II WORLD CONGRESS ON INTEGRATED CROP-LIVESTOCK-FORESTRY SYSTEMS
May 4th and 5th, 2021 - 100% Digital

IMPLEMENTATION OF LOW-CARBON TECHNOLOGY IN THE BRAZILIAN AMAZON

Julia Graziela da SILVEIRA [1]; Luís Tadeu ASSAD [2]; Sílvio Nolasco de Oliveira NETO [3]; María Suárez BONET [4]; Ana Carolina Barbosa do CANTO [6]; Fernanda Reis CORDEIRO [5]; Fernanda Figueiredo Granja Dorilêo LEITE [7]; Alejandro Muñoz MUÑOZ [8]; Roberta Roxilene dos SANTOS [9]; Renato de Aragão Ribeiro RODRIGUES [10]

[1] Forest Engineer. PhD candidate. Department of Forest Engineering, Federal University of Viçosa (UFV); [2] Fisheries Engineer. Director-President. Brazilian Institute of Development and Sustainability (IABS); [3] Forest Engineer. Professor. Department of Forest Engineering, Federal University of Viçosa (UFV); [4] Industrial Engineer. Operational Coordinator. Brazilian Institute of Development and Sustainability (IABS); [5] Agricultural and Environmental Engineer. PhD candidate. Federal Fluminense University (UFF); [6] Agricultural and Environmental Engineer. Master in Biosystems. Federal Fluminense University (UFF); [7] Agricultural and Environmental Engineer. PhD candidate. Federal Fluminense University (UFF); [8] Degree in Marine Sciences. Director of Internationalization. Brazilian Institute of Development and Sustainability (IABS); [9] Geographer. Regional Director. Brazilian Institute of Development and Sustainability (IABS); [10] Biologist. Researcher. Embrapa Soils

ABSTRACT
The Amazon biome still suffers from deforestation and the implementation of sustainable agricultural systems is important for the biome preservation, through the effect of saving land. Public policies and rural development projects allow training and dissemination of knowledge about production systems that bring benefits to producers and the environment. *The Sustainable Rural Project* promotes the implementation of low-carbon technologies in rural properties, allowing for better land management and preservation of biodiversity. Thus, the objective of this work was to identify the main low-carbon technologies that small and medium producers have implemented in the Amazon biome through the actions of the project. The supported technologies were: Agroforestry Systems (AFS); Recovery of Degraded Areas with Pasture (RDAP); Recovery of Degraded Areas with Forest (RDAF); Forest Planting (FP) and; Management of Native Forests (MNF). Thus, more than 1,600 rural producers were impacted on more than 20 thousand hectares in the biome. The main technology deployed was RDAP and the one of least interest was MNF and FP. It was observed that the majority of producers chose not to modify the land use and cover before the project, maintaining the activities that were already common on the property.
Key words: sustainable development; climate change; public policy

INTRODUCTION

The Amazon Forest is the largest tropical forest in the world, with enormous biodiversity, it provides ecosystem services and contributes to climate regulation and the global hydrological cycle (INPE, 2020; RUIZ-VÁSQUEZ et al., 2020). Despite this, about 300,000 km^2 have been deforested in the past 20 years (INPE, 2020). From 2019 to 2020, there was an increase of more than 35% or 9,216 km^2 of the deforestation rate in the Legal Amazon (TERRABRASILIS, 2020).

One of the causes of deforestation in the Amazon is the opening of areas for the expansion of beef cattle and soybean crops (SILVA; BARIONI; MORAN, 2021), with this high contribution to deforestation carried out by a small minority of farmers (about 2% of properties) (RAJÃO et al., 2020).

The challenge of preserving the Amazon can only be overcome with effective changes in production systems and with sustainable rural development policies, which include the economic, environmental, and social spheres (STRASSBURG, 2019).

For this, there is a need to bring the context of climate change closer to agricultural production, improving and encouraging the transmission of information and training, especially in the context of small and medium producers (MELLO-THÉRY et al., 2020). Since the lack of information and technical assistance to producers is one of the major problems for sustainable practices to be adopted more, besides, financial incentives, such as rural credits, are also an obstacle to the adoption of these technologies, mainly due to the initial costs of implementation (CORTNER et al., 2019).

