerns about risk and return. Political stability, timber market and landownership are the most quoted concerns. According to Mendel et al (2011), international investments involve a significant risk, most countries do not guarantee basic legal structural issues and can have capital repatriation issues.

Most factors studied in this research have a significant impact on the investment strategies. As every economic analysis, risks and returns were ranked as the most important aspects .However, these two factors alone are not enough to convince an investor to invest overseas. It is required broad knowledge about economics, technical and political aspects to provide accurate results.

There are different strategies and features that can influence investors' decisions for an investment. As observed in the cluster analysis, there are two main groups of variables that have similar behavior in forest asset investment, according to the TIMOs. These groups can be denominated as (i) Institutional and Forest factors, and (ii) Economics factors.

On the other hand, the Forest Investment Attractiveness Index (IAIF) developed by the Inter-American Development Bank (IADB) uses a different segregation in their investment analysis. The IAIF uses three groups of Sub-Index defined as: (i) SUPRA: macroeconomic factors and to other factors that can affect the profitability of any productive sector on the country, (ii) INTER: factors that could affect the forest-industrial business and, (iii) INFRA: factors related to the forest sector that could affect profitability of forest-industrial business (IADB, 2008)

The groups formatted in the cluster analysis indicate different strategies adopted by the different players in the forest sector. The study conducted by IADB aimed to formulate an index for the entire forest sector, including the industry and independent timber producers. This can justify the division in three groups; however, when focusing on specific players in the forest sector, investors seem to aggregate key variables into two groups, as shown in our research.

Another aspect we observed was the link between investors' strategies and TIMOs' business plan. Clearly, the business plan elaborated by TIMOs is adapted to each client's feature. Forest certification requirement, for example, is often required by European funds; therefore, TIMOs' business plans present this option to European clients and its pros and cons. The different requirements in a business plan are discussed by Manson; Stark (2004). According to the authors, each investor has different criteria to approve an investment according to the business plan presented. They affirm that bankers focus heavily on the financial criteria while, venture capitalists and business angels balance the investment analysis between market and financial criteria. Comparing these results to ours, TIMOs' investors seem to have similar preferences to venture capitalists and business angels. TIMOs considered the financial criterion essential (table 2.3, topic 2.3.3 General Analysis). On the other hand, given that forest management is a long-term investment, the market must be strong and stable enough to guarantee low risks during the period of investments.

2.5 Conclusion

The recent internationalization of forest investments has driven TIMOs in the United States to different markets and prompted greater interest in making investments abroad. TIMOs want to make investments in Brazil and elsewhere, and they require deeper information about those opportunities and the use of economic analysis for their decisions.

Understanding the TIMOs' strategies gives support to countries and investors to make better decision in timberland investments. Governments that want to attract new investments must show a safe environment for business as well as attractive silvicultural and economic performance. An improved connection among TIMOs, countries and investors can increase opportunities. While governments can develop their socio-economic situation by enhancing the timber production chain, TIMOs and investors can enrich their portfolio with assets that are more profitable.

The traditional forest producing countries, namely the U.S.A., Brazil, Chile, and China still have land available for new investments. However, other governments have become more aggressive and offered more incentive to foreign investors in timberland, e.g., Colombia (Mendell et al, 2011). This market competition is good for investors and for the entire timberland market. Nevertheless, TIMOs are just a part of the timberland market; further studies must be conducted to better understand the strategies of the other investors.

The models adopted by the U.S.A., where TIMOs and REITs own the land, tend to be used in other countries. This perspective motivates even more the participation of the institutional investors. In addition, new agricultural and forest production frontiers must be explored in Latin America, Asia, and Africa.

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3 THE ECONOMIC COMPETITIVENESS AMONG TRADITIONAL REGIONS AND NEW AGRICULTURAL FRONTIERS IN FOREST INVESTMENTS IN BRAZIL.

Abstract

Forest economists from financial institutions and government constantly analyze the economic aspects of investments in forest assets to support their decision-making process. They are seeking for new opportunities and the timberland market trend. In Brazil, forest business is expanding into areas where silviculture is not a conventional activity. This chapter investigates the aspects related to forest project analysis in the states of São Paulo, Mato Grosso do Sul and MAPITO (an acronym for the neighboring states of Maranhão, Piauí and Tocantins). To determine the economic feasibility we performed Net Present Value (NPV), Land Expectation Value (LEV), Internal Rate of Return (IRR) and Willingness to Pay for Land, considering future land value (WPL). Moreover, the criteria outputs were simulated by Monte Carlo methods and sensitive analysis. The attractiveness of the regions varied according to financial criteria used by investors. The WPL analysis showed the best returns among the criteria analyzed; when considering an increase in the land value presented, the WPL presented a return of R$ 871.79, R$ 1,427.49 and R$ 1,138.69 per hectare in the states of MAPITO, Mato Grosso do Sul and São Paulo, respectively. MAPITO was the region where the current land price had less effect than timber market and operational efficiency. On the other hand, the State of São Paulo is not as attractive in reason of the high land prices.

Keywords: Forest valuation; Investment analysis; Return rate; Monte Carlo simulation; Risk

Resumo

Economistas Florestais de instituições financeiras e governamentais analisam constantemente os aspectos econômicos dos investimentos em ativos florestais. Investidores em florestas plantadas procuram novas oportunidades para maximizar seus retornos. Brasil é um país em que está passando pelo processo de expansão de suas áreas de florestas plantadas para regiões com pouca tradição em silvicultura. Esse capítulo tem como objetivo estudar a viabilidade econômica de projetos florestais nos estados de São Paulo, Mato Grosso do Sul e MAPITO (Maranhão, Piauí e Tocantins). Foram utlizados como critérios econômicos o Valor Presente Líquido (VPL), Valor Experado da Terra (VET), Taxa Interna de Retorno (TIR) e a Valor Pago pela Terra (VPT). Posteriormente, esses critérios foram simulados pelo método de Monte Carlo e análises de sensibilidade.A atratividade das regiões variam de acordo com o tipo de critério econômico utilizado. As análises do VPT apresentaram os melhores retornos, quando considerando o aumento no valor da terras teve um retorno médio de R$ 871.79, 1,427.49 e 1,138.69 por hectares nos estados do MAPITO, Mato Grosso do Sul e São Paulo respectivamente. Os projetos florestais na região do MAPITO sofreram menor influência da variação de preços da terra que a variação de preços da madeira, da produtividade florestal e dos rendimentos operacionais. No estado de São Paulo, por outro lado, o preço de terra teve maior impacto no resultado final do fluxo de caixa que os outros fatores analisados.

Palavras - chaves: Avaliação Florestal; Taxa de retorno; Simulação de Monte Carlo; Análises de investimentos; Risco

3.1 Introduction

Similar to the first settlers during Brazil's colonization, the Brazilian agribusiness sector has been searching for new opportunities and resources in unexplored areas over the last decades. Competition in traditional forest-planted areas has increased land prices and consequently, initial investment in land acquisition became higher than years ago. Furthermore, all speculation around the new agricultural frontiers has attracted companies, independent producers and institutional investors to invest in agriculture and tree plantations in these regions

This chapter investigates the economic competiveness between the traditional timber-regions and the agricultural frontier in forest assets investments in Brazil. We will discuss the main aspects that affect the decision-making process to invest in a given region. Additionally, we performed a cash flow analysis to examine the economic criteria results and their sensibility in returns of investments of forest projects.

3.1.1 The forest sector in traditional regions in Brazil

Brazil is a worldwide reference in silviculture of fast growth trees due to the favorable soil and climate conditions, investments in new technologies and genetic improvements. Productivity levels are the highest in the world in Brazil; the main species planted (Eucalyptus) can growth annually at range between 20 to 70 m^3 ha^{-1} (GONÇALVES *et al.*, 2013).

Concomitantly to the physiological aspect, the Brazilian government has an important contribution to success of tree plantations by granting tax incentives to the forest sector between the 1960s and 1980s (BACHA,2008). The combination of all these aspects boosted the installation of forest companies in the country and expanded planted areas.

In 2011, the total area covered by planted trees reached 6.5 million hectares (ABRAF, 2012); most of it occupied by the genus Pine or Eucalyptus. The Southern and Southern regions were the pioneers to establish the first commercial forest plantations. In 2011, the total roundwood production in these regions amounted 98 million cubic meters, which accounts for 77% of the total national production (116 million cubic meters) (IBGE,2013). The region has 4.8 million planted hectares (73 % of the total) and the highest concentration of wood processing mills per planted hectare. There are 23 companies altogether, where 7 produces wood panels (Medium Density Fiberboard, Oriented Strand Board), 6 produce cellulose and paper and 10 steel mills.

There is a large economic flow in the forest industries, once they provide a large amount of jobs and tax. According to ABRAF2012, the sector generated 1.2 million direct and indirect jobs and generated taxes at the amount of R$ 7.4 billion in 2011.

The benefits of forest plantations exceed the socio-economic requirements, most industries in Brazil are subject to a severe social and environmental regulation in order to acquire or maintain the forest certification, e.g., Forest Stewardship Council (FSC). In Brazil, 207.3 million (natural and plantations) hectares are certificated by FSC. Moreover, the forest industry in the South and Southeast preserves an area equivalent to 1.5 million hectares of natural vegetation (ABRAF2012). This area is 10 times larger than the largest national park in the South (the Iguacu Water Falls Park with 169 thousand hectares).

The establishment of the forest sector in the Southern and Southeastern regions occurred due to the historic development and the high demand for wood in the region. With a larger number of companies installed, the region became the most economically developed and attractive to every economic sector in general.

3.1.2 Business Environment

The South and Southeastern regions are the most economic developed regions in Brazil. In 2010, the Gross Domestic Income (GDI) of these regions amounted 71 % of the total in the country (IBGE 2012). The presence of several types of industries and the high-density population make the consuming sector strong and attractive to all type of investments.

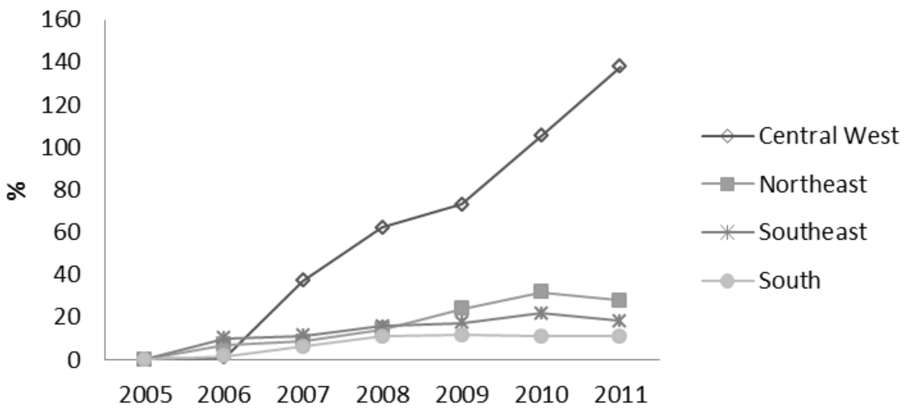
According to the rank of the best regions to invest in Brazil elaborated by the Economist Intelligence Unit (EIU) and published by the Brazilian magazine Veja (2012), the Southern and Southeastern states in the traditional regions are the best ranked and their business environment is classified as the second highest grade.

The EIU rank analyzed 8 aspects regarding the business environment: 1) Political environment, 2) Economic environment, 3) Taxes and regulations, 4) Foreign investment policy, 5) Human Resources, 6) Infrastructure, 7) Innovation and 8) Sustainability. In all criteria, the South and Southeast regions were better classified than the others, except for taxes and regulations, where the Southeastern and Central-western regions obtained the highest classification.

3.1.3 Forest Sector Investment Expansions

Although Southeastern and Southern region have a better business environment, the agribusiness and the forest sector investments have followed different paths and started to produce in unexplored and not very friendly business environments.

There are evidences that the forest sector is not investing as much as usual in the South and Southeast. Between 2010 and 2011, the planted area in the Southeastern and Southern regions shrank 2% and 0.16 %, respectively (Graph 3.1).



Graph 3.1 Planted forest expansion, year basis 2005. Source: ABRAF,2012.

Only one new mill was started in the south, as the company called Klabin is currently studying the installation of a new mill in the north of Paraná State with capacity to produce 1.5 million tons of cellulose from Eucalyptus and Pines (KLABIN S.A., 2011).

On the other hand, the expansion in the Central-western region is clearly larger. In 6 years, the region has more than doubled the planted areas. The city of Três

Lagoas, located in Mato Grosso do Sul State in the Central-western region, is known as the world capital of cellulose. Two cellulose mills (Fibria and Eldolrado) are installed in the city and together they produce 2.8 million tons of cellulose per year, equivalent to 25 % of the Brazilian production (BRACELPA, 2013). Both mills were started recently, Fibria in 2009 and Eldolrado in 2012.

Eldolrado invested 6.2 billion reais and plans to produce 5 million tons of cellulose per year until 2020 (CAMPO GRANDE NEWS, 2012). Fibria invested US$1.5 billion to produce 1.3 million tons of cellulose per year. Fibria's mill was the first to produce more than 1 million tons of cellulose per year (FIBRIA CELULLOSE S.A., 2011).To supply these mills, Fibria has 207 thousand hectares planted including areas owned by the company and partners, while, Eldolrado has 110 thousand hectares planted, including areas owned by partners. Eldolrado is planning to reach 160 thousand hectares until 2020.

The border between the states of Maranhão, Piauí and Tocantins, called MAPITO, is another region that is attracting several investors (FERRO, 2012). According to Stefano (2009), the group Suzano purchased 35 thousand hectares in south of Maranhão State. Additionally, Suzano announced the installation of two new cellulose mills, and one will start to produce at the end of 2013 and another in 2016. The total investment amounts to US$2.3 billion. These mills will produce 3 million tons of cellulose per year. Furthermore, Suzano is investing in the production of pellets for European consumers. The companies says that investments will reach US$8 million in three new mills to be installed in the region where each mill will produce 1 million tons of pellets per year (SUZANO, 2013).

As the productions from mills are exported to Europe or/and the U.S.A, the MAPITO location is strategic. Companies are able to transport the final products faster than companies installed in the South. Another crucial advantage is the land availability in the Central West and in MAPITO, the lower competition and lower land prices make forest projects more attractive and land acquisition easier in these regions than in the traditional ones (MF CONSULTORIA FLORESTAL, 2010).

3.1.4 Land Market in Brazil

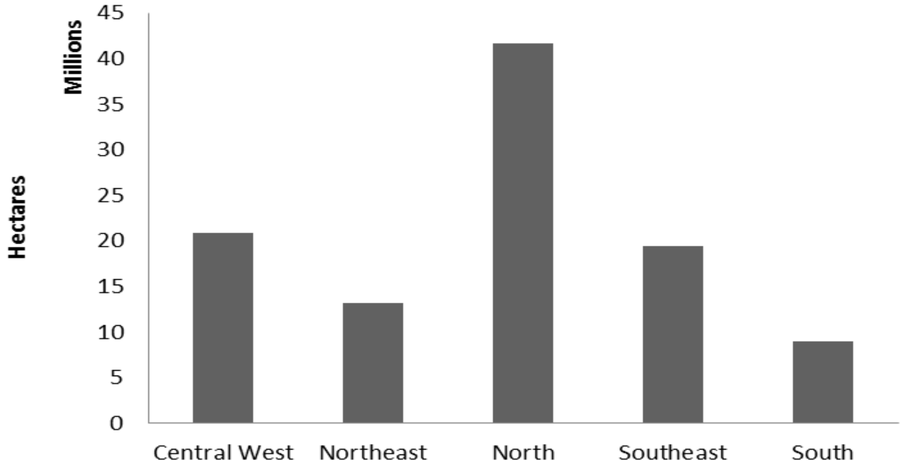
Land price is one of the key factors to make forest projects viable. High investments in land acquisition impact the cash flow analysis in the first years

(BERGER; SANTOS, 2011). Therefore, understanding the land market is essential for investors to make the best decision regarding time and location.

