Sustainable Biodiesel Production from Cottonseed Chain in Brazil

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ABSTRACT:

This study aims to assess the sustainability (economic viability, capacity of integration of family farming, and the minimization of impacts on the environmental) of the production of biodiesel from cottonseed produced in semi-arid region of Brazil, specifically in the SaaoFrancisco Valley. The study is based on the Method for Integrated and Sustainable Agribusiness Projects (NEVES and CASTRO, 2007) and also on the literature from the Transaction Cost Economics (TCE) (ZYLBERSZTAJN, 1995). Therefore, a literature review (desk research) was held, a qualitative, exploratory and not structured research, using the technique of data survey and in-depth interviews. As a result, there is a description of the cotton's AGS (Agro-industrial System), and a proposition of Business Models for Cotton in the Sao Francisco Valley, and finally, an analysis of the economic viability of the fiber, vegetable oil and biodiesel made out of cottonseed. Taking into consideration the integration of small rural producers, the proposed business model provides a consistent minimum income as a criterion for social, as well as the inclusion of these agents in the transnational agribusiness chain. With this study, the economic viability of the project for all the involved agents could be verified through the analysis of the competitiveness of the cotton's agro-industrial system in the Sao Francisco Valley, through the use of the best agricultural and management techniques available, to minimize environmental impacts and make better use of finite natural resources, especially water from the Sao Francisco River.

Key Words: Biodiesel, Analysis of viability, Supply Chains

1. INTRODUCTION

The biodiesel is a perfect substitute for diesel oil, with environmental externalities (positive energy balance, low emissions of pollutants) and social (space for inclusion of family farming) positive. The use of diesel fuel is predominant in buses and trucks. In some countries, such as Europe, the diesel reaches also be used by light vehicles.

The market for biodiesel has grown so exponentially in recent years. World production in liters, increased from 1.4 billion in 2003 to just over 8 billion in 2006 (FOR Licht's, NBB and EBB). The current targets for mandatory addition were imposed by the countries that should increase the demand to almost 90 billion liters. However, the installed capacity in the world won't be able to meet this demand. Adding up all existing production units to those in construction, the worldwide capacity of biodiesel production reaches about only 35 billion liters.

The Brazilian program for this sector is very similar to the European one, establishing the compulsory addition of at least 3% of biodiesel in all the diesel that has been sold since July 2008, which it's being studied the possibility of anticipating the requirement of B5 (addition of 5% of biodiesel to the regular diesel), from 2013, as provided for in the original program, to 2010.

With the change of B2 to B3, the estimative of consumption for the year 2008 jumped from 840 million to 1.2 billion liters. It is estimated that this figure will be around 2.5 billion liters when B5 becomes mandatory. Considering the trend in the business sector of transport to add, on a voluntary basis, larger volumes than the B3, and a scenario of B5 in 2010, the steady market would be over 4 billion liters / year.

According to the Ministry of Mines and Energy (MME), the installed capacity in Brazil to produce biodiesel in 2006 was 850 million liters. In 2007, with the entry into operation of new plants, production capacity was around 1.8 billion liters, therefore, it is over the needed demand to B3 (1.4 billion liters).

A strong limitation to the production planning and to the adoption of targets of compulsory addition by the countries, in terms of biodiesel, is the growth of the international market for oil pulled by strong population growth, economic prosperity and competition for food, feed and energy. This is reflected in the records set by oil prices in the main stock exchanges of the world.

The main raw material plant used until now in Brazil to meet this capacity has been the soybean oil (80%), due to its production scale. According to the MAD (Ministry of Agrarian Development), the participation of soybeans in biodiesel production tends to decrease as the main product is the soybean meal and the oil content is very low. Besides, by directly competing with food production.

The use of agricultural raw materials for the processing of biodiesel depends, in most cases, of the production itself to guarantee the supply of plants. To obtain a secure source of oil, economic agents have to evaluate some aspects of the different types of oil: the potential expansion of cultivated areas; (ii) crop yield (tons of crops per hectare); (iii) oil yield (% de oil per seed) and; (iv) the production cycle (annual, perinea e semi-perinea).

The biodiesel comes as a new source of remuneration for the cotton crop. The objective of the cotton plantation is to obtain the fiber, and the cottonseed is a sub-product that is being used for oil production. However, compared to other crops, the cottonseed has a low yield in oil (15.2%), but the high productivity per hectare offset this limitation.

With the progress of the infrastructure projects promoted by the Brazilian government (CODEVASF – Sao Francisco and Parnaíba Valleys *Development Company*), the region of the Sao Francisco Valley (SFV) becomes a potential cluster development for many agribusiness chains. The region has good structure and good regional distribution of the production (rail, waterway and road) for the supply for both the internal and external market. In terms of domestic market, the region is able to provide for the entire Northeast, which has one of highest rates of national growth in recent years and is in deficit in production of biodiesel.

In this context, this article focuses on the production of cotton, considering the competitive advantages of biodiesel made from the cottonseed, soil and climatic conditions as well as the existing infrastructure in the Valley of Sao Francisco for a competitive production of fibers with high quality and oil at a competitive cost.

