Núcleo de Meio Ambiente
Universidade Federal do Pará
Rua Augusto Corrêa, 01, Guamá
Belém, Pará, Brasil
https://periodicos.ufpa.br/index.php/agroecossistemas

AGROFORESTRY VS CONVENTIONAL SYSTEMS: A SUSTAINABILITY EVALUATION OF TWO AGROECOSYSTEMS IN THE SOUTHERN BAHIA LOWLANDS

Samara Lima Coqueijo
Universidade Federal da Paraíba
samaracoqueijo@hotmail.com

Gustavo Ferreira Costa Lima
Universidade Federal da Paraíba
gust3lima@uol.com.br

Edevaldo Silva
Universidade Federal da Paraíba
edevaldos@yahoo.com.br

ABSTRACT: This research aimed to evaluate the sustainability of two different agroecosystems, a agroforestry system (AF) and a conventional system. As to specific objectives, it aimed to rescue the history of the emergence of the assessed agroforestry system and to carry out a socioeconomic and environmental diagnosis of the studied agroecosystems. To this end, an exploratory and descriptive case study was conducted, considering an AF agrosystem and a conventional one, both located in the Dandara dos Palmares settlement, in the Southern Bahia Lowlands region. The methodology used was MESMIS (Framework for the Evaluation of Management Systems using Indicators), which is a method that encourages the participation of farmers throughout the evaluation process. Throughout the research, it was perceived that there are important gaps to be considered in relation to agricultural public policies, such as in the offer of differentiated credit and technical assistance; in the creation of marketing channels which are more favorable to small producers; in training policies and purchase guarantees; in research into inputs and techniques adapted to family farmers, such as seed banks and biological pest control; and in social policies on education, health and rural retirement. In this case study, the forest agroecosystem under study is more sustainable than the conventional agroecosystem. Further field studies are important to report the efficiency of the AF in comparison with other agroecosystems.

KEYWORDS: Agricultural ecology, Family farms, Natural resource management protocols.

Received: 2022-05-31
Evaluated: 2022-06-21
Accepted: 2022-09-21

SISTEMA AGROFLORESTAL VS AGRICULTURA CONVENCIONAL: AVALIAÇÃO DA SUSTENTABILIDADE EM DOIS AGROECOSSISTEMAS NO BAIXO SUL DA BAHIA

RESUMO: Esta pesquisa objetivou avaliar a sustentabilidade de dois agroecossistemas diferentes, um florestal (SAF) e outro convencional. Como objetivos específicos, visou resgatar a história do surgimento do sistema agroflorestal avaliado e realizar um diagnóstico socioeconômico e ambiental dos agroecossistemas estudados. Para tanto, foi conduzido um estudo de caso exploratório e descritivo, considerando um agrossistema SAF e outro convencional, ambos localizados no assentamento Dandara dos Palmares, na região do Baixo Sul da Bahia. A metodologia utilizada foi o MESMIS (Marco para a Avaliação de Sistemas de Manejo de Recursos Naturais incorporando Indicadores), que é um método que estimula a participação dos agricultores durante todo o processo avaliativo. Através da pesquisa, percebeu-se que existem lacunas importantes a serem consideradas em relação a políticas públicas agrícolas, como a oferta de crédito diferenciado e de assistência técnica; na criação de canais de comercialização mais favoráveis aos pequenos produtores, políticas de capacitação e de garantia de compra; em pesquisas de insumos e técnicas adaptadas ao agricultor familiar, como os bancos de sementes e o controle biológico de pragas; e em políticas sociais de educação, saúde e aposentadoria rural. Neste estudo de caso, o agroecossistema florestal estudado é mais sustentável do que o agroecossistema convencional. Estudos de campo ulteriores são importantes para reportar a eficiência do SAF em comparação com outros agroecossistemas.

PALAVRAS-CHAVE: Agricultura familiar, Ecologia Agrícola, Protocolos de manejo de recursos naturais.

AGROFORESTERÍA FRENTE A LA AGRICULTURA CONVENCIONAL: EVALUACIÓN DE LA SOSTENIBILIDAD EN DOS AGROECOSISTEMAS DEL BAJO SUR DE BAHÍA

RESUMEN: El objetivo de esta investigación era evaluar la sostenibilidad de dos agroecosistemas diferentes, uno forestal (SAF) y otro convencional. Como objetivos específicos, se pretendió rescatar la historia del surgimiento del sistema agroforestal evaluado y realizar un diagnóstico socioeconómico y ambiental de los agroecosistemas estudiados. Para eso, se realizó un estudio de caso exploratorio y descriptivo, considerando un SAF y un agrosistema convencional, ambos localizados en el asentamiento Dandara dos Palmares, en la región de Bahía Sur. La metodología utilizada fue el MESMIS (Marco de Evaluación de Sistemas de Gestión de Recursos Naturales que incorpora Indicadores), que es un método que fomenta la participación de los agricultores en todo el proceso de evaluación. A través de la encuesta, se percibió que hay importantes lagunas a considerar en relación a las políticas públicas agrícolas, como la oferta de crédito diferenciado y asistencia técnica; en la creación de canales de comercialización más favorables a los pequeños productores, políticas de capacitación y garantías de compra; en la investigación de insumos y técnicas adaptadas a los agricultores familiares, como bancos de semillas y control biológico de plagas; y en las políticas sociales de educación, salud y jubilación rural. En este caso de estudio, el agroecosistema forestal estudiado es más sostenible que el agroecosistema convencional. Es importante realizar más estudios de campo para informar sobre la eficacia del SAE en comparación con otros agroecosistemas.

