Agrosilvopastoral Production System in Ceará Semiarid Region

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ABSTRACT

"Agrosilvopastoral techniques have been empirically developed and been used for many generations by indigenous people and countrymen in different parts of the world, but only recently they have aroused the interest as a scientific activity."

"Agroforestry, agropastoral, silvopastoral and agrosilvopastoral systems developed in response to demands for food production for human population and animals integrate the exploration of perennial ligneous species associated with agricultural crops and pasture to ensure production stability, enhance soil productivity, diversify production, increase soil fertility and good quality fodder supply."

In the State of Ceará, practical agrosilvopastoral system experiments that went further were carried out by Embrapa Caprinos e Ovinos. In addition to the experimental agrosilvopastoral system model implanted in Embrapa experimental field, several other demonstration units were implanted and followed up by Embrapa in Ceará central backwoods, in INCRA settlements and in Canindé under PRODHAM.

In PRODHAM, agroforestry system diffusion was necessary in light of joint adoption of vegetative, edaphic and mechanical practices. Even by sensitizing and training the farmers in agrosilvopastoral exploration, experiments did not succeed as expected, because of rain shortage in the years of system implantation (2005 and 2008), change of beneficiaries' behavior along the process, and high implantation costs.

The core of the system is the area division into three plots, one of which constituted an agropastoral subsystem, the second constituted a silvopastoral subsystem based on manipulated brushwood, and the last constituted a silvopastoral system.

EMBRAPA indicators show that the system, as compared to the conventional system, produces 50.6% more, employs 25.9% more workforce, and uses only 26% of conventional system area.

Key words: SAFs, Agrosilvopastoral system; Manipulated brushwood, Semiarid, Ceará, Sustainable development; Family agriculture.

INTRODUCTION

"Agrosilvopastoral techniques have been empirically developed and been used for many generations by indigenous people and countrymen in different parts of the world, but only recently they have aroused the interest as a scientific activity" (Constantin, 2009).

In general, agroforestry systems have been considered highly important, because of their contribution to rural communities' development. In the tropical world, such techniques have been used effectively, especially to meet the need of human and animal food production, by associating agricultural crops, livestock exploration and forest species management.

The innovative difference of this system is the inclusion of vegetation and forest extraction exploration in the group of company's products. Firewood, coal, stakes, honey and other products provided by brushwood diversity become as much important as agricultural and livestock production.

The improvement of the ecological hydrographic microbasin standard and consequently the agricultural company standard through both the valuation of pastures and association of timber trees that protect the soil, crops and animals, will contribute to the high economic valuation of land benefited of that exploration system.

1. CURRENT AND FUTURE FARMING EXPLORATION SYSTEM

According to Wolf (2009), "following the end of World War II, a process of decadence of traditional agriculture that had prevailed until then started." In the 1960s, a new agriculture, called modern agriculture, started to be implanted, which is characterized by the great use of external inputs, use of heavy machines, poor soil management, use of chemical fertilizers and biocides.

Although modern agriculture has existed for just a few years, the collapse of its techniques has already become evident. This way, it cannot actually be considered a sustainable agriculture, if compared to traditional agriculture that has hundred of years of history and long-term sustainability.

Given the imbalances, dependence and uncertainties resulting from the lack of sustainability of prevailing agricultural and livestock model, alternatives to modern agriculture have appeared, which are expected to become widespread, as they are based on technical and scientific sustainability, equanimity, stability and profitability grounds. Among all such trends aimed to bring technological and philosophical changes to agriculture, this paper focuses on permaculture, which is consistent with the Brazilian semiarid region agriculture. According to Wolff (2009), the main characteristics of that sustainable agriculture trend, include: adoption of cultivation systems (agrosilvopastoral systems), composting, closed nutrient cycles, integration of animals to agricultural and forestry systems, and integrated landscape and architecture.

Therefore, among the wide range of sustainable agricultural exploration models promoted by permaculture trend, this textbook will study the agroforestry systems, more specifically the agrosilvopastoral exploration system, in the brushwood ecosystem of the State of Ceará.

2. SUSTAINABLE AGRICULTURE PRINCIPLES

Altieri (1995) detailed the required characteristics of ecological agroecosystems.