2. OBJECTIVES AND METHODS

This study aims to assess the sustainability (economic viability, capacity of integration of family farming, and the minimization of impacts on the environmental) of the production of biodiesel from cottonseed produced in semi-arid region of Brazil, specifically in the Sao Francisco Valley.

The semi-arid region is out of Bahia’s economic axis (metropolitan area), but has great potential from investments in infrastructure provided by the Brazilian government for the development of the region.

For the analysis a study was performed to identify the business models (productive arrangement) that stimulate inter-organizational relations in the production system. From this model, the whole analysis of economic feasibility can be built taking into consideration the inclusbion of family farmers to the network of the agriculture anchor, using the best techniques for managing the natural resources available in the region.

The method used in this paper is the literature review (desk research) with exploratory character and a qualitative research using the technique of in-depth interviews.

The literature review is essential to the knowledge around the Cotton Agrindustrial System (Cotton AGS). This review involves first the Method for Integrated and Sustainable Agribusiness Projects (NEVES and CASTRO, 2007), which aims to attract investment to new frontiers of production in a sustainable way, and then, the literature on Economy of Transaction Costs (ETC) (Zylbersztajn, 1995) will be studied to understanding the governance structure for the analyzed transactions.

In a second phase, interviews were conducted with semi-structured questionnaires involving professionals from research institutes (EMBRAPA Cotton and EMBRAPA Semi-Arid), industry associations (AIBA - Association of Farmers and Irrigants of Bahia - and ABAP-BA - Association of Cotton producers from Bahia), private companies (Multigrain and AdecoAgro) and independent consultants (Professional Consultancy).

3. LITERATURE REVIEW

The concept of family farming began in the early 1990s. Before that, the producers were categorized only as small farmers, subsistence producers or producers of low-income (FERREIRA, 2008).

Family farmers face difficulties in achieving prosperity in their cultivation. There are difficulties in purchasing inputs and a lack of coordination among producers. The income generation related to the area of cultivation of the producer is low. Their competitiveness and therefore their survival seem impossible in the current scenario of agribusiness. Thereby, it is of extreme importance to the integration of small family producers into the coordinated subsystems in order to introduce them into agribusiness (GIORDANO, 1997).

In this context, the objectives of organizations are to develop options for economically viable investments, but that are also socially and environmentally responsible. The intent is to respond to the phenomenon that considers the environment as part of strategic decisions, as is the sustainability (GIORDANO, 2003).

For the study, the model of sustainability called 3 P's (People-People, Profitability and Profit-Planet-planet) was used.

By applying the concept of the 3 P's in the production of biodiesel from cottonseed in the Sao Francisco Valley, the first P (Profit) seeks the economic viability of the investment. The second P (People) is related to the efficient governance of transactions, as specified in the theory of transaction costs economics (TCE), which will be applied to the local production (with the integration and organization of family farmers) and supply contracts established among the participants of the production. The third P (Planet) is linked to the environmental suitability for the cultivation of cotton, using the best technology for extraction and production of oil and biodiesel ("eco-efficiency") and the biofuel is environmentally better than those derived from petroleum. Now these concepts will be detailed.

3.1. The Method for Integrated and Sustainable Agribusiness Projects

The Method for Integrated and Sustainable Agribusiness Projects, developed and implemented by Neves and Castro (2007), deals with the analysis of the economic viability, the incorporation of family farming, the minimization of environmental impacts, and exploit opportunities of "green" business. The method begins with an anchor company (the strategic focus). This company has the role of managing the sub-AGS (strictly coordinated agribusiness subsystem), but also visioning the market, with focus on the customer's perspective, understanding their needs and their intermediaries.

Figure 01: Key dimensions of the Method for Integrated and Sustainable Agribusiness Projects

In tegrated	Sustainable	Business	Project
• Interorganizational • Chain and Network Perspective • Technological Transfer and requested specificities • Cooperatives • Associations • Government Participation • Coordinated System • Public Banks participation	• Environmental Friendly • Fair trade • Organic • Job Creation • Social Development • Regional Development • Work Conditions	• It is made for profit attainment • Cost control • Innovation • Continuous Search for Competitiveness • Quality Refinement	• Rigorous Analysis • Rigorous Marketing Analysis • Organization, Scheduling, Implementation

Source: Neves e Castro (2007)

Therefore, the four dimensions of the method will be detailed below:

Project Management Dimension: the feasibility and attractiveness of the project are questioned. A suitable region for the production of food or fiber must be determined. The Sao Francisco Valley has favorable soil and climatic conditions for cotton plantation, which favors the mechanized production in the region and protects against the attack of pests and diseases.

Then, the market analysis of the final product should be studied. It is not interesting to invest in a product that has many competitors or has difficulties in accessing market. When production is considered feasible and the market is favorable to its commercialization, a simulation of economic viability of a investment project of the activity in the region is made.

Integrated Dimension: a systemic and integrated vision of the business is needed when carrying out a project, from the analysis of the governance structure to the coordination of sub-SAG (subsystem agribusiness). According to Neves e Castro (2007), a company to become competitive in the region must buy from suppliers and sell to their customers, managing the relationship during the transaction with their agents (Farina et al., 1997).

The analysis of the relationship with suppliers and the creation of a model of inclusion, which aggregates the largest possible number of independent producers, are carried out in this step. The goal is to lead to a healthy relationship between the producer and the anchor company in order to avoid concentration.