The land asset is attractive to many types of investors due to the possibility to gain profits in two ways: 1) the land expected future value and, 2) the productive capacity (ROMEIRO; SAYAD,1982). The expected future value is highly connected with market speculation and future production. In less-developed areas, future investments expectation in infrastructure or any other improvements in the region adds value to the land. Moreover, the land value is directly connected with the expected price of its products (ZILLI, 2010). According to the author, as prices of commodities keep increasing, it will push the land prices upward.

The potential Brazilian agriculture moves the land market in the country. The current macroeconomic scenario, world demand for bioenergy and fiber and land availability have encouraged national and international investors to purchase land in Brazil (KRÖGER, 2012; ZILLI, 2010).

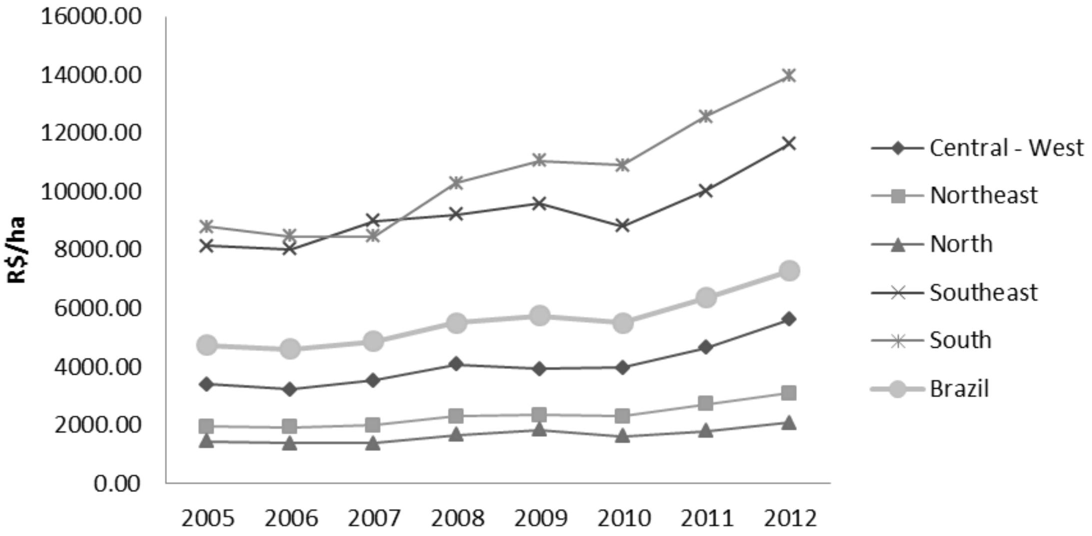
Data from AGRAFNP (2010) shows that Brazil had 104 million hectares available for agriculture production in 2010. Most available areas are located in the North and Central-west (Graph 3.2). In these regions, the likelihood to purchase land with desirable characteristics (low prices, reasonable size, near roads, access to water sources and good soil condition) is higher than in the traditional regions.



Graph 3.2 Available area for agricultural land per region. Source: AGRAFNP,2009

The interest to purchase land assets has increased the rural land prices in the last years. The prices of cultivable lands increased 153 % in the last 7 years

(AGRAFNP,2013). The Central-western region showed the highest increased with 165 %, while the South presented the lowest with 145 % (Graph 3.3).



Graph 3.3 Average land price in Brazil. Source: AGRAFNP, Adapted by the author

The less expensive lands are located in the Northern region. The lack of infrastructure, environmental restrictions and conflicts in local properties are some of the reasons of the low demand for land in this region.

Between 2009 and 2010, land prices declined in most regions in Brazil. This fact is related with restrictions imposed by the Brazilian Union Legal Council (Advogados da União), changes in the interpretation of law number 5.709 of 1971 and restrictions for land acquisition by companies with foreign capital (FERRO, 2012). Despite these restrictions, land prices increased in the following years. Between 2010 and 2012, land prices raised 32 % in the country, where, the highest rate observed in the Central West (42 %) and Northeast (35%).

Investors face therefore a dilemma: they either acquire land in frontier regions with an apparent tendency for higher profitability or keep their investment directed to traditional regions with a better business environment, stronger timber market, tree species productivity already developed and clones already developed and productive.

3.1.5 Resource Focus

The business environment is an important factor that investors use to decide to invest in a given region. Nevertheless, a detailed analysis is required to support their decision. In forest projects, components of productivity, market, revenues and cost performances must be carefully analyzed to provide accurate answers to the investors. Furthermore, analysis of forest projects becomes even more challenging in a country with a large territorial dimension like Brazil. An economic analysis, such as discounted cash flow, must be performed and investors must be aware of the possible returns and risks.

In a cash flow analysis, land acquisition is a crucial process for the viability of forest projects; the land acquisitions are normally made during the first years and the discount rate has lower influence in the present value. On the other hand, future expectation values of the bare land make land acquisition viable in regions where the land prices are constantly increasing.

Industries, independent producers and institutional investors are seeking new opportunities in agricultural frontiers in order to obtain greater returns and consequently assume higher risks. The traditional regions in the South and Southeast do not seem as attractive as used to be, mainly because of the higher initial investment. Based on these statements, this chapter aims to answer the following hypothesis:

1) Forest investment in the Southern and Southeastern regions is not viable due to the higher land price,
2) Forest investment in new agricultural frontier is riskier than in traditional regions.

3.2 Methodology

Due to the vast sources and types of data, we used different approaches to achieve a common denominator and thereby compare the economic aspects among the regions studied. In this section, we will introduce the study location and its characteristics, including a historical description of geographical locations and land prices. Afterwards, we will demonstrate and detail the financial criteria and process of building the cash flow analysis as well as the parameters and the criteria used to describe the sensitive analysis. We finished this topic by describing the statistical methods used to fit the distribution and to run the Monte Carlo simulation.

3.2.1 Study sites

The São Paulo State are in the traditional planted forest region and was selected as their representative state, while, Mato Grosso do Sul and MAPITO are the new frontiers (graph 3.4).

Graph 3.4 Study sites

3.2.1.1 São Paulo State

Located in the Southeastern region, the state of São Paulo has three predominant climates types: tropical, high tropical altitude and tropical humid (IBGE, 2002). The temperature ranges from minus 0º Celsius, in the areas near to mountain ranges, in the winter to 40 º Celsius in the summer. The rainfall averages 1,490 mm per year (CARVALHO, 2005) with heavy rains in the summer and a dry season during the winter. There are different types of vegetation in the state, ranging from Cerrado, predominant in dry regions, to tropical forest in coast of the state.

The São Paulo State has the strongest economy in Brazil; its GDP is equivalent to 33.1 % (1.2 trillion reais in 2010) of the total GDP in the country. São Paulo State economy is based on industrial and agricultural production. The state is Brazil's major sugarcane producer and one of the most important states in the Brazilian forest sector. The forest sector in São Paulo produces 29 thousand cubic meters of roundwood in 2011, equivalent to the 22 % of the total production in the country, setting the state as the largest producer in the country (IBGE, 2012). Furthermore, Eucalypt areas in São Paulo State have the highest average productivity in the country: 45 $m^3.ha^{-1}$ per year (ABRAF, 2012) thereby making the state even more attractive.

In terms of planted area, the state has 18 % of the total area in Brazil, where 1.2 million hectares are planted with Pine (150 thousand hectares) and Eucalypt (1.05 million hectares) (ABRAF,2012). Additionally, São Paulo has the largest concentration of the verticalized forest companies in Brazil, with 24 % of the 54 companies located in the state.

3.2.1.2 Mato Grosso do Sul State

The state of Mato Grosso do Sul is located in the Central-western region and has Bolivia and Paraguay as neighbors in the west, Mato Grosso State in the north and São Paulo, Minas Gerais and Paraná States in the east.

Cerrado is the predominant natural vegetation and the climate is mostly tropical and high tropical of altitude (IBGE, 2002). The rainfall in the state is in average 1,500 mm per year with rainy summers and dry winters. The average temperature during the year is 26º C (1minimum of 10 ºC and maximum temperature 40 ºC). The economy of the state is based mainly on agricultural production. Mato Grosso do Sul has the largest cattle herd of Brazil. Its geographic localization and efficient transport systems make the state an important place to redistribute products from the Southern and Southeastern to the North and Central western regions of Brazil.

Mato Grosso do Sul was considered a new agricultural frontier a few years ago (FERRO, 2012). Currently, it is one of the most promising states in the forest sector. The state increased its production from 536,976 cubic meters to 5,618,708 between 2000 and 2011 (IBGE, 2012). Eucalyptus is the predominant genus and the area planted rose from 305 thousand to 970 thousand hectares between 2005 and 2010 (ABRAF,2012). Two of the most modern pulp mills are located in the state, which account for 20 % of the national cellulose market (BRACELPA, 2011).

3.2.1.3 MAPITO region

The MAPITO region comprises the states of Maranhão, Piauí and Tocantins. This region is considered the new Brazilian agricultural frontier; soybean and cattle producers initiated their migration to the region in 1999 (NETTO, 2009)

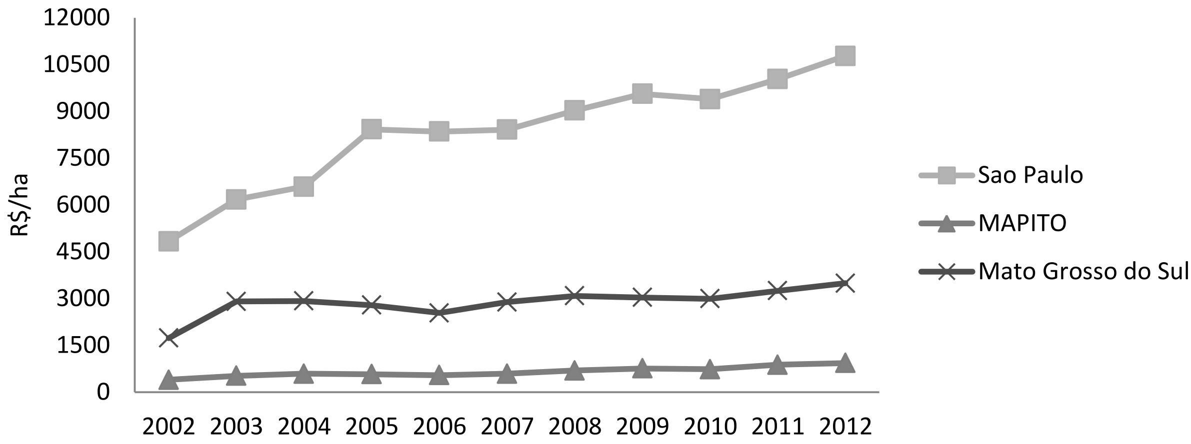
Cerrado is the predominant vegetation in the region , the climate is tropical (IBGE, 2002) with an average annual rainfall of 1,400 mm The dry season is severe from December to April and the rainy months are from May to July. Thermometers in MAPITO can reach 43º Celsius in the hottest period and 20º Celsius during the winter.

According to Netto (2009), although the region presents several problems with infrastructure, investors are optimist for future returns. In the forest sector, Eucalypt plantations in MAPITO five-folded , from 125,738 in 2005 to 517,124 hectares in 2011. Most of these areas have not been harvested yet (IBGE, 2012), only the state of Maranhão has commercialized wood in 2011 (151,798 cubic meters of roundwood).

There are many uncertainties regarding Eucalypt production in the region. The lack of knowledge of most productive species and silvicultural regime are some of the challenges for research teams and investors in the region. On the other hand, the macroeconomic scenario is favorable. The Brazilian government is encouraging investment in infrastructure to make transportation more accessible in MAPITO. Moreover, the access to the Atlantic Ocean in the north brings many logistic advantages to exporting companies.

3.2.2 Land price historic

The bare land in the state of São Paulo is one of the most expensive in Brazil. The land price of areas suitable for forest plantation production is on average eleven times higher than in MAPITO and three times than in Mato Grosso do Sul. Despite the higher prices, historical data of land prices did not show any sign of stability. In the last 11 years, land prices increased 123 % in real terms in the state (Graph 3.5).



Graph 3.5 Land price historical data (real terms) in São Paulo, MAPITO and Mato Grosso do Sul States. Source: Informa Economics AGRAFNP.

Land prices in MAPITO and Mato Grosso do Sul State more than doubled in real terms. MAPITO presented the highest increase (136 %) between 2002 and 2012, while Mato Grosso showed 101 % in the same period.

Land prices have demonstrated a similar behavior along the years and, unless an unexpected economic crisis strikes, land prices tend to increase in the upcoming years.

3.2.3 Financial criteria for investments in forest projects

Financial criteria give support to investors to allocate their capital to maximize asset values. Furthermore, through financial criteria, investors can accept or reject the project according to expected returns. Four economic criteria were used in this research: (1) Net Present Value, (2) Internal Rate of Return, (3) Land Expectation Value and, (4) Willingness to Pay for Land, considering future land value.

An essential aspect must be addressed before discussing the financial criteria: the minimum accepted rate of returns (MARR). The MARR is the minimum acceptable rate of return for a project that an investor is willing to accept (KLEMPERER, 1996). The value used in this chapter is 11.35 %, which is based on experts' answers from the interviews applied in chapter 2 (topic 2.2.7 Minimum Acceptable Rate of Return).

3.2.3.1 Net Present Value

Net Present Value (NPV) of a project is the current value of revenues subtracted by the current value of costs (equation 3.1).

$$NPV = \sum_{t=0}^{n} R_t (1+i)^{-t} - \sum_{t=0}^{n} C_t \, (1+i)^{-t} \tag{3.1}$$

Where:

R_t is the revenue in the year t;

C_t is the cost in the year t;

i is the MARR; and

t is the year.

A project is viable if the NPV is greater or equal to zero. In other words, the current value of revenues must be greater than or equal to the current costs in an investor's minimum acceptable rate of returns.

3.2.3.1 Internal Rate of Return

The Internal Rate of Return (IRR) is the discount rate that the NPV is equal to zero (equation 3.2).

$$\sum_{t=0}^{n} R_t (1+i)^{-t} - \sum_{t=0}^{n} C_t \, (1+i)^{-t} = 0 \tag{3.2}$$

According to the IRR guidelines, a project is viable if its IRR is equal to or greater than the MARR.

3.2.3.2 Land Expectation Value

Land Expectation Value (LEV) computes the maximum buyer's willingness to pay for bare land and, conversely, the minimum seller's willingness to sell. LEV is very popular among the forest economists. The LEV concept was developed by Faustmann (1849) and calculated as the NPV of a perpetual series in an optimal rotation (equation 3.3).

$$LEV = \frac{\sum_{t=0}^{n} R_t(1+i)^t - \sum_{t=0}^{n} C_t(1+i)^t}{[(1+i)^p - 1]} \qquad (3.3)$$

Where:

R_t is the revenue in the year t,

C_t is the cost in the year t,

p is the forest cycle length,

t is the clear-cutting income.