PALABRAS CLAVES: PALABRAS CLAVES: Agricultura familiar, Ecología agrícola, Protocolos de manejo de recursos naturales.

INTRODUCTION

Since its origin, in the Neolithic period, agriculture has expanded bringing about major transformations in human culture and economy. The agricultural revolution was the leverage for the development of civilizations as it enabled the production of surpluses, the population growth, access to a varied diet and the development of other activities beyond mere survival (MAZOYER; ROUDART, 2010).

In capitalist modernity, in parallel to subsistence farming, another system of commercial agriculture has developed with the main focus on increasing productivity and profitability. It constituted a strategy for the industrialization of agriculture through the creation of a large agro-industrial complex consisting of modified seeds, pesticides, nitrogen fertilizers, tractors and agricultural machinery, as well as various agroindustries (AGUIAR, 1986). In Brazil, this project began during the military governments as from the 1970s, with the support of government credit and research policies as well as incentives for the sector's large multinationals (BELIK, 2017).

Regarding the outcomes, the Green Revolution benefited large-scale producers and the agroindustrial and export sectors, but had damaging social and environmental consequences for family farming and natural ecosystems (AGUIAR, 1986; DELGADO, 2013; PATEL, 2013).

Brazil is currently one of the largest agricultural producers and the second largest importer of pesticides, as well as the largest consumer of pesticides in the world (PIGNATI et al., 2017). In contrast, the use of pesticides has increased dramatically over the last fifty years, and their indirect costs need to be balanced against their benefits (ALTIERI, 2012; DUTRA; SOUZA, 2017). The Ministry of Agriculture, Livestock and Supply (MAPA) reported that in 2021, 562 new pesticide registrations were approved in the country (BRASIL, 2022).

As a counterpoint to this agricultural model, agroecology has emerged as a new field of practical knowledge for the development of a sustainable agriculture that promotes the security and sovereignty of rural communities (LEFF, 2002; ROSSET; ALTIERI, 2017).

Agroforestry systems (AF) are alternative production practices that encourage the conservation of native forests and, in many cases, their restoration, improving soil fertility, protection against erosion, generation of ecosystem services, the sequestration of atmospheric carbon dioxide, among other socio-environmental advantages (ALTIERI; NICHOLLS, 2011).

The essence of AF lies in the ecological interactions that take place between the trees and the other elements of the agroecosystem. Agroforestry practices propose a diversified production, where the aim is to create more life, more fertility in the soil and to make the system more prosperous, the use of fire, chemical products and heavy machinery not being common (PANTERA et al., 2021; PAVLIDIS; TSIHRINTZIS, 2018).

Given the critical scenario in modern agriculture, this study has questioned the sustainability and implementation aspects of these two productive models: the AF and the conventional one.

In this sense, based on a case study, this research had as a general objective to evaluate the sustainability of two different agroecosystems, a agroforestry and a conventional one, and as specific objectives to rescue the history of the emergence of the evaluated agroforestry systems, as well as to carry out the socioeconomic and environmental diagnosis of the studied agricultural systems.

MATERIAL AND METHODS

This research was a descriptive and exploratory case study, focusing on the detailed description of historical aspects and agricultural practices of two families practicing different agroecosystems.

The research was carried out in the Southern Lowlands of the State of Bahia, located in the Northeast region of Brazil (Figure 1). This region covers an area of 6,451 km², being home to 2.08% of the population of Bahia (BRITO, 2007). The territory covers 14 municipalities, including Camamu, where the researched community is located.

Figure 1. Map showing the location of the Southern Bahia Lowlands region, Brazil, and the data collection site (yellow dot).

Source: Elaboration Oliveira (2019).

The choice of the study area was due to being a region of high relevance for global biodiversity, as it is located in an area of Atlantic Forest, which makes it more vulnerable to the impacts of conventional agriculture. Historically, this region was marked by the growth of cocoa-cabruca, a form of agroforestry system developed in the region under the shade of patches of original forest (SETENTA et al., 2005). In addition, the region has a significant presence of family farmers, which has been accentuated since 1984 with the crisis of the cocoa system and the reconversion of unproductive latifundia into new agrarian reform settlements (AGUIAR; PIRES, 2019).