According to the New Institutional Economics (NIS), cooperatives and associations are the best way for producers to coordinate themselves (within the same link of production). At the same time, companies in different technological levels (which belong to more than one link) can reduce conflict and improve the distribution of their earnings by forming coordinated subsystems (Zylbersztajn and Farina, 1999), and making the supply chain sustainable. Consequently, there must be a development of alliances, such as cooperatives and associations (horizontal coordination) and integrated sub-systems, long-term relationships between agents of different links (vertical coordination).

Business Dimension: in this dimension, the profitability and competitiveness of the productive system is determined. For the agents that are involved in the business, it should be clear that their survival depends on innovation and the quality of their products, which will generate income. There are several factors that help in this operation, for example, for biodiesel out of cottonseed, investments in research and development by Embrapa Cotton, with the help of universities and public (CODEVAF) and private funding (traditional groups cotton).

Sustainability Dimension: it is necessary to examine how sustainable the development can be ensured in the production of biodiesel from cottonseed, with an analysis of the 3 P's cited above: People, Planet and Profit. Here, one should also take advantage from the opportunities on "green" businesses (organic, fair trade, carbon credits) with seals and origin certifications.

After the analysis of the Method for Integrated and Sustainable Agribusiness Projects, the types of contracts that will be proposed for the production chain should be considered. For this, we must consider the importance of the theory of Transaction Costs Economics (TCE).

Thinking the firm as a “nexus of contracts" (Coase, 1937), it becomes possible, according to Zylbersztajn (2005), to study the organizations as institutional arrangements, bounded by contracts that are either formal or informal agreements, through which transactions are conducted.

Williamson (1985) specifies that these exchange relationships have costs and can be identified only as trades between two companies or even as exchange of resources between levels of vertical integration of the same company.

In Neves (1995), there are examples of ex-ante transaction costs, as the costs of searching and acquiring information on the parties. There are also ex post transaction costs such as monitoring the performance and the cost of renegotiation. The way a company indicates the best way to manage a transaction with an agent is the governance structure.

There are different kinds of institutional arrangements to conduct each transaction in the market, explained by differences in the attributes of these transactions. Neves et al. (2007) cite the three attributes of Williamson (1985): the first is how often these transactions occur, as to the regularity and sequence; the second is the attribute of uncertainty, which reflects the lack of knowledge around the elements which will be related to the transaction; and the third transaction attribute is the specificity of assets, related to how specific the activity is to the investment being made and whether their relocation to another use is costly.

The contracts are the structures to support transactions, which aim to control the variability and soften the risk, increasing the value of the transaction or series of them (ZYLBERSZTAJN, 2005).

The transaction costs economics (TCE) provides relevant considerations to the understanding of the contract design of the specific Cotton sub-AGS, which will be shown below.

4. RESULTS

4.1 The Cotton Agrindustrial System (AGS)

4.1.1. The Cotton Culture

Although there are varieties resistant to drought, more than 60% of the cotton cultivation in the world is performed under irrigation. This can be explained by the high gains in productivity that this system provides, which, according to Embrapa Cotton (2003), may triple when compared to the productivity of farming in barren area.

In Brazil, the irrigated cultivation of cotton began to gain strength at the end of the 1990s, and the most used methods are the irrigation by area and by sprinklers, while the located irrigation (by drip) has been gaining more space.

There are two types of cotton: the Herbaceous and the Tree, which are differentiated by the soil and climatic requirements, yield (ton / ha) and the quality of the fiber. In the Brazilian *Cerrado* (Savanna), like the region of the West of Bahia, the predominant culture is the Herbaceous cotton. In the semi-arid region, the type that dominates is the cultivation of cotton Tree, which has a lower productivity. However, the cultivars Trees have a higher resistance to drought, their fibers are longer and have better quality, and there is also the possibility of producing naturally colored fibers and also organic cotton.

4.1.2. Cotton Fiber Manufacturing

From 140 to 170 days after planting (depending on the cultivar) the harvest is performed, and it is done mechanically nowadays. Once harvested, the cotton is sent to the manufacturing unit called cotton gin, where mechanical operations separate the fiber from the cottonseed. Besides the fiber and cottonseeds, there are certain amount of other materials known in the whole as "impurities" (sand, earth, the remains of leaves, small fruits, seeds of weeds, etc.) that receive the trivial name of "breaking". It represents, on average, 5% of the gross product. Figure 2 shows the processing of cotton.

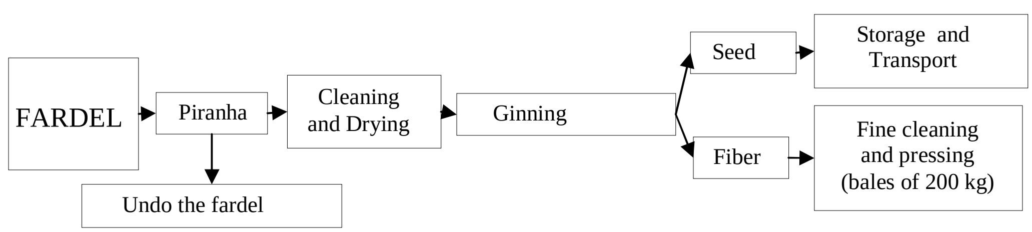

Figure 2: Procedure for the cotton processing
Source: Elaborated by the authors.

