IS THE "F WORD" AN OPTION FOR BRAZILIAN FARMERS? THE PLACE OF FORESTRY IN FUTURE INTEGRATED FARMING SYSTEMS

Sub Theme***:*** Entrepreneurship (Diversification & adding value)

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Abstract:

This study analyses the economic viability of forestry in integrated farming systems (IFS) in Brazil. A 12-year cash flow was built with both experimental data and estimates for three IFS in the Savannah region: ICL (crops + cattle); ICLF1 (ICL + 227 eucalyptus trees/ha); and ICLF2 (ICL + 357 eucalyptus trees/ha). Investment analysis showed all IFS were viable, but ICL was more profitable than ICLF, due to occasional high crops and beef prices and low wood prices in 2016. In extreme scenarios, i.e. all commodities prices were high (SCE I) or all low (SCE II), results remained the same. However, an alternative, most likely, scenario (SCE III) showed ICLF were more economically recommended than ICL, as beef and crop prices dropped and wood prices increased, which is expected because of commodities price volatility. Thus, the introduction of forestry in future IFS is economically viable, although market risks remain. Further adoption of IFS with trees relies on innovative and follower farmers, with strong support of R&D, technology transfer programs and IFS policies.

Keywords: *ABC Plan; Agroforestry; Economic analysis; Integrated crop-livestock-forestry systems; Sustainable farming systems.*

Introduction

Brazil has become a major player in the world agricultural commodities market, historically developing forestry, crops and pasture under large monocultures. This production model has been efficient, from a supply perspective, given the joint expansion in area and productivity. Martha Junior, Alves and Contini (2012) demonstrated that, between 1950 and 1975, productivity in Brazil explained only 14% of the beef production growth, while pasture expansion accounted for 86%. Between 1996 and 2006, land-saving technologies allowed for major productivity gains, with 122% increase in beef production, despite reductions in total pasture area. The freed land was devoted to sugarcane, soybeans and other crops.

Despite this productivity growth, marginal gains of further technology intensification tend to decrease. Pasture degradation, crops pests and diseases, and other monoculture-associated problems have evidenced some of these farming models weaknesses, making room for consideration of new, more integrated and sustainable, farming systems.

Sustainable farming systems is a great challenge for the agricultural sector. Increasingly, integrated farming systems (IFS) have been in the spotlight given their potential to meet this challenge. IFS, in addition to promoting sustainability, may result in rapid and significant increases in meat, grains and wood supply altogether. Oliveira et al. (2014), for instance, showed an integrated crop-livestock-forestry (ICLF) system with 357 trees/ha obtained carrying capacities between 0.8 and 1.0 animal unit per hectare (AU/ha), similar to the Brazilian average. Diversification using IFS is possibly the major paradigm shift in Brazilian agriculture, since the green revolution in the 1960's.

IFS have been long known and practiced worldwide, but usually associated with small-scale production (e.g. Rana, 2015). In Brazil, however, the uptake has increased mostly among large-scale commercial farms, where conservation practices have been successfully carried out for decades. A survey with 7,909 farmers indicated around 11.5 million hectares (Mha) of IFS in Brazil (Embrapa, 2016), mainly established in the following states: Mato Grosso do Sul (2.0 Mha); Mato Grosso (1.5 Mha); Rio Grande do Sul (1.4 Mha); Minas Gerais (1.0 Mha); and Santa Catarina (0.68 Mha). The IFS in use involve different combinations of crops, livestock and forestry. Among cattle farmers using IFS, 84% adopt crop-livestock (ICL), 9% combine crop-livestock-forestry (ICLF), and 7% use livestock-forestry integration (ILF). Among crop farmers using IFS, 99% adopt ICL (Embrapa, 2016). Given the great uncertainties and still underdeveloped support systems for IFS, farmers using such systems are possibly innovators and early adopters, as Rogers (2003) proposes. They help "translating" technologies from research centres to commercial environments (Garb and Friedlander, 2014; Pereira et al., 2016), and are usually less averse to risk than other farmers. They are, therefore, crucial, for the technologies diffusion process.

The potential area of 67.8 million hectares (Mha) for IFS adoption in Brazil

(Balbino, Barcellos and Stone, 2011), there is plenty of room for further developments.

However, changing farmers' mind-set and practices, from production specialization to diversification combining crops, livestock and forestry altogether is a difficult task.

