Brazilian agroforestry systems for cattle and sheep

Roberto Giolo de Almeida [A], Carlos Maurício de Andrade [B], Domingos S. C. Paciullo [C], Paulo C. C. Fernandes [D], Ana Clara R. Cavalcante [E], Rodrigo Amorim Barbosa [A] and Cacilda Borges do Valle [A]

[A] Embrapa Beef Cattle, Brazil, www.cnpgc.embrapa.br
[B] Embrapa Acre, Brazil, www.cpafac.embrapa.br
[C] Embrapa Dairy Cattle, Brazil, www.cnpgl.embrapa.br
[D] Embrapa Eastern Amazon, Brazil, www.cpatu.embrapa.br
[E] Embrapa Tropical Semi-Arid, Brazil, www.cpatsa.embrapa.br
Contact email: roberto.giolo@embrapa.br

Abstract. Agroforestry systems for animal husbandry, including integrated crop-livestock-forest systems (ICLF) are rather diversified in the five Brazilian regions. They present several technical, environmental and socioeconomic benefits. However they are not broadly adopted, mainly because of their higher complexity compared with traditional systems as well as a certain lack of understanding by farmers regarding their benefits. To change this situation, in the last five years, the Brazilian government has directed financial resources for credit as well as for research and technology transfer addressing ICLF systems, including good agricultural practices and mitigation of greenhouse gases emissions. The goal is to improve competitiveness of the Brazilian agribusiness sector.

Keywords: Beef cattle, Brazilian regions, integrated crop-livestock-forest systems, tropical grasslands.

Introduction

Agroforestry systems have been developed in all Brazilian regions, having specific characteristics regarding plant and animal species, component arrangements in time and space as well as system's purposes and functionality. However, these systems are generally understood as multispecies, more complex and diversified than the ICLF systems discussed in this work. The later encompass at least two of the three components in a context of mechanized agriculture (machine or animal power), with rotation of crops and pastures associated with no-till systems (Macedo 2010, Balbino *et al.* 2011a). These systems allow higher land use efficiency, traduced into technical, environmental and socioeconomic benefits.

Information about traditional cattle systems, integrated crop-livestock systems (without the tree component) and the evolution of studies with forage species and pastures in Brazil can be found in Ferraz and Felício (2010), Carvalho *et al.* (2010) and in Euclides *et al.* (2010), respectively.

According to Costa *et al.* (2011), considering favorable environmental conditions and land availability in Brazil, sheep husbandry is not well developed in terms of total production or yields of meat and hides, when compared to countries like Uruguay, Argentina, New Zealand and Australia. About 54% of the flock in Brazil are hair sheep breeds, concentrated in the Northeastern part of the country, in the semi-arid environment (Table 1). The remainder is spread in the other regions, especially Rio Grande do Sul (Southern Brazil) with 23% of the national flock.

With a cattle herd of 212.8 M head (IBGE 2011), Brazil is one of the largest beef exporters in the world. Cattle ranching is spread throughout Brazil, being a very important economic activity. However, official statistics for herd rearing on agroforestry systems are limited.

Regarding sown pasture areas, official data indicate that only 10.7% are spoiled, even though some authors indicate, in the last decades, that over the half of sown pastures in Brazil present some degree of spoilage, either in the Cerrado biome (Sano *et al.* 1999, Zimmer and Euclides 2000) and Rain Forest biome (Serrão *et al.* 1993).

Table 1. Cattle and sheep herds (data from 2011), areas with natural grasslands, sown pastures in good conditions and spoiled, and areas with agroforestry systems holding cattle (AFS, data from 2006) per region. Brazilian official statistics.