The main cotton product is the fiber. Once separated from the cottonseed, they go through the process of classification. A universal classification consists of five numerical digits, the first digit: type, the second digit: color; third digit: leaf, fourth and fifth digits: universal code for length. For example, a universal classification (obtained in the classification certificate) 41237, means that the cotton type 4, has white color, white, leaf 2 and length 37 (CONAB).

According to Freire (2005 apud MAPA, 2007), northeastern producers would be able to benefit from significant differentiation in their product, with the valorization of: a) up to 20% above the reference cotton (type 6) when produced out of good varieties, hand-harvested and without external contaminants; b) up to 30% above reference cotton, when obtained from varieties with long and extra-long (34-36 and 36-38 mm), fine (3.4 to 4.0 mm) and resistant (up from 32 to 34 gf.tex-1) fibers; and c) up to 100% of the reference value for types that are naturally colored (organic) and / or have certificate of social compliance.

4.1.3. Extraction of cottonseed oil

Another product from the cultivation of cotton, which has gained economic importance, is the cottonseed. As a byproduct of the cotton productive chain, the cottonseed becomes a viable raw material for the production of vegetable oil, and can also be used to produce biodiesel. Additionally, its cake and meal are used for animal food industry. In the process of the oil extraction, the primary byproducts are obtained, which are the Linter, the shell and the almond; the secondary byproducts are the integral flour, the crude oil, the cake and the meal; and the tertiary byproducts are the refined oil, the grain, and the defatted flour (Embrapa Cotton). Figure 3 summarizes the sub-products of cotton:

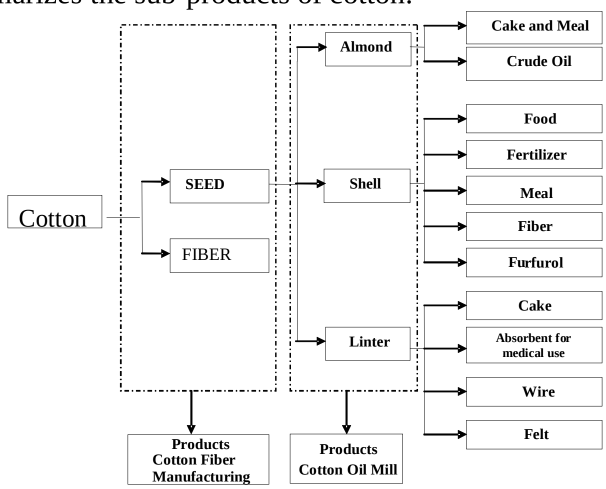

Figure 3: Sub-products of the cotton AGS
Source: Elaborated by the authors.

In the cotton oil mill the peeler separates the shell from the almond. The shell is highly digestible and can be used pure or mixed with other products in the composition of diets, not requiring grinding. It may also be used as biomass for fertilizer or fuel.

The oil obtained in the extraction process has dark color, caused by pigments that in the gossypol. This toxicity must be eliminated with the refinement of oil.

The Linter is extracted by a process called “delinting process”. It is classified depending on the number of the processed cuts, which is: Linters from the first cut, the second cut and third cut. The first-cut, which has longer fibers, is used for the cotton manufacture (absorbent) and surgical tissues. The second cut of Linter is used for the pulp manufacture, as in the third cut of Linter (Embrapa Cotton).

4.1.4. Biodiesel from cottonseed

The process of producing biodiesel is simple and of public domain. Basically consists in putting together the animal tallow or vegetable oil with an alcohol in a catalyst to have the process of transesterification, in which the oil is separated from the glycerin.

The biodiesel comes as a new source of income for the cotton crop. However, compared to other crops, the cottonseed has a low yield of oil (15.2%). Thus, the yield of biodiesel from cottonseed is in the order of 160 liters per ton of raw material (seed) (Parente, 2003).

However, studies developed by Embrapa Meio-Norte also showed that the cottonseed is the raw material with the greatest potential for biodiesel production, as informs the researcher and research coordinator José Lopes Ribeiro. Some experiments were made in the states of Piaui and Maranhao, the cottonseed, usually, can have an oil percentage from 18% to 20% and an average yield of 4.2 tonnes of seed cotton per hectare.

According to Catarina Riodrigues Pezzo, project coordinator of the National Center of Biofuels (PoloBio), of the University of Sao Paulo (USP), the most viable and affordable biodiesel in the country is from cottonseed, at a cost of $ 0.81 a liter produced in the region. The analysis of PoloBio was made in July 2007, based on the five regions of Brazil and on their main typical crops for biofuel. In the Southern region there were used sunflower and soybean; in the Midwest region there were compared sugarcane, cotton, soybean and sunflower; in the Southeastern region there were compared peanuts, soybean and sunflower; in Northeastern region there were used castorbean, soybean and cottonseed; and in the Northern region there were compared palm and soya.