Costa et al. (2014) identified some limiting factors for generalised adoption of IFS:

- Farmers' short-term vision, prioritizing immediate gains;
- Specialization enables economies of scale;

- Change in usual infrastructure and machinery to meet the new products requirements;
- The increased carrying capacity resulting from improved pastures may require further purchase of cattle, even by ranchers;
- Need for management skills and information technology, given the higher complexity of IFS (see Almeida et al. (2015) for further comments);
- Minor concerns about social and environmental issues, possibly because they provide no direct compensation;
- Lack of initiative and risk-taking behaviour among traditional farmers.

Additionally, different farmer types have different sets of goals and values, which can also limit, or facilitate, technologies uptake, including those involved in IFS. Pereira et al. (2016), for instance, claimed that nature-oriented farmers are possibly keener on sustainable practices, including IFS, than strongly production-oriented farmers.

To encourage further adoption of IFS in Brazil, public policies and private sector initiatives are underway. The Brazilian government launched the National Plan for Low Carbon Emissions in Agriculture, the so-called "ABC Plan", as part of a strategy to meet its voluntary commitment at COP 15 to reduce greenhouse gas emissions (GEE) by 36-38% by 2020 (Mello, 2015). The Plan, implemented in 2010, promotes the adoption of IFS, degraded pasture recovery practices among others, by making rural credit available for farmers at “low” interest rates (7.5% to 8% *per annum*)[1]. In 2012, the Brazilian Agricultural Research Corporation - Embrapa - launched the “ICLFS Fostering Network”, a public-private partnership to promote and transfer IFS technologies to farmers (Embrapa).

1 The current Brazilian interest rate is 12.25% *per annum*.

An example in the research field is the "Pecus Network" project, which has been studying beef production systems, as monoculture or in IFS, capable of mitigating GEE (CPPSE). Many other studies have shown the biophysical advantages of using IFS, such as improvement in microclimate and animal welfare (Karvatte Junior et al., 2016), in pasture quality (Almeida et al., 2014), systems resilience (Jose, Walter and Kumar, 2017), crops, beef and wood yields (Franchini et al., 2014). However, most fail to present economic analysis of empirical data (Lazarotto et al., 2009; Martha Junior, Alves and Contini, 2011).

Nonetheless, further adoption of these novel IFS requires more information about their economic performance, reason why this study focusses primarily on this issue. Such concern is particularly important for IFS with trees, given their long-term horizon and associated uncertainties. Moreover, unlike the crop-livestock integration, forestry is a foreign activity for crop and beef farmers. The objective of this study, therefore, is to fill this void and to evaluate the economic viability of introducing forestry in IFS in Brazil

Methods

Since 2008/2009[2], three integrated systems have been studied in Campo Grande/MS, Brazil, as alternatives to recover degraded pasture in Savannah-like regions, in Central Brazil: ICL (crops + cattle); ICLF1 (ICL + 227 trees/ha); and ICLF2 (ICL + 357 trees/ha). The experiments consisted of three consecutive four-year cycles: one year with crop followed by three years with pasture, with or without trees (*Eucalyptus grandis* × *E. urophylla* hybrid). Eucaliptus is the main planted tree in Brazil, covering 5.6 Mha of the total 7.7 Mha of planted forests (IBA, 2017).

The experiments were originally designed to evaluate the effect of tree density and spatial arrangements on crop and beef production, with trees planted in single rows, with 2 m between trees and 22 or 14 m between rows, in ICLF1 and ICLF2, respectively. Crops, followed by pasture, were sown between tree rows.

An experimental area of 18 ha (6 ha per IFS) was prepared, subsoiled and cultivated twice in September/2008. In November/2008, 3 t/ha of limestone, 1 t/ha of gypsum, preplant herbicides and 300 kg/ha of 05-25-15 (Nitrogen-Phosphorous-Potassium (NPP)) fertilizer were applied. Soybean was cultivated from November/2008 to March/2009, associated, or not, with trees (i.e. ICLF). After soybean harvest, palisade grass (*Urochloa brizantha* Piatã) was sown. Once the trees reached 7 cm in diameter (May/2010) and

[2]The agricultural year starts on the 1st of July and finishes on 31st of June of the following calendar year.

were resistant to cattle rub, Nellore heifers (160 kg) were introduced in all IFS. Meanwhile, the systems produced hay (2009/2010 season) (see Oliveira et al. (2014) and Pereira et al. (2014) for further details).