Sustainability

To become sustainable, agrosystem should be based on the limited use of energy and external resources to reestablish the food chains, by keeping the biogeochemical cycles closed as much as possible. The next step will be the restoration of vegetal community stability, by reestablishing the nutrient recycling, ensuring the efficient energy flow, enhancing the exploration rate, and maximizing the use of land.

Another component that is significant for agricultural and livestock production sustainability is strengthening the family agriculture, the production logic of which is based on diversified and potentially more resistant agricultural systems. Finally, local production should be encouraged and adapted to the national socioeconomic scenario to meet the internal market demands.

b) Equanimity

Equanimity means the increase of agricultural production without increasing the social cost. This means that the objective of a production system is both the unrestricted access of its benefits by local community, and an implementation that shall not result in social losses for the community, such as poverty increase and income concentration.

c) Stability

Stability of a production system has been defined as the production stability under a set of environmental, economic and management conditions. In this sense, the system should have a high environmental adaptation level based on the selection of vegetation and animal species appropriate to such conditions. Finally, it is important to select the set of technologies that are most adjustable to the producer's objectives, resources and needs.

d) Productivity

The productivity of an agroecosystem expresses the production per area or input unit. However, the increase productivity not always constitutes the producer's most desired objective, especially under high risk conditions, when risk reduction and consequent production optimization become the goals to be achieved. With respect to modern agriculture, technological investments focused on an increasingly higher productivity have become subsistence crops more vulnerable to plagues and diseases.

3. CHARACTERIZATION OF SUSTAINABLE AGROFORESTRY SYSTEMS

3.1 Definition

According to Constantin (2009),

> the "objective of agroforestry systems is to optimize production per surface unit, always in line with the continuous yield principle, especially through the

> conservation/preservation of production potential of renewable natural resources: soil, water resource fauna and native forest preservation."

Therefore, agroforestry production system (SAF) is defined as the harmonic set of sustainable natural resource management practices where Forest species, agricultural cultivation and/or animal breeding are combined a single exploration area, in a simultaneous or sequential temporal manner (ALTIERI, 1996).

Agroforestry production systems try to simulate natural ecosystems and then produce in harmony with nature, based on renewable natural resource preservation, what will result in improved productivity and production sustainability.

Concept of agrosilvopastoral systems focused by this textbook is commented by Araújo Filho (2002) to mean:

> "agroforestry, agropastoral, silvopastoral and agrosilvopastoral production systems developed in response to pressures for production of food for human and animal consumption integrate the exploration of perennial ligneous species associated with agricultural crops and pastures to ensure production stability, increase soil productivity, diversify production, enhance soil fertility and increase the supply of good quality fodder".

3.2 Types

Four categories of agroforestry production systems can be identified, each one them comprising a great number of models from ecological, economic, social and cultural conditions.

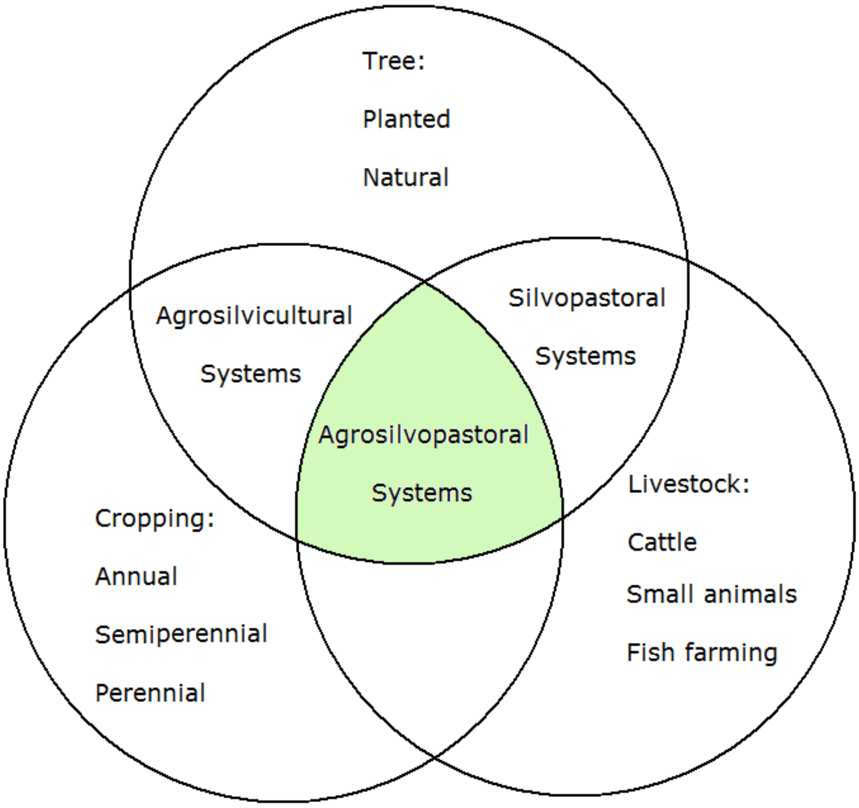
a**) Agrosilvocultural**: characterized by the association of forest species with annual or perennial agricultural crops.