A similar research, conducted by the Center for Studies in Logistics (CEL) of the Federal University of Rio de Janeiro (UFRJ), concluded that biodiesel from cottonseed provides the lowest costs when compared with the main oils. The study established scenarios with different levels of integration within the chain, considering the costs of crop acquisition, production, logistics and taxation, in addition to the revenue arising from the sale of by-products (glycerin, cake and meal) (BENZECRY, 2008). A model shown in Table 1:

Table 1: Costs of the chains (R $ / L)

Level of integration	Soybean	Cotton	Bean	Sunflower	Castorbean	Palm
Without verticalization	1,717	1,446	2,492	1,806	2,654	2,464
Integrating agriculture + smashing	1,717	1,442	2,490	1,799	2,645	2,464
Integration smashing + biodiesel plant	1,487	0,882	2,050	1,593	1,891	1,457
Integration Agriculture + Smashing + Biodiesel plant	1,348	0,881	1,890	1,725	1,828	1,302

Source: BENZECRY, 2008

When there is integration in the chain, the major advantage for biodiesel is the price of cotton oil, which average over the period considered by Benzercry (June 2006 to April 2007) was R$ 968.00 per ton, while Soybean Oil average cost was R$ 1304.00. In the case of fully integrated production, the revenue derived from the sale of the fiber results in a great advantage for cotton compared to the other chains.

4.2 The Business Model Proposed for the Cotton in Sao Francisco Valley

The business model aims the production of competitive cotton fiber as well as facilitating the production of biodiesel out of cottonseed. Thus, the relations between cotton growers, cotton gins, cottonseed oil mills, and biodiesel unities should be strengthened.

For any such interaction, there is a range of contractual options that may be used between companies. Among them there were selected three possible methods:

• Contract of Partnership: mode of association by means of contract. Tax and accounting purposes are treated separately (for each company).

• Establishment of a Consortium: voluntary contract that creates a legal figure (the "Consortium") that centralizes the internal legal relations (between the associated companies) and external (wont to the business). It allows the development of specific statements of the business, although they are recorded internally by the associated companies.

• Establishment of a Specific Purpose Company (SPC): kind of corporate association widely used by companies to manage new businesses which are not necessarily object to the wont of their core business. It allows the individualization of the business, without contaminating other activities of the company.

In the case of the cotton business, the structure of the value chain indicates that the anchor should be a large producer, for those not only have the expertise on farm, but also usually vertically integrate farming and ginning. The anchor company may also be formed through an association of producers. In this case, the gin would be formed through a SPC (1).

The anchor is to assist the integrated growers in terms of production, manufacturing and marketing. The model also proposes the creation of a cooperative of family farmers that would facilitate the relations between these and the anchor company.

During processing, the cottonseeds from the gin are purchased by a second SPC (2), to which both the oil mill and the biodiesel unit belong. This SPC would have as major shareholder a trading or an agrindustrial cooperative and as minor shareholder a investment fund, which could provide access to funding for investment and working capital. The following figure illustrates the business model:

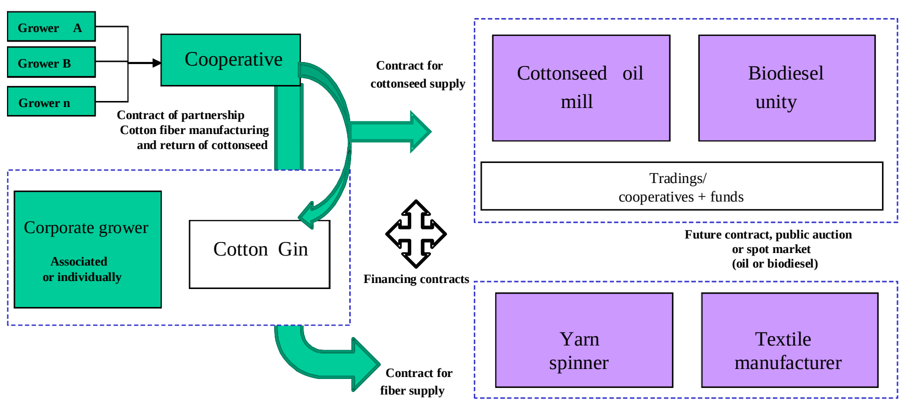

Figure 4: Business Model - Overview
Source: Elaborated by the authors.

The best form of integration between the family farmers and the anchor company is through a an agricultural partnership. Under this type of contract, in one hand the cooperative members must follow the agricultural planning of the anchor. In the other hand, they receive technical assistance, use the service of the gin to manufacture the cotton, and may access financing through the anchor.

Meanwhile, the SPC-1 gins all the seed cotton and sells the agricultural products (seeds and fiber), creating scale advantages to small growers when dealing with the processing industries. The revenue from the sales of the fiber and the seeds is passed to the integrated small cotton grower, discounted the payment of expenses incurred in assisting, a fee for the ginning service, and eventual financing plots. In addition to ensuring ginning services and technical assistance, the partnership with the anchor company can facilitate the financing of the production of the integrated small family growers.

Under a supply contract, the SPC-1 sells all the cottonseed produced to the SPE-2, which sells the oil and / or biodiesel produced in the spot market, through futures contracts or public auctions. Here, as a mean for dividing risks and benefits, it is interesting coupling the price of the cottonseed to the price of cottonseed oil.