The Southern Lowlands were a pioneer area in the occupation process of colonial Brazil (BAHIA, 2018), having an economic history marked by cocoa production. In the period of the cocoa crisis, caused by the witches' broom fungus (*Crinipellis perniciosa*), many farms were abandoned, becoming unproductive latifundia. The strong presence of the Landless Workers' Movement (MST) in the southern region of Bahia, along with the existence of these abandoned and unproductive properties in the 1990s (post-cocoa crisis), favored and boosted the creation of various Agrarian Reform settlement projects (BRITO, 2007), such as the Dandara dos Palmares settlement.

Situated in the municipality of Camamu, in the Southern Bahia Lowlands, Dandara dos Palmares is an MST Agrarian Reform settlement founded in 1998 by the National Institute for Colonization and Agrarian Reform (INCRA). Sixty-five families currently live there, with the total area of the settlement being 1,297.79 hectares, of which 422.49 ha are set aside for farming (6.5 ha per family); 233.39 ha are defined as permanent preservation areas; and 616.11 ha are demarcated as legal reserves, since the community is settled in an Atlantic Forest area (REZENDE, 2004).

The choice of the Dandara dos Palmares settlement as a research unit was guided by criteria such as: the maturity of agroforestry practices by the selected farmer and by the community; the possibility of comparing two agroecosystems in the same settlement; the presence of family farming in the community; and the existence of the Advisory Services to Rural Popular Organizations (Sasop) in the region, which facilitated the researcher's relationship with the community.

METHODOLOGICAL PROCEDURES

The research carried out a transversal study comparing a reference system, in this case a conventional monoculture, with an alternative system (AF), following a quali-quantitative approach. For this purpose, the following research and data collection techniques were used jointly: the bibliographical research; participant observation; the collection of primary data through semi-structured interviews; the application of the MESMIS indicators (Framework for Evaluating Natural Resource Management Systems Incorporating Sustainability Indicators), and soil analysis in the laboratory.

The field research was carried out in January, April, May, October and November 2018. The bibliographical research and participant observation focused on the perception of the problems caused by conventional agriculture, the origin and historical evolution of AF in the region, the relationship with present or absent public policies, and the feasibility and difficulties encountered by farmers in production by means of AF. For the field observations, the researcher spent time living with the studied community, trying to follow and participate in their daily life, in the local social relations and in the ways of organizing the production and commercialization of their final product.

The MESMIS indicators propose an analysis based on a critical reflection of the experience developed in order to improve the possibilities of success of the production systems and even the way of evaluating them. The MESMIS was chosen because of its flexibility, its holistic participatory nature and its suitability for analyzing family-based agricultural forestry production systems. It follows six main stages (MASERA et al., 1999): 1) characterization of the agroecosystems; 2) determination of the strengths and weaknesses of the systems and management; 3) selection of diagnostic criteria and strategic indicators; 4) measurement and monitoring of the indicators; 5) presentation and integration of results;

and 6) conclusion and recommendations of the research. Thereby, each of these stages is the object of study and analysis, thus being presented, in that order, in the results of the study. The methodological course developed for each aforementioned stage is described below. This entire path was based on Masera et al. (1999).

Stages 1 and 2 were developed based on exploratory observation and, mainly, through semi-structured interviews with farmers in both agroecosystems involved in this case study.

In the interviews, data were collected as from variables of classification (name, age, gender, marital status, education), socioeconomic (family income and whether it derives only from agriculture, family monthly expenditure, whether they are satisfied with the family income), infrastructure (size of the property, facilities, equipment and tools of the property for production, storage and processing of products), health and education (whether they had access to health services and school and how they perceive their quality, time for leisure and rest), besides other questions related to management and applied techniques, social assistance, commercialization, soil, biota, and solid waste (Table 1).

Table 1 describes the aspects that guided the interview questions, separated into social, economic and environmental aspects. For the social and economic diagnosis, questions related to the technical-productive arrangement, commercialization, education, health, access to credit, housing conditions and technical assistance were addressed. The environmental aspects covered questions related to resources available in the area, soil fertility, water availability, diversity of species cultivated, type of management used and waste recycling.

Table 1. Questions applied to farmers in both agroecosystems studied in Dandara dos Palmares, Bahia, 2019.