Region	Cattle[1]	Sheep[1]	Natural grasslands[2]	Sown pastures[2] Good conditions	Sown pastures[2] Spoiled	AFS[3]
	---------- M head (%) -------			-------------------------------- M ha (%) --------------------------------		
North	43.24 (20)	0.63 (4)	6.00 (10)	18.70 (20)	2.20 (22)	0.61 (15)
Northeast	29.59 (14)	10.11(57)	16.03 (28)	12.34 (13)	2.24 (23)	2.15 (52)
Southeast	39.34 (19)	0.77 (4)	10.96 (19)	15.21 (17)	1.66 (17)	0.58 (14)
South	27.99 (13)	4.95 (28)	10.84 (19)	4.39 (5)	0.45 (4)	0.22 (5)
Central-Western	72.66 (34)	1.21 (7)	13.81 (24)	41.87 (45)	3.36 (34)	0.56 (14)
Brazil	212.82	17.67	57.64	92.51	9.91	4.12

[1] Available at: http://www.sidra.ibge.gov.br/bda/tabela/listabl.asp?z=t&c=73; [2] Available at: http://www.sidra.ibge.gov. br/bda/tabela/ listabl.asp?z =t &c=854; [3] Available at: http://www.sidra.ibge.gov.br/bda/tabela/listabl.asp?z=t&c=1011

In the context of cattle husbandry, ICLF systems have been adopted as alternative for sown pasture reclamation, farm diversification and intensification. According to Zimmer *et al.* (2012), average beef yields on natural grasslands and sown pastures under traditional management are respectively 30 and 90 kg/ha/year, while potential yields for improved pastures, either using traditional reclamation or adopting ICLF systems, are respectively 180 and 340 kg/ha/year. This illustrates the substantial progress Brazilian cattle industry can achieve in the next few years if ICLF systems are adopted to satisfy domestic and exports demand for beef.

From an environmental perspective, ICLF systems having 250 to 350 eucalyptus trees per hectare, designed for harvesting trees between eight and twelve years, would yield 25 m^3 wood per ha/year (Ofugi *et al.* 2008).This corresponds to an annual sequestration of around 5 t/ha carbon or 18 t/ha CO_2 eq., which would compensate for GHG emissions of 12 adult beef animals. However, due to the higher complexity of ICLF systems, their adoption remains limited, though growing in the last five years.

According to Balbino *et al.* (2011b), Brazil has around 67.8 M ha land suitable for several different ICLF models, with no need for further clearing of areas of original vegetation. In 2010, it was estimated that a total area of 1.6 M ha was covered with some sort of ICLF system while the official census from 2006 indicated an area of 4.1 M ha with agroforestry systems holding cattle (Table 1).

Availability of official credit for implementing ICLF systems from 2008, through the 'Programa de Produção Sustentável do Agronegócio (Produsa)' (Sustainable Agribusiness Program), has raised attention from farmers to adopt these technologies. In 2009, from the commitment made at the (COP-15, Copenhaguen), the Brazilian Government created a program named ABC, '*Agricultura de Baixa Emissão de Carbono*' (Low Carbon Emissions Agriculture), whose goal is to stimulate voluntary reduction of GHG emissions from the agricultural sector. This program makes available credit for reclaiming 15 M ha of spoiled pastures including implementation of ICLF systems on 4 M ha of them by 2020. Demand for professionals specialized in design and implementation of ICLF projects is higher than their availability and is a critical limit to development of such systems (Almeida *et al.* 2012b). The Brazilian Agricultural Research Corporation (Embrapa), together with some States' research organizations, universities and private companies have focused on demonstrating the benefits of these systems and expanding their adoption, through setting Technology Reference Units (TRUs) in several strategic locations throughout Brazil. These demonstration fields usually located on private farms, in a partnership with them. While serving as a demonstration, these TRUs are also used for technical and scientific observation for improving these systems based on remarks from farmers and scientists involved. In 2011 there were 194 TRUs in operation throughout Brazil (Porfírio-da-Silva and Baggio 2003, Balbino *et al.* 2011b, Almeida *et al.* 2012b).

More recently, Embrapa and its national and international partners created the Pecus Network (www. cppse. embrapa.br/redepecus/) with the aim of studying integrated cattle systems, with improved management techniques compared with traditional systems, reducing GHG emissions and increasing carbon sequestration in order to provide guidelines for official policies regarding the sector in Brazil.

The next sections will discuss peculiarities of integrated systems for animal husbandry in the five Brazilian regions, based in an array of economic, social and political peculiarities and their interactions with local conditions.