Thus, the roles of agents are outlined regarding the responsibilities that are expected of them. The functions of each of the agents are detailed in Table 2.

Table 2 Functions of agents

Small farmers cooperative	Anchor Company (SPE-1)	Oil mill+ biodiesel unity (SPC-2)	Financial agent
-Integrated under contract of partnership with the anchor. -Consolidates equipments and labor for integrated producers. -Over time, performs activities of purchasing and distributing inputs and technical assistance to producers. -Manages activities of planting, management and harvesting. -Follows the agricultural planning of the anchor. - Can have a minor share in the ginning business.	-Receives grant of land (CDRU). -Divides the land into family lots and makes the distribution among the selected families. -Sets the agricultural planning. -Performs own production. -Orients the creation of the cooperative. -Provides technical assistance to growers. - Can help growers in the purchase of inputs and endorse agricultural financing. -Acquires and manages the irrigation system. -Gins and markets the cotton produced by the integrated growers, returning them the revenue after discounting the costs of services (ginning and eventually other such as technical assistance). -Provides oil mill with cottonseeds.	-Contract for supply of cottonseed with the anchor, with price fixed in the amount of oil. - Manufacture of oil and / or biodiesel. -Commercialization through futures contracts, public auction or spot market.	-Collection of resources to finance agricultural activity (investments and working capital). -Financing for implementing oil mill and biodiesel unities. -Financing of irrigation systems. -Possible minor participation on both SPCs (gin / oil mill / biodiesel plant) and profit.

Source: compiled by the authors.

Among the advantages of this model we can cite: (i) benefits of vertical integration without incurring the costs of capital immobilization in land, (ii) coordination of agricultural activities, with mutual benefit among the involved agents, (iii) stimulation of entrepreneurship of family farmers, (iv) production of biodiesel on land and with raw-material that do not compete with the production of food, and (v) sustainability of production, with the positioning of the company before its social and environmental responsibilities.

4.3 Analysis for the economic viability of fiber, vegetable oil and Biodiesel

The following are the financial results for those involved in various business here analyzed: production, processing of cotton, crude oil extraction and production of biodiesel. Are separated into two stages, the first of the agricultural production and processing of cotton, and second, the extraction of oil and production of biodiesel.

4.3.1. Assumptions

Based on interviews with producers of irrigated cotton in western Bahia, on data from Embrapa (Brazilian Agriculture Research Corporation), and information given from suppliers of irrigation equipments, it is concluded that the edafoclimatic characteristics of the Sao Francisco Valley together with the use of modern technologies of cultivation enables yields of 6 tons of seed cotton per hectare in the case of large growers. In the case family growers, a less technological, with lower costs, is necessary, what implies in yields of 3 tons of seed cotton per hectare.

For the necessary culture rotation, it was decided to use the winter maize. Besides helping to fight pests, this option is an alternative income to the producer for the off-season cotton, using the same land.

It was also considered the need of using more rustic and of less risky crops in the first 3 years of cultivation, which is referred to as the "opening of the agricultural area." In areas of *cerrado* (savanna), as in the region of the West of Bahia, is common to use soybeans in the first year, maize in the second and third and cotton only in the fourth year.

Tables 3 and 4 present the assumptions of yield and production according to the area adopted in this study. The levels of productivity refer to the use of drip irrigation. This is the technology that allows the best gains in productivity and more rational use of the water resources. Some countries already use drip irrigation for growing cotton with commercial success. In family areas, the drip tubes are on the surface and must be collected manually or using specialized equipment before each harvest. For the corporate areas, the drip tube should be buried, as it is done for the culture of sugar cane.

Table 3: Cotton - Agricultural Productivity and Production

Anchor	**1 hectare**		**Total hectares**	**6,000.00**
	ton/ha	**@/ha**	**Tons**	**@**
Fiber	2.28	152.00	13,680.00	912,000.00
Seed	3.18	212.00	19,080.00	1,272,000.00
Cottonseed	6.00	400.00	36,000.00	2,400,000.00
Cooperative	**1 hectare**		**Total hectares**	**2.000,00**
	ton/ha	**@/ha**	**Tons**	**@**
Fiber	1.14	76.00	2,280.00	152,000.00
Cottonseed	1.59	106.00	3,180.00	212,000.00
Seed Cotton	3.00	**200.00**	6,000.00	400,000.00
Total Production	**Average productivity**		**Total hectares**	**8.000,00**
	ton/ha	**@/ha**	**Tons**	**@**
Fiber	2.00	133.00	15,960.00	1,064,000.00
Cotton in Fiber	2.78	185.50	22,260.00	1,484,000.00
Seed Cotton	5.25	350.00	42,000.00	2,800,000.00

Source: Elaborated by the authors, based on interviews with farmers of the west of Bahia, Netafim and Embraba Cotton.

Regarding the winter maize, the technological resources of the large farmers and of the family farming, assisted by the cooperative and the anchor, allows the same productivity results.

Table 4: Winter Maize - Agricultural Productivity and Production

Factor	Sacks of 60kg	Tonnes
Productivity (ha)	78	4.70
Total Production	2,256	37,600

Source: Elaborated by the authors

For industrial income used in simulation, data were obtained from the Unit of Cotton Products of Aboissa Vegetable Oils, as well as interviews with professionals working in many areas of manufacturing and transformation of cotton products. These assumptions are presented in table 5.