Access to social and technical assistance
Is there access to public policies related directly or indirectly to AF? Which ones?*
Is there access to the Technical Assistance and Rural Extension service? *
How often and what type of assistance does the technician provide to the family? *
Is there access to agricultural credit? Of what type? *
Do you have any kind of agricultural debt? And how are you paying it off?
Has the Rural Environmental Registry been conducted? *
Do you have access to public policies, e.g. family allowance, pension, unemployment insurance of the closed fishing season, PRONAF, or state and municipal agricultural policies?
Technical, production and commercialization aspects
Is the family self-sufficient in the production of their food?
Do you have a regular channel for commercializing your production? Which one?
How do people access the market: fairs, directly selling to consumers, institutional markets in government programmes (e.g. PAA, PNAE)? *
Do you depend on middlemen to sell your products?
How far are these markets? *
What are the conditions of transport and access roads like? *
Which products are most accepted in the market?
Is the price of this product on the market worth the cost? *
What is your relationship with the land where you live?
How many people in the family have available family workforce?
Do you need to hire people from outside for the harvest? *
Do you use irrigation techniques? Which ones?
Is management efficient and does it provide good physical performance? *
Do you have access to means of transport for the demands of production and commercialization? Which ones?
At the end of the agricultural year is there any monetary surplus left to invest in the next crop? *
Do you participate in any association, cooperative or trade union? Which one?
What are the months of rain and sowing?
Who carries out the sowing and management work?
Collective and training actions
Do you participate in collective policies or decisions?
What is your means of access to information?*
Are there any solidarity activities, such as joint efforts, mutual aid, exchange of daily tasks, etc.?
Is there any action in which you identify support from the collective to the farming family (e.g. someone from the community representing the farmer in fairs)?*
Is there any involvement in spheres of social participation (committees, commissions, forums, etc.)?
Natural resources, soil, water and solid waste
Is the quality/fertility of the soil satisfactory? If not, why not?*
In your opinion, how fertile is the soil?*
Concerning the land: does it get waterlogged? Is it steep? Is it compacted? Is it well drained? Is there a water source nearby?*
Is there a source of nutrients nearby (limestone, rock dust, sawdust, manure, agro-industry by-products, ash)?*
Is there a source of planting materials nearby (seeds, seedlings and stakes)?
Is there any native vegetation nearby?
Is the property in compliance with environmental regulations?*
Are there native areas and perennial water sources in the property?
Is the forest used? How is it used?
Have you ever been involved in reforestation?
What species do farmers produce?
Is the agroecosystem diversified? If not, please justify.
Is there vegetation diversity? If not, please justify.
Is there fauna diversity?
What agricultural activities are developed?
Is the production system diverse and consortial? If not, please justify.
How is waste treated locally?
Do you use inputs - chemical fertilizers and pesticides?
Is there any erosion?
Do you use agroecological techniques? If so, which ones?

* These issues were also confirmed with consultations with the Sasop president and AF engineers and technicians.

Some questions in the interview (all asterisked in Table 1) that dealt with technical aspects were also confirmed and/or complemented in consultation with four other specialists in the area, namely: the Sasop president, a forestry engineer who works with AF, an agricultural technician who works with communities in the North of the country making use of AF, and an agronomist with agroecological experience.

In step 2, the critical and constraining points (listed in the results) of each agroecosystem were defined based on the data mentioned above. They were linked according to strong or constraining aspects of productivity (yield, product quality), stability and resilience (soil degradation, deforestation, water and soil contamination, pest damage), adaptability (high prices or high dependence on external consultancy), self-management, which comprises the lack of organization of the producers with regard to aspects of management and administration (MASERA et al., 1999).

As of this diagnosis, the diagnosis criteria that would be studied were selected (step 3). In this case, the social, economic and environmental criteria were chosen, which resulted in 22 indicators also chosen among those that presented greater critical influence and relevance for this study, eight of which were environmental indicators, seven social indicators and seven economic indicators. Each indicator was scored between 1 (non-desirable condition for sustainability), 2 (regular condition) or 3 (desirable condition). All indicators are presented in the results and discussion.

To contemplate the "organic matter" environmental indicator, the amount of organic matter in the soils of both agrosystems was analyzed in the laboratory. For this analysis, soil samples were collected from layers 0-20 cm deep. The organic matter was extracted and quantified (in g kg^{-1}) according to Duarte (1994).

RESULTS AND DISCUSSION

Characterization of the agroecosystems and their strengthening and constraining aspects

The agroecosystems chosen are neighboring, as they are part of the same family's area. One plot of land, where the agroforestry system is developed, is headed by the mother and father. The other plot, where the conventional monoculture system is developed, is headed by the son of the couple and his wife. This proximity facilitated the comparison between the two productive models, as the natural conditions are similar. After the land was expropriated by the INCRA, both producers became owners of their plots.

Figure 2. images of the forestry agroecosystems (AF) on the left, and the conventional one on the right, studied in the Dandara dos Palmares settlement, Bahia, Brazil.

Source: Elaborated by the authors (2018).

AGROECOSYSTEM 1: THE AGROFORESTRY SYSTEM (AF)

The AF began to be implemented in 2005, as part of the Sasop project. The farmer is 49 years old, has finished primary education and is a health agent in the community. She has lived in the settlement since its establishment in 1991. The family unit consists of herself and her husband. Her son (a conventional agroecosystem farmer) and daughter-in-law live in the settlement and help with the management.

