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ECONOMIC VIABILITY OF A CROP-LIVESTOCK-FORESTRY INTEGRATION SYSTEM IN SÃO CARLOS, SP

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ABSTRACT
This paper aims to analyze the economic viability of a crop-livestock-forestry integration system carried out in São Carlos, SP, Brazil and estimated for a 100-ha area. The total area was divided into three plots, and the integration system was implemented in three years. The first year after eucalyptus planting, there was a soybean (first season) and a corn (second season) production in consortium with pasture. Beef cattle were raised in the pasture between the rows of eucalyptus in the remaining years. A 14-year cash flow was estimated for the project, taking the prices observed in 2020. The Internal Rate of Return (IRR) was 10.54 per year, and the Net Present Value (NPV) was R$ 570,555.77.
Key words: economic viability; crop-livestock-forestry integration system; agrosilvopastoral

INTRODUCTION

There is a need to accommodate the growing demand for food and reduce the environmental impact caused by agriculture (CORDEIRO et al., 2015). Crop-livestock-forestry integration systems (CLF), which include the crop-livestock (CL) and forestry-livestock (FL) arrangements, have proved to be reliable alternatives. They are a more sustainable production strategy in which crops, livestock, and/or forests are jointly produced (BALBINO et al., 2011). The adoption of CLF integration systems brings environmental benefits, such as the improvement of physical, biological, and chemical quality of the soil and economic and social gains (MACEDO 2009; BALBINO et al., 2011).

The CLF integration systems are among sustainable technologies supported by Brazilian policies to reach the national goal to reduce GHG emissions (VINHOLIS et al., 2021). Information on the economic viability of CLF integration systems is essential for farmers to decide whether to adopt them. This study analyzes the economic viability of a crop-livestock-forestry (CLF) integration system carried out in São Carlos, SP, Brazil.

MATERIAL AND METHODS

A 14-year cash flow was estimated for a production area of 100 ha. Technical coefficients were obtained from a CLF integration system carried out since 2011 on the farm of Embrapa Southeast Livestock. The year zero of the cash flow comprises expenses with infrastructures, such as perimeter fence and corral, and the purchase of machinery and implements. Information on technical lifetime, residual values, and maintenance cost of machinery and infrastructure followed the CONAB methodology. Prices were collected for the year 2020 on the websites of the Instituto de Economia Agricola (IEA), Center for Advanced Studies in Applied Economics (CEPEA), Scot Consultoria and

input suppliers. The income tax was calculated according to the method "Livro Caixa Digital do Produtor Rural (LCDPR)" as determined by the Brazilian Federal Revenue Office. The Net Present Value (NPV) was calculated by the equation:

$$NPV(i) = \sum_{j=0}^{n} \frac{CF_j}{(1+i)^j}$$

Where:

i= discount rate (3.48% per year);

j= cash flow period;

CFj= net cash flow for t=0, …, n;

n= number of flow periods.

The Internal Rate of Return (IRR) refers to the rate in which the NPV is zero.

The area of 100 ha was divided into three plots of 33 ha each. One hectare was destined for the grazing of the horse used in cattle working. The system was implemented in the first 3 years of the cash flow, 1/3 per year. Single rows of eucalyptus were planted in an east-west orientation and a 15 × 2m spacing (15m between rows and 2m between trees in the rows), which resulted in a population density of 333 trees ha^{-1}. One year after planting, the eucalyptus, soybean (first season), and corn (second season) were planted in consortium with pasture. Local partners under contract farmed these two crops. At the end of this cycle, the pasture was recovered, allowing beef cattle to graze in the fattening phase. This strategy avoided investments in fences to protect the trees. Thus, in the first year, 2/3 of the area was occupied with pasture in which beef cattle were raised, and 1/3 was occupied with trees in consortium with crops. In the second year, 1/3 of the area was occupied with pasture in which beef cattle was raised, 1/3 was occupied with trees in consortium with the crop, and 1/3 was occupied with the CLF integration system, which replaced the pasture area of the first year. In the third year, 1/3 was occupied with trees in consortium with the crop, and 2/3 with the CLF integration system. In the fourth and following years, the total area was fully occupied with the CLF integration system. Tree thinning was performed when the trees were 4 and 8 years old. The remaining trees were cut down in the final three years of the cash flow (trees were 12 years old).

