Intensive Silvopastoral Systems: improving sustainability and efficiency in cattle ranching landscapes

Colombia, Mexico and Brazil

Authors: Enrique Murgueitio[1], Rolando Barahona[2], Rogerio Martins[3], Martha Xóchitl Flores[4], Julián Chará[1], Francisco J. Solorio[5]

Institutional affiliation: [1]Centre for Research in Sustainable Agricultural Production Systems, CIPAV. Cali, Colombia. www.cipav.org.co

[2] Universidad Nacional de Colombia, Medellín. www.unal.edu.co

[3] Universidade Federal de São João del-Rei, Brazil. www.ufsj.edu.br/ppbe/

[4] Fundación Produce Michoacán. Morelia, México.

[5]Universidad Autónoma de Yucatán, México

Email: enriquem@fun.cipav.org.co

Types of livestock produced (genera and species): cattle (beef, milk), sheep (beef), buffalo (beef, milk, work)

Introduction

Recently, several studies have demonstrated that some forms of natural intensification can play a key role on the provision of good quality food, the rehabilitation of degraded ecosystems and the mitigation of climate change, and have also proposed their use to increase agricultural production without the negative effects of industrialized systems (Calle et al., 2013, Gerber 2013, Havlik et al., 2014). Silvopastoral systems (SPS) are a type of agroforestry that allows the intensification of cattle production based on natural processes that are recognized as an integrated approach to sustainable land use (Nair et al., 2009).

Intensive Silvopastoral Systems (iSPS) are a type of SPS that combine high-density cultivation of fodder shrubs (4.000 to 40.000 plants per ha) with: (i) improved tropical grasses; and (ii) trees species or palms at densities of 100–600 trees per ha. These systems are managed under rotational grazing with occupation periods of 12 to 24 hours and 40 to 50 day resting periods, including ad libitum provision of water in each paddock (Calle et al., 2012).

The iSPS is a successful example of integration and natural intensification of production, initially developed in Colombia and that has expanded to Mexico and Brazil, among other countries.

Due to the structural and biological complexity of the system with more than three stratums of production including grass, shrubs and trees, the cover and food resources for birds, mammals, reptiles and invertebrates are enhanced. The presence of N-fixing legumes and other tree species improves production and nutrient cycling and eliminates the need of chemical N fertilizers. Deep rooted trees also contribute to recover nutrients and water from deeper soil layers and increase carbon sequestration both below and above ground. Tree cover also provides better environmental conditions and welfare for cattle and delivers more biomass, nutrients and shade to

the animals reducing stress and improving production and body condition (Broom et al., 2013, Cuartas et al. 2014).

Livestock operation and impact

Biodiversity of birds, plants, soil invertebrates and services they provide for pest control.

The iSPS promote higher biodiversity compared to the treeless systems. In Colombia, silvopastoral systems have five times as many bird species as pasture monocultures in the same region (Fajardo et al., 2009, Calle & Méndez, 2008). Ant diversity is also 30% higher in iSPS (Rivera et al., 2008) and dung beetle abundance and diversity are more than two times higher in relation to monoculture pastures (Giraldo et al., 2010). All this increased diversity plays an important role in biological control of plant pests and cattle parasites (Giraldo et al., 2010) and is an important indicator of land sustainability.

Reduced land needed and release areas for forest protection.

Due to all the positive interactions and nutrient cycling promoted in iSPS (particularly N_2-fixing trees and C sequestration), these systems produce more dry matter, digestible energy and crude protein per ha, and increase milk or meat production while reducing the need of chemical fertilizers and concentrate feeds (Murgueitio et al., 2010). In the study of Cuartas et al. (2014), animals grazing in iSPS had greater dry matter intake as a percentage of body weight (2.61 *vs*. 2.04) and crude protein (954 *vs*. 499), calcium (62.1 *vs*. 36.2) and fat (94.2 vs. 69.6) than those grazing in a monoculture pasture, respectively. When compared with degraded pastures the amount of meat produced per ha increased from 74 to 1.060 kg $year^{-1}$ in Colombia (Mahecha et al. 2011) and from 456 in an improved pasture to 1.971 kg in a iSPS in Mexico (Solorio-Sánchez et al., 2011). However, this increment in dry matter intake and daily gain is not accompanied by increased methane emissions per unit of weight gain (Molina et al., 2014). Thus, in a kg of weight gain basis, steers in iSPS emit at least 33% less methane than steers in grass-only pastures, whereas emissions per liter of milk could be 50% in iSPS (Thornton and Herrero, 2010). Increases in meat and milk production and reductions in methane emissions are related to improved nutritional fodder quality in the iSPS compared with pastures in monoculture.