The AF covers 0.5 hectares and is defined as an agroforestry-pastoral system, where native species such as “sucupira” (*Pterodon emarginatus* Vogel.), “pequi” (*Caryocar brasiliense* Camb.), “matataúba” (*Schefflera morototoni* (Aubl.) Maguire,Steyerm. & Frodin.), blackberry (*Morus* sp.), “pau Paraíba” (*Tabebuia cassinoides* (Lam.) DC.), “cajá”

(*Spondias mombin* L.), among others are grown. The foodstuffs grown in consortium were the following: cocoa (*Theobroma cacao*), "cupuaçu" (*Theobroma grandiflorum* (Willd. Ex Spreng.) K. Schum.), "açaí" (*Euterpe oleracea* Mart.), papaya (*Carica papaya* L.), banana (*Musa ssp.*), "pupunha" (*Bactris gasipaes* Kunth.), lemon (*Citrus latifolia*), soursop (*Annona muricata* L.), "paca" fruit (*Pouteria Cliolata*), Indian clove (*Syzygium aromaticum* (L.) Merr. & L.M.Perry), cassava (*Manihot esculenta* Crantz.), orange (*Citrus sinensis*), and the free-range farming of chickens.

The farmer said that she never used fire to prepare the soil and did not use fertilizers or agrochemicals, but there was the application of lime (by her son, every 4 months) to correct the pH of the soil. The main tools used in farming were machetes, chainsaws and hoes. Besides the heavier four-monthly management, there was always some planting and small pruning to reinforce the soil cover. During intensive harvests, extra paid labor was hired. The area had no irrigation system, although water was available nearby.

The family was well organized as regards infrastructure and owned equipment that helped in the production and marketing of the produced goods, such as means of transport (car and motorbike), brush cutter, chainsaw, and basic tools (machete, hoe, sickle etc.). For processing the products, the family had equipment such as a pulping machine, an industrial cooker, a freezer, a kiln for drying grains and a packaging machine.

The marketing channels were varied: a solidarity economy shop, a cooperative of processed products from Valença (Bahia), private orders and the open street market held on Fridays and Saturdays in Camamu (Bahia). However, some products (cocoa, cloves and "guaraná") were poorly sold in fairs, being sold even at less fair prices to middlemen.

Farmers should always seek diversified marketing channels that provide them with some financial security after the harvest. With diversified channels, the producer has the possibility to obtain better prices for his products, to reduce production and market risks and to improve his final income (BUENO et al., 2020).

The family income of the AF producers came primarily from agriculture and the processing of products. The farmer had the Declaration of Aptitude to Pronaf (DAP). In addition, she received a minimum wage as a health agent.

As regards her social articulation, the farmer actively participated in the settlement's residents' association, being in charge of community decisions and the organization of activities developed internally. She also took part in other social organizations, such as the cooperative of processed products from Valença and the solidarity economy product shops. She often travelled to fairs and meetings, delivering lectures precisely due to the liaison she had with social movements and organizations and with the Sasop itself.

The involvement and participation in community actions brought clear benefits to farmers. In addition to encouraging solidarity, the group's cooperation and unity tend to increase the social and political capital when faced with demands or economic transactions of buying and selling (SANGALLI et al., 2015).

AGROECOSYSTEM 2: CONVENTIONAL MONOCULTURE AGRICULTURE

The conventional agroecosystem was a monoculture of "pupunha" heart-of-palm. The farmer in charge, son of the previously described AF farmer, finished secondary education and is a technician in agriculture and animal husbandry. The family unit consisted of him, his wife and two small children.

The heart-of-palm production, implemented in 2012, has 0.3 hectares and produces about 450 kg of heart-of-palm/year. The farmer invests about R$1,200.00 reais/year in NPK (nitrogen, phosphorus and potassium) chemical fertilizers, and does not use pesticides or herbicides.

The soil is steep, compacted and acid, making it necessary to correct its pH with lime. The by-product of the harvest (palm trees) was left in the soil (protection) and given to the pigs that the farmer raised in captivity for family consumption. This technique of protecting the soil was a rescue from their experience with AF. It prevents erosion, leaching, lowers soil temperature and preserves soil moisture.

The area did not have an irrigation system and management was carried out by weeding, tillage and fertilization. The main tools used were the hoe, the machete and the brush cutter. Harvesting is carried out four times a year. A small part of the production is consumed by the family, most of it being sold. The direct sale to the consumer was more profitable, but the sale to middlemen was more frequent because they negotiated the whole harvest. The heart-of-palm stems were sold whole, in natura, to the middlemen. To the direct consumer or when sold to the National School Feeding Program (PNAE), the heart-of-palm was cut and packed, ready for consumption.

Table 2 describes the aspects that strengthen and limit sustainability, observed in the two agroecosystems evaluated.

Table 2. Aspects that strengthen and limit sustainability in the AF and conventional agroecosystems evaluated, Dandara dos Palmares, Bahia, 2019.