Table 5: Cotton - Industrial Revenue

Cotton's Composition	
Fiber Yield	38%
Cottonseed Yield	53%
Impurities "break"	6.5%
Fibrils	2.5%
Cottonseeds' Composition	
Cottonseeds Oil's Yield	15.2%
Linter residual	12.5%
Linter Yield	7%
Cake Yield	46.7%
Shell Yield	20.7%
Residue Yield	4.9%
Oil Yield	
Density of Biodiesel (Kg/L)	0.88
Convertion rate oil/biodiesel	98%

Source: Elaborated by the authors based on the Unit of Cotton Products of Aboissa Vegetable Oils and interviews with professionals of cotton ginner, cotton oil mill and biodiesel plants.

Table 6 brings the price of products used in the study. All these represent historical averages of prices in markets close to the Valley of Sao Francisco in the period of 2006 to 2008. The price of biodiesel is the average of average prices achieved in the first eleven auctions conducted by the ANP (National Petroleum, Natural Gas and Biofuel Agency) .

Table 6: Factors of Revenue

Product	Unit	Price
Fiber	@	R$ 39.97
Cottonseed	Tonne	R$ 292.65
Fibrils	@	R$ 15.83
Cake	Tonne	R$ 521.74
Crude Oil	Tonne	R$ 1,329.96
First Cut Linter	Tonne	R$ 904.84
Gross Glycerol	Tonne	R$ 141.67

Biodiesel	Liter	R$ 2.13

Source: Elaborated by the authors based on Seagri, Aboissa and ANP.

4.3.2. Investment and Operating Costs

The main *on farm* investment is the acquisition of the drip irrigation system. Estimated at R$ 6,800.00 per hectare. Another investment considered in this study, is the opening of the agricultural area. For the first year of opening, the soybean crop was used, requiring an estimated investment of R$ 1,571.47 per hectare.

Regarding to the production costs, the basis for the calculations of costs of the agricultural division of the anchor company was the Brazilian Yearbook of Agriculture (Agrianual, 2008) published by FNP, related to the production of irrigated cotton (cycle of 160 days) by central pivot in the state of Bahia. Then, the data were adjusted according to the experiments of Netafim Brasil to the drip irrigation conditions and the input prices have been updated after interviews with producers in the west of Bahia. To the survey data of operational costs for the integrated cotton grower, the operations were based on survey conducted by Embrapa Agropecuaria Oeste for the season of 2008/2009 in Itaquiraa (state of Mato Grosso do Sul), where most of the producers are small producers and the mechanized operations are outsourced (RICHETTI . 2008). Table 7 shows the agricultural costs per hectare for the anchor company and for the integrated producer.

Table 7: Operating Cost Agricultural

	Cotton		Winter Maize
Operations/Activities	**Anchor**	**Integrated**	**All**
A.1. Soil Conservation	R$ -	R$ -	R$ 15.08
A.2. Soil Preparation	R$ 124.01	R$ 165.00	R$ -
A.3. Plantation	R$ 72.23	R$ 145.77	R$ 75.76
A.4. Culture Treatments	R$ 505.41	R$ 248.10	R$ 56.09
A.5. Harvest	R$ 411.70	R$ 480.00	R$ 80.64
A.6. Irrigation	R$ 442.45	R$ 442.45	R$ 442.45
B.1. Fertilizers/Correctives	R$ 1,524.29	R$ 418.50	R$ 411.60
B.2. Seeds	R$ 97.30	R$ 91.77	R$ 169.00
B.3. Agrochemical	R$ 1,448.45	R$ 175.00	R$ 105.88
B.4. Other inputs that are used	R$ -	R$ -	R$ -
C – Management	R$ 68.28	R$ 52.14	R$ 89.29
D – Post-Harvest	R$ 884.00	R$ 442.00	R$ 181.37
Operational Cost (R$/ha)	R$ 5,578.13	R$ 2,660.73	R$ 1,627.16
Operational Cost (R$/@ of cotton fiber and sack of maize)	R$ 36.70	R$ 35.01	R$ 20.77

Source: Elaborated by the authors based on Agrianual, Embrapa Agropecuária Oeste and interviews with producers in the west of Bahia.

The main industries of capital goods explained their needs for investment, within their respective sectors, and their production capacity. These investments are: (a) cotton ginner Busa of 30 bales / hour (R$ 5.3 million), (b) Cotton oil mill TecBio of 100 tonnes / day and delinting (R$ 6.7 million), and (c) biodiesel plant TecBio of 10 tonnes / day (R$ 2.6 million). The operational costs of each of these divisions are represented in table 8.

Table 8: Costs of operating divisions industrial

Step	**Unit**	**Value**
Ginner	Burden	R$ 4.00
Cotton Oil Mill	Tons of cottonseed	R$ 19.52

Biodiesel Plant	Liter of biodiesel	R$ 0.30

Source: Elaborated by the authors with data from Busa and Tecbio.