3.2.3.3 Willingness to Pay for Land, considering future land value

Forest investors may want to sell their assets at the end or before the cutting cycle. To calculate the land value at that time, the LEV equation (3.3) must be adapted. According to Klemperer (1996), the Willingness to Pay for Land (WPL), considering the future land value, is the current value of all revenues subtracting all current costs including the land market value of bare land as revenue after clear – cutting (equation 3.4).

$$WPL\ (FLV) = \sum_{t=0}^{n} R_t(1+i)^{-t} - \sum_{t=0}^{n} C_t\ (1+i)^{-t} + FL(1+i)^{-p} \qquad (3.4)$$

Where:

R_t is the revenue in the year t,

C_t is the cost in the year t,

i is the MARR,

p is the forest cycle length,

FL is the future bare land value.

3.2.4 Revenues

Due to its importance in the current market and its versatility, Eucalyptus was the genus chosen to simulate the cash flow analysis. The assumptions adopted of the silvicultural aspects were: 1) spacing between the trees of 3 x 2 meters (1667 plants per hectare), 2) 1 % of mortality after the first plantation, 3) silvicultural regime of 2 rotations of 7 years and 4) the second rotation production was considered 10 % lower than the first due to coppice management influences (REZENDE; OLIVEIRA;RODRIGUES, 2005).

3.2.4.1 Stumpage price

We selected energy and pulp for the timber market. The average timber prices (Table 3.1) were collected from the *Instituto de Economia Agrícola* (IEA) in São Paulo and by interviews with local producers and consumers in the other states.

Table 3.1 Stumpage price per region

Region	**R$.m^{-3}**
Sao Paulo	53.00
Mato Grosso do Sul	50.46
MAPITO	52.00

3.2.4.2 Volume Estimation

To accurately estimate productivity, we used the software SISEucalipto developed by the Brazilian Agricultural Research Corporation (EMBRAPA). SISEucalipto is a powerful forest management tool, which simulates forest productivity based on characteristics of the site and the trees.

The SISEucalipto models are based on the permanent inventory in national level of the specie *Eucalyptus grandis*. The simulation occurred in an integrated model of site index (equation 3.5) and volume (equation 3.6).

$$H = S * e^{(-2.72*(A^{-0.51}-15^{-51})} \quad (3.5)$$

Where:

H is the total height

S is the Site Index

A is the tree age.

The volume model is:

$$V = 7.854 * 10^{-5} * DBH^{2*0.39*H} \quad (3.6)$$

Where:

V is the total volume in cubic meters,'

DBH is the Diameter at Breast Height, and

H is the total tree height.

The model runs based on assumptions 1, 2 and 3, presented in topic 3.2.4 Revenues and the site index values. The volume prognoses used a site index at the base age 7 (SI_7) provided by local producers (Table 3.2). The names of the local producers cannot be provided due to a pre-accord between researchers and interviewees.

Table 3.2 Site Index in meters in the study areas

Region	**Minimum**	**Average**	**Maximum**
São Paulo	20	29	38
Mato Grosso do Sul	25	30	35

We did not use the site index value for the region of MAPITO in our research because of the lack of information in the region. Consequently, we used the Mean Annual Increment (MA) provided by local producers in the region as growth model (Table 3.3).

Table 3.3 Mean Annual Increment in cubic meter in the region of MAPITO

Region	**Minimum**	**Average**	**Maximum**
Tocantins	28	35	41

3.2.5 Costs

Local companies and institutes provided data on costs. The sources from private companies were not quoted because of the agreement between researchers and interviewees as in the revenue data source.

3.2.5.1 São Paulo State

Costs in the state of São Paulo were formulated based on field performance of each operation carried out by local companies in their forest plantation (Table 3.4). These field performances were then fitted into an accumulative statistic distribution by means of the Maximum Likelihood Estimators method and after they were ranked by the Chi Square Statistics. These methods are discussed in topic 3.2.6 Monte Carlo Method. To estimate the cost per hour, we divided costs in Labor Hour per Hectare (LHH) and Machine Hour per Hectare (MHH).

Table 3.4 Silvicultural operations in the state of São Paulo.

Silvicultural Operations
Opening internal and external roads (Trail)
Limestone Aplication
Administration
Ant Control
Weed Control - Chemical
Subsoiling
Fertilization I (Base)
Plantation
Irrigation
Ant Control II
Ant Control III
Replantation
Irrigation
Weed Control - Between the lines - Chemical
Fertilization II
Fertilization III
Administration
Road conservation
Weed Control - Between the lines - Chemical
Weed Control - in the lines
Ant Control II
Fertilization II

3.2.5.1.1 Labor Cost

The cost of Labor Hour per Hectare was calculated based on the daily salary provided by the *Instituto Economico Agrícola.* We assumed a work journey of 8 hours per day and added more 100 % of the salary representing the Brazilian social and labor taxes (Table 3.5).

Table 3.5 Labor Hour per Hectare

Labor	R$/hour
Tractor Operator	12.72
Field Worker	10.13

3.2.5.1.2 Machinery Costs

Machinery cost were estimated according to MAKER, 2009. According to the author, machinery costs are divided into fixed costs and variable costs.

3.2.5.2.1 Fixed Costs

Fixed costs (also called ownership costs) are defined as the cost computed even when machinery is not operating. The fixed cost formation includes depreciation, opportunity costs, taxes, insurance, housing and maintenance facilities (equation 3.7).

$$Fixed\ Costs\ =\ TD + OP + TIH \tag{3.7}$$

Where:

TD is the total depreciation,

OP is the opportunity cost and,

TIH is the tax, insurance and housing.

3.2.5.2.1.1 Depreciation Cost

Depreciation is the cost resulting from use, obsolescence and age of machinery. Before calculating the total depreciation, we needed to specify the salvage value.

The salvage value represents the value of machinery at the end of its economic life, and is defined in the following equation:

$$SV = CP * RFV \quad (3.8)$$

Where:

SV is the Salvage Value;

CP is the Current Price and;

RFV is the Remaining Value Factor[2]

Once the salvage price is computed, the total depreciation value is calculated according to the following equation:

$$TD = PP - SV \quad (3.9)$$

Where:

TD is the total depreciation,

PP is the purchase price and,

SV is the salvage value.

3.2.5.2.1.2 Opportunity Cost

Opportunity cost of machinery is the cost of any activity in the farm business measured in terms of value of the next best alternative. The opportunity cost was calculated as Capital Recovery, which means the terminating equal annual revenue required to justify the initial investment in machinery (equation 3.10) (Kleperer,1996, MAKER, 2009).

$$CRV = PP * (i/1 + (1 + i)^{-n}) + SV * i \quad (3.10)$$

Where:

CRV is the capital recovery value,

PP is the purchase price of machinery,

i is the interest rate,

n the estimated life of machinery[3] and,

SV the salvage value.

[2] The Remaining Value Factors (RVF) was derived from MAKER, 2009, p.4.
[3] The estimated life was computed according to the American Society of Agricultural Engineers. Source: ASAE Standards, ASAE D497.4, Agricultural Machinery Management Data, St. Joseph American Society of Agricultural Engineers, 2003. p. 377.

3.2.5.2.1.3 Taxes, insurance, housing (TIH)

We used a value of 1 % of the machine purchase price to represent the TIH cost as other papers used (MAKER, 2009; PRATA, 2012).

3.2.5.2.1.4 Variables Costs

The variable costs (operating costs) are the costs computed when machinery is operating in the field. It comprises costs with fuel and repairs. The fuel cost is computed through the following equation:

$$F = EP * 0.163 * FP \quad (3.11)$$

Where:

F is the fuel cost,

EP is the engine power,

0.163 is the consumption factor for diesel engines[4] and,

FP is the fuel price in reais.

The repair cost is defined by the equation 3.12:

$$RP = PP * RC/EL \quad (3.12)$$

Where:

RP is the repair cost,

PP is the purchase price,

RC is the repair factor[5] and,

EL is the estimated machinery life

[4] The consumption factor for diesel engines was provided by GONÇALVEZ, 2002.
[5] The machinery repair factors were estimated according to the American Society of Agricultural Engineers. Source: ASAE Standards, ASAE D497.4, Agricultural Machinery Management Data, St. Joseph American Society of Agricultural Engineers, 2003. p. 377.

3.2.5.2 MAPITO and Mato Grosso do Sul State

Unlike for the state of São Paulo, we did not have access to the operational performance in the states of MAPITO and Mato Grosso do Sul. Therefore, the operational costs of Mato Grosso do Sul State (Table 3.6) and the states of MAPITO (Table 3.7) were collected as monetary values.

Table 3.6 Operation list of the state of Mato Grosso do Sul

Operation
Site Preparation
Planting
Weeding
Fertilizing
Weeding & Fertilizing
Weeding II
Fertilizing II
Forest Protection
Administration

Table 3.7 Operation list of the MAPITO region

Operation
Site Preparation,
Planting
Administration
Weeding, Etc.
Maintenance/Protection

3.2.5.3 Land Price

Land prices for the states of MAPITO and Mato Grosso do Sul were collected from the annual report AGRIANUAL, 2013, and from the *Instituto de Economia Agricola* (IEA) for the state of São Paulo data set.

The land category was selected by different means in the study areas. In the São Paulo state database, we collected the bare land price of forest plantation areas. We considered the land use changes already stable in the state and the areas with agricultural or cattle production would not change to Eucalypt production in the long-term.

The opposite scenario is observed in the MAPITO region. Due to changes in land use, the bare land prices selected were the degraded, low productive pasture, low productive agriculture areas and green field areas. In the Mato Grosso do Sul State, degraded and low productive pasture; low productive agricultural and forest plantation areas were selected as prices for bare land.

3.2.5.3.1 Land Opportunity Cost

The land opportunity cost concept is the same as discussed previously in topic 3.2.5.3.1 Opportunity Cost for machinery costs. The land opportunity cost is the amount that investors foregone to make in other activity. The land opportunity cost was calculated according to the equation 3.13 (SILVA, M. L. S. *et al.*, 2008):

$$LOP = CP * i \tag{3.13}$$

Where:

LOP is the land opportunity cost,

CP is the current land price and,

i is the interest rate.

The land opportunity cost is added to the cash flow analysis as an annual cost (leasing cost).

3.2.5.3.1 Land price speculation scenarios

As demonstrated in topic 2.3.1 Willingness to Pay for Land, considering the future land value, the investor may eventually desire to keep the land for a determinate period. In this scenario, the land acquisition is computed as cost in year zero and as revenue at the end of the investment cycle (14 years), that is, when the investor decides to sell the land. To evaluate the impact of this future land value, three scenarios were assumed during the production cycle (14 years):

1) The land price will have real annual increase rates as shown in topic 2.2 (12.29 % in São Paulo, 13.57 % and 10.16 % in MAPITO and Mato Grosso do Sul State, respectively).
2) The land price will keep constant real price in the next 14 years.
3) The land price will decrease at average negative rates occurred in each region in the last 10 years (-1.3 % in São Paulo,-3.4 % in MAPITO and -4.1 % in Mato Grosso do Sul State).

3.2.6 Monte Carlo Method

The Monte Carlo Method is used to simulate the various sources of uncertainty that affect returns of the investment (in this research the returns were measured by LEV, NPV, and WPL). The results are composed of a random simulation of the input values according to their statistical distribution function shape.

This method is largely used in financial and risk analysis. We used the software @Risk[6] to perform the Monte Carlo Simulation.

3.2.6.1 Input Statistical Distributions

The input statistical distributions were defined according to the data availability. Except for the silvicultural operations in the state of São Paulo, the other statistical distributions of input were assumed as a triangular behavior (Table 3.8) composed by the maximum, minimum and most likely value. Alternatively, to define de statistical

[6] More information about the software available at http://www.palisade.com/risk/5/tips/en/gs/.

distribution in silvicultural operations in the state of São Paulo, we utilized the Maximum Likelihood Estimators Methods and the Chi-Square test.

Table 3.8 Factor distributions assumed as triangular

Inputs
Volume in first and second rotation
Land Price
Operational cost in MAPITO and MS

3.2.6.2 Maximum Likelihood Estimators (MLEs)

The MLEs methodology was used to fit the distribution of the operational performance in São Paulo State. The MLEs of a distribution are the function parameters that maximize the probability to obtain a given data set. The likelihood expression of is defined as:

$$L = \prod_{i=1}^{n} f(X_i, \alpha) \tag{3.14}$$

Where:

L is the likelihood,

X_i are the sample values and,

α are the variables.

The MLE that maximize the L is the derivate of L due to α:

$$\frac{dL}{d\alpha} = 0 \tag{3.15}$$

3.2.6.3 Chi – Square test

The Chi-Square test is used to measure the goodness of fit between the observed and expected outcome frequencies. This test is defined by the following equation:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{(E_i)} \tag{3.16}$$

Where:

O_i is the observed distribution and,

E_i is the expected (tested) distribution.

The best distribution is the one where the Chi-Square is the minimum.

3.2.7 Sensitive Analysis

To evaluate the effect of some specific variables, we performed a sensitive analysis by keeping fixed parameters and simulating different outputs in the cash flow analysis. The fixed parameters were chosen according to their influence in the result of the financial criteria. The financial criteria and their respective parameters are:

1) NPV and IRR : land price, volume, stumpage price, sum of current operational costs
2) LEV: stumpage, volume, sum of current operational costs.
3) WPL: considering future land value: Land price, volume, stumpage price, sum of current operational costs and expected annual valorization of the land. The land price, volume and stumpage price were simulated in three scenarios.

The sensitive analyses were performed within a fixed range of values (Table 3.9). This range was divided into 20 steps and for each step, 1,000 combinations were run, thereby totalizing 20,000 simulations for each parameter.

Table 3.9 Parameters range used in the sensitive analysis.

Parameters	São Paulo		MAPITO		Mato Grosso do Sul	
	Max	**Min**	**Max**	**Min**	**Max**	**Min**
Land price ($R\$.ha^{-1}$)	18,181.80	2,280.20	2,716.66	173.33	12,433.30	266.70
Stumpage Price ($R\$.m^{3}$)	60.00	45.00	60.00	45.00	60.00	45.00
Volume ($m^{3}.ha^{-1}$)	417.70	104.00	287	182	359.20	180.10
Sum of the present operational cost ($R\$.ha^{-1}$)	7,428.64	6,045.32	7,882.67	6,255.62	6,016.58	4,362.20
Expected Valorization (%)	12.29	-1.30	13.57	-3.40	10.6	-4.10

In the final part of the sensitive analysis, we used the average outputs, e.g., the average NPV, to compare results.