Southeast Region

Southeast region encompasses the States of Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo, covering an area of 0.92 M km^2 corresponding to 11% of the Brazilian territory. It is the most industrialized and rich part of Brazil. Its climate is predominantly tropical, some areas having high-altitude tropical climate, sub-tropical and humid-coastal. The region usually has two well-marked seasons, one hot and rainy (Spring/Summer) and the other with little rain and lower temperatures (Fall/Winter). The tropical forest (Atlantic Forest) is the original dominant vegetation, which as a result of deforestation, now occupies less than 10% of the original area.

The Southeast region has 27.8 M ha pastures, stocking 39.3 M cattle and 0.7 M sheep (IBGE 2006, 2011), being the agribusiness sector well developed and diversified. Cattle production, especially dairy, has an important position in the region. It was originally based on *Melinis minutiflora* and *Hyparrhenia rufa* pastures, later replaced by *Brachiaria* and *Panicum* grasses, which dominate the grazing systems in the area. The first integrated systems in the region were non-systematic, mainly through cattle grazing on eucalyptus plantations held by commercial afforestation companies at the end of the 70's and early 80's (Garcia and Couto 1997). In such systems, cattle grazing reduced implementation costs and helped to control understory vegetation, reducing fire risk in the first years. From the 90's, research on actual silvopastoral systems were intensified, in which, tree and cattle components were intended to coexist in the system during its whole productive cycle. In both systems, the main tree species used were from the genera *Eucalyptus* and *Corymbia*, while *Brachiaria* was used for pastures. At that time, another pasture shading model was started, using legume-tree species to reduce *in loco* temperatures and therefore to improve animal thermal comfort. This would also incorporate nutrients to the system, especially Nitrogen, through the biological fixation from these species. In the long term, improving soil fertility would improve yields and the better pasture would reduce soil exposure, promoting pasture sustainability (Carvalho *et al.* 2001).

Systematically including the crop component on the model, characterizing the ICLF systems, happened only on the late 90s, mainly using maize, sorghum, rice and soybeans integrated with *Eucalyptus* spp. and *Brachiaria* spp. Adoption of integrated systems had been limited by scarce resources for its implementation as well as by the small number of qualified professionals for technical advice. The high initial investment problem has been solved by favaiability of inancial resources through federal and state credit policies for the sector. In parallel, regular training opportunities for agriculture related professionals, through continued education and courses has reduced the problem with technical advice in the area. Such initiatives start to show results. This can be observed through the increasing numbers of integrated systems implemented in different parts of the Southeast region. The model uses eucalyptus

tree plantations, cultivated in rows spaced 10 to 20 m over *Brachiaria* spp. pastures, with or without integrating annual crops has expanded over traditional grazing areas. For beef production, the cattle breed is usually Nelore whereas for dairy, a crossbred Holstein and Zebu cow is mostly used.

Under integrated systems, competition for growing elements increases as trees grow. Shading level on understory progressively increases, causing morphologic and physiologic changes on the forage. Intense shading, usually over 50% of full photosynthetically active radiation, drastically reduces forage yields from pastures, endangering its presence and therefore the sustainability of the system (Paciullo *et al.* 2010). For this reason, management strategies of the tree component must allow only moderate reduction of radiation incidence on pastures. When using species from the *Eucalyptus* genera, the most convenient distance for tree rows are the ones resulting in tree densities from 150 to 450 trees per hectare. One must also consider aspects like tree component purpose (timber, fodder, shade/shelter), local relief characteristics, especially slope, machinery specs when cultivating crops integrated with pasture and finally on-farm management (paddocks size, erosion inhibition).

If the main goal is to produce higher quality timber (added value), a lower tree density is recommended (150 to 300 trees/ha) in single rows. In the other hand, higher densities using intermediary thinning to allow radiation into the understory provides intermediary financial incomes (4-5 years, 8-9 years and 12-15 years). Regarding animal production in integrated systems, results have been satisfactory. Managed pastures under silvopastoral systems, without or with little fertilization have showed carrying capacities from 1.5 to 2.5 AU/ha, yields of 0.5 to 0.7 kg/animal/day and 200 to 350 kg beef/ha/year (Paciullo *et al.* 2011, Bernardino *et al.* 2011). Some studies have shown that efficient fertilization can be carried out with moderate doses under also moderate shading (Andrade *et al.* 2001, Bernardino *et al.* 2011). However, in despite of the growing adoption, the total area under these systems is still modest when compared to the potential they have to improve agribusiness in the Southeast region.