AF Agroecosystem
Strengthening aspects - Management that preserves soils and biodiversity; - Greater resistance to disease and pest attack; - Diversified and satisfactory harvest throughout the year; - Ownership of equipment and tools; - Almost complete autonomy of external inputs; - Access to information and training; - Channeling part of the production to short commercialization circuits; - Active participation in cooperatives and associations; - Reuse of organic waste.
Constraining aspects - Scarcity of agroecological fairs, generating dependence on middlemen; - Lack of certification of organic products and policies for access to credit; - Inconsistency of the Rural Technical Assistance Program (RTAP); - Precariousness in the local health and education systems; - Presence of acid, steep and compacted soils.
Conventional Agroecosystem
Strengthening aspects - Satisfactory production (in quantity); - Presence of soil cover; - Access to information and training.
Constraining aspects - Investment costs of fertilizers (NPK); - Non-diversified production (monoculture) and limited to certain periods of the year; - Presence of acid, steep and compacted soils; - Greater susceptibility to pest attacks or diseases; - Inconsistency of the RTAP; - Dependence on chemical fertilizers and on middlemen to sell products.

Source: Elaborated by the authors (2019).

INDICATORS STUDIED: EVALUATION AND MEASUREMENT OF AGROECOSYSTEMS

The results for the MESMIS indicators are described in Table 3 and Figure 3. Agroecosystem 1 (AF) presented scores equal to or higher than agroecosystem 2 in all indicators. In agroecosystem 2 (conventional), scores between 1 and 2 points predominated (83% of the indicators).

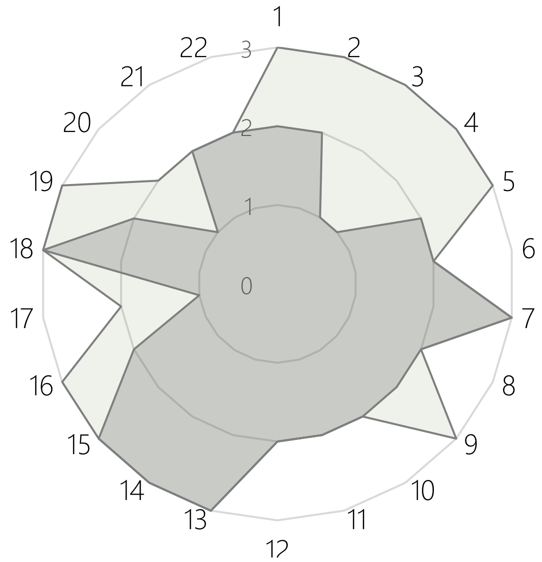
Table 3. Measurement of environmental, social and economic indicators in the agroforestry farming (AF) and conventional (CF) agroecosystems of the Dandara dos Palmares settlement.

Indicators	Agroecosystems	
Environmental indicators	AF	CF
1. Organic Matter	3	2
2. Use of soil cover	3	2
3. Number of species grown	3	1
4. Number of native vegetal species	3	1
5. Presence of wild animals	3	2
6. Incidence of pests and diseases	2	2
7. Waste recycling	3	3
8. Water availability	2	2
Social indicators		
9. Access to technological innovations, training and technical education	3	2
10. Dialogue with the RTAP	2	2
11. Access to health, education and sanitation services	2	2
12. Housing conditions	2	2
13. Level of satisfaction with life in the countryside	3	3
14. Participation in associations and cooperatives	3	3
15. Use of traditional knowledge and local skills	3	3
Economic indicators		
16. Cost of purchasing chemical inputs	3	2
17. Self-sufficiency in food	2	1
18. Debts incurred	3	3
19. Fixed sales channels	3	2
20. Dependence on middlemen	2	1
21. Dependence on extra family labor	2	2
22. Access to credit	2	2

Source: Elaborated by the authors (2019).

The agroecosystems had their indicators scored as: 1 (non-desirable condition for sustainability), 2 (regular condition) or 3 (desirable condition), according to Masera et al. (1999). Source: Elaborated by the authors.

Figure 3. Radial diagram of the MESMIS indicator scores for both agroecosystems studied in Dandara dos Palmares, Bahia, 2019.



Source: Elaborated by the authors (2019).

Caption: 1. Organic matter, 2. Use of soil cover, 3. Number of cultivated species, 4. Number of native plant species, 5. Presence of wild animals, 6. Incidence of pests and diseases, 7. Waste recycling , 8. Availability of water, 9 Access to technological innovations, training and technical training, 10. Dialogue with Ater, 11. Access to health, education and basic sanitation services, 12. Housing conditions, 13. Level of housing with life in the countryside, 14. Participation in associations and cooperatives, 15. Use of traditional knowledge and local skills, 16. Cost of acquiring chemical inputs, 17. Food self-sufficiency, 18. Debts incurred, 19. Fixed stability channels , 20. Dependence on middlemen, 21. Dependence on extra-family labor, 22. Access to credit.

Thus, the productive areas of agroecosystems 1 and 2 presented extremely disparate results in terms of the amount of organic matter in the soil and of production, despite being neighboring areas. This shows that the management techniques adopted by each farmer influenced the performance of the indicators.

The AF agroecosystem presented twice as much organic matter in the soil (63.83g/kg) when compared to the conventional agroecosystem (31.39g/kg), even the latter using soil cover. These results corroborate what Altieri and Nicholls (2011) report about AF presenting better soil quality and fertility. They report that the trees in AF add large amounts of organic matter and recycle nutrients, in addition to the leguminous plants that fix nitrogen. Therefore, the diversity of crops and species favors sustainability.