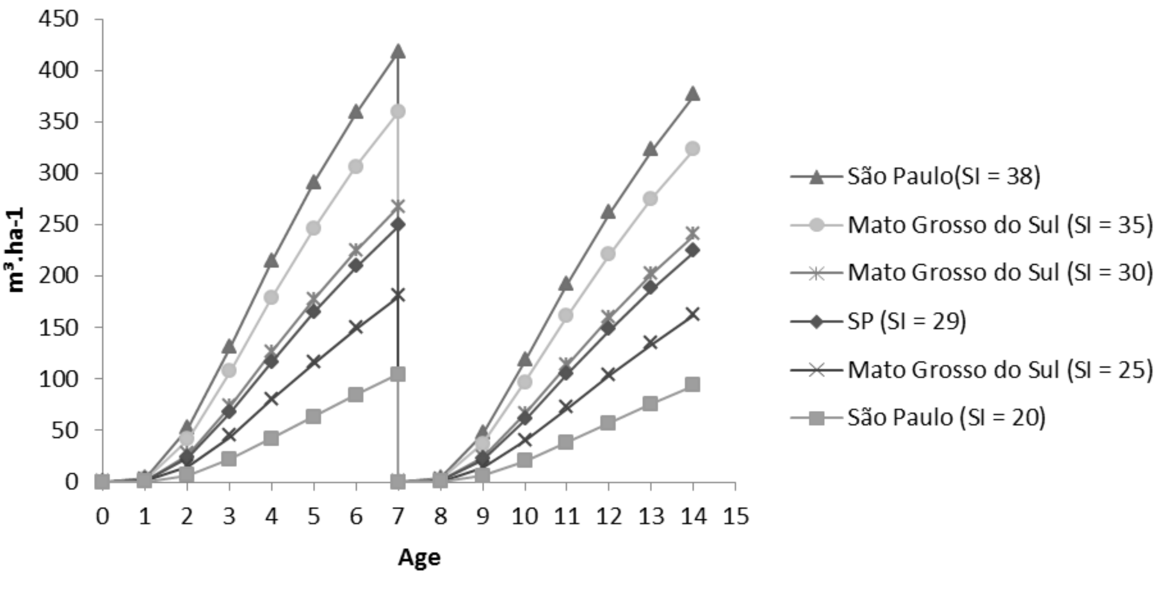
3.3 Results And Discussion

This topic will cover firstly the aspects related to revenues and costs. We will discuss the yield model, the statistic distribution for the silvicultural operations costs and land price values. Finally, we will present the financial criteria analysis and the sensitivity analysis of the main aspect that influenced the return of investment in each region.

3.3.1 Revenues

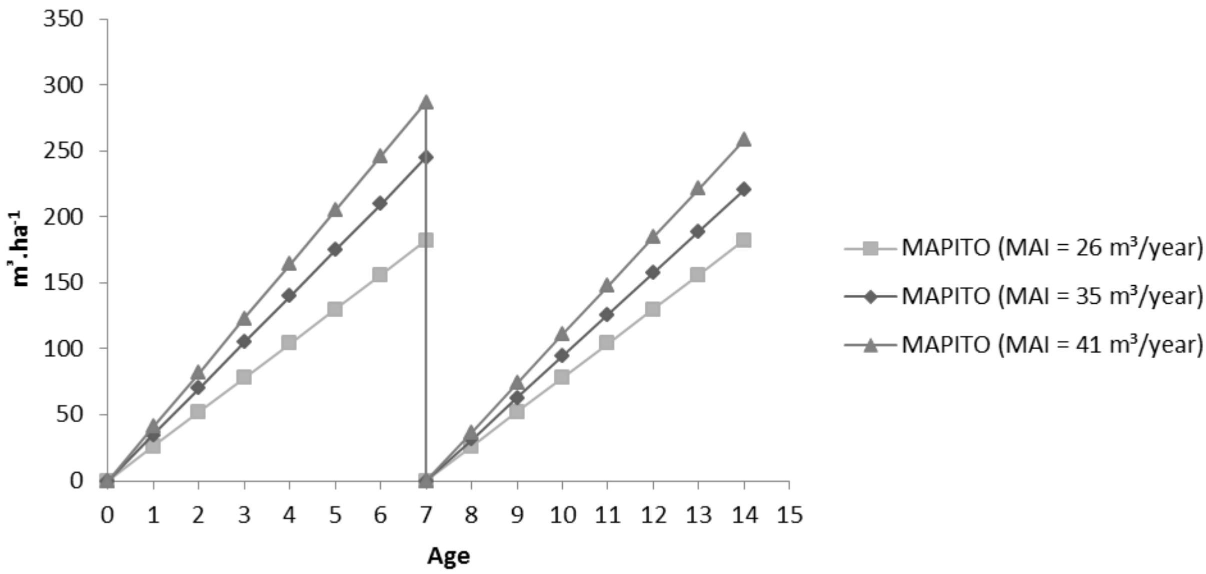
3.3.1.1 Yield models

As the same model (EMBRAPA) was applied to the states of São Paulo and Mato Grosso do Sul, productivity increased directly proportional to the Site Index (SI) value (Graph 3.6).



Graph 3.6 Eucalypt yield models in the states of São Paulo and Mato Grosso do Sul according to different Site Indexes

The MAPITO region had a simpler model and showed a linear growth (Graph 3.7):



Graph 3.7 Eucalypt yield models in the MAPITO region.

On average, sites in Mato Grosso do Sul State had higher production than the other regions (Table 3.10). The state of São Paulo had the highest stand deviation (the coefficient of variation was 25 %) while in the MAPITO region and Mato Grosso do Sul State, the coefficient of variation was 7% and 13 %, respectively.

Table 3.10 - Volume in the seventh year in m³.ha-1 per region

		Total Volume in m³			**Mean Annual Increment**		
Rotation	**Category**	**MAPITO**	**Mato Grosso do Sul**	**São Paulo**	**MAPITO**	**Mato Grosso do Sul**	**São Paulo**
First	Minimum	182.00	180.10	104.30	26.00	25.73	14.90
	Mean	245.00	266.30	248.40	35.00	38.04	35.49
	Maximum	287.00	359.20	417.70	41.00	51.31	59.67
	Standard Deviation	18.55	36.56	64.04	2.65	5.22	9.15
Second	Minimum	163.80	162.09	93.87	23.40	23.16	13.41
	Mean	220.50	239.67	223.56	31.50	34.24	31.94
	Maximum	258.30	323.28	375.93	36.90	46.18	53.70
	Standard Deviation	16.70	32.90	57.64	2.39	4.70	8.23

The range of volumes found for the state of São Paulo covered the values observed in the literature. Simões et al.(1980) affirmed that yield of *Eucalyptus* *grandis* could reach 471,88 steres.ha^{-1} on the seventh year, equivalent to 330 $m^3.ha^{-1}$ [7],in the region near the municipality of Itupeva (Southeastern São Paulo State). Gonçalves et al*.* (1990) studied the relation between SI and soil characteristics for *Eucalyptus grandis* in several sites of São Paulo State. The authors found a yield range between 13.28 to 32.8 $m^3.ha^{-1}$ of average annual increase. Bôas et al*.* (2009) modeled the volume of different species in the region around the municipality of Marília (center region of São Paulo State) and affirmed that *Eucalyptus grandis* plantations can yield an average increase of 31 $m^3.ha^{-1}.year^{-1}$.

The other research studies demonstrated a similar Eucalypt yield model in the state of Mato Grosso do Sul. Silveira (2009) interviewed local producers and observed an MAI range between 175 and 301 $m^3.ha^{-1}$ in Eucalypt plantations with seven years of age.

Forest plantations were recently established in the MAPITO region and do not provide enough database to model yield. However, comparing to other regions occupied by the same vegetation cover (Cerrado), Morais (2006) studied the yield of clonal Eucalypt in the Northwest of Minas Gerais State, and obtained the volume 374,31 $m^3.ha^{-1}$ in plantations with 7 years of age .

The yield models proposed in this research attempted to capture the average production in the regions of MAPITO, São Paulo and Mato Grosso do Sul States. T Literature results provided an idea about the model precision. Nevertheless, to achieve more specific results, it is necessary to develop local yield models by investigating soil conditions and performing a complete statistical analysis based on a forest inventory database.

[7] In this research, we used 0.7 as factor of conversion volume in steres to cubic meter (SBS, 2008)

3.3.2 Cost

3.3.2.1 Silvicultural Operations

Most companies, which have silvicultural operations data, considered the operations performance strategic for their planning and market competition. Therefore, they preferred to provide the maximum, minimum and most likely values for a given operation rather than the complete database. We used these data to assume a triangular distribution in the states of MAPITO and Mato Grosso do Sul (Table 3.11 and 3.12).

Table 3.11 - Cost of silvicultural (R$.ha^{-1}) operations in the MAPITO states

Name	**Distribution**	**Min**	**Mean**	**Max**	**Median**	**Mode**	**Std Dev**
Administration /	Triangular	100.00	133.33	180.00	131.01	120.00	17.00
Maintenance/ Protection	Triangular	160.00	188.00	216.00	188.00	188.00	11.43
Site Preparation, Planting	Triangular	3690.00	4340.67	4992.00	4340.50	4340.00	265.77
Weeding, Etc.	Triangular	562.00	660.67	760.00	660.50	660.00	40.42

Table 3.12 - Cost of silvicultural (R$.ha^{-1}) operations in the state of Mato Grosso do Sul

Name	Distribution	Min	Mean	Max	Median	Mode	Std Dev
Administration	Triangular	100.00	133.33	180.00	131.01	120.00	17.00
Fertilizing I	Triangular	350.00	606.67	800.00	618.33	670.00	94.55
Fertilizing II	Triangular	160.00	226.67	280.00	229.28	240.00	24.94
Maintenance/ Protection	Triangular	50.00	64.67	80.00	64.51	64.00	6.13
Maintenance/ Protection	Triangular	50.00	64.67	80.00	64.51	64.00	6.13
Planting	Triangular	850.00	976.67	1080.00	981.34	1000.00	47.67
Protection II	Triangular	36.00	49.33	72.00	48.00	40.00	8.06
Site Preparation	Triangular	480.00	646.67	800.00	649.71	660.00	65.49
Weeding	Triangular	100.00	173.33	300.00	165.84	120.00	44.97
Weeding I	Triangular	400.00	633.33	1000.00	612.70	500.00	131.23

On the other hand, we had access to a full database of silvicultural operations in the state of São Paulo, except for data on administration, replanting operation costs and opening primary and secondary roads.

The silvicultural operations data in the state of São Paulo were fitted according to MLEs and selected the best distribution by the Chi Square test (Table 3.13).

Table 3.13 - Cost of silvicultural (R$.ha^{-1}) operations in the state of São Paulo

Name	Distribution	Min	Mean	Max	Median	Mode	Std Dev
Opening primary and secondary roads[8]	-	818.30	818.30	818.30	818.30	818.30	818.30
Administration	Triangular	100.00	133.33	180.00	131.01	120.00	17.00
Ant Control	Log-Logistic	22.13	24.71	34.53	23.91	22.82	2.44
Ant Control II	Inverse Gaussian	13.96	19.45	33.80	17.84	13.99	5.00
Ant Control III	Inverse Gaussian	9.46	14.95	29.30	13.34	9.49	5.00
Fertilization I (Base)	Log-Normal	365.43	409.57	598.80	394.24	365.63	45.10
Fertilization II	Log-Logistic	235.46	276.07	429.77	267.68	256.77	31.08
Fertilization II - Maintenance I	Log-Logistic	235.45	276.07	429.75	267.68	256.29	31.10
Fertilization II - Maintenance II	Log-Logistic	235.46	276.07	429.51	267.68	256.77	31.08
Fertilization III	Log-Logistic	156.86	209.12	335.12	204.20	195.16	28.50
Irrigation	Normal	20.86	40.49	68.01	39.35	33.53	12.00
Limestone Application	Normal	219.47	314.90	436.99	312.43	305.89	51.35
Manual Mowing	Normal	8.10	23.02	34.02	23.46	24.65	6.30
Plantation	Triangular	515.82	536.16	554.42	536.62	538.13	8.00
Replanting	Triangular	12.24	28.83	38.35	29.92	38.28	6.65
Subsoiling	Weibull	97.02	149.58	336.59	140.78	98.21	40.60
Weed Control - Between the lines – Chemical	Inverse Gaussian	189.52	319.83	725.79	278.04	190.09	123.90
Weed Control - Chemical	Logistic	106.82	128.78	146.57	129.16	129.28	9.00
Weed Control - Chemical II	Logistic	66.82	88.78	106.57	89.16	89.28	9.03
Weed Control - in the lines	Logistic	76.37	103.06	119.38	103.87	105.67	9.20

[8] Source: PRATA, G. A. **Estimação do risco e do valor da floresta para fins securitários no Brasil**.2012. Thesis (Mestrado em Recursos Florestais) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba,2012.

3.3.2.2 Land Price

Land price values are composed by a range of different uses in the states of MAPITO and Mato Grosso do Sul and areas suitable for forest plantation in the state of São Paulo. Moreover, the land price distribution was assumed as triangular ; the highest land price value (18,181.82 R$.ha^{-1}) was found in São Paulo State and the lowest values (173.82 R$.ha^{-1} and 266.67 R$.ha^{-1}) in areas occupied by natural vegetation in the states of MAPITO and in degraded pasture in the state of Mato Grosso do Sul, respectively (Table 3.14).

Table 3.14 - Land price (R$.ha^{-1}) statistical distribution

State	**Distribution**	**Min**	**Mean**	**Max**	**Std Dev**	**Coefficient of Variation**
São Paulo	Triangular	2,280.24	10,411.41	18,181.82	3,248.40	31.20%
MAPITO	Triangular	173.33	1,385.49	2,716.67	520.86	37.59%
Mato Grosso do Sul	Triangular	266.67	5,778.16	12,433.33	2,516.21	43.55%

Land prices in the state of São Paulo are on average seven times higher than in MAPITO and 1.8 times greater than in Mato Grosso do Sul. This difference increases in the minimum values twelve times over the land price in MAPITO and eight times in relation to Mato Grosso do Sul State.

Even though the state of São Paulo showed the highest standard deviation, the coefficient of variation (CV) was the lowest (31.20%), indicating lower mean variation than the CV observed in the other regions. In other words, the likelihood to find the average value is greater in the land market of the São Paulo State.

3.3.3 Financial criteria

Once the statistical distribution from the revenues and cost was fitted and set into a discounted cash flow, the Monte Carlo simulation was performed for each financial criterion.

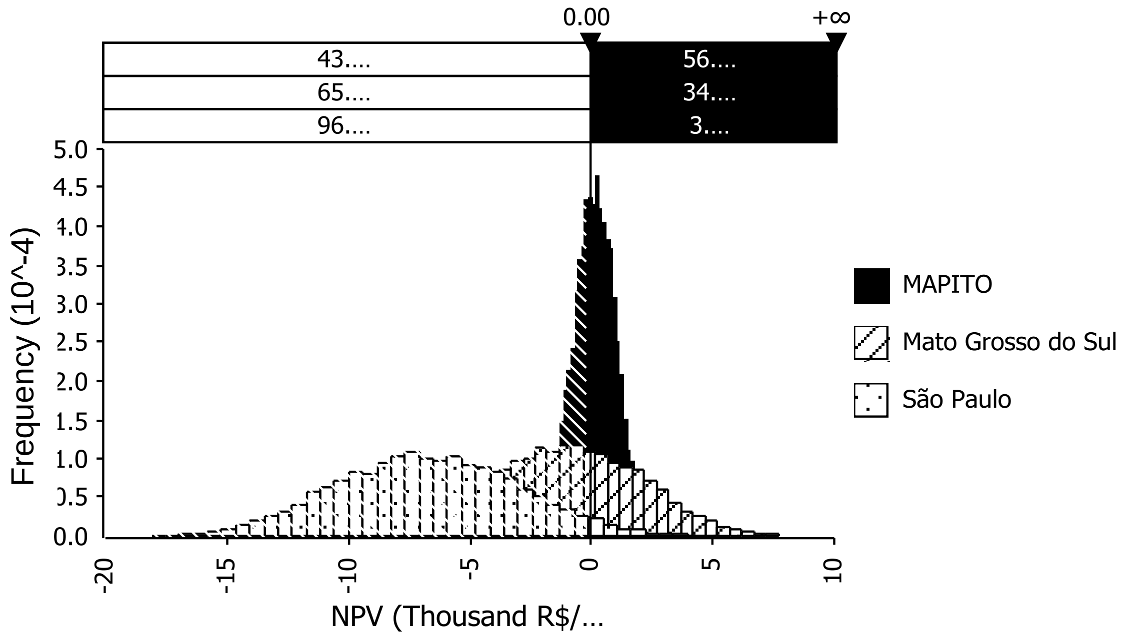
3.3.3.1 Net Present Value (NPV)

Among the three regions analyzed, only MAPITO presented NPV greater than zero on average, that is, the only region that the average return of investment could be classified as accepted and feasible at 11.23 % of discount rate (Table 3.15).