The second cycle (2012/13 – 2015/16) repeated the first cycle (2008/09 - 2011/12), but introduced annual pasture fertilization with 05-25-15 NPK (300 kg/ha) and urea (110 kg/ha), as the carrying capacity was reducing.

The third cycle (2016/17 - 2019/20) has just started and repeats the second cycle, but with corn instead of soybean as a crop. Recently, the thinning of 67% of ICLF2 reduced the number of trees from 357 to 118 trees/ha; in ICLF1, trees/ha diminished from 227 to 113 (50%). The spatial arrangement also changed from 22 x 2 m to 22 x 4 m in ICLF1, and from 14 x 2 m to 28 x 4 m in ICLF2. Cattle weight and grazing period were controlled within each IFS to estimate the annual average weight gain. Varying stocking rates were applied to keep forage availability around 1,800 kg Dry Matter (DM)/ha ("put-and-take" system). Table 1 presents all IFS yields and the average commodities prices in 2016.

Table 1 – Commodities yield and output prices[1] from IFS (2016)

Commodities	***Yield (unit/ha)***			***Prices (USD/unit)***[2]
	ICL	***ICLF1***	***ICLF2***	
Hay		t		
Palisade grass hay (Year 1)	4	4	4	47.83
Cash Crops		t		
Soybean (Year 1)[a]	2.10	2.10	2.10	377.67
Soybean (Year 5)[a]	2.94	2.28	2.04	377.67
Corn (Year 9)[b]	5.70	4.80	4.80	167.33
Beef (annual averages)		kg of live weight (kg LWT)[3]		
Cycle 1 production (yrs 2 - 4)[a]	**567 (1.0)**	475 (0.8)	355 (0.6)	1.42
Cycle 2 production (yrs 6 - 8)[c]	737 (1.3)	475 (0.8)	323 (0.5)	1.42
Cycle 3 production (yrs10-12)[b]	737 (1.3)	425 (0.7)	425 (0.7)	1.42
Wood		m^3		
Charcoal (thinning - year 8)[a]	-	81,5	193	10.04
Charcoal (logging - year 12)[b]	-	130	153	10.04
Timber (logging - year 12)[b]	-	35	38	28.68

[1] Average exchange rate (2016): 0.287 BRL:USD (www.xe.com/pt/currencytables/).
[2] The measuring unit is shown on the yield columns (e.g. USD 28.68/m^3 for timber).
[3] In brackets, an index shows the proportion of beef production using ICL yield in the first cycle as reference (1.0).
[a] Experimental data; [b] Estimated data; [c] Partial experimental data (years six and seven; year eight data are being processed).

Amongst IFS, the beef production reduced as the density of trees increased (Table 1), and over time for ICLF1 and ICLF2. In contrast, it increased 30% for ICL. Equal beef production was estimated for ICLF1 and ICLF2 in the third cycle, given their similar number of trees/ha after thinning. Between the first and second cycles, soybean production increased for ICL and, to a lesser extent, for ICLF1, but reduced slightly for ICLF2, which had more trees competing for resources, corroborating Franchini et al.'s (2014) findings. In the third cycle, corn production estimates considered a more favourable environment for crops after trees thinning (i.e. less competition for resources), although they remained below ICL estimate. Wood production increased with tree density.

Considering the experiments long-term nature, a 12-year cash flow was prepared using all the above parameters. Additionally, an investment analysis was carried out, using an annual discount rate of 10%[3] to determine the net present value (NPV), benefit-cost ratio (B/C) and discounted payback period in years (PBK) for the three IFS (i.e. Reference Scenario). Given ICLF cash flow contained more than one signal reversal, the internal rate of return (IRR) was inconsistent (Rae, 1994), and, thus, disregarded.

We assumed most farmers have the necessary infrastructure to implement IFS and, thus, additional machinery and buildings were disregarded. We used machinery hire prices, defined for several farming operations and available at Richetti (2016). The cash flow included only running costs and, consequently, the systems implementation costs (season 2008/09) consisted of seeds/seedlings, fertilizer, chemicals and all services. Labour costs were priced at 14.34 USD/day. Beef operational costs were estimated at 0.75 USD/kg LWT. Given beef revenue considered only the additional meat produced within each IFS, production costs were assessed accordingly, not including animal purchase. Additionally, the cash flow included ant control, thinning (year 8) and logging (year 12) costs.