b) Agropastoral: characterized by the association of annual and perennial agricultural crops with fodder plants and animals.

c) Silvopastoral: characterized by the combination of trees or shrubs with herbaceous fodder plants and animals.

d) Agrosilvopastoral: combination of crops, essential forests and animals in a single area or in a time sequence.

Figure 1 shows a systemic structure of conventional and agroforestry exploration models, where agroforestry models correspond to the intersection between specific systems, with emphasis to agrosilvopastoral system, which provides the intersection or combination of all other systems.



Source: Lourenço (2007).

Figure 1 – Systemic structure of conventional and agroforestry exploration models and related intersections

3.3. Advantages

a) Optimization of soil nutrient renewal cycle;
b) biodiversity maintenance;
c) seasonality labor use and rural exodus reduction;
d) increase of net family income;
e) increase and stability of farming and forestry production supply;
f) reduction of risks and uncertainties due to production diversification;
g) drastic reduction of dependence on inputs and external financing.

3.4 Disadvantages

a) complex agroforestry system management;
b) high implantation costs;
c) limitation for mechanization under normal standards; and
d) farming technicians' inability and farmers' lack of motivation to adopt SAFs.

4. AGROSILVOPASTORAL PRODUCTION SYSTEM IN CEARÁ SEMIARID REGION

In the State of Ceará, practical agrosilvopastoral system experiments that achieved a greater progress were those performed by Embrapa Caprinos e Ovinos headquartered in Sobral-CE.

"Experimental Agrosilvopastoral System model is implanted in Crioula Farm testing field owned by Embrapa Caprinos e Ovinos. It was designed with four objectives:

a) to establish agriculture in the land;

b) to stop environmental degradation;

c) to increase small farm productivity in semiarid region;

d) to improve family income (ARAÚJO FILHO *et al.*, 2006).

In addition, demonstrative units were implanted and followed up by Embrapa Caprinos e Ovinos in INCRA settlements located in several areas of Ceará backwoods and in Cangati River microbasin in Canindé-CE. Canindé experiment in include in PRODHAM-Ceará Hydroenvironmental Development Program coordinated by the Secretariat of Water Resources.

In project, diffusion of agroforestry systems was necessary because of the joint adoption of vegetative, edaphic and mechanical practices to achieve the sustainable development in four PRODHAM hydrographic microbasins. Even sensitizing and training the farmers in agrosilvopastoral exploration, experiments did not achieve the expected success, due to water shortage in the system implantation years (2005 - 2008), change of beneficiaries' behavior along the process, and high implantation costs.

4.1 Brief semiarid region characterization

Based on studies performed by SUDENE in 2005, the Brazilian sub-region defined as semiarid region accounts for 54.6% if its operation area (981,821.9 km²), was populated in 2000 by a little more than 20 million inhabitants, and is considered the poorest region in the country.

Semiarid zone of the State of Ceará, in turn, accounts for 86.8% of its territory and is included in the Northeastern semiarid region with highest soil limitations.