Table 3.15 - Descriptive statistics of the Net Present Value (R$.ha^{-1})

Region	Min	Mean	Max	Median	Mode	Std Dev
MAPITO	-2,762.39	130.21	3,100.60	141.65	262.16	855.16
Mato Grosso do Sul	-12,326.03	-1,454.82	7,704.93	-1,311.91	-994.79	3,325.48
São Paulo	-18,120.69	-6,738.99	5,131.96	-6,758.81	-5,824.14	3,679.80

Furthermore, MAPITO showed less risk, the lowest standard deviation value (858.57 R$.ha^{-1}) and distribution in the histogram (Graph 3.8). Conversely, the states of São Paulo and Mato Grosso do Sul indicated the extremes values. São Paulo presented the lowest NPV values (-18,120.69 R$.ha^{-1}), while Mato Grosso do Sul (7,704.93 R$.ha^{-1}) had the highest NPV.



Graph 3.8 - Net Present Value histogram

The results indicated that the likelihood to have a viable forest project in São Paulo State is lower than in Mato Grosso do Sul and MAPITO. Only 3.4 % of the NPV distribution is greater than zero in São Paulo State. The likelihood found in Mato Grosso do Sul and MAPITO was 31.5 % and 52.8 % greater than in São Paulo, respectively.

3.3.3.2 - Internal Rate of Return (IRR)

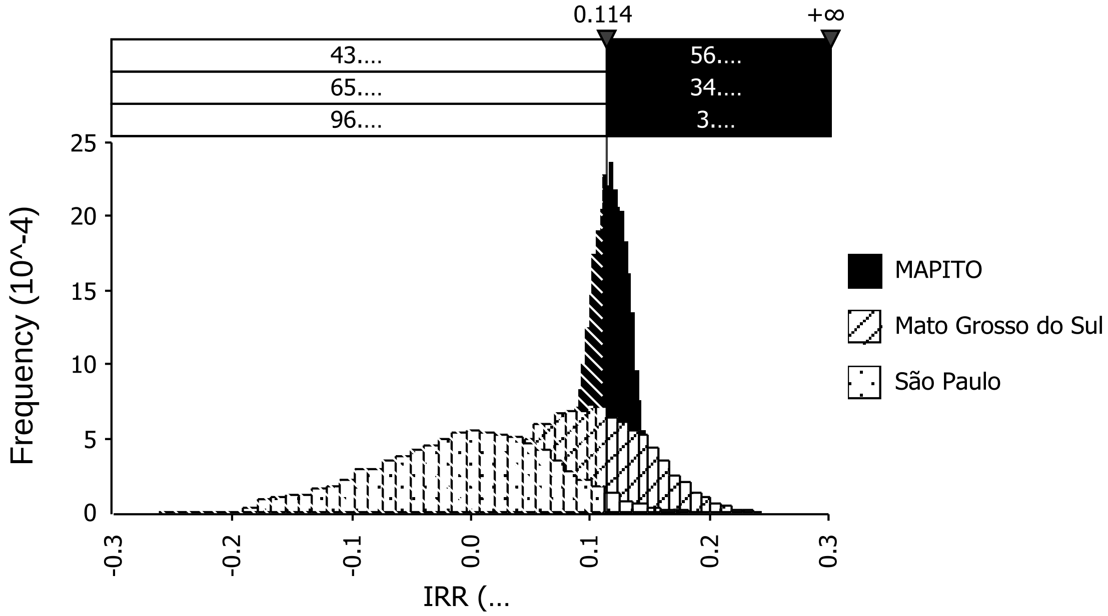
The IRR showed similar results to those found for the NPV criteria. Only the MAPITO region presented IRR higher than the minimal interest of return (11.35%) indicating economic feasibility.

Table 3.16 - Descriptive statistics of the Internal Rate of Return

Region	Min	Mean	Max	Median	Mode	Std Dev
MAPITO	5.00%	11.58%	17.55%	11.63%	11.78%	1.69%
Mato Grosso do Sul	-10.37%	9.00%	24.49%	9.22%	8.43%	5.42%
São Paulo	-26.16%	-0.76%	19.47%	-0.29%	2.16%	7.14%

Volatility was also favorable for the MAPITO region. The standard deviation was lower than in the other regions as observed in the NPV results. In certain combinations, however, the states of Mato Grosso and São Paulo can provided greater IRR, 24.49 % and 19.47 % respectively.

The histogram showed the same rate of feasibility for the three regions, as observed for the NPV (Graph 3.9).



Graph 3.9 - Internal Rate of Return histogram

3.3.3.3 Land Expected Value (LEV)

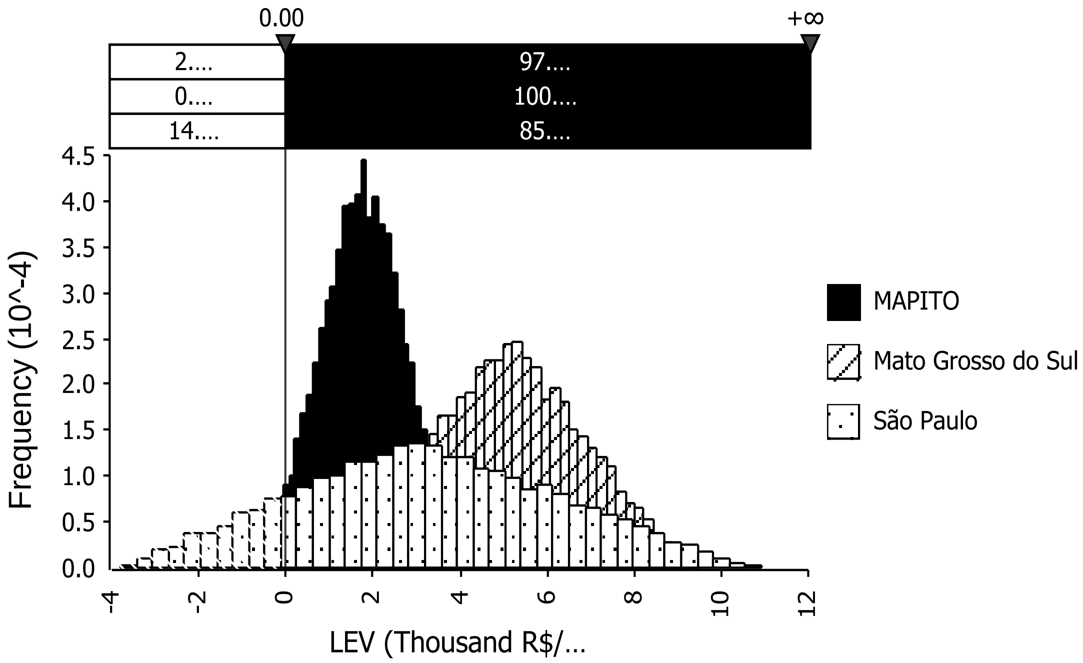
3.3.3.3.1 General Analysis

The results indicated Mato Grosso do Sul as the most favorable region for Eucalypt production accourding to the LEV criteria. The state was the only area that showed positive LEV, even in a less profitable combination and lower coefficiente of variation (Table 3.17).

Table 3.17 - Descriptive statistics of Land Expected Value (R$.ha^{-1})

Region	Min	Mean	Max	Median	Mode	Std Dev	Coefficient of Variation
MAPITO	-1,041.76	1,754.99	4,759.14	1,769.57	1,684.23	914.20	52%
Mato Grosso do Sul	1028.97	5166.296	9571.674	5151.94	5134.69	1625.148	31%
São Paulo	-3,953.44	3,268.41	10,818.93	3,187.90	2,684.67	2,940.33	90%

São Paulo and MAPITO presented minimum negatives values. These results indicated that landuse for forest production is not adequate in some occasions in both states. Nevertheless, the likelihood to obtain these results is not high, given that 85.4 % of the combinations in the state of São Paulo and 97.2 % in the states of MAPITO resulted in LEV above zero (Graph 3.10).



Graph 3.10 - Land Expected Value Histogram

3.3.3.3.2 Land Bid Prices

In a land bid negotiation, LEV is one of the tools for the appraisal the timberland value.LEV values indicate the minimum possible price offered by the buyer and the maximum possible price proposed by the seller. Therefore, people involved in the negotiation must be aware of the land price value in the market to validate LEV results and to analyze the economic viability of the project. The project is considered viable if its LEV is equal to or greater than the market land price. For this analysis, we considered market land prices in Table 3.9 (topic 3.3.2.2 Land Price).

Despite having the highest LEV values, Mato Grosso do Sul did not show the highest feasibility of projects, comparing the average land price (5,778.16 R$.ha^{-1}), 35 % of LEV distribution results were greater than the market value. The states of MAPITO presented the highest rates, 65.5 % of the LEV simulated are higher than the average land price (1,385.49 R$.ha-1), while the state of São Paulo presented the lowest, where only 0.1 % of its LEV were higher than the average market land price (10,411.41 R$.ha^{-1}).

Moreover, the state of São Paulo showed the worst scenario for the minimal and maximum market land prices, where 62.1 % was higher than the minimum (2,280.24 R$.ha-1) and none of the combination presented LEV higher than the maximum land price (18,181.82 R$.ha-1). On the other hand, the state of Mato Grosso do Sul presented the best scenario for minimal values, where 100 % of LEV distribution were higher than the market price (266.67 R$.ha^{-1}), and the worst scenario for maximum values, similar to São Paulo State, none of the LEV combinations was creater than the maximum market value (12,433.33 R$.ha^{-1}). The LEV results for the MAPITO region were the only to surpass the maximum market value, where 15.7 % of the LEV simulations were greater than 2,716.67 R$.ha^{-1} in the region.

3.3.3.4 Willingness to Pay for Land (WPL), considering future land value

The WPL ,considering future land value, computes the land acquisition at the beginning of the project as part of costs and, at end of the planning horizon, as part of revenue. The following topics will discuss the different scenarios for future land value.

3.3.3.4.1 Land price will increase in real terms:

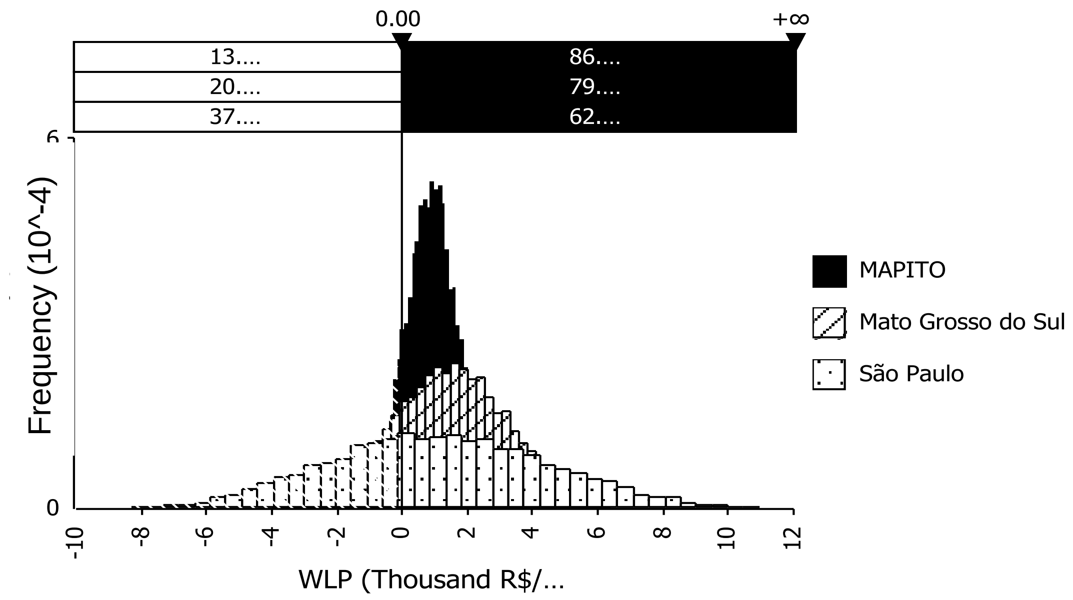
The region of MAPITO had the highest annual land price rate among the regions studied, where the land price increased 13.57 % per year in the last 10 years. In the same period, land prices increased 12.29 % and 10.16 % per year in São Paulo and Mato Grosso States, respectively.

In this scenario, the results showed a drastic difference between the current NPV and WPL, considering the future land value. Despite having the lowest risk (lowest standard deviation) and the highest minimum value, the region of MAPITO did not show the most attractive values according to these criteria and scenario. Conversely, Mato Grosso do Sul and São Paulo States had economically feasible projects according to the mean values (Table 3.18).

Table 3.18 - Descriptive statistics of WPL (R$.ha^{-1}), considering an increase in the future land price

Region	Min	Mean	Max	Median	Mode	Std Dev
MAPITO	-1,477.61	871.79	3,339.56	883.18	741.61	738.32
Mato Grosso do Sul	-3,778.75	1,427.49	6,451.20	1,445.47	1,465.74	1,686.36
São Paulo	-7,858.97	1,138.69	10,881.06	1,043.92	1,078.45	3,234.81

The rate of the feasible projects also increased in the states of São Paulo and Mato Grosso do Sul. The likelihood to have NPV greater than zero raised from 34.9% to 79.3 % in the state of Mato Grosso do Sul, 3.4 % to 62.5% in the state of São Paulo and 56.2% to 87.0 % in the MAPITO region (Graph 3.11).



Graph 3.11 - Histogram of WPL (R$.ha-1), considering an increase in the future land price

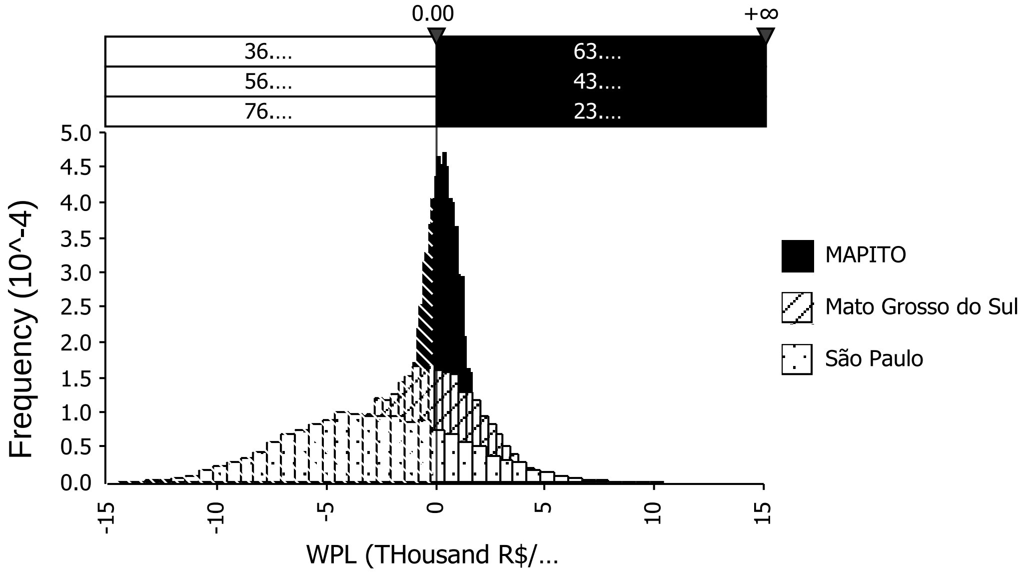
3.3.3.4.2 Land price will keep the same level in real terms

As expected, this scenario presented less attractive results for investors than the previous item. Moreover, the results showed distinct attractiveness levels among the regions. MAPITO was the most attractive region according to the mean value (287.47 R$.ha^{-1}) and in Mato Grosso do Sul, WPL surpassed the current value of the state of São Paulo by 335.84 R$.ha^{-1} (Table 3.19).