Trees in iSPS also promote higher carbon sequestration per ha. In iSPS, the aboveground carbon sequestration potential ranges from 1.5 Mg ha^{-1} yr^{-1} (Ibrahim et al., 2010; Montagnini et al., 2013) to 6.55 Mg ha^{-1} yr^{-1} (Kumar et al., 1998).

The presence of trees leads to increased soil humidity through reduced evaporation under the canopy, which increases grass growth and resilience to drought. In terms of animal welfare, animals grazing in iSPS have a constant provision of good quality fodder, and their anxiety and fear are reduced since trees and shrubs provide the possibility of partial or complete concealment (Broom et al., 2013). In hot days, shade provided by trees in iSPS protect the animal from intense and direct

solar radiation. The presence of trees reduces temperatures from 42 °C to 34 °C generating a microclimate that improves thermal comfort for grazing animals.

Challenge faced/critical points

According to Calle et al. (2013), the main barriers to the adoption are i) financial capital barriers: iSPS require high initial investment which defies the prevailing view of tropical cattle ranching as a low-investment activity, ii) knowledge barriers: the technical complexity of some iSPS demands a specialized knowledge that is not available among farmers, professionals, conventional academia, or commercial rural extension companies in the field (Calle, 2008), iii) political issues: many governments still continue providing economic support to traditional livestock systems and encourage the use chemical fertilizers and pasture monocultures.

Solutions tested

A recent FAO study on policies to encourage sustainable farming in Mesoamerica concluded that in the region there are different types of policy instruments that can be used to encourage the development of SPS. These instruments include the strengthening of institutional capacities for research and training and increased technology transfer especially on the farmer organizations levels with emphasis on the establishment and management of the SPS. It also highlights the application of the methodology of agricultural field schools, the design of financial support instruments linked or not to rural credit, payment for environmental services, as used in Colombia, and access to different markets. The success of these processes depends on the simultaneous and coordinated implementation of several of them (Acosta et al., 2014). One aspect that is most important in the transfer of the SPS is the dialogue between scientific knowledge and local expertise and the farmer to farmer exchange through informal meetings or meetings with producers, technicians and scientists to share experiences between different regions and countries with similar problems.

Impact generated

The Project Mainstreaming Biodiversity into Sustainable Cattle Ranching in Colombia (GEF, World Bank, ICF-DECC UK, FEDEGAN, CIPAV, TNC, Fondo Acción) that works with 2500 farmers in five regions of Colombia, combines payment of environmental services, technical assistance and credit with 40% discount offered by FINAGRO (a second tier bank in Colombia).

In Mexico ISPS network led by Fundación Produce Michoacán with support of SAGARPA has established about twelve thousand hectares of iSSP in 15 states in less than four years (Xochitl and Solorio, 2013). Currently, it works with about 500 farmers aimed at increasing the profitability of the tropical livestock with the conversion of degraded pastures or deforested areas to production systems. The system offers 5.8 times more protein per hectare than a traditional monoculture

pasture, has 2.6 times higher stocking rate and an individual daily gain 50% higher than a traditional pasture system, and reduces 25 to 40% the methane emissions. Steers grazing in iSPS had better animal welfare and are less susceptible to metabolic digestive disorders than those fattened in feedlots (Corral et al., 2013).

In Brazil there has been a great deal of research on agroforestry systems during the last two decades (Carvalho et al., 2000). The adoption of silvopastoral systems in different biomas of Brazil has increased and several research studies have demonstrated the positive effects of trees on the productivity and nutritional value of different grass species (Luciano et al., 2010; Paciullo et al., 2011) and also soil fertility (Reis et al., 2009). Research has also been done by Embrapa showing the positive effects of trees for rearing dairy heifers compared to monoculture pasture due to the higher body weight gain per heifer and per area (Paciullo et al., 2011). There are several approaches adopted to install SPS. The use of natural regeneration of natives trees (e.g. Viana et al., 2002) or recently, the use of integration of production of agriculture with livestock and timber production (ILPF; integrated agriculture, livestock and forestry) which has support by a public policy within the federal Low Carbon Agriculture (ABC) are promising examples.

Since 2011, the first experiences of iSPS in the states of Pará and Maranhão by the CBPS (Brazilian Center of Sustainable Livestock), UFSJ (Federal University of Sao Joao) and CIPAV have shown promising results with pioneering producers in the context of the eastern Amazon which increased stocking rate from 0.6 to 4 animal units and obtained 15% higher weight gain (Alves- Cangassu et al., 2012). A combination of policies that ensure permanent protected areas, incentives to iSPS such as low cost credits and technical specialized assistance and payment for environmental services provided, would encourage landscape-scale multiplication of nature-friendly cattle ranching that rehabilitate millions of hectares of land degraded (e.g. 50% of the 105 million hectares of cultivated pastures in Brazil are degraded or in process of degradation), by pasture monocultures and the use of fire in this region. Hopefully, in the next few years, Brazil will show that it is possible to obtain beef from forests (Fioravanti, 2012) and milk from iSPS for Brazil and for the world.