The main characteristics of that region include:

a) Low, irregular precipitation around 750 mm/year, concentrated in a single season extending for three to five months with frequent drought occurrence;

b) high temperatures and negative evapotranspiration rates and water balance for the most part of the year;

c) very strong insolation (2,800 hours/year), combined with a low relative air humidity;

d) high potential evapotranspiration rates as high as 2,700 mm per year;

e) shallow, poorly permeable soils originated from crystalline rocks, subject to erosion and having a reasonable natural fertility;

f) predominance of brushwood vegetation with a vegetative succession indicative of environmental degradation process;

g) use of itinerant subsistence agriculture characterized by very low productivity, frequent ground clearance by fire, grazing pressure, deforestation and non-replaceable extraction of firewood; and

h) distorted land tenure and lack of technical assistance and cooperativism.

In farming exploration in that region, environmental impacts cause the destruction of fauna and flora biodiversity, soil degradation and reduced water resource availability. This has precluding the maintenance of sustainability levels of populations living in semiarid region, which present high vulnerability and life quality within the limits of human survival, especially in more critical dry periods.

4.2 Current agricultural production systems

Farming activities in Ceará are characterized by a very low productivity level, high risks of periodic droughts, low cultivation level, and farmers' low income. That scenario is a direct consequence of an exploration model inappropriate for semiarid conditions of production zones, and the continued competitiveness reduction, as compared to other production zones in Brazil.

Farming GDP is only 6.1% of the State GDP; however, it occupies more than de 30% of its economically active population, what reflects the low performance of Ceará agriculture.

With respect to agricultural production, Ceará was the leading cotton producer in Brazil with 1.3 million hectares in 1980, but today it cultivates a little more than 4,000 hectares.

Among the main crops explored, maize productivity of 760 kg/ha corresponds to 60% of Northeast average. For beans, in turn, average yield if 370 kg/ha, equivalent to 87% of Northeast yield. Such figures are highly variable because of periodic droughts and excessive precipitation.

With respect to livestock, the situation is less serious. According to IBGE data for 2008, bovine cattle herd in Ceará amounted to 2.4 million heads, accounting for 9% of regional herd, which made Ceará rank third among the Northeastern States with the highest number of cattle heads. Ovine herd is quite significant (2.0 million heads), accounting for 22% of the total in the region. Caprine cattle herd amounts to some 1 million heads. Milk production per cow/year is 823 liters, while in Minas Gerais it is as high as 1,488 liters/cow/year.

Data above show that livestock in Ceará appears to be less affected by climatic irregularities and best adapted to semiarid conditions. However, modernizing the activity through agroforestry practices supported by scientific bases is necessary.

Finally, vegetal extractivism is a significant component of Ceará rural economy. The State produces 4.5 million m³ or steres of firewood, accounting for 20% of the whole production in the Northeast (IBGE, 2009).

Vegetal coal production is little significant accounting for only 1% of that in Northeastern region. According to information provided by SEINFRA-CE (2008), in percentage terms, firewood accounted for 35.5% of primary energy production in the State in 2007, corresponding to 13.6% of internal energy supply. Farming sector consumed only 3.1% of that energy input.

This way, forest production in the State has some influence on economy and therefore needs to be modernized and guided by the new sustainable development assumptions.

4.4 Adequacy of agrosilvopastoral system to semiarid region

Given the semiarid region vulnerability to irrational exploration, its sustainable use should be made by diversified, integrated, production systems that are energetically balanced and ecologically consistent and feasible at both economic and social levels.

The technological rational exploration model for semiarid region is expected to make rural properties more resistant to climate adversities that are common in the region, thus ensuring a greater economic stability, lower risk, higher productivity and improved environmental conditions. That will be possible by adopting techniques hat would allow a better use of water, soil, vegetation and animals from an integrated view of agricultural activities and their relationship with agents located "out of the farm borders."

As shown above, agrosilvopastoral system appears to be the most consistent with and feasible for the ecological, economic, and cultural environment of semiarid region. As such, this exploration model focused on small animals and adopted by family farmers seems to be the alternative most likely to succeed.

From a long-term view of agroforestry systems, Veloso (2007) says that

> "probably in the future any farm will be seen as a component of a hydrographic basin or an agroecosystem under a continuous monitoring by one or more public institutions responsible for ensuring a sustainable agrosilvopastoral production."