Thus, public policies and projects for the implementation of low-carbon agriculture technologies aimed at smallholders for sustainable development and recovery of degraded areas are paramount in combating climate change (TEIXEIRA et al., 2018).

In this sense, the Sustainable Rural Project was prepared in the form of technical cooperation, based on financing from the International Climate Fund and the UK Department of Environment and Rural Affairs (Defra), with the Ministry of Agriculture, Livestock and Supply of Brazil (MAPA) as its beneficiary, through the Secretariat of Social Mobility, Rural Producers and Cooperatives.

The project had the Inter-American Development Bank (IDB) as executor and financial manager. This Technical Cooperation was financed by the British Government. Brazilian Institute of Development and Sustainability (IABS) was the institution selected to carry out the execution and operational services of administrative and logistical activities of the Rural Sustainable project and the Brazilian Agricultural Research Corporation (Embrapa) the scientific coordinator of the project.

The Sustainable Rural project aimed to improve land and forest management, poverty reduction, biodiversity conservation, and climate protection through financial incentives and technical assistance for the implementation of low-carbon technologies in rural properties (ASSAD et al., 2019). The success of this type of project depends on convincing producers that it is necessary and possible to change their practices in rural properties (NEWTON et al., 2016).

Thus, we sought to identify the main low-carbon technologies that small and medium-sized producers implemented in the Brazilian Amazon biome through the actions of the Rural Sustainable project.

MATERIAL AND METHODS

This study is based on the Phase I Sustainable Rural Project (PRS I) that was carried out in the Amazon biome, with rural producers, distributed in 30 municipalities in the states of Rondônia, Pará, and Mato Grosso, with 10 municipalities in each of these states. Details of the project can be checked at http://mata-atlantica-amazonia.ruralsustentavel.org/ and in the book by Assad et al. (2019).

One of the actions of the project was to identify, support, and financially encourage the implementation of low-carbon technologies in properties of small (modules less than or equal to 4) and medium (modules between 4 and 15) rural producers. Fiscal module is a unit of measure, in hectares (ha), which the value is fixed for each municipality, taking into account several factors, such as the type and income of predominant activity and others. The supported technologies were: Agroforestry Systems (AFS); Recovery of Degraded Areas with Pasture (RDAP); Recovery of Degraded Areas with Forest (RDAF); Plantation of Commercial Forests (FP) e; Sustainable Management of Native Forests (MNF). Each producer could choose the technology that would be best for their reality, being able to choose the implementation of more than one.

Following the scope of the project, 1,604 rural properties were contemplated. In these properties, the technology (s) that the producer (s) implanted (AFS, RDAP, RDAF, FP, and MNF) and the soil cover before the technology (s) were identified, it can be: crop, pasture, forest, and others that do not include the mentioned activities.

For these issues regarding technologies and previous coverage, it was identified by area of intervention, that is, if the producer adopted more than one technology on his property in different areas, it was analyzed separately. The data were presented through descriptive statistics.

RESULTS AND DISCUSSIONS

With the actions of the project, 2,036 interventions were carried out resulting from the implementation of AFS, RDAP, RDAF, FP, and MNF technologies in the 1,604 properties, that is, in some cases, one (a) producer implanted more than one low-carbon technology in different areas of your property. The main technologies deployed were RDAP (56.5%), AFS (26.9%), and RDAF (14.7%), in areas referring to 13,657; 5,313 and 936 ha, respectively. On the other hand, FP and MNF represented the lowest percentage of implantation (1.4% and 0.5%, respectively) (Table 1).

Table 1. Number of technologies deployed (n) and the total area in hectares for each technology.

Implanted technology	n	%	area (ha)
AFS	548	26.9	5,313
RDAP	1,151	56.5	13,657
RDAF	299	14.7	936
FP	28	1.4	68
MNF	10	0.5	44
Total	2,036	100.0	20,019

n: number of interventions (technology deployed) and; %: percentage of interventions in each class. AFS: agroforestry systems; RDAF: recovery of degraded areas with forest; RDAP: recovery of degraded areas with pasture; FP: forest planting and; MNF: management of native forest.