List key stakeholders

Colombia: FEDEGAN, CIAT, Universidad Nacional de Colombia, Universidad de Antioquia, El Hatico Natural Reserve, Ministry of Agriculture and Rural Development, Ministry of Environment and Sustainable Development.

Mexico: Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), COFUPRO, Fundación Produce Michoacán, Universidad Autónoma de Yucatán.

Brazil: Centro Brasileiro de Pecuaria Sustentável (CBPS), EMBRAPA, IDESAM.

Key lessons learned and steps forward

In Latin America, livestock intensification with generation of environmental services should be based on agroecological principles. Intensive silvopastoral systems are a good example of the natural way to do agroecological agriculture, so needed in the contemporary world. These models can be scaled up to large landscapes and regions by combining different strategies and incentives that have already been tested. When this is achieved, there will be many benefits for producers in rural areas and for people in the cities. Rarely it is possible to find simultaneous benefits such as higher profitability, generating positive environmental services while facing climate change (adaptation and mitigation at the same time) increasing production of goods derived from animal production (meat, milk, dairy products, manure) and from plants, in special timber, charcoal and non-wood products (Murgueitio et al., 2013).

References:

Acosta, A., Murgueitio, E., Zapata, C. y Solarte. A. 2014. Establecimiento de sistemas agrosilvopastoriles institucionalmente sostenibles. En: Lineamientos de Política para el desarrollo sostenible del sector ganadero. Ed. Acosta A. y Díaz T. FAO, 112 p.

Alves-Cangassu, M., Nacur-Cangassu, J., Fernandes-Sousa, L., Martins-Mauricio, R., Cezar de Macedo, A., Rocha e Silveira, S., Zapata, A. 2012. Experiencias en sistemas silvopastoriles intensivos en la Amazonia oriental brasileña. En: IV Congreso Internacional Sistemas Silvopastoriles Intensivos. Morelia y Valle de Apatzingán/Tepalcatepec. Fundación Produce Michoacán, Cofupro, Sagarpa, CIPAV, UADY. Morelia (Michoacán), México, pp 59-63.

Calle, Z., Murgueitio, E., Chará J., Molina C. H., Zuluaga A. F., & A. Calle (2013) A Strategy for Scaling-Up Intensive Silvopastoral Systems in Colombia, Journal of Sustainable Forestry, 32:7, 677-693, DOI: 10.1080/10549811.2013.817338

Calle, Z., Murgueitio, E., and Chará, J. 2012. Integrating forestry, sustainable cattle-ranching and landscape restoration. Unasylva 63:31-40

Carvalho, M.M; Alvim, M. e Carneiro, J.C. 2001. Sistemas silvipastoris: opções de sustentabilidade para áreas tropicais e subtropicais. Juiz de Fora – Brasil: EMBRAPA-CNPGL, pp 414.

Cuartas, C,A, Naranjo, J.F, Tarazona, A,, Correa, G.,,&. Barahona, R. 2014. Estimation of forage voluntary intake by beef steers grazing in intensive silvopastoral systems based on *Leucaena leucocephala*. *Submitted*

Gaviria-Uribe, X; Naranjo, JF; Bolívar-Vergara DM; Barahona-Rosales, R. 2014. Consumo y digestibilidad de nutrientes en novillos cebuínos pastoreando en un sistema silvopastoril intensivo. *Submitted*

Fajardo D., Johnston-González R., Neira L., Chará J., Murgueitio R. 2009. Influencia de los sistemas silvopastoriles en la diversidad de aves en la Cuenca del río La Vieja, Colombia. Revista Recursos Naturales y Ambiente, No 58: 9-16.

Fioravanti, C. 2012. A carne da floresta. Colombianos criam gado entre árvores e inspiram brasileiros. Rev. Pesquisa FAPESP Edição Impressa 192 - Fevereiro de 2012
online http://www.revistapesquisa.fapesp.br/?art=4625&bd=1&pg=2&lg=
Sao Paulo, Brasil.

Souza, Luciano Fernandes, Maurício, Rogério Martins, Moreira, Guilherme Rocha, Gonçalves, Lúcio Carlos, Borges, Iran, Pereira, Luiz Gustavo Ribeiro. Nutritional evaluation of "Braquiarão" grass in association with "Aroeira" trees in a silvopastoral system. Agroforestry Systems (Print). 2010.