Central-Western Region

The Central-Western region, or Central Brazil, is composed by the States of Goiás, Mato Grosso, Mato Grosso do Sul and the Federal District. The total area is 1.61 M km^2, representing 19% of the Brazilian territory. Its economy is based essentially on agricultural activities. It has mostly tropical climate with some areas of subtropical climate in the southern part of the region. It has the largest cattle herd in Brazil, counting 72.6 M head cattle and 1.2 M sheep, with a grazing area of 59 M ha (IBGE 2006, 2011). In this region are common husbandry systems with dual purpose and beef, with remarkable predominance of Zebu cattle, especially the Nelore breed. Goiás State shows the most developed dairy systems of all States in this region.

This region has three major biomes: Pantanal, Rain Forest and Cerrado (Savannah). The Pantanal biome is a floodable plain covering about 15% of the region. Its cattle systems are traditionally extensive cow-calf operations grazing natural grasslands, resulting in low production coefficients. In some non-flooded areas *Brachiaria* spp. is sown for pasture.

At the Rain Forest biome in Central Brazil, the development of agroforestry systems for cattle is similar to Northern Brazil. Main forage species are *Brachiaria brizantha* cv. Marandu, *B. decumbens* and *B. humidicola*. Less significant, but also used, are some *Panicum maximum* cultivars. Grass-legume mixed pastures use mostly *Pueraria phaseoloides* as legume species (Teixeira *et al.* 2000).

The Cerrado biome, with a Savannah type vegetation, covers over 50% of the region. Cattle systems have a broader variation. Integrated systems are mostly associated with no-till crop systems mostly growing soybeans, maize, sorghum and rice. The most used trees in these systems are *Eucaliptus* and *Corymbia* genera. According to Macedo (2005), predominant forage species, ranked by area are: *Brachiaria decumbens* (55%), *B. brizantha* (20%), *Panicum* spp. (12%), *B. humidicola* (9%), and others (4%). Over transition areas between Cerrado and Rain Forest, silvopastoral systems usually have larger variety of tree species, using either native (*Schizolobium amazonicum*, *Swietenia macrophylla*, *Astronium fraxinifolium*, *Hevea brasiliensis*) or introduced species (*Tectona grandis*, *Ochroma pyramidale*, *Khaya ivorensis*, *Acacia mangium*, *Azadirachta indica*).

Under ICLF systems, crops are grown between tree rows for the first two or three years so that trees can grow strong enough to tolerate animal browsing. Crops are replaced by pastures until tree harvesting. The pasture production decreases with increased shading caused by trees, however with tree densities from 227 to 357 trees per hectare, carrying capacities ranging from 1.3 to 1.8 AU/ha, yields from 0.4 to 0.7 kg/animal/day and 130 to 245 kg beef/ha/year (Almeida *et al.* 2012a, b).

Silvopastoral systems are usually used in areas with limitations for grain crops, like poor soils, climate, inadequate infrastructure and logistics.

In regards to research, there were few experiments involving ICLF systems in Central Brazil until the early 2000's (Daniel *et al.* 2001), therefore, guidelines were based on studies carried out in Southeast Brazil. Looking at future research and technology transfer demands, the formal research group 'Sistemas de produção sustentáveis e cadeias produtivas da pecuária de corte (GSP)' (Sustainable production systems and beef cattle value chain) from Embrapa Beef Cattle, carrying out research at the Cerrado Biome (Zimmer *et al.* 2012) has identified the following needs: (1) to evaluate new grass forage options adapted to shading under ICLF; (2) to evaluate legume forage options aiming to interrupt the cycle of parasites and diseases while improving nitrogen fixation, reducing production costs and improving animal diet, with reflex on yields; (3) select tree species to broaden options beyond eucalyptus; (4) to develop cultivation strategies to allow planting trees while reclaiming pastures without grain crops when local conditions are not suitable or farmers are not willing to; (5) to expand experiments with extensive dairy and sheep; (6) to improve assessments of carbon balance and life-cycle analysis of products from ICLF systems; (7) to improve long term experiments in strategic locations, in order to evaluate carbon dynamics and soil quality changes; (8) expand technology transfer initiatives and assessment of economic aspects on ICLF systems, especially on commercial farms in different areas; and (9) to establish a strategic zoning for different ICLF systems considering soils, climate and existing infrastructure.