Of these 2,036 interventions, only 10 were related to MNF, where no land-use changes were made, only sustainable forest management. Therefore, these interventions were not considered in previous coverage.

In this context, pasture was the previous coverage of most of the areas where the technologies were implemented, being AFS (63.7%), RDAP (93.1%), RDAF (72.0%), and FP (78.6%). The forest was the second-largest previous cover in the areas that implemented RDAP (4.0%), RDAF (19.7%), and FP (17.9%). For the areas that implemented AFS, the crop was the second-largest previous cover (15.7%), after pasture. The coverage before the implementation of the four technologies was distributed among other uses, as shown in Table 2.

Concerning the implementation of technologies, most producers implemented RDAP, in an area of more than 13 thousand hectares, which previously were mostly degraded pastures with livestock. These results demonstrate that rural producers in the Amazon still opt for livestock practices. Data from the IBGE Agricultural Census (2017) showed that livestock, in addition to being the predominant activity in the biome, was also the one that grew the most in recent years, so worrying about the recovery of degraded pastures is essential for maintaining the activity and environmental quality.

Table 2. Previous coverage of areas deployed with low-carbon technologies.

Implanted technology	Coverage prior to technology deployment	n	%
AFS	Crop	86	15.7
	Pasture	349	63.7
	Forest	39	7.1
	Other	74	13.5
RDAP	Crop	1	0.1
	Pasture	1,072	93.1
	Forest	46	4.0
	Other	32	2.8
RDAF	Crop	3	1.0
	Pasture	216	72.0
	Forest	59	19.7
	Other	21	7.0
FP	Crop	0	0.0
	Pasture	22	78.6
	Forest	5	17.9
	Other	1	3.6

n: number of interventions performed. AFS: agroforestry system; RDAF: recovery of degraded areas with forest; RDAP: recovery of degraded areas with pasture; FP: forest planting.

With RDAP it is possible to recover areas, previously unproductive or with low productivity rates, reducing the opening of new areas of the native forest through deforestation, resuming the physical, chemical, and biological quality of the soil, also improving the productive and economic capacity of the properties, mainly when performed with integrated crop-livestock systems (MACEDO, 2009; REIS et al., 2019; SALTON et al., 2014; VILELA et al., 2011; WILKINS, 2008).

AFS was the second most deployed technology by rural producers with more than 5,000 ha, largely replacing livestock areas (previous coverage). There was a good representation and acceptance of technology by producers in the Amazon, given several possible environmental and economic benefits, because with the diversification of products it is possible to increase income (PINHO; MILLER; ALFAIA, 2012; POMPEU et al., 2012; VOSTI et al., 1998; YAMADA; GHOLZ, 2002).

RDAF, the third technology most deployed by producers in the biome. The reforestation of degraded or unproductive areas can collaborate with the reduction of deforestation in the Amazon region, and at the same time help in the environmental regularization of rural properties (Piketty et al., 2015), which may have influenced producers to adopt the technology, after all, environmentally regulated properties have easier access to credit (L'ROE et al., 2016; ROITMAN et al., 2018).

The lesser implantation of FP technology by producers cannot be understood as less important or inefficient. Therefore, it is believed that the lower availability of area (small and medium producers) and the need to increase income with the primary activities already adopted, made the technologies less attractive to producers. Another important point that may have led to the lesser adoption of the FP is the slow economic return concerning other activities such as livestock and farming (SIMMONS; WALKER; WOOD, 2002).

Even though the project enabled the proper management of native forests (MNF), with the possibility of return, the acceptance was very low. It is understood, therefore, about the need to strengthen projects, public policies, and training for maintenance and, consequently, the preservation of the native Amazonian Forest.

CONCLUSIONS

From the results obtained, it was observed that the producers chose not to modify the use and cover of the soil before the project, maintaining the activities that were already common on the property. Therefore, most are producers who do not seek to change their production system and obtain new knowledge from other cultures.

Even so, the implementation of low-carbon technology has impacted more than 1,600 rural producers on more than 20 thousand hectares in the Amazon biome. This will enable the dissemination of knowledge and possibilities for improvements in production systems, through sustainable production, which preserves native forests, improves producers' income and quality of life.