Molina, I.C., Angarita, E, A., Mayorga, O.L, Chará, J. and Barahona R,R.. 2014. Effect of *Leucaena leucocephala* on methane production of Lucerna heifers fed a diet based on *Cynodon plectostachyus*. *Submitted*

IPCC. 2007. Climate Change 2007: Synthesis Report. (C. W. Team, R. K. Pachauri, & A. Reisinger, Edits.) Intergovernmental Panel on Climate Change. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm. (Accessed 10 September 2013)

Montagnini, F., Ibrahim, I. & Murgueitio E. 2013. Silvopastoral systems and climate change mitigation in Latin America. Bois et Forêts des Tropiques VOL 67/316 - 2013 - pp.3-16.

Murgueitio, E., Calle, Z., Uribe, F., Calle, A., Solorio, B. 2011. Native trees and shrubs for the productive rehabilitation of cattle ranching lands. Forest Ecology and Management 261: 1654-1663.

Murgueitio, E,,Chará J. Solarte, A.,Uribe, F,, Zapata, C.,& Rivera, J. 2013. Agroforestería Pecuaria y Sistemas Silvopastoriles Intensivos (SSPi) para la adaptación ganadera al cambio climático con sostenibilidad. Revista Colombiana de Ciencias Pecuarias 2013; 26:313-316

Naranjo J F, Cuartas C A, Murgueitio E, Chará J and Barahona R. 2012. Balance de gases de efecto invernadero en sistemas silvopastoriles intensivos con *Leucaena leucocephala* en Colombia. Livestock Research for Rural Development 24 (8). http://www.lrrd.org/lrrd24/8/nara24150.htm

Reis, Guilherme Lanna, Lana, Ângela Maria Quintão, Mauricio, R. M., Lana, Regina Maria Quintão, Machado, Rodrigo Matta, Borges, Iran, Neto, Talmir Quinzeiro. Influence of trees on soil nutrient pools in a silvopastoral system in the Brazilian Savannah. Plant and Soil (Print), p.111 - 117, 2009.

Rivera L., Botero M., Escobar S., Ambrecht I. 2008. Diversidad de hormigas en sistemas ganaderos. En: Murgueitio E, Cuartas C. y Naranjo J. F. (eds.). Ganadería del futuro: Investigación para el desarrollo. CIPAV. Cali, Colombia. 490 p.

Paciullo, D.S.C., de Castro, C.R.T., Gomide, C.A.de.M., Mauricio, R.M., Pires, M.de.F.A., Muller, M.D., Xavier, D.F., 2011. Performance of dairy heifers in a silvopastoral system. Livestock Sci. 141, 166–172.

Paciullo, D.S.C., Lopes, F.C.F., Malaquias Jr., J.D., Viana Filho, A., Rodriguez,N.M., Morenz, M.J.F., Aroeira, L.J.M., 2009. Características do pasto e desempenho de novilhas em sistema silvipastoril e pastagem de braquiária em monocultivo. Pesq. Agropec. Bras. 44, 1528–1535.

Paciullo, D.S,C., Pires, M.F.A, Aroeira,L.J.M., Morenz,M.J.F.,Maurício,R.M., Gomide, C.A. & Silveira, S.R. 2014, Sward characteristics and performance of dairy cows in organic grass–legume pastures shaded by tropical trees . Animal, page 1 of 8 doi:10.1017/S1751731114000767

Solorio-Sánchez FJ, Bacab-Pérez HM, Ramírez-Avilés L. 2011. Los Sistemas Silvopastoriles Intensivos: Avances de Investigación en el Valle de Tepalcatepec, Michoacán. Memorias III Congreso sobre Sistemas Silvopastoriles Intensivos, para la ganadería sostenible del siglo XXI. Morelia, México: Fundación Produce Michoacán, COFRUPO, SAGARPA, Universidad Autónoma de Yucatán – UADY.

Viana, V.M., Maurıcio, R.M., Matta-Machado, R., Pimenta, I., 2002. Manejo de la regeneracion natural de especies nativas para la formacion de sistemas silvopastoriles en zonas de bosques secos del sureste de Brasil. Agrofor. Am. 9, 48–52.

Xóchitl M y Solorio B. 2012. Ganadería Sustentable. 2a Etapa del Proyecto Estratégico de Prioridad Nacional “Desarrollo y Fomento de los Sistemas Silvopastoriles Intensivos como alternativa alimenticia para la producción de carne y leche en regiones tropicales. Editores: Martha Xóchitl Estrada y Baldomero Solorio Sánchez. Fundación Produce Michoacán, SAGARPA, COFUPRO, UADY. Michoacán, México, 215 p.