Northern Region

The Northern region covers the States of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins, being the largest area, with 3.86 M km^2 (45% of the national territory). It is also the region with the lowest population density, being today the Brazilian agricultural frontier. The equatorial climate is predominant, with the Amazon or Equatorial Rain Forest covering 90% of the surface and some natural fragments of Cerrado. Pasture occupies 26.9 M ha, carrying 43.2 M head cattle and 0.6 M head sheep (IBGE 2006, 2011).

Most of the research on silvopastoral systems in Northern Brazil (Amazon) involves isolated and incremental studies to: (1) select forage species tolerant to shading; (2) identify promising native tree species for silvopastoral systems; (3) broaden knowledge on selected native tree species; (4) evaluate introduced tree species like eucalyptus (*Eucalyptus* spp.), teak (*Tectona grandis*), African mahogany (*Khaya ivorensis*) and Indian Neem (*Azadirachta indica*); and (5) evaluate certain interaction aspects among system's components, especially tree-forage-soil.

As a whole there is a substantial lack of studies about productive and reproductive performance of animals under these systems, especially long term, multidisciplinary studies carried out in mature silvopastoral systems.

Despite advances in the last 15-20 years, silvopastoral and ICLF systems can still be considered a developing technology in Northern Brazil. For this reason, adoption levels of these systems are still low and a series of technical and socioeconomic hindrances have been identified (Dias-Filho and Ferreira 2008): (1) need for relatively high initial investments, with tree plantation and cultivation practices; (2) low turnover, with low initial profitability (first three or four years); (3) higher intrinsic complexity of integrated systems, demanding more commitment and higher level of knowledge regarding the tree species and future market perspectives for tree products; and (4) farmers' incomplete perception regarding benefits of silvopastoral systems beyond shading for cattle.

The most common silvopastoral system in Northern Brazil is the scattered trees on pastures model, usually with native trees from natural recovery. This happens because shading is the major motivation for farmers having trees on pastures, since local high temperatures and moisture causes remarkable thermal stress on cattle, especially crossbreds with higher European content. In this region, potential for losses on milk production caused by thermal stress ranges from 10 to 20% in cows yielding 15 L/day (INMET 2012). On the Cerrado spots in the Northern region, integrated systems follow the patterns used in Central Brazil.

Northeast Region

The Brazilian Northeast encompasses the States of Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe, having a total area of 1.55 M km^2 or 18% of Brazil. From that, 0.96 M km^2 are located in the semiarid zone of the country. Its pasture area has 30.6 M ha, of which 52% is natural grasslands, stocking a total of 29.6 M cattle, 10.1 M sheep and 8.5 M goats (91% of the national goat herd) (IBGE 2006, 2011).

Predominant climate is hot semiarid with annual rainfall ranging from 400 to 650 mm, irregular precipitation with dry periods up to eight months per year. Sometimes the dry season can last over the years and these phenomena are cyclical and variable from three to ten years. Vegetation is composed by xerophyla, woody, decidual, usually thorny with juice plants being either as bush or trees. Caatinga is the main vegetation type that covers the semiarid (Araújo Filho 2006). Average biomass production in Caatinga is 4 tons DM/ha/year, of which only 10% is considered as forage. Animal and plant production systems are characterized by diversification, where usually cattle are grown along with sheep and goats. In cropping areas, basically subsistence agriculture is carried out, where animals graze over crop residues. In the traditional systems, slash and burn native vegetation for clearing new cultivation areas, as well as overgrazing of natural grasslands has caused negative impacts on the ecosystem, increasing the area undergoing degradation and desertification (Carvalho 2006). Production systems based on agroforestry have been proposed as an alternative to the traditional model. The goal is to retrieve an ecosystem's characteristics like equability and stability as well as their harmonization with production aiming to assure sustainability to agricultural practices in this environment.