Table 3.19 - Descriptive statistic of the WPL (R$.ha-1), considering zero increase in the future land price

Region	Min	Mean	Max	Median	Mode	Std Dev
MAPITO	-2,492.05	287.47	2,929.73	301.88	52.81	821.74
Mato Grosso do Sul	-7,882.45	-476.03	6,304.83	-409.59	-430.47	2,340.07
São Paulo	-14,604.92	-2,838.05	8,693.34	-2,871.25	-2,635.16	3,898.76

The likelihood to have a feasible project decreased as well. The highest decrease was observed in the state of São Paulo, where the likelihood dropped from 62.4 % to 23.5 % while in MAPITO, the drop was from 87.0 % to 63.7 %. Despite showing lower likelihood, Mato Grosso still had the highest values, followed by São Paulo and MAPITO (Graph 3.12).



Graph 3.12 - Histogram of WPL (R$.ha-1), considering zero increase in the future land price

3.3.3.4.3 Land price will decrease annually at the same rate as the average of the negative rates observed in each region in the last 10 years.

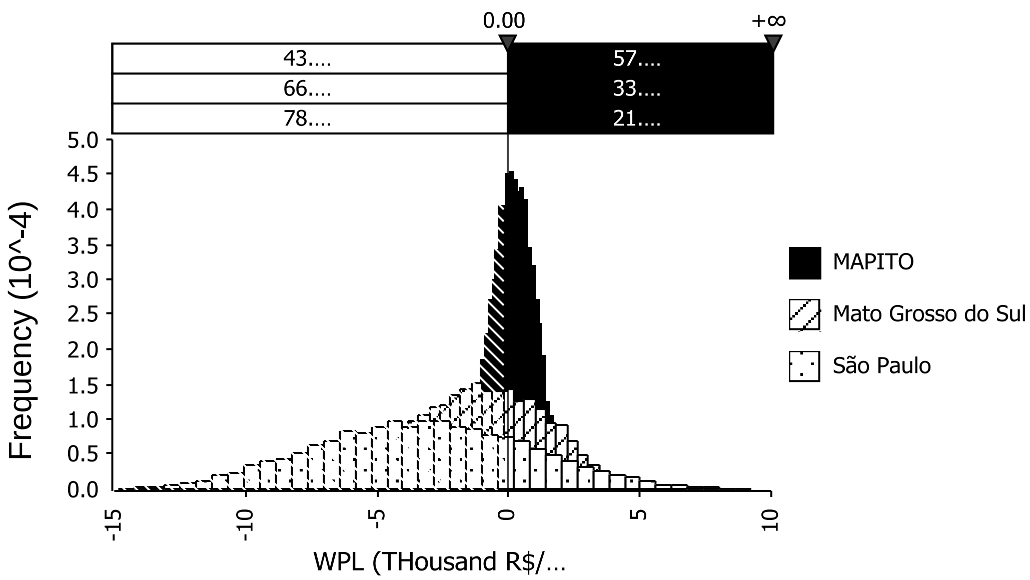
Among the scenarios proposed, by far this is the least favorable. We assumed an annual decrease of 1.3 %, 3.4 % and 4.1 % for São Paulo, MAPITO and Mato Grosso do Sul, respectively, for the next 14 years.

The expected mean is below zero for every region and the likelihood to have a feasible project is the lowest among the scenarios. MAPITO was the only region that showed positive average (141.06 R$.ha^{-1}). São Paulo and Mato Grosso did not present likelihood for a feasible project . Nonetheless, the maximum values demonstrated excellent return of investments in all the scenarios. São Paulo showed the highest values for return of investments (9,969.05 R$.ha^{-1}) (Table 3.20).

Table 3.20 - Descriptive statistic of WPL (R$.ha-1), considering a decrease in the future land price

Region	Min	Mean	Max	Median	Mode	Std Dev
MAPITO	-2,745.79	141.06	3,092.670	152.49	298.00	856.26
Mato Grosso do Sul	-9,811.45	-1,212.31	6,670.560	-1,135.82	-1,161.09	2,615.31
São Paulo	-15,434.95	-3,258.70	9,969.05	-3,260.17	-2,490.02	4,013.86

The rate of feasible projects decreased in all studied states. Moreover, in the state of Mato Grosso do Sul, the rate decreased to 34.4 % (Graph 3.13), which is not only the lowest among the scenarios proposed for the state, but also, lower than the rate computed in the net present value scenario (34.9 %) (Considering land opportunity cost) in topic 3.3.3.1.



Graph 3.13 - Descriptive statistic of WPL (R$.ha-1), considering a decrease in the future land price.

3.3.4 Sensitive Analysis.

We carried out the sensitive analysis for NPV, IRR, LEV and WPL, considering the future land price in the studied areas. For each financial criterion, we selected specific parameters discussed in topic 2.7 Sensitive Analysis and analyzed their influence in the results.

3.3.4.1 Net Present Value (NPV)

In the NPV criteria, the region of MAPITO showed a distinct behavior from the other regions analyzed. The difference between the minimum and maximum NPV indicated lower influence of the land leasing on the results. However, the final volume including the stumpage price and sum of the operational current costs had higher impact on NPV results in the MAPITO region (Table -3.21).

Table 3.21 - Sensitive analysis of the Net Present Values

MAPITO				
		Parameter	Net Present Value ($R\$.ha^{-1}$)	
	Average value in the region	NPV = 0	MIN	MAX
Land Leasing ($R\$.ha^{-1}.year^{-1}$)	143.75	186.00 - 171.59	-1,056.51	1,211.06
Stumpage Price ($R\$.m^{-3}$)	52	50.00 - 51.00	-1,009.48	1,432.79
Volume ($m^3.ha^{-1}$)	245	242 - 237	-1,986.40	1,677.00
Sum of the Operational Current Costs ($R\$.ha^{-1}$)	7,101.12	7,428.24 - 7,037.28	-196.82	976.0624
Mato Grosso do Sul				
	Average value in the region	NPV = 0	MIN	MAX
Land Leasing ($R\$.ha^{-1}.year^{-1}$)	526.01	539.02 - 466.34	-7,064.92	3,781.70
Stumpage Price ($R\$.m^{-3}$)	50.45	56	-2,115.42	587.17
Volume ($m^3.ha^{-1}$)	266.3	302.64 - 293.21	-4,125.68	1,937.98
Sum of the Operational Current Costs ($R\$.ha^{-1}$)	5,072.11	4116.60 - 3799.95	-2076.24	-492.93
São Paulo				
	Average value in the region	NPV = 0	MIN	MAX
Land Leasing ($R\$.ha^{-1}.year^{-1}$)	1.222.24	353.79 - 258.80	-13,666.55	509.86
Stumpage Price ($R\$.m^{-3}$)	53	93.17 - 91.31*	-8,117.27	-5532.75
Volume ($m^3.ha^{-1}$)	248.4	447.57 - 443.21*	-12,172.55	-1017.23
Sum of the Operational Current Costs ($R\$.ha^{-1}$)	5,770.79	-	-7650.14	-6465.92

On the other hand, land leasing prices had a higher impact on NPV in the states of São Paulo and Mato Grosso do Sul. Land leasing prices was the only parameter capable of making the forest project feasible in the state of São Paulo. Furthermore, forest projects in the state of São Paulo were not attractive using the current stumpage price offered in the market (52 $R\$.ha^{-1}$) or the maximum production assumed in this research (417 m^3 in the first rotation). Stumpage price needed to increase 38.31 R$.$m^{-3}$ and production 26.12 m^3 to make projects feasible. Furthermore, the worst aspect was the sum of the operational current costs. Even the most efficient operation process (the less expensive) was not capable of making NPV average greater or equal to zero in the state.

As occurred in the state of São Paulo, where stumpage price made NPV equal to zero, Mato Grosso do Sul showed a higher value than offered in the market (50.46 R$.$ha^{-1}$). Conversely, in the MAPITO region, stumpage price was lower than in in the market (52 R$.$ha^{-1}$).

The Mato Grosso do Sul State was more attractive compared to the regions analyzed. Land leasing in the state could be higher and still be profitable, while MAPITO showed the lowest land leasing prices.

3.3.4.2 Internal Rate of Return (IRR)

The IRR showed the same behavior as NPV in the results for the sensitive analysis. Nevertheless, the parameters that made IRR equal to the minimal accepted rate (11.35 %) showed slightly different values (Table 3.22) These different values are due to the distinguish combination in the simulation performance.

Table 3.22 -´Sensitive analysis of Internal Rate of Return

MAPITO				
		Parameter	**Internal Rate of Return (%)**	
	Average value in the region	**IRR = 11,35%**	**MIN**	**MAX**
Land Leasing (R$.ha^{-1}.year^{-1})	143.75	171.69	9.27%	13.75%
Stumpage Price (R$.m^{-3})	52	51.31	9.20%	13.96%
Volume (m³.ha^{-1})	245	242.78	6.91%	14.42%
Sum of the Operational Current Costs (R$.ha^{-1})	7,101.12	7428.24 -7037.28	11.03%	13.31%
Mato Grosso do Sul				
	Average value in the region	**IRR = 11,35%**	**MIN**	**MAX**
Land Leasing (R$.ha^{-1}.year^{-1})	526.01	466.34	-0.023	20.00%
Stumpage Price (R$.m^{-3})	50.45	56.84	0.067	12.48%
Volume (m³.ha^{-1})	266.3	302.64	0.01	15.01%
Sum of the Operational Current Costs (R$.ha^{-1})	5,072.11	4116.60 - 3799.95	0.074	10.45%
São Paulo				
	Average value in the region	**IRR = 11,35%**	**MIN**	**MAX**
Land Leasing (R$.ha^{-1}.year^{-1})	1222.64	258.85	-0.095	11.81%
Stumpage Price (R$.m^{-3})	53	95 - 93.15	-0.04	1.67%
Volume (m³.ha^{-1})	248.4	443.21 - 4,38.84	-0.139	10.13%
Sum of the Operational Current Costs (R$.ha^{-1})	5,770.79	-	-0.035	-1.16%

3.3.4.3 Land Expectation Value (LEV)

The production volume parameter had the greatest impact on LEV criteria. In the state of São Paulo, LEV can vary 14,338.31 R$.ha^{-1} (from -3,715.61 to 10,622.70 R$.ha^{-1}) depending on the volume produced (Table 3.23). Furthermore, only the highest volume performed (417.70 m^3.ha^{-1} at the end of the first rotation) could make LEV equal to the average land price offered in the market in the state (R$ 10,411.41 R$.ha^{-1}).

Table 3.23 - Sensitive analysis of Land Expectation Value

MAPITO				
		Parameter	Net Present Value ($R\$.ha^{-1}$)	
	Average value in the region	**LEV >= R$/ha 1.385.49**	**MIN**	**MAX**
Stumpage Price ($R\$.m^{-3}$)	52	50.52 - 49.73	290	3,429.12
Volume ($m^3.ha^{-1}$)	245	237.00 -231.00	-965.6	3,743.09
Sum of the Operational Current Costs ($R\$.ha^{-1}$)	7,101.12	7,142.40	621.92	2,782.01
Mato Grosso do Sul				
	Average value in the region	**LEV >= R$/ha 5,778.16**	**MIN**	**MAX**
Stumpage Price ($R\$.m^{-3}$)	50.45	52.80 - 52.10	3901.67	7375.35
Volume ($m^3.ha^{-1}$)	266.3	293.21 - 283.78	1317.97	9111.8
Sum of the Operational Current Costs ($R\$.ha^{-1}$)	5,072.11	0	-2668.57	-633.48
São Paulo				
	Average value in the region	**LEV >= R$/ha 10,411.41**	**MIN**	**MAX**
Stumpage Price ($R\$.m^{-3}$)	53	85.78 - 85.78	1496.71	4818.67
Volume ($m^3.ha^{-1}$)	248.4	417.7	-3715.61	10622.7
Sum of the Operational Current Costs ($R\$.ha^{-1}$)	5,770.79	781.96	2189.73	4199.89

Unlike the results for NPV, LEV was positive in the operational costs in the state of São Paulo. The region of MAPITO showed more attractive return of investments despite high costs, the maximum operational current cost proposed was 7,882.76 $R\$.ha^{-1}$, which is 740.27 higher than the minimum cost that make the project feasible. On the other hand, in the state of Mato Grosso do Sul, lower operational costs were not higher than land prices practiced in the market.

Stumpage price in this scenario was lower than in NPV criteria; however, prices were higher than the market, except for the MAPITO region of. The highest stumpage price was observed in São Paulo with 32.78 $m^3.ha^{-1}$ against the market price 52 $m^3.ha^{-1}$.

3.3.4.4 Willingness to Pay for Land, Considering Future Land Value

3.3.4.4.1 Land price will increase in real terms.

The production volume parameter was most drastically impacted cash flow in this scenario. São Paulo state showed the most influence of this parameter, where final NPV ranged from -5,913.06 to 8,554.04 R\$.ha^{-1} (Table 3.24).

Table 3.24 - Sensitive analysis of WPL, considering an increase in the future land price

MAPITO				
		Parameter	**Net Present Value (R\$.ha^{-1})**	
	Average value in the region	**NPV = 0**	**MIN**	**MAX**
Land Price (R\$.ha^{-1})	1266.48	3,842.98 - 3,749.12	602.66	1,316.79
Stumpage Price (R\$.m^{-3})	52	46.57 - 45.78	-163.34	2,278.91
Volume (m³.ha^{-1})	245	215.15 - 209.63	-1,140.22	2,523.18
Sum of the Operational Current Costs (R\$.ha^{-1})	7,101.12	8,052.91 – 7,967.79	90.26	1749.77
Mato Grosso do Sul				
	Average value in the region	**NPV = 0**	**MIN**	**MAX**
Land Price (R\$.ha^{-1})	4634.47	9,231.56 – 8,591.21	-1,557.74	3,899.86
Stumpage Price (R\$.m^{-3})	50.45	43.68 - 42.36	443.93	3,146.55
Volume (m³.ha^{-1})	266.3	227.23 - 217.80	-1,566.42	4,497.24
Sum of the Operational Current Costs (R\$.ha^{-1})	5,072.11	6,534.16 – 6,482.41	483.14	2066.45
São Paulo				
	Average value in the region	**NPV = 0**	**MIN**	**MAX**
Land Price (R\$.ha^{-1})	10,772.18	13,997.06 – 13,160.24	-1,938.47	4,359.35
Stumpage Price (R\$.m^{-3})	53	48.15 - 47.36	-650.06	2,704.12
Volume (m³.ha^{-1})	248.4	236.08 - 219.57	-5,913.06	8,564.04
Sum of the Operational Current Costs (R\$.ha^{-1})	5,770.79	7,834.64 – 7,699.30	670.677	1863.17

Surprisingly, the land price did not change NPV results as much as the other parameters did in the MAPITO region, where NPV could range from 602.66 to

1,316.79 R\$.ha^{-1}, depending on the land price simulated. In the states of São Paulo and Mato Grosso do Sul, however, operational current costs had the lowest influence on the results.