5. CHARACTERIZATION OF AGROSILVOPASTORAL PRODUCTION SYSTEM

> "Implanting an agroforestry system requires a prior understanding of its development and its dynamics. Identifying a good project implies making decisions involving not only the selection of species and planting method, but also the composition of agroforestry structure according to the current succession stage, that is, quantity and consolidated life quality [...] to allow the selected species to have the necessary "talent" to make the whole system develop" (OSTERROHT, 2002 apud CONSTANTIN, 2009).

Therefore, the proposed agrosilvopastoral system described below fully corresponds to the experimental agrosilvopastoral production model that Embrapa Caprinos e Ovinos has been developed over the last 11 years, as shown in Figure 2. Both its text and full description were extracted from Araújo Filho *et al.* (2006).

Photo: João Ambrósio de Araújo Filho

Figure 2 – Sheep grazing in a brushwood area subject to agrosilvopastoral system

The basis for the system is its division into three plots, one of which will constitute an agropastoral system, the other will constitute a silvopastoral system, and the last will constitute a silvopastoral subsystem based on a forest area. Integration between systems is very important, where animals play an important role for nutrient redistribution. Figure 3 shows a sketch of space use distribution in agrosilvopastoral system developed by Embrapa Caprinos e Ovinos.

<table>
<tr><td rowspan="2">Livestock Area (60%)
Breeding, Rebreeding and Termination</td><td>Legal Reserve
(20%)</td></tr>
<tr><td>Agricultural Area
(20%)</td></tr>
</table>

Figure 3 – Use of space in agrosilvopastoral system developed by Embrapa Caprinos e Ovinos.

The system is proposed for productive systems in areas not smaller than 3 hectares. Preliminary data suggest eight to nine hectares as the property size that would provide a gross income of up to two monthly minimum wages.

Most important products in proposed agrosilvopastoral production system include: timber for several purposes, hay, grains and animal products (meat, milk, manure, skin and honey). Currently, the occurrence of many opportunities for system income diversification is foreseen, through the economic exploration of native fruits and wildlife animals and the inclusion of new activities, such as apiculture, country chicken breeding and environmental services.

5.1. Agricultural Area

Area preparation in agricultural plot includes the reduction of arborous vegetation and preservation of some 200 trees per hectare, what corresponds to a coverage of approximately 20%, thus ensuring an annual production of organic matter of some 1,500 kg/ha at leaf fall in the beginning of dry season. Until a perennial leguminous plant is fully established to be the main source of green fertilization, uprooting should be avoided, as native species re-sprouting will constitute an important source of green fertilization during the rainy period.

After useful timber is removed, the sale of which will cover implantation costs, splinters will be disposed perpendicularly to the soil slope, 3-m spaced from each other, to protect the soil from erosion. Then, a leguminous plant is cultivated linearly on both sided of barriers, 0.50-m spaced from each other. Leucena, gliricídio, sabiá, jurema preta, mororó and camaratuba may be used.

Experience has shown that establishing a leguminous plant not always is successful at the first attempt. Planting should be made with seeds, but seedling preparation in the first year for replanting is important. Splinter decomposition in barriers is fast, lasting not more than three years, when the perennial leguminous plant shall have been fully established to replace splinters for soil protection. Food crops cultivation should be made in 3.0-m long strips between lines.

Multicrop practice is recommended, as the use of several integrated crops will help to reduce the ecosystem complexity, and promotes a diversified diet for human population, thus resulting in a greater income generation, production stability, risk reduction, plague and disease incidence reduction, efficient labor use and increased return at low levels of technology.

Continuous allocation of organic matter on the soil is ensured by five different sources. The first consists of leaves from trees preserved from tree felling, and may reach 1.5 ton/ha/year. The second consists of the overhead portion of stub sprout, which is cut and incorporated to the soil during the rainy period, and may reach some two tons per hectare. The third originates from native weeds that are cleared or cut and then incorporated to the soil during the cultivation cycle, and may reach up to three tons per hectare. The form originates from the cut of overhead portion of perennial leguminous plant established along both sides of splinter lines, amounting to further two tons.

And finally, the fifth and last organic matter source originates from manure randomly distributed at the end of dry period, which amounts to as much as three tons per hectare. Then, up to 11 tons of organic matter per hectare are added every year to the soil in cultivated area.