ACKNOWLEDGMENTS

Thanks to the International Climate Fund and the UK Department of Environment and Rural Affairs (Defra), the Ministry of Agriculture, Livestock and Supply (MAPA) of Brazil, the Inter-American Development Bank (BID), the IABS - Brazilian Institute of Development and Sustainability, and to the Brazilian Agricultural Research Corporation (Embrapa) for the composition of the institutional arrangement of the Sustainable Rural Project; to Capes for granting a scholarship to the corresponding author.

REFERENCES

ASSAD, L. T.; MUÑOZ, A. M.; BONET, M. S.; SELVA, G. V. **Projeto rural sustentável fase I**: promovendo o desenvolvimento e a agricultura de baixa emissão de carbono na Amazônia e na Mata Atlântica. Brasília: Editora IABS, 2019.

CORTNER, O.; GARRETT, R. D.; VALENTIM, J. F.; FERREIRA, J.; NILES, M. T.; REIS, J.; GIL, J. Perceptions of integrated crop-livestock systems for sustainable intensification in the Brazilian Amazon. **Land Use Policy**, v. 82, p. 841–853, 2019.

IBGE. **Censo Agropecuário 2017**, 2017. Available at: <https://biblioteca.ibge.gov.br/visualizacao/periodicos/3096/agro_2017_resultados_definitivos.pdf>

INPE. **PRODES**: Monitoramento do Desmatamento da Floresta Amazonica Brasileira por Satelite, 2020. Available at: <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>.

L'ROE, J.; RAUSCH, L.; MUNGER, J.; GIBBS, H. K. Mapping properties to monitor forests: Landholder response to a large environmental registration program in the Brazilian Amazon. **Land Use Policy**, v. 57, p. 193–203, 2016.

MACEDO, M. C. M. Integração lavoura e pecuária: o estado da arte e inovações tecnológicas. **Revista Brasileira de Zootecnia**, v. 38, n. SPE, p. 133–146, 2009.

MELLO-THÉRY, N. A. DE; LIMA CALDAS, E. DE; FUNATSU, B. M.; ARVOR, D.; DUBREUIL, V. Climate Change and Public Policies in the Brazilian Amazon State of Mato Grosso: Perceptions and Challenges. **Sustainability**, v. 12, n. 12, 2020.

NEWTON, P.; GOMEZ, A. E. A.; JUNG, S.; KELLY, T.; MENDES, T. A.; RASMUSSEN, L. V.; REIS, J. C.; RODRIGUES, R. A. R.; TIPPER, R.; HORST, D. VAN DER; WATKINS, C. Overcoming barriers to low carbon agriculture and forest restoration in Brazil: The Rural Sustentável project. **World Development Perspectives**, v. 4, p. 5–7, 2016.

PIKETTY, M. G.; POCCARD-CHAPUIS, R.; DRIGO, I.; COUDEL, E.; PLASSIN, S.; LAURENT, F.; THÂLES, M. Multi-level Governance of Land Use Changes in the Brazilian Amazon: Lessons from Paragominas, State of Pará. **Forests**, v. 6, n. 5, p.1516–1536, 2015.

PINHO, R. C.; MILLER, R. P.; ALFAIA, S. S. Agroforestry and the Improvement of Soil Fertility: A View from Amazonia. **Applied and Environmental Soil Science**, 2012.

POMPEU, G. DO S. S.; ROSA, L. S.; SANTOS, M. M.; MODESTO, R. S.; VIEIRA, T. A. Adoption of agroforestry systems by smallholders in brazilian amazon. **Tropical and Subtropical Agroecosystems**, v. 15, n. 1, 2012.

RAJÃO, R.; SOARES-FILHO, B.; NUNES, F.; BÖRNER, J.; MACHADO, L.; ASSIS, D.; OLIVEIRA, A.; PINTO, L.; RIBEIRO, V.; RAUSCH, L.; GIBBS, H.; FIGUEIRA, D. The rotten apples of Brazil's agribusiness. **Science**, v. 369, n. 6501, p. 246–248, 2020.