4.3.3. Simulation of the viability of the agricultural production and manufacturing of cotton

For cotton production in 8000 hectares of the Sao Francisco Valley, it was simulated the integration of 100 farmers to be installed in 25% of the total area, while the other 75% would be under control of the anchor company (here represented by a single large producer). Therefore, each one of those 100 families would cultivate 20 ha and the large producer would produce in 6,000 ha. The following table provides simulations of the IRR (Internal Rate of Return) and NPV (Net Present Value) for a single farmer family and the large producer. For the first one, the simulation considers the financing of all the investment with the Bank of the Northeast with a rate of 3.19% per year. But the large producer would finance half of its investments in the development of the culture and irrigation, also at the Bank of the Northeast, with a rate of 4.20% per year. In both cases there is a grace period of four years and a payment deadline of 12 years.

Table 9: Duties of officers

	Agricultural Business		Ginner Business	Integrated Business
Agents	Small	Large	Large	Large
Participation	25%	75%	100%	100%
Investment	R$ 164,904.50	R$ 57,290,449.54	R$ 5,350,000.00	R$ 62,640,449.54
IRR	14%	13.6%	13%	10.5%
NPV - Own Capital	R$ 18,346.70	R$ 4,999,284.94	R$ 1,543,545.58	R$ 6,492,431.06

Source: Elaborated by the authors.

For the integrated producer, it is also interesting to analyze the average income obtained. The results show the average annual incomes in nominal values of $ 12.372.56.

The ginner business is considered under the control only of the large producer. For the agricultural production, the investments needed for this business are 50% financed, with a rate of 4.71% per year and the same grace periods and payments.

Besides the high processing costs (45% of the distribution of annual results) compared to the revenue from the service of ginning (53%), the ginner business is known for its large initial investment. As the first three years are devoted to the opening and the management the agricultural area, this investment occurs in year 2 of the simulation.

The integrated model includes the production of the large agricultural producer (75%) and the cotton ginner. Thus, the producer will receive all their cotton at cost price. Moreover, the cotton ginner, now owned by the producer, starts to count only with the income of the cotton processing of small producers (25%).

4.3.4. Simulation of the viability of oil extraction and production of biodiesel

As seen in the description of the business model, the stages of cotton oil mill and production of biodiesel have two new players: a cooperative or trading and an investment fund. Also these two stages are financed in the same manner as the cotton ginner: 50% of the financing value, 4.71% per year, and four-year grace period and payment deadline in 12 years. The next table illustrates the results of these steps.

Table 10: Duties of the agents

	Cotton Oil Mill Business	Biodiesel Plant Business	Integrated Business

Agents	Cooperatives\ Tradings	Investment Fund	Cooperatives\ Tradings	Investment Funds	Cooperatives\ Tradings	Investment Funds
Participation	51%	49%	51%	49%	51%	49%
Investment	R$ 3,410,.421.00	R$ 3,276,679.00	R$ 2,638,716.63	R$ 1,267,618.77	R$ 2,638,716.63	R$ 2,535,237.55
IRR	36.9%	36.9%	28.9%	28.9%	26.4%	26.4%
NPV – Own Capital	R$ 8,100,049.09	R$ 7,782,400.11	R$ 4,152,625.68	R$ 3,989,777.62	R$ 7,876,178.20	R$ 7,567,308.46

Source: Elaborated by the authors.

The extraction of oil from cottonseed is very attractive due primarily to the recent recovery of the oil, the cotton cake and the Linter. Thus, even with the high prices of cottonseed, the cotton oil mill remains a very attractive business.

Like the cotton oil mill, the biodiesel plant has a high internal rate of return (IRR) of 28.9%. Its structure follows the oil mill, with the same staff and financing requirements. Besides the recovery of the price of biodiesel, low investment in the industrial plant explains this performance.

The analysis of the business of oil extraction and production of biodiesel is made in an integrated way, with an IRR of 26.4%, the initial investment is $ 2.638.716.63 and the NPV of own capital results in R$ 7,876,178.20.

5. CONCLUSIONS

Soybean has been the main supplier of vegetable oil to the brazilian plants since the first moments of the Brazilian National Program of Biodiesel due to its established scale of cultivation. However there’s no lack of interest for the use of other crops and sources of oils that have higher profitability and raw material with a most competitive cost.

From this context, this paper focused on the cultivation of cotton, with comparative advantages of biodiesel produced from oil of the cottonseed, the edaphoclimatic conditions and infrastructure of the Valley of the Sao Francisco and Parnaiba Rivers for the competitive production of good quality fibers and cottonseeds with a good oil content as well as being a sub-product, so there’s no competition with the production of food.

The objective of this paper was to present an analysis of the economic viability, with detailed and credible information, to potential investors, who wish to produce cotton in the irrigated Valleys of Sao Francisco and Parnaiba Rivers, combining the security of mature businesses (grain and vegetable oil) with opportunity to capture the market value of biodiesel.

Considering the integration of small rural producers, the business model provides a consistent minimum income as a criteria for social inclusion and inserts these agents in the chain of transnational agribusiness. Furthermore, in the analysis of the competitiveness of the cotton agrindustrial system in the Sao Francisco Valley, the economic viability of the project to all stakeholders can be checked, using the best agricultural and management techniques available to minimize environmental impacts and make the best use of the finite natural resources, especially the water from the Sao Francisco River.

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