The AF studied showed superior vegetal biodiversity, with many native species. Some were planted by the farmer, others sprang naturally, in addition to a beehive of native bees ("uruçu") that appeared naturally as well as the presence of wild animals (birds, rodents, capybaras, "pacas", deer, etc.), which proved to be a relevant indicator of biodiversity. In the conventional agroecosystem, on the other hand, the farmer states that he rarely sees wild animals in the plantation area.

Brown et. Al. (2006) also reported that species diversification and the inclusion of trees in agricultural systems favor improved soil organic life and can be a defense against climatic and sanitary disturbances in soils and their crops.

Udawatta et al. (2019) also observed more biota (fauna, flora and microbes in the soil) in AF than in monocultures. They attributed this biodiversity to factors such as heterogeneous vegetation, tree spatial distribution, soil conditions, organic carbon and mild microclimate.

Brown et al. (2018) state that research on AF highlights that the adoption of these practices has generated positive impacts on agricultural productivity, on the maintenance or recovery of ecosystem services, on food security, on water quality and on the prevention of environmental degradation. Altogether, it can be said that the benefits generated simultaneously meet agricultural, environmental and socioeconomic objectives.

The monoculture of hearts-of-palm in the conventional system may be less nutritious due to the artificial growth stimulus caused by the NPK fertilizer. This practice does not contribute to the food sovereignty and self-sufficiency that family farming should aim for. AF provides healthy and diversified products, being a source of income that can be used for various purposes, such as food, fuel production, wood, as well as for medicinal and ornamental uses.

The variety of AF products offers different ways of selling them, despite the lack of policies to support this trade.

This diversity eases the seasonality and generates security to the farmer, because when the cocoa harvest period ends, the clove harvest period begins, then comes the "guaraná", besides the products that are grown throughout the year (banana, papaya, cassava, etc.). Plant biodiversity also favors the biodiversity of animals and insects that perform important ecological functions in the developed agroecosystem.

Due to commercial viability, farmers often give preference to certain products that have guaranteed sales, such as cocoa, clove, "guarana", rubber and heart-of-palm. This was one of the factors that led the conventional agroecosystem farmer to opt for planting hearts-of-palm in his area. According to Belik (2017, p. 242), "Commercialization is the key to a balanced and non-exclusive rural development". It is important, however, to emphasize that the sustainability of the family unit needs, in addition to marketable products, consumer goods such as food, firewood, wood, among others, which directly and indirectly guarantee the family' s subsistence and sustenance.

The weakest points of the social aspects of both agroecosystems were related to access to and quality of health, education and basic sanitation services, which are insufficient and unsatisfactory. With regard to health and education, residents need to go to the nearest town (Camamu). The teaching of peasant culture in schools and the participation of young people in training courses and courses on alternative technologies can encourage them to stay in the communities (SOUSA, 2017), avoiding the need to hire extra labor. The research identified, in one of the collected accounts, the complaint on the part of one of the farmers that education and schooling could be more aligned with the agricultural activity that they develop in the community.

Regarding basic sanitation, the community's water supply comes from the Mucuba River, but this study did not contemplate analyses of its potability. Both farming families separate an area for dry waste, which is collected once a month by the municipal cleaning service. The organic waste is given to the animals and/or transformed into compost to fertilize the productive area. The strongest points of the social indicators of both agroecosystems were related to the use of traditional knowledge, to access to information and technology, to satisfaction with life in the countryside and to active participation in associations and social movements. These positive indicators contribute to strengthening the farmers' culture, independence and quality of life.

After the farmers of the AF agroecosystem implemented it, environmental, social and economic changes were perceptible, such as the farmer's enhanced training, which led to better management in the distribution of products and in a healthier family diet; improvement in income, since AF provides products throughout the year; less hard work, since it was no longer under the sun but in the shade, and no more pesticides. Agricultural credit was never accessed by farmers due to the bureaucracy involved in contracting this service. The rules and adjustments required for credit are usually complicated to be met by family farmers who produce in an agroecological way. Recent evaluations on credit lines to farmers show (AQUINO et al., 2017) that the volume of resources applied and the number of effective contracts is still low because the payment conditions are not suitable for small farmers, and the environmental and technical requirements are very bureaucratic.

RTAP services were once more active in the community; today there is shortage and irregularity in the supply of this strategic service. Recent studies point to RTAP as the main bottleneck for the development of family farming in Brazil, especially regarding agroecology, organic production and green credit lines (Observatório ABC, 2015; BRASIL, 2021). Analysts argue that technical assistance and the training of the professionals involved are instructed in the productivist and technicist standards of the Green Revolution and that this "School" ends up hindering the understanding and meeting the demands of sustainable agricultural alternatives.