Investment analysis of alternative scenarios (Olson, 2011) were undertaken varying commodities prices, all else remaining the same, to evaluate how IFS affects profitability. In scenario I (SCE I), wood prices increased by 25%; in scenario II (SCE II), beef and cash crop prices reduced 15% and 20%, respectively; and scenario III (SCE III) combined SCE I and SCE II. These scenarios simulate possible market conditions, given prices cyclical waves.

Results

[3] We used the Brazilian government ten-year bond returns (around 10%) as opportunity cost for capital, considering IFS long-term. Alternatively, savings account rates (6% *per annum*) can be used.

As expected, implementation costs increased with the increase of tree densities, being 19% and 30% higher in ICLF1 and ICLF2, respectively, than in ICL (Table 2). This result may help explaining the lower adoption of IFS with trees compared to crop-livestock integration found in the survey mentioned earlier (Embrapa, 2016). This cost could be prohibitive for some farmers, particularly small landowners or those in need of further machinery or infrastructure to start IFS.

Table 2- Implementation costs (USD/ha) of pasture, crops and trees under three IFS, in Mato Grosso do Sul state, Brazil, season 2008/2009.

Inputs	ICL	ICLF1	ICLF2
Seeds	112.61	112.61	112.61
Tree seedlings	-	29.61	46.67
Lime/Fertilizer	330.94	390.88	423.57
Chemicals[1]	51.10	74.36	81.89
Subtotal	494.65	607.46	664.75
Services			
Labour	28.68	54.49	67.39
Machinery	32.15	346.08	379.94
Transport	19.75	19.75	19.75
Subtotal	374.57	420.32	467.08
Total	**869.22**	**1,027.78**	**1,131.82**
Cost index (ICL = 100)	100	118	130

[1] Includes herbicides, pest and disease control.

The annual net benefit (NB = Receipts - Costs) was also remarkably different across the farming systems with and without trees (Figure 1). ICLF1 and ICFL2 benefitted from major wood sale in years eight and 12, after the trees thinning and logging, respectively. In contrast, ICL presented the most even NB across the years, and often higher, than both ICLF.

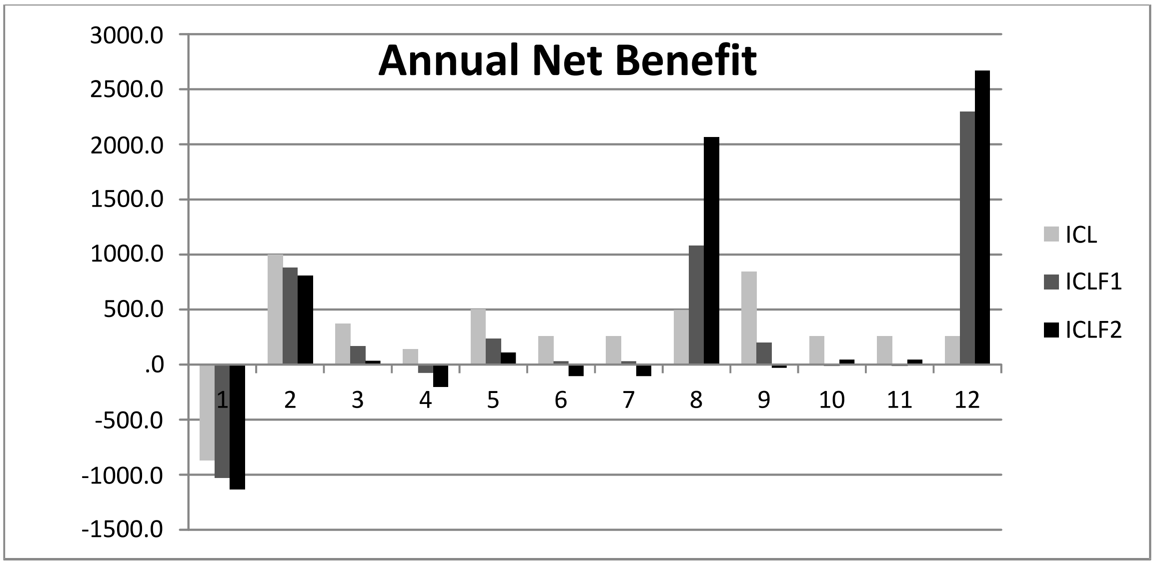

Figure 1 – Cash flow of three IFS in Mato Grosso do Sul state, Brazil.