The three studied areas could show less favorable values in the cash flow analysis than in NPV analyzed in the previous topic and still have a feasible project, according to the parameters studied. In the state of São Paulo the volume and stumpage price decreased 48 % (from 447.57 to 236.08 m^{3}.ha^{-1}) and 47 % (from 93 to 48.15 R\$.m^{-3}), respectively, and operational costs were higher than the average practiced in the market.

MAPITO had the most favorable values for the parameters volume in the cost analysis. The region could manage higher operational costs (8,052.91 to 7,967.78 R\$.ha^{-1}) and lower productive levels (215.15 to 209.63 m^{3}.ha^{-1}) than the other regions. In the land price parameter, São Paulo presented the best return of investments despite higher costs for land acquisition (13,997.06 to 13,160.24 R\$.ha^{-1}) and Mato Grosso showed the best return of investments, despite lower stumpage prices.

3.3.4.4.2 Land price will keep at the same price in real terms.

As predicted, as the expected future value reduced, the values of land price and operational cost decreased and volume and stumpage price increased to keep the project still feasible in the three regions. The land price had the highest drop in the MAPITO region, where the land price reduced 53 % (from 3,842. 98 to 1,779.52 R\$.ha^{-1}). Conversely, stumpage price had the highest increase (from 48 to 76.36 R\$.m^{-3}) in the state of São Paulo.

The land price and stumpage price demanded higher values than market prices and lower operational costs in the state of São Paulo (Table 3.25). On the other hand, MAPITO was the only region that showed higher value in the land price and operational costs, and lower in the stumpage price and in the volume and while, in the state of Mato Grosso do Sul only the stumpage price surpassed market prices.

Table 3.25 - Sensitive analysis of WPL, considering zero increase in the future land price

MAPITO				
		Parameter	**Net Present Value (R$.ha^{-1})**	
	Average value in the region	**NPV = 0**	**MIN**	**MAX**
Land Price (R$.ha^{-1})	1266.48	1779.52 - 1645.65	-748.21	1,230.78
Stumpage Price (R$.m^{-3})	52	50.52 - 49.73	-852.2	1,590.06
Volume (m³.ha^{-1})	245	237.26 - 231.73	-1,829.09	1,834.31
Sum of the Operational Current Costs (R$.ha^{-1})	7,101.12	7467.80 - 7052.91	-494.06	1,165.44
Mato Grosso do Sul				
	Average value in the region	**NPV = 0**	**MIN**	**MAX**
Land Price (R$.ha^{-1})	4634.47	5389.47 - 4749.13	-5,653.81	3,811.90
Stumpage Price (R$.m^{-3})	50.45	53.68 - 52.89	-1,459.82	1,242.77
Volume (m³.ha^{-1})	266.3	283.78 - 274.36	-3,470.08	2,593.58
Sum of the Operational Current Costs (R$.ha^{-1})	5,072.11	4749.93 - 4443.26	-1420.83	479.14
São Paulo				
	Average value in the region	**NPV = 0**	**MIN**	**MAX**
Land Price (R$.ha^{-1})	10,772.18	7301.75 - 6464.83	-8,883.46	3,488.12
Stumpage Price (R$.m^{-3})	53	67.36 - 65.52	-4,626.79	-1,272.67
Volume (m³.ha^{-1})	248.4	318.63	-9,889.59	4,587.51
Sum of the Operational Current Costs (R$.ha^{-1})	5,770.79	3909.81 - 3518.82	-3,677.85	2,113.93

While the final volume had more influence on the state of São Paulo and in the MAPITO region, the land price had more impact on the results of the Mato Grosso do Sul. Additionally, the sum of operational current costs had less influence in the MAPITO region and Mato Grosso do Sul State, while in the São Paulo State, stumpage price did not affect as much as the other NPV parameters of.

3.3.4.4.3 Land price will decrease annually following the same average rate as the negative rates.

This scenario indicated even lower results than the previous scenario. The decrease in the expected future price demanded values more attractive for the parameters analyzed. The parameter with the highest decrease was the sum of the operational cost in the state of Mato Grosso do Sul, where costs decreased from 4,749.93 to 3,799.95 R$.ha^{-1}. Conversely, the highest increase was found in the parameter of stumpage price in the MAPITO region (from 50.52 to 57. 63 R$.m^{-3}).

The volume had the greatest influence on NPV in the MAPITO region and São Paulo State. The difference between the minimum and maximum NPV were 14,477.10 R$.ha^{-1} in São Paulo and 3.663.40 R$.ha^{-1} in MAPITO. In the state of Mato Grosso do Sul, on the other hand, NPV results were mostly influenced by land price acquisition (from -7,238.11 to 3, 77.92 R$.ha^{-1}) (Table 3.26).

Table 3.26 - Sensitive analysis of WPL, considering zero increase in the future land price

MAPITO				
		Parameter	Net Present Value (R$.ha^{-1})	
	Average value in the region	NPV = 0	MIN	MAX
Land Price (R$.ha^{-1})	1,266.48	1,645.65 – 1,511.77	-1,035.25	1,212.53
Stumpage Price (R$.m^{-3})	52	52.11 - 51.32	-998.65	1,443.61
Volume (m³.ha^{-1})	245	242.78 - 237.26	-1,975.55	1,687.85
Sum of the Operational Current Costs (R$.ha^{-1})	7,101.12	7,467.79 – 7,052.91	-640.46	1,019.05
Mato Grosso do Sul				
	Average value in the region	NPV = 0	MIN	MAX
Land Price (R$.ha^{-1})	4,634.47	4,748.13 – 4,108.78	-7,238.11	3,777.92
Stumpage Price (R$.m^{-3})	50.45	57.63 - 56.84	-2,196.07	506.51
Volume (m³.ha^{-1})	266.3	312.06 - 302.6421	-4,206.31	1,857.34
Sum of the Operational Current Costs (R$.ha^{-1})	5,072.11	3,799.95	-2157.16	-573.85
São Paulo				
	Average value in the region	NPV = 0	MIN	MAX
Land Price (R$.ha^{-1})	10,772.18	6,464.83 – 5,627.90	-9,618.09	3,395.95
Stumpage Price (R$.m^{-3})	53	69.21 -67.36	-5,047.69	- 1,693.59
Volume (m³.ha^{-1})	248.4	351.65 - 335.14	-10,310.45	4,166.65
Sum of the Operational Current Costs (R$.ha^{-1})	5,770.79	3,518.82 - ,3127.84	-4098.78	- 2925.83

The stumpage price did not achieve the average value required by the market in all the regions studied except in MAPITO. The simulation indicated that, on average, land price should reach 8 and 22 %higher than the current market prices in the Mato Grosso do Sul and São Paulo States, respectively.

In the MAPITO region and Mato Grosso do Sul State, land price was lower value than the minimum required to make the project feasible. In the sum of operational current costs, only the states of MAPITO had better values than practiced in the market. As occurred in the scenario with no land price increase, the worst return of investments was found in the state of São Paulo, where land prices did not achieve the average value required by the market in all parameters analyzed.

3.3.4.4.4 Expected Valuation Analysis

In this topic, we present the influence of the expected valuation of land price on the NPV criteria. The MAPITO region had the most attractive results. The land provides a feasible project even depreciating 7 % per year (Table 3.27).

Table 3.27 - Sensitive analysis of WPL, considering the different speculation prices

Region	**NPV = 0**	**MIN**	**MAX**
MAPITO	- 7.0 %	139.28	888.26
Mato Grosso do Sul	2.8 % -2.0 %	-1,212.01	1,427.68
São Paulo	8.9 % - 8.1 %	-3,258.70	1,138.84

The state of São Paulo showed the highest variation for this aspect (R$ -3,258.70 to R$ 1,138.84 per hectare). The minimum increase in land price were between 8.1 and 8.9 % per year to keep the project feasible in the state.

3.4 Discussion

One of the main objectives of this research was to investigate timberland investments in traditional areas and in new agricultural frontiers in Brazil. The results showed both negative and support some of the hypotheses tested. We predicted that forest projects were not as feasible in traditional areas as in the new agricultural frontiers due to land price; however, this was not completely true. Moreover, risk aspects were attractive to all profiles of investors.

3.4.1 Land cost effect

The different scenarios of a forest project must be studied deeply by the investors and their team, as well as criteria and methods used that may influence the project feasibility. The way land price is incorporated into the cash flow analysis was an important factor in the economic criteria analyzed in this chapter.

The results showed that the decision between purchasing and renting the land was crucial for the viability of the project. The land price affected directly the return of investments of the project in the three regions analyzed. The forest project was more attractive in the Willingness to pay for Land (WPL), considering future scenarios, than in the Net Present Value (NPV). Silva et al*.* (2008) discussed this effect and stated that the land price is always higher when it is incorporated into the cash flow analysis as an opportunity cost than when it is purchased at the beginning of the investments and selling at the end expecting at least zero of real increase in the price land.

Berger and Santos, 2011 discussed land price effect in an economic analysis in pine plantation in the south of Brazil. The authors found that WPL was more attractive than NPV, wihout considering the land as revenue at the end of the period. In our worst scenario (item 3.3.3.4.3, land prices decrease annually for the next 14 years), the results was similar. Despite increasing land prices , MAPITO showed better return of investments in all price variations at the end of the cycle, while São Paulo and Mato Grosso do Sul States were feasible only if the land price has had a minimum increase of 8.9 and 2.8 % per state, respectively.

Despite the less attractive risk/return relation, the state of São Paulo still has good oportunities to invest. In the worst viable scenario (Topic 3.3.3.3. Land Expected Value), the maximum accetable land price in the state was 3,518.82 R$.ha^{-1}. For this price, investors can find properties in the municipalities of Registro (Southwest) and Tupã (Central west) (IEA, 2012). However, desirable characteristics (adequate size, near roads, good characteristics and infrastructure) should be carefully analyzed in available lands for plantations.

MAPITO and Mato Grosso, conversely, have land available and the market seems to be more dynamic than in São Paulo. Investors are able to find great land opportunities in all over the theses states, even in the region of Três Marias in Mato Grosso do Sul where the timberland market is currently more competitive due to the pulp mill installed there.

3.4.2 Risk valuation

In the financial literature, project feasibility is not discussed without measuring return of investments and risks. Deterministic analysis provides to investors only an average opinion of the returns. Unpredictable changes, e.g., operational performance or in the timber market, affect the final values and investors should be aware of externalities and their impact on the expected return.

The results of deterministic analysis are discussed in several papers (BERGER *et al.*, 2011; PAIXÃO *et al.*, 2006; SIREGAR; RACHMI, 2007); however, they are useless if professionals do not take into account the risk involved in each cost and revenue parameters. To attract investors' attention, stochastic analysis should be performed, where the relationship between risk and return is measured and thereby adapted to the investors' profile.

Our results allowed to make an analysis of the investors' risk aversion. Klemperer (1996) discussed the types of investors according to their risk aversion. According to the author, there are three profiles of investors: 1) Risk-averse: considers that the risk-revenue is worth less than a safer investment of the same expected value. 2) Risk-neutral: the amount of variation in return makes no difference to them and 3) Risk-seeker: for them, the possibility to make more money than expected is more interesting than having a safer return.

Therefore, risk-averse investors would prefer to invest in the MAPITO region rather than in São Paulo or Mato Grosso do Sul States despite the possibility to have lower returns. The MAPITO region was the least risky region to invest. The standard deviation was lower than other regions in all criteria. This fact is mainly linked to land price and volume that showed the smallest range, 173.33 to 2,716.66 R$.ha^{-1} for land price and 182 to 287 m^3.ha^{-1} at the end of the seventh period. Risk seekers and risk neutral profiles, on the other hand, would prefer to invest in São Paulo or Mato Grosso do Sul, because of the greater likelihood to have higher returns. In the WLP, considering the increase of land price criteria, investors can make 6,451.20 R$.ha^{-1} in Mato Grosso do Sul and 10,881.06 R$.ha^{-1} in São Paulo States.

São Paulo presented by far riskiest project in all economic criteria among the regions analyzed. The standard deviation had the highest value in the state. This is linked mainly to the range of production levels at the end of the rotations (104 to 417 m^3.ha^{-1}) and the land price range (2,280.20 to 18,181.80 R$.ha^{-1}).

The risk of failure of the project was reduced when we considered WLP criteria. São Paulo presented the most drastic change, rising from 3.3 % in the NPV to 21.4 % considering a decrease in the land prices. Castro et al., 2007 found results that are more attractive for the state of Minas Gerais (a traditional Eucalypt producer) in terms of likelihood. The authors reported that 30 % of NPV in that state were higher than zero in a Eucalypt project to produce charcoal. However, the authors used as minimal acceptable rate of return of 8.75 % and fewer variables than we did in our research. They used 5 variables and did not include land price variation.

3.5 Conclusion

In this chapter, we have presented an economic analysis of forest projects in different regions in Brazil. We have found significant evidence for higher attractiveness in forest projects in new agriculture frontier than in traditional regions.

The land price range is one of the main aspects to influence the attractiveness of traditional regions. The traditional producing regions still have attractive areas to establish new forest plantations; however, investors' desirable characteristics (reasonable size, price and site quality) should be investigated.

The risk analysis is essential to support the investors' decision because determinist methods give only a small fraction of the economic analysis. Moreover, despite a careful study, a project is subject to some immeasurable risks such as changes in the political and business environments.

Brazil's territorial dimension favored the study to be applied in a macro analysis. Institutional investors are looking for new regions and countries that do not have tradition in forest projects. Analyzing forest projects in foreign countries demands deeper investigation due to the distinct laws, taxes and business culture. However, criteria for a project evaluation must reflect the attractiveness in countries, as attractiveness among regions was reported in this research.

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APPENDIX

4.1 Survey

US South – Brazil Timberland Investment Questionnaire

This interview is designed to learn more about your investment practices in the U.S. and Brazil as relevant. This research will provide general information about forest investments that could be useful for investment benchmarking and to provide to prospective investors. We have questions about your strategies and specific factors that influence them. You do not need to answer any questions that you feel would present a problem with proprietary business information, of course.

I. Introduction

1. Date ____

2. Name of Interviewee___________________________________

3. Location (city/state)___________________________________

   ____

4. Email: __________________ 5. Tel: ______________________

II. Background Information

6. When did your company start making forest investments (specify year)?

a. In the USA? _______

b. In Brazil? _______

7. What are your company forest investment specializations—e.g., regions, countries, species, etc.?

8. How much forest land do you own or manage?

Type	U.S. (ac)	Brazil (ha)
Total		
Planted Pine		
Natural Pine		
Hardwoods		
Eucalyptus		
With Conservation Easements		

9. What are the characteristics of your current investment?

Characteristic	Units	World	U.S.	Brazil
Total Assets of Funds	Dollars			
Number of Funds	No.			
Employees	No.			
Minimum Tract Size	Ac.			