The restored pasture was divided into 7 plots, where beef cattle were raised in rotation. Steers were annually bought in April and then fattened until March of the following year when the cattle were sold. Those animals were fed with protein mineral salt as a nutritional complement during 150 days in the dry season, and with mineral salt for 210 days during the wet season. Fertilization with NPK (20-05-20) was applied (500 kilograms per hectare per year). Additional fertilization with superphosphate (500 kilograms per hectare) and limestone (1.8 tons per hectare) was carried out every 3 years. The official protocol of vaccination and preventive deworming were performed. Technical coefficients used to estimate the cash flow values are presented in Table 1.

Table 1. Technical coefficients for animal production.

	Extensive (before CLF integration system)	CLF integration system	Intensive (after removal of trees)
Stocking rate (animal/ha)	1.78	2.65	2.93
Dead weight gain (Kg/day)	0.277	0.297	0.400
gain of @/ha	11.99	19.18	28.49
Animal final weight (@)	16.24	16.73	19.22
sale of @/ha	28.9	44.39	56.34

Trees were harvested three times to be sold every four years. The first and second harvests' estimated productions were obtained in field experiments at Embrapa: 64.45 m^3 / ha and 75.35 m^3 / ha, respectively. Production of the last harvest was estimated at 126.73 m^3 / ha.

RESULTS AND DISCUSSIONS

Table 2 shows the estimated cash flow.

Table 2. Cash flow of CLF integration system (R$).

Item/Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Cash inflow	-	567.303	600.800	732.404	1.092.762	1.190.870	1.190.870	1.130.680	1.298.366	1.298.366	1.298.366	1.130.680	1.412.705	1.513.083	1.613.460
1.1 Beef cattle sale	-	490.578	524.075	655.679	1.032.573	1.130.680	1.130.680	1.130.680	1.130.680	1.130.680	1.130.680	1.130.680	1.130.680	1.231.058	1.331.436
1.2 Wood sale	-	-	-	-	60.190	60.190	60.190	-	167.685	167.685	167.685	-	282.025	282.025	282.025
1.3 Partnership	-	76.725	76.725	76.725	-	-	-	-	-	-	-	-	-	-	-
2. Cash outflow	500.736	524.900	670.405	784.485	1.115.113	1.102.495	1.100.836	1.100.836	1.100.836	1.100.836	1.111.009	1.100.836	1.100.836	1.131.630	1.015.894
2.1 Machines and implements	435.311	4.230	27.114	21.622	21.794	4.802	4.802	4.802	4.802	4.802	14.975	4.802	4.802	4.802	-141.626
2.2 Beef cattle inputs	-	403.088	523.643	687.511	1.017.560	1.022.972	1.022.972	1.022.972	1.022.972	1.022.972	1.022.972	1.022.972	1.022.972	1.053.766	1.084.458
2.3 Forestry inputs	47.664	47.664	47.664	-	-	-	-	-	-	-	-	-	-	-	-
2.4 Employees	-	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475	44.475
2.6 Other	17.761	25.443	27.508	30.877	31.285	30.245	28.587	28.587	28.587	28.587	28.587	28.587	28.587	28.587	28.587
Accumulated cash flow	-500.736	-458.333	-527.938	-580.019	-602.370	-513.994	-423.960	-394.116	-196.587	943	188.300	218.144	530.012	911.465	1.509.031
Income tax	-	-	-	-	-	-	-	-	-	-	51.782	8.207	85.764	104.900	164.331
Net cash flow	-500.736	42.403	-69.605	-52.081	-22.351	88.376	90.034	29.844	197.529	197.529	135.575	21.637	226.105	276.553	433.235

The CLF integration system presented an IRR of 10.54% per year and a NPV of R$ 570,555.77. The integration system proved to be economically viable. These results confirm other authors' findings. Müller et al. (2011) evaluated the economic viability of an agrosilvopastoral system in Minas Gerais. The authors found an IRR of 10%, assuming the sale of standing timber. Tupy et al. (2019) evaluated a FL integration system with eucalyptus in an extensive beef cattle system, and found a positive NPV.

CONCLUSIONS

The results suggested that the crop-livestock-forestry integration system is viable. We recommend caution in generalizing the results because the analysis was performed in a single farming area, and the prices refer to a single year. It should be pointed out that some prices were high in the 2020 scenario when steer and fattened cattle prices reached high values. We suggested risk analysis as an additional evaluation in future studies.

Important environmental aspects of the CLF integration system were not measured and valued in this analysis. For example, carbon credits could have been included in the cash flow. Future studies should also consider the environmental aspects when evaluating these systems.

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