Average productivity obtained in agricultural area of the Experimental Model ranged between 722 kg/ha in 1998, and 2,625 kg/ha in 2007, averaging 1,384 kg/ha in that period. It should be considered that 30% of that area is intended for environmental preservation (ciliary forest, rows of leguminous plants and trees), and that productivity is well above that obtained under the traditional system, that is, 400-575 kg/ha of maize.

After the harvest of food crops, straw may be collected and packed for use as bulky food supplement during the dry season, when the agricultural plot will then play the role of protein bank. For that, cattle will remain every day in the area for a period of one to one and a half hour, to allow the animals to use the perennial leguminous plant, stub sprout and remains of crop stubbles. In case of family agriculture, preference should be given to the exploration of sheep and goats.

5.2. Livestock area

In that area, several sustainable brushwood management models for pastoral purposes can be adopted, especially thinning, lowering and enrichment.

5.2.1. Brushwood thinning

When properly followed, three basic recommendations ensure the sustainability of brushwood manipulation technologies: preservation of up to 400 trees per hectare or the equivalent to 40% of total trees, maximum use of 60% of available forage, and preservation of ciliary vegetation all over the pasture drainage pattern.

Arborous-shrubby vegetation thinning consist of the selective control of ligneous species with the objective of increasing the production of herbaceous layer phytomass by reducing shading and density of undesirable trees and shrubs, thus leading to the formation of a native pasture of high productivity (Figure 4).

Photo: João Ambrósio de Araújo Filho

Figure 4 – Thinned Brushwood in Sobral, CE.

Some 40% of thinned brushwood areas should be provided with tree and/or shrub shading, corresponding to some 400 medium-size trees per hectare. This practice will allow a considerable increase of phytomass production in the herbaceous layer, which will then contribute some 80% of available pasture phytomass. Thinning is recommended for bovine and/or ovine cattle exploration.

In a thinned brushwood, forage availability is equivalent to 60% of phytomass produced, which originates an annual support capacity of 3.5 ha/head for bovine cattle, and 0.5 ha/head for caprine and ovine cattle.

5.2.2. Brushwood lowering

Lowering means manual cut of ligneous species to increase access to tree and shrub forage, improve their feeding quality, and extend the production of green leaves for a longer period in dry season. Probably, it constitutes the alternative that is most adequate to different types of brushwood in Brazil's Northeastern semiarid region, as in average, some 70% of tree and shrubby species are fodder plants. That technique should be used in areas of ligneous vegetation where recognizably foraging trees and shrubs predominate.

Those species of recognized forage value should be lowered, such as sabiá, mororó, jurema-preta and quebra-faca. At the end of the following dry season, sprouts of ligneous forage species should be cut out, leaving one or two sprouts per stub.

Photo: João Ambrósio de Araújo Filho

Figure 5 – Lowered brushwood

Lowered brushwood (Figure 5) should be preferably explored for caprine cattle, or the combination of bovine and caprine cattle. Annual capacity support is 5.0 ha for bovine cattle and 0.7 ha for caprine cattle.

5.2.3. Brushwood enrichment

Enrichment can be made at herbaceous or ligneous layer level. Preferably, sowing should be made under minimum cultivation practice focused on the preservation of the native herbaceous layer rich in fodder leguminous plants in more typical backwoods sites. Two hundred (200) trees per hectare should be maintained.

Photo: João Ambrósio de Araújo Filho
Figure 6 – Enriched brushwood.

Fodder plant cultivation should be made during rainy periods. With the objective of covering part of costs in the first year, fodder plant cultivation may be combined with the cultivation of a subsistence crop (maize, sorghum, beans, manioc, etc). As phosphor tends to be the most insufficient nutrient in most brushwood soils, a phosphate fertilization is recommended at the level of 100 kg/ha of P_2O_5.

Support capacity is increased to 1.1 head/ha/year for bovine cattle and 10.0 heads/ha/year for caprine and ovine cattle.

6. HERD MANAGEMENT

For an agrosilvopastoral system in an 8.0-ha area, 20 ovine or caprine animals may be bred if the pastoral plot is thinned brushwood. For enriched brushwood, the system will allow up to 50 heads.