REIS, J. C. DOS; KAMOI, M. Y. T.; LATORRACA, D.; CHEN, R. F. F.; MICHETTI, M.; WRUCK, F. J.; GARRETT, R. D.; VALENTIM, J. F.; RODRIGUES, R. A. R.; RODRIGUES-FILHO, S. Assessing the economic viability of integrated crop-livestock systems in Mato Grosso, Brazil. **Renewable Agriculture and Food Systems**, p. 1-12, 2019.

ROITMAN, I.; VIEIRA, L. C. G.; JACOBSON, T. K. B.; BUSTAMANTE, M. M. C.; MARCONDES, N. J. S.; CURY, K.; ESTEVAM, L. S.; RIBEIRO, R. J. C.; RIBEIRO, V.; STABILE, M. C. C.; MIRANDA FILHO, R. J.; AVILA, M. L. Rural Environmental Registry: An innovative model for land-use and environmental policies. **Land Use Policy**, v. 76, p. 95–102, 2018.

RUIZ-VÁSQUEZ, M.; ARIAS, P. A.; MARTÍNEZ, J. A.; ESPINOZA, J. C. Effects of Amazon basin deforestation on regional atmospheric circulation and water vapor transport towards tropical South America. **Climate Dynamics**, v. 54, n. 9–10, p. 4169–4189, 2020.

SALTON, J. C.; MERCANTE, F. M.; TOMAZI, M.; ZANATTA, J. A.; CONCENÇO, G.; SILVA, W. M.; RETORE, M. Integrated crop-livestock system in tropical Brazil: Toward a sustainable production system. **Agriculture, Ecosystems & Environment**, Integrated Crop-Livestock System Impacts on Environmental Processes. v. 190, p. 70–79, 2014.

SILVA, R.; OLIVEIRA; BARIONI, L. G.; MORAN, D. Fire, deforestation, and livestock: When the smoke clears. **Land Use Policy**, v. 100, 2021.

SIMMONS, C. S.; WALKER, R. T.; WOOD, C. H. Tree planting by small producers in the tropics: A comparative study of Brazil and Panama. **Agroforestry Systems**, v. 56, n. 2, p. 89–105, 2002.

STRASSBURG, B. B. N. Conservation provides multiple wins for Brazil. **Nature Ecology & Evolution**, v. 3, n. 4, p. 508–509, 2019.

TEIXEIRA, H. M.; VAN DEN BERG, L.; CARDOSO, I. M.; VERMUE, A. J.; BIANCHI, F. J. J. A.; PEÑA-CLAROS, M.; TITTONELL, P. Understanding Farm Diversity to Promote Agroecological Transitions. **Sustainability**, v. 10, n. 12, 2018.

TERRABRASILIS. **Amazônia Legal Brasileira - avisos de Desmatamento, 2020**. Available at: <http://terrabrasilis.dpi.inpe.br/app/dashboard/alerts/legal/amazon/aggregated/#>. Accessed on: Oct. 2020.

VILELA, L.; MARTHA JUNIOR, G. B.; MACEDO, M. C. M.; MARCHÃO, R. L.; GUIMARÃES JÚNIOR, R.; PULROLNIK, K.; MACIEL, G. A. Integrated crop-livestock systems in the Cerrado region. **Pesquisa Agropecuária Brasileira**, v. 46, n. 10, p. 1127–1138, out. 2011.

VOSTI, S. A.; WITCOVER, J.; OLIVEIRA, S.; FAMINOW, M. Policy issues in agroforestry: technology adoption and regional integration in the western Brazilian Amazon. In: NAIR, P. K. R.; LATT, C. R. (Eds.). Directions in Tropical Agroforestry Research: Adapted from selected papers presented to a symposium on Tropical Agroforestry organized in connection with the annual meetings of the American Society of Agronomy, 5 November 1996, Indianapolis, Indiana, USA**. Forestry Sciences**. Dordrecht: Springer Netherlands, 1998. p. 195–222.

WILKINS, R. J. Eco-efficient approaches to land management: a case for increased integration of crop and animal production systems. **Philosophical Transactions of the Royal Society B: Biological Sciences**, v. 363, n. 1491, p. 517–525, fev. 2008.

YAMADA, M.; GHOLZ, H. L. An evaluation of agroforestry systems as a rural development option for the Brazilian Amazon. **Agroforestry Systems**, v. 55, n. 2, p. 81–87, set. 2002.