The agrosilvopastoral system proposed for the Brazilian semiarid region aims to stabilize agriculture, to efficiently use native vegetation as forage and rationalize wood extraction in an integrated and diversified system (Araújo Filho *et al.* 2006). Strategies for reaching these goals start by eliminating fire and full deforestation. Next, tools for forage budgeting are used for adjusting carrying capacity and, finally, a systematic pruning management of native trees is proposed to explore local wood and timber potential. The resulting system is composed of three modules: crop, grazing and forest.

The crop component is characterized by selective thinning of forest instead of full land clearing. In this method, 10 to 15% of the area is kept mainly as native trees (Araújo Filho *et al.* 1998). Following, bush-tree species, mainly *Gliricidia sepium* and *Leucaena leucocephala* are planted to be used as green manure in the rain season. They are combined with crops like maize, beans, gergelim, cotton, mamona and sorghum. Legume species are kept low and their canopy, at the end of the rain season can be used as hay for animal feeding. These legumes, from the second year can be browsed by sheep and goats at the beginning of dry season. With forest thinning, understory forage availability increases, which can be grazed after crops harvest at the end of the rain season. In the dry season the area can be used as protein source, through grazing the grass component and browsing crop residues. The crop component, therefore, is shared for plant and animal production.

The grazing component is a Caatinga area where 30 to 40% of tree cover is kept, varying according to pasture floristic composition. The maximum level of utilization allowed is 60%. Knowing the floristic composition is essential for setting the management plan, which might estimate stocking rates based on forage available. This is important to avoid spoiling the forage potential of native grasslands. Forest thinning as a management strategy for Caatinga greatly contributes to increase amounts of forage available, being able to convert from 10 to 90% the amount of forage available for grazing animals (Araújo Filho *et al.* 2002). As a strategy to improve forage production, perennial grass species as *Cenchrus ciliaris*, *Urochloa mosambisensis* and *Panicum* spp. cv. Massai, can be intro-

duced, producing up to three extra tons of forage. Stocking rates have varied from 0.5 to 3 ha per adult sheep or goat. Areas combining thinning with improved grasses show the highest stocking rates.

The forest component is composed by the original Caatinga vegetation itself. Some species with timber potential are cut in seven years average cycles and can be used either for timber of forage (Carvalho *et al.* 2004). This forest area can be used for grazing during the dry season (Araujo Filho *et al.* 1998). The basis of agrosilvopastoral system for the Caatinga is manipulating the wooden component through thinning into savannah. This procedure is still done by hand, both on system's implementation and maintenance. It is had as one of the major limitations for such systems (Campanha *et al.* 2010) due to rural labor scarcity. To face this scenario, there is a current trend of developing appropriate machinery for mechanizing this activity, specific to Caatinga conditions, including its topography. These machines would have to be able to cut trees and regrowth bushes as well as grinding their branches and stems, reducing demand for human labor.

Seeding and crop maintenance are also carried out with man power. The fact that this model does not use pesticides increases the need for interventions especially to fight weeds. Mechanization for these activities as well as the use of biological pest control and phytotherapic products to restrain growth without eliminating native grasses can add for the solution of these problems.

Regarding animal production, it is recommendable to use phytotherapic products for main diseases control, especially worms. In the integrated system, this problem is more acute on goats than sheep (Campanha *et al.* 2010), making sheep husbandry more viable than dairy goats. Dairy goats are a very interesting option to assure a quick return of investment. The activity in the semiarid region currently is included in several governmental purchase programs. In this sense it should not be left aside as an option for the system. To succeed, it is necessary that farmers have some previous experience with dairy animal management, in order to avoid sanitary problems, which mostly affect the systems financial viability.

Adjusting stocking rates through grazing management is also a challenge (Campanha *et al.* 2010). It is important that when working with the native grass components, local forage resources are known, in order to make stocking rates adjustments based also on quality, not only total biomass. This mistake can lead to spoilage through overgrazing of highly palatable forage species leaving behind less palatable ones. Establishing a workable grazing management policy , with well-defined grazing and resting periods is crucial for this kind of system.

There is also a need to make better use of the timber potential of some Caatinga native species that are kept in the forest module.