The herd will occupy the plots in the following sequence: 30 days in legal reserve area at the beginning of rainy season. Then, it will be moved to the pastoral plot, where it will remain until June, or the end of humid period. During the firs 30 days of dry period, it will occupy again the legal reserve area. Following that short period, the herd will return to the pastoral plot where it will remain for the whole dry period and be subject to food supplement constituted of hay and corn flour.

7. ECONOMIC AND SOCIAL FEASIBILITY

Taking into account that economic sustainability is provided by alternation and diversification of agricultural, livestock and forestry exploration, this topic identified and analyzes the indicators of financial and economic feasibility of the exploration system referred to above.

Results showed in this document were extracted from the article titled “Model for ovine and caprine cattle exploration by family farmers in semiarid region under agrosilvopastoral system” presented by França (2007).

That work considered a model where the following variables are adopted: a) sale of live animals; b) 55.3% of animal food originates from manipulated brushwood; c) herd is constituted of 280 mixed-race animals; d) facilities are rustic; and e) sanitary control is reasonable. For production scale of model under analysis, total investments amount to R$ 69,400, 69% of which corresponds to new investments in a total area of only 50 ha.

Magnitudes of result indicators indicate the exploration feasibility according to the related assumptions, as the annual net profit amounted to R$ 6,832.96, equivalent to a profitability of 22.2%.

Return on investments is expected in 10 years. Monthly family income composed of net profit plus the family labor remuneration amounts to R$ 1,419.41, without considering the repayment of the bank loan, and R$ 1,020.25 considering that disbursement.

The internal return rate (IRR) was 35.48% from financial standpoint, and 52.03% from economic standpoint, both of which are reasonable, as the minimum rate desirable for agribusiness is 25%. The difference between both IRRs represents the contribution that producers of ovine/caprine animals give to the population, which accounts for 29.5% of net present value generated from economic view. Benefit/cost ratio was 1.39 from the financial standpoint, and 1.59 from economic standpoint, both of which were excellent.

Table 1 – Comparison of Results Obtained for Agrosilvopastoral Model and Conventional(*) Model

Results Obtained	Agrosilvopastoral Type Model	Conventional* Type Model
Stabilizing herd – heads	280	280
Land surface area – ha	50	193
Valuation of naked land	281%	0%
Total investment – R$	69,400.00	80,418.00
New investments – R$	47,900.00	30,068.00
Cost of labor – R$	10,200.00	8,100.00
Profitability - %	22.20	18.50
Return on investments	10 years	more than 10 years
Annual net profit – R$	4,972.96	368.84
Monthly net profit – R$	569.41	267.07
Monthly family income – R$	1,419.41	942.07
Financial IRR - %	35.48	23.67
Economic IRR - %	52,03	35.17
Benefit/cost ratio	1.39	1.27

Source: FRANÇA et al., (2007).
(*) Through the adoption of technologies recommended by EMBRAPA Caprinos e Ovinos.

Based on results shown in Table 1, it can be said that the main advantages of agrosilvopastoral system, as compared to the conventional system, include:

- economic: available monthly family income is 50.6% higher;
- social: additional 25.9% of labor is employed;
- environmental: total required area is only 26% of area explored in conventional system for the same number of animals.

8. FINAL REMARKS

Feasibility of ovine and caprine cattle exploration by family farmers, especially by the adoption of agrosilvopastoral system, is based on the following factors:

- Low cost of animal food, because of qualitative and quantitative abundance of manipulated native pasture (brushwood);
- farmer's higher economic and social stability due to the greater production diversification and greater resistance to annual water shortage and periodic droughts;
- increased land productivity, for accounting for just one third of area required in traditional exploration system;
- landed estate valuation, because of ecological gains, non-occurrence of ground clearance by fire, dead cover and soil enrichment;
- low property management cost, because the land is small and easily managed by its owner, who also performs the role of rural worker.

For consolidation and sustainable management of proposed model, the following is recommended:

- corporate organization and sustainable management of production processes;
- sensitization and capacity building of family farmers on new paradigms derived from focus on agribusiness and sustainable agriculture;
- qualification and availability of technical assistance agents specialized in sustainable agricultural production systems;
- creation of mechanisms to enable the family farmers' access to financing and incentives, in line with an ecologically correct production line;
- possibility of differentiation of sold products by means of organic and/or origin labels.

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