Figure 1 also shows that both ICLF presented negative net results in some years due to the systems continuing costs, including ant control and pruning, which were not always timed with revenue from cattle and/or crop. This can pose a threat to farmers' cash flow position and they must be prepared for periods where, eventually, costs can exceed receipts.

An investment analysis brought further insights on relevant parameters for farmers' investment decisions. All three farming systems were economically viable in the Current Scenario (CRT-SCE), given their positive net present value (NPV) and Benefit/Cost ratio greater than one (Table 3).

Table 3 – Investment parameters of three IFS, in Mato Grosso do Sul state, Brazil (2016).

Parameters	ICL	ICLF1	ICLF2
NPV (USD/ha)	2,047.44	1,493.99	1,448.60
B/C	3.36	2.37	2.02
PBK (yr)	0.96	3.90	6.54

In the CRT-SCE (Table 3), IFS with trees were economically less interesting than the ICL. ICL had higher NPV and benefit-cost ratio (B/C), and shorter payback period (PBK) than ICLF. Between ICLF1 and ICLF2, the former performed better than the latter, suggesting that the less trees in the IFS, the better the economic performance, *ceteris paribus*.

Nonetheless, these results should be interpreted with caution and within their context. At high discount rates, i.e. 10% p.a., ICLF systems are "penalised" for providing economic benefits mainly in the long term. Additionally, in 2016, crops and beef prices boosted, while prices for wood-based products reduced (GWMI, 2016). Therefore, the IFS more reliant on timber were doubly impacted in this scenario: (1) the reduction of wood prices reduced the estimated revenue from forestry (i.e. the higher number of trees, the higher the reduction in relative revenue); and (2) ICLF did not fully benefit from crops and beef prices increase due to their lower yields (Table 1). Moreover, farmers using ICLF can delay the trees harvest for a few years, increasing the chances of better prices and, thus, of improved returns. Our research protocol, however, did not allow for this alternative.

Given price volatilities, three alternative scenarios were then analysed: higher wood prices (SCE I); lower beef and crops prices (SCE II); and, SCE III as a combination of SCE I and SCE II (Table 4).

Table 4 – Investment parameters (NPV, B/C and PBK) under three scenarios of changing commodities prices for IFS.

Parameters	***SCENARIO I***			***SCENARIO II***			***SCENARIO III***		
	ICL	**ICLF1**	**ICLF2**	**ICL**	**ICLF1**	**ICLF2**	**ICL**	**ICLF1**	**ICLF2**
NPV (USD/ha)	2,047.4	1,777.37	1,870.69	915.4	666.2	742.2	915.4	949.6	1,164.3
B/C	3.36	2.63	2.27	2.05	1.50	1.42	2.05	1.70	1.64
PBK (yr.)	1.0	3.9	6.4	1.7	10.1	10.2	1.7	6.8	6.8

The sensitivity analysis suggested that IFS, with and without trees, remained economically viable (NPV > 0 and B/C > 1), even under low commodities prices (i.e., SCE II). However, different scenarios affected more, or less, particular IFS, often changing the most profitable system. Results indicated better economic performance for ICL in extreme conditions: when all commodities prices were high or, low. The analysis of SCE III, which combined low prices for crops and beef with high prices for timber, showed both ICLF performed better than ICL, in sharp contrast to CRT-SCE. For some scenarios, the payback period was over six years, which could bring financial risks to farmers low in equity, should they face a long period of accumulated negative balance.

Discussion

An analysis of Tables 3 and 4 suggests that the economic performance of IFS may vary significantly under different scenarios of output prices. Martha Junior, Alves and Contini

(2011) argue that the economic performance of IFS is a function of input/output relative prices, which our results corroborate. At given input prices, and in the context of high beef and crops prices, ICL usually performed better than ICLF, also favoured by the high discount rate used in this study. At higher wood prices, ICLF performed better (SCE I) and even, exceeded ICL (SCE III), but subject to relative beef and crop prices.

These prices were peaking, in 2016, resulting in rather unrealistic long-term scenario (CRT-SCE), since grains returns are highly volatile (Lazarotto et al., 2009), given commodities cycles, public policies etc. To address this situation beef and crop prices reduced in scenario II. However, the low timber prices prevented ICLF from improving its performance. The 25% increase in timber prices benefited ICLF in SCE I, but did not ensure, by itself, a result that surpassed ICL, given beef and crops high prices. Under this optimistic scenario, all IFS achieved their best economic performances, with similar NPVs for ICLF1 and ICLF2, but lower than ICL results. Scenario III simulates 2014, when timber market was heated and beef and crops prices were low. Under these conditions, the more trees in the IFS, the higher was the profitability, corroborating Pereira, Costa and Almeida's (2015) findings.