10. What is your U.S. organization type?

a. _____C-Corporation
b. _____Limited Liability Corporation
c. _____ S-Corporation
d. _____ Other (specify) ____________________

11. What is your Brazil organization type?

a. _____ Limited Liability (Limitado)
b. _____ Anonymous Society (Sociedade Anônima)
c. _____ Limited Partnership with Share (Limitada com Divisão de Ações)

d. _____ General Partnership (Sociedade)
e. _____ Corporation (Corporação)
f. _____ Other (specify) _____________________

12. How did your company invest in Brazil?

a. _____ Acquiring an existing company
b. _____ Develop a partnership with a local company
c. _____ Establishing your own branch in Brazil
d. _____ Other (Specify) _____________________

13. What legal arrangements were required to start and operate business in Brazil?

III. Investment Characteristics

1. How do you choose your investments?

2. Do you prefer:
a. U.S. or international investments? Why?
b. Natural forests or plantations? Why?

3. How important are the following country macroeconomic factors in your forest investment decisions?

(Circle the level of importance that applies: 1=not important; 2=slightly important; 3=somewhat important; 4=quite important; 5=extremely important)

Characteristic	Not at all Important		Somewhat Important	Extremely Important	
Country GDP	1	2	3	4	5
GDP growth	1	2	3	4	5
Market size	1	2	3	4	5
Political risk	1	2	3	4	5
Personal risk	1	2	3	4	5
Trade	1	2	3	4	5
Other (specify)	1	2	3	4	5

4. How important are the following institutional factors in your forest investment decisions?

(Circle the level of importance that applies: 1=not important; 2=slightly important; 3=somewhat important; 4=quite important; 5=extremely important)

Characteristic	Not at all Important ⟵		Somewhat Important		⟶ Extremely Important
Infrastructure	1	2	3	4	5
Ease of doing business	1	2	3	4	5
Land ownership laws	1	2	3	4	5
Current land use	1	2	3	4	5
Land price	1	2	3	4	5
Land location	1	2	3	4	5
Access to domestic credit	1	2	3	4	5
Tax rates	1	2	3	4	5
Tax complexity	1	2	3	4	5
Other (specify)	1	2	3	4	5

5. How important are the following forest factors in your investment decisions?

(Circle the level of importance that applies: 1=not important; 2=slightly important; 3=somewhat important; 4=quite important; 5=extremely important)

Characteristic	Not at all Important ⟵		Somewhat Important		⟶ Extremely Important

Timber growth rates	1	2	3	4	5
Timber markets	1	2	3	4	5
Investment returns	1	2	3	4	5
Investment risks	1	2	3	4	5
Technical capacity	1	2	3	4	5
Environmental laws	1	2	3	4	5
Social/community relations	1	2	3	4	5
Forest certification	1	2	3	4	5
Incentives and subsidies	1	2	3	4	5
Other (specify)	1	2	3	4	5

6. Which of the proceeding macroeconomic, institutional, and forest factors are most important in making your investment decisions?

7. How does the importance of these macroeconomic, institutional, and forest factors differ by country—in the U.S. vs. Brazil—or by region within a country in your decisions?

8. What are the economic expectations and requirements for your current investments?

Characteristic	**U.S.**	**Brazil**
Discount rate (%)		
Annual rate of return expected (%)		
Time to start a business (days)		
Average tax rate on profits (%)		

9. Do you have minimum timber growth rates expected by your country for investments? If so, how much per area per year?

IV. Investors

1. What type of investors do you have and what is their expected rate of return?

Type	Share of Company's Land Investments (%)	Expected Annual Rate of Return (%)
Pension funds		
Insurance companies		
Financial institutions		
Universities		
Other: (specify)		

2. What are the main reasons an investor chooses to make a forest investment?

3. Do investors rate of return expectations differ by country or within regions ofeach country?

4. Do investors recognize differences among regions, species, markets, and seek particular types of timber investments?

5. What are the main concerns of investors?

6. Do investors require forest certification, social and community programs, environmental compliance, or sustainability rankings/assurance to make forest investments? Which ones, and why?

7. What are the minimum requirements to become an investor in your company?

8. How do investors become a client of your company?

V. Concluding Thoughts

1. Have we missed any important factors that influence your timberland investments in the U.S. and Brazil, and if so what are they and how are they important?

2. Do you plan to expand or contract your timberland investments in the future? Where?

3. Thank you very much for your participation in this survey.

4.2 Consent Document

North Carolina State University
INFORMED CONSENT FORM FOR RESEARCH

Project: Brazil–US Southern Appraisal and Market Assessment

Research Team:

Bruno Kanieski da Silva [a]
Luiz C.E. Rodriguez[b]
Fred Cubbage[c]
John Welker [d]
Chris Singleton [e]

[a] Master Student in Forest Resources at College of Agriculture Luiz de Queiroz - University of São Paulo, Brazil.
[b] Professor at College of Agriculture Luiz de Queiroz - University of Sao Paulo, Brazil.
[c] Professor at Department of Forestry and Environmental Resources – North Carolina State University, USA.
[d] Senior Vice President/ Director, Technical and Data Services of American Forest Management, USA.
[e] Certified General Appraiser at American Forest Management, USA.

Some general features you should know about research studies

Your company is being invited to take part in a research study. Your company has the right to choose not to participate or to stop participating at any time without penalty. The purpose of this research is to gain a better understanding about timberland investments in the Americas. It is not guaranteed to you any personal benefits from being part of this study. This consent form provides details about the research. If you do not understand something in this form, it is your right to ask the researcher for clarification or further information. A copy of this consent form will be provided for you.

Purpose of this study

This interview is part of a dissertation of the student Bruno Kanieski da Silva to obtain the title of master at the University of Sao Paulo, Brazil, in cooperation with American Forest Management Inc. and North Carolina State University. As part of the research team, this project has as main advisor Professor Luiz C.E. Rodriguez from the University of Sao Paulo, Professor Fred Cubbage from the North Carolina State University, Chris Singleton and John Welker from American Forest Management. The intention of this study is to understand the current status of forest investments in Brazil and USA. In addition, this study will assess the actual barriers and future expectations of forest investments.

Participation in this study

If your company agrees to participate in this study, you will be asked to answer some questions about the characteristics of the forest asset managed by your company, your understanding of actual and future opportunities and the expected returns of investors. The complete process will take approximately 2 hours.

Benefits

Confidentiality

The information in these records will be kept confidential to the full extent allowed by law. Data will be stored securely in paper form and on a single computer hard drive. The original interview forms will be destroyed after the completion of the thesis, or in two years at the most. No reference will be made in oral or written reports which could link your company to this study.

Compensation

Your company will not receive any kind of payment for participating in this study.

Questions about this study

If there are any questions about this study or the procedures, you may contact the researcher at any time:

Bruno Kanieski, at 1930 A Gion Street, Sumter, SC, 29150, brunokanieski@gmail.com or telephone 704-351-7865 or Fred Cubbage at fred_cubbage@ncsu.edu, or 919-515-7789.

Questions about your rights as a research participant

If the condition mentioned were not fallowed or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator, Box 7514, NCSU Campus (919/515-4514).

Consent to Participate

“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose to stop participating at any time without penalty to which I am otherwise entitled.”

Subject's signature____ **Date** ________________

Investigator's signature___________________________________ **Date** ________________

4.3 Institutional Review Board (IRB) approval

North Carolina State University is a land-grant university and a constituent institution of the University of North Carolina

Office of Research and Innovation
Division of Research Administration

NC STATE UNIVERSITY

Campus Box 7514
Raleigh, North Carolina 27695-7514

919.515.2444 (phone)
919.515.7721 (fax)

From: Carol Mickelson, IRB Coordinator
North Carolina State University
Institutional Review Board

Date: March 27, 2012

Title: Timberland Investment in Brazil and US South

IRB#: 2575

Dear Drs. Bruno Kanieski da Silva and F. Cubbage,

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101. b.2). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations. For NCSU projects, the Assurance Number is: FWA00003429.

2. Any changes to the research must be submitted and approved by the IRB prior to implementation.

3. If any unanticipated problems occur, they must be reported to the IRB office within 5 business days.

Please forward a copy of this letter to your faculty sponsor, if applicable. Thank you.

Sincerely,

Carol Mickelson

Carol Mickelson
NC State IRB

4.4 Commands in the software R

```
####### ECONOMIC, INSTITUTIONAL AND FOREST FACTOR ANALYSIS ######

# Variables #
##load the .csv file ##
mydata02 = read.csv(file="multivariada_entrevistados13.csv",sep= ",")
mydata02$NOME = NULL
mydata02

# Run the Packages "Ecodist"

# Correlation

cor.distance <- as.dist(1-((cor(mydata02))))
cd = cor.distance

# Dendrogram

hclust.cd = hclust (cd,"complete")
plot (hclust.cd)
```

4.5 Machinery fixed cost in the state of São Paulo.

Machine	Initial Price R$(2012)	Estimate Life(hours)*	Annual Hours	Estimate Life (years)
Grader	480,000.00	16000	400.00	40.00
Tractor 125 HP	110,000.00	12000	400.00	30.00
Tractor 85 HP	90,000.00	12000	400.00	30.00
Implements	**Initial Price R$(2012)**	**Estimate Life(hours)***	**Annual Hours**	**Estimate Life (years)**
Forest Subsoiling (Heavy duty disk)	27,000.00	2000	400.00	5.00
Limestone Spreader	16,800.00	2000	400.00	5.00
Reservoir (6000 liters)	7,900.00	2000	400.00	5.00
Reservoir (500 liters)	4,800.00	2000	400.00	5.00
Seedling Supporter	5,000.00	3000	400.00	7.50
Fertilizer Spreader	7,500.00	1200	400.00	3.00
Mower	13,500.00	1200	400.00	3.00

4.5 Machinery fixed cost in the state of São Paulo.

Machine	Interest Rate	Remaining Factor Value	Salvage Price	Depreciation	Capital recovery factor	Capital recovery (R$ per year)	Source
Grader	11%	17%	81,600.00	398,400.00	0.115	55,101.78	Agrianual 2013
Tractor 125 HP	11%	23%	25,300.00	84,700.00	0.118	12,882.91	Agrianual 2013
Tractor 85 HP	11%	20%	18,000.00	72,000.00	0.118	10,553.25	Agrianual 2013
Implements	**Interest Rate**	**Remaining Factor Value**	**Salvage Price**	**Depreciation**	**Capital recovery factor**	**Capital recovery (R$ per year)**	**Source**
Forest Subsoiling (Heavy duty disk)	11%	26%	7,020.00	19,980.00	0.273	6,250.44	Agrianual 2013
Limestone Spreader	11%	29%	4,872.00	11,928.00	0.273	3,808.80	Agrianual 2013
Reservoir (6000 liters)	11%	20%	1,580.00	6,320.00	0.273	1,904.42	http://www.mercadomaquinas.com.br/
Reservoir (500 liters)	11%	20%	960.00	3,840.00	0.273	1,157.11	http://www.mfrural.com.br/
Seedling Supporter	11%	16%	800.00	4,200.00	0.205	952.05	http://www.mfrural.com.br/
Fertilizer Spreader	11%	29%	2,175.00	5,325.00	0.412	2,439.20	http://www.mfrural.com.br/
Mower	11%	21%	2,835.00	10,665.00	0.412	4,712.62	http://www.mercadomaquinas.com.br/

* Source : Agricultural Machinery Management Data - Stands - 2003

4.5 Machinery fixed cost in the state of São Paulo.

Machine	**TIH (Taxes, Insurance and Housing)**	**Total Fixed Cost R$ per year**	**Fixed cost (R$/ha/hour)**
Grader	4,800.00	59,901.78	149.75
Tractor 125 HP	1,100.00	13,982.91	34.96
Tractor 85 HP	900.00	11,453.25	28.63
Implements	**TIH (Taxes, Insurance and Housing)**	**Total Fixed Cost R$ per year**	**Fixed cost (R$/ha/hour)**
Forest Subsoiling (Heavy duty disk)	270.00	6,520.44	16.30
Limestone Spreader	168.00	3,976.80	9.94
Reservoir (6000 liters)	79.00	1,983.42	4.96
Reservoir (500 liters)	48.00	1,205.11	3.01
Seedling Supporter	50.00	1,002.05	2.51
Fertilizer Spreader	75.00	2,514.20	6.29
Mower	135.00	4,847.62	12.12

4.6 Machinery variable cost in the state of São Paulo.

Machine	Hoursepower	Kw	Consumption Factor (Diesel)*	Average Diesel fuel consumption (L/hour)
Grader	190.00	141.68	0.163	23.09
Tractor 125 HP	125.00	93.21	0.163	15.19
Tractor 85 HP	85.00	63.38	0.163	10.33
Implements	**Hoursepower**	**Kw**	**Consumption Factor (Diesel)***	**Average Diesel fuel consumption (L/hour)**
Forest Subsoiling (Heavy duty disk)				
Limestone Spreader				
Reservoir (6000 liters)				
Reservoir (500 liters)				
Seedling Supporter				
Fertilizer Spreader				
Mower				

4.6 Machinery variable cost in the state of São Paulo

Machine	Diesel Price (R$/L)	Average fuel cost per hour (R$/hour)	Lubrication **	Repair Factor***	Repair cost per hour	Total Variable Cost (R$/ha/hour)
Grader	2.00	46.19	6.93	100%	30.00	83.12
Tractor 125 HP	2.00	30.39	4.56	80%	7.33	42.28
Tractor 85 HP	2.00	20.66	3.10	100%	7.50	31.26
Machine	**Diesel Price (R$/L)**	**Average fuel cost per hour (R$/hour)**	**Lubrication ****	**Repair Factor*****	**Repair cost per hour**	**Total Variable Cost (R$/ha/hour)**
Forest Subsoiling (Heavy duty disk)				60%	8.10	8.10
Limestone Spreader				80%		0.00
Reservoir (6000 liters)				50%	1.98	1.98
Reservoir (500 liters)				50%	1.20	1.20
Seedling Supporter				50%	0.83	0.83
Fertilizer Spreader				80%	5.00	5.00
Mower				150%	16.88	16.88

*Book - Conservação e Cultivo de solos para plantações florestais. Capítulo 13.
**Paper - Estimating Farm Machinery Costs
*** Source : Agricultural Machinery Management Data - Stands - 2003 (total R&M Cost)

4.7 Machinery total cost in the state of São Paulo

Machine	Total Cost (R$/hour)
Grader	232.87
Tractor 125 HP	77.24
Tractor 85 HP	59.90

Implements	Total Cost (R$/ha/hour)
Forest Subsoiling (Heavy duty disk)	24.40
Limestone Spreader	9.94
Reservoir (6000 liters)	6.93
Reservoir (500 liters)	4.21
Seedling Supporter	3.34
Fertilizer Spreader	11.29
Mower	28.99

4.8 Inflation Correction

Appendix 4.8 – Inflation Correction

Year	IGP - DI (%)	IGP-DI (Base year 2012) %	Index Factor (2012)
2002	26%	54%	185.93%
2003	8%	58%	172.68%
2004	12%	65%	154.00%
2005	1%	66%	152.15%
2006	4%	68%	146.59%
2007	8%	74%	135.87%
2008	9%	80%	124.54%
2009	-1%	79%	126.34%
2010	11%	88%	113.52%
2011	5%	93%	108.10%
2012	8%	100%	100.00%

Source: Fundação Getúlio Vargas