Since these systems present some differentiated characteristics like sustainable use of natural resources, family labor and traditional goods, costs are higher and yields are lower, making it difficult to compete in the regular market with conventional products from the area. Therefore, it is necessary to better explore specific markets like fair trade and organic, adding value to goods coming from such production systems. Another important aspect is the need for an environmental services compensation policy. At least three services from the system can be identified: plant bio-

diversity, carbon sequestration and organic matter deposition in the soil (Aguiar 2011).

In short, agrosilvopastoral systems for the Brazilian semiarid are a group of aggregated technologies aiming sustainable plant and animal agriculture. These technologies can be grouped according to the three components:

Crop component: no burning, improved maize and sorghum varieties adapted to the area, crops for biodiesel production, environmental service as biodiversity preservation and organic matter deposition, no-tillage seeding.

Cattle component: sustainable management of Caatinga vegetation through management of the wooden component for animal grazing, use of low cost locally produced supplements (ex: sorghum silage, crop residues and protein-forage reserves).

Forest component: *Mimosa caesalpiniaefolia* management for wood and forage production.

Agrosilvopastoral systems, despite of their technological challenges, have been adopted mainly by rural communities, whose production model is based on agroecological principles and land redistribution projects in the Brazilian semiarid. Such communities adhere to the basic principles of the model, like no use of fire, selective cut of tree species and preservation of gallery forests. Additionally, these communities have inserted some new elements to the system, expanding products diversity through growing different traditional crops like cassava, mamona, mellons and wild honey.

These systems are evolving, but the basic principles are well defined. Therefore it is necessary to solve small technical hindrances and to focus on broader aspects to develop, involving policies and markets, so that the full potential of agrosilvopastoral systems in the semiarid can be generate better living conditions for the numerous population who lives in this part of Brazil.

Southern Region

Brazilian Southern region covers the States of Paraná, Rio Grande do Sul and Santa Catarina. Its area covers 0.58 M km^2 (7% of the national territory), being the second most developed region in the country and the one with the largest HDI. It keeps about 13% of the cattle herd and 28% of the sheep flock, with pastures covering around 16 M ha (IBGE 2006, 2011). In Rio Grande do Sul and Santa Catarina, natural grasslands correspond to over 80% of the total pasture areas. Climate varies from tropical to humid subtropical, which is predominant. Vegetation is characterized by tropical forests at the coast and subtropical in the inlands. In the Southern part the biome is called Campos Sulinos (Southern Plains). Cattle in this region enjoy a good level of herd management, however, yields are still less than its technical potential because of limiting factors like seasonal feed deficiency and spoiled pastures.

In Southern Brazil, Paraná State is the one with the longest record on silvopastoral systems, especially in beef cattle operations. Main driver for its adoption is the beneficial presence of trees on pastures, especially on colder months (Ribaski *et al.* 2012).

Other initiatives developed in the region, particularly in Rio Grande do Sul, point out silvopastoral systems as an important strategy for sustainable rural development. At the Campos Sulinos (grass-bush steppe) the tropical or subtropical grasses have markedly seasonal forage production.

This kind of vegetation has a major influence on socioeconomic life of farmers, due to its importance as forage source for their cattle and sheep herds besides other livestock species (Coelho 1999). However, natural soil fragility together with its low suitability for crops, as well as traditional land use for extensive cattle ranching has accelerated erosion, gradually increasing areas with scattered vegetation and large sandy spots. These environmental losses have negatively reflected on socioeconomic conditions, leading to losses on life quality of farmers. Sustainable development in the area has been a subject for several studies. There is a consensus in their results about the need to diversify local production matrix, in order to improve incomes for the productive sector. The use of silvopastoral systems has been seen as an important strategy for sustainable land use, and also as a new source of economic added value for farmers through wood production (Ribaski *et al.* 2012).

Conclusion

Despite many benefits from integrate crop-livestock-forest or ICLF systems for cattle production, as well as technologies available for such, there are still limiting factors for its broader adoption in Brazil, especially related to research, technology transfer, capacity building and credit availability. However, in the last five years, the Brazilian government has strongly invested in these aspects, aiming to overcome the above limitations. Specific demands for research with these systems have been raised, as guidelines for future studies.

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