Costa et al. (2012), Silva (2014) and Pereira et al. (2015) also studied the IFS[4] presented here and found similar results to those in SCE III. Pereira et al. (ibid), for example, showed ICLF2 achieved a NPV 1.5 times higher than ICL, which had the lowest performance of all IFS. This is in sharp contrast to the CRT-SCE, using current data. The prices in 2014 were USD 0.99/kg LWT, USD 282/t, USD 35.27/m^3 and USD 13.19/m^3 for beef, soybeans, timber and charcoal, respectively. Compared to 2016, these prices increased by 52% and 34% for the former two and decreased by 19% and 24% for the latter two.

The question remaining to be answered is whether the current scenario (CRT-SCE) is probable to replicate or scenarios I, II or III likely to occur (or new scenarios considered). From January to February/2017, beef and soybeans average prices have already dropped to USD 1.38/kg LWT and USD 357,33/t, respectively, with corn prices remaining stable (CEPEA, 2017; a, b, d). In contrast, average wood prices reached USD 32.71/m^3 in March/2017 (CEPEA, 2017 c), suggesting markets are moving towards SCE III.

[4] Except that soybean was the crop in the three production cycles.

Our results suggest the long-term market trends for the wood-based products are important for farmers thinking of introducing forestry in IFS. The Brazilian economic crisis, in 2015, resulted in drops in wood sales (5%) and prices (GWMI, 2016). Despite uncertainties around further developments of the wood industry, Brazilian economy started to recover. Inflation is controlled, investment levels increased and a 0.5% economic growth rate is expected for 2017, creating an inviting environment for wood demand to grow. The pulp and paper industry, for instance, is expanding and benefiting from major international trade (The Economist, 2016). Other wood-based products exports increased 21.6% between 2015 and 2016, reaching US$ 250 million (GWMI, 2017). In 2017 (Jan/Feb), wood panels production and exports increased 8.5% and 40%, respectively, compared to Jan/Feb 2016 (IBA, 2017).

Beyond the commodities markets, other initiatives are needed to further support the adoption of forestry in IFS. Credit through the government "ABC plan" is readily available and the uptake is increasing (i.e. over 25,000 contracts, between 2010-2015) (Mello, 2015). New steel mills and other investment projects in Brazil will increase the demand for wood-based products, although, at unknown pace. Other initiatives, such as the Carbon Neutral Brazilian Beef (CNBB) protocol may add value to IFS products, including timber. CNBB allows for the design of premium payments for certified wood and/or beef under silvopastoral or agrosilvopastoral systems, following welfare and good practices guidelines, so that trees neutralise the cattle methane emissions (Almeida et al., 2016). Planted forests also contribute to reduce the pressure for deforestation, providing relevant environmental services (e.g., avoided GEE). Environmental services market in Brazil is only incipient, but growing, supported by the country's intention to establish itself as a "world reference in carbon trade" (GEF, 2013; p. 14).

Given the uncertainties still present in IFS, with unclear markets for potential added-value products and limited economic studies, the diffusion of future IFS, particularly with forestry, seems to rely primarily on innovative, perhaps least-averse-to-risk, farmers in Brazil. Lead farmers are relevant to the innovation system, as they display technologies to other potential adopters (followers) (Pereira et al., 2016). Further economic research considering changing input/output prices and yields, and risks assessments are required. Policies to minimize forest investors' risks must be prioritised to support farmers introducing trees in IFS.

Conclusions

Our results, and other IFS economic assessments, indicate, at given yields and input prices, the relative output prices seem to determine the most profitable farming system. The number and spatial arrangements of trees impact investment parameters, given the trade-offs between long-term benefits, and implementation and running costs. These must be assessed accordingly.

Generally, the introduction of forestry in future IFS in Brazil is economically viable, as long as the wood industry is solid. Since farmers make less than optimal decisions, due to lack of full knowledge of possible scenarios (Lazarotto et al., 2009), all studied IFS are economically acceptable. Further introduction of trees in IFS relies on innovative and followers farmers, with the support of R&D, technology transfer programs and IFS policies.

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