CONCLUSION

Amongst the studied agrosystems, the sustainability indicators are most expressive and successful in the one that develops the agroforestry system (AF). Nevertheless, there are important gaps to be filled in relation to agricultural public policies, such as the offer of differentiated credit and the RTAP adapted to agroecological systems, as well as the creation of commercialization channels that are more favorable to small rural producers. The AF system has shown to be promising in a likely transition of Brazilian agriculture, especially AF.

However, as this research is a case study and not a generalist one, further medium and long-term studies on the efficiency of the AF system are important to validate the results on a larger scale. Finally, in order to develop consolidated AF studies, greater funding and monitoring is needed, so that farmers understand how the system works over the years and the maintenance management techniques that should be carried out when AF is already developed.

REFERENCES

AGUIAR, R. C. **Abrindo o pacote tecnológico**: Estado e pesquisa agropecuária no Brasil. São Paulo: Polis; Brasília: CNPq, 1986.

AGUIAR, P. C. B de; PIRES, M. M. A região cacaueira do sul do estado da Bahia, Brasil: crise e transformação. Cuadernos de Geografía: **Revista Colombiana de Geografía**, v.28, n.1, p. 192-208, 2019.

ALTIERI, M. **Agroecologia**: Bases científicas para uma agricultura sustentável. São Paulo: Expressão Popular, 2012.

ALTIERI, M. A.; NICHOLLS, C. I. O potencial Agroecológico dos Sistemas Agroflorestais na América Latina. **Revista Agriculturas**, v.8, n.2, p.31-34, 2011.

AQUINO, J. R.; GAZOLLA, M.; SCHNEIDER, S. O financiamento público da produção agroecológica e orgânica no Brasil: inovação institucional, obstáculos e desafios. In: SAMBUICHI, R. H. R.; MOURA, I. F. de; MATTOS, L. M. de; AVILA, M. L. de; SPINOLA, P. A. C.; SILVA, A. P. M. da (Org.). **A política nacional de agroecologia e produção orgânica no Brasil**: uma trajetória de luta pelo desenvolvimento rural sustentável. Brasília: Ipea, 2017. 463 p.

BAHIA. **Planos Territoriais de Desenvolvimento Sustentável**. 2018. Disponível em: http://www.seplan.ba.gov.br/arquivos/File/politic a territorial/PUBLICACOES_TERRITORIAIS/Planos-Territoriais-de-Desenvolvimento- Sustentavel-PTDS/2018/PTDSS_BAIXO_SUL_.pdf. Acesso em: 10 de jun. 2021.

BELIK, W. Circuitos de agricultura familiar no Brasil: notas para discussão. In: DELGADO, G. C.; BERGAMASCO, S. M. P. P. (orgs.) **Agricultura familiar brasileira**: desafios e perspectivas de futuro. Brasília: Ministério do Desenvolvimento Agrário, 2017.

BRASIL. **Plano nacional de agroecologia e produção orgânica – Planapo**: relatório de balanço 2013-2015. Brasília: MDA, 2021.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. 2022. **Registro de Agrotóxicos**. Disponível em: https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/agrotoxicos/informacoes-tecnicas. Acesso em: 27 de mai. de 2022.

BRITO, M. R. Ocupação de Terras e Reforma Agrária no Baixo Sul. In: NASCIMENTO, A.; FISCHER, C. M.; PLERINI, C.; FISCHER, F.; ROCHA, L.; MATOS, L. B.; SANTANA, L.; VINHAES, L.; SANTOS, M. E. P.; BRITO, M. R.; SANTOS FILHO, N. G. (Org.) **Baixo Sul da Bahia**: Uma proposta de desenvolvimento territorial. Salvador: GIAGS/UFBA, 2007, p. 164-169.

BROWN, G.; RÖMBKE, J.; HÖFER, H.; VERHAAGH, M.; SUTTER, K. D.; SANTANA, D. L. Q. Biodiversity and function of solo animals in Brazilian agroforestry. In: GAMA-RODRIGUES, A. C.; BARROS, N. F.; GAMARODRIGUES E. F. da (Org.) **Sistemas agroflorestais**: bases científicas para o Desenvolvimento sustentável. Rio de Janeiro: Universidade Estadual do norte Fluminense Darcy Ribeiro, 2006, p. 217-242.

BROWN, S. E.; MILLER, D. C.; ORDONEZ, P. J.; BAYLIS. K. Evidence for the impacts of agroforestry on agricultural productivity, ecosystem services, and human well-being in high-income countries: a systematic map protocol. **Environmental Evidence**, v.7, n.24, p.1-16, 2018.

BUENO, S. C.; AZEVEDO, J. de; CHRISTOFARI, L. F.; CASARIN, M. A. B. Análise econômica comparativa de diferentes canais de comercialização utilizados pela agricultura familiar. **Revista IDEAS**, v.14, p.1-20, 2020.

DELGADO, G. C. Reestruturação da economia do agronegócio: anos 2000. In: STEDILE, J. P. **A questão agrária no Brasil**: o debate na década de 2000. São Paulo: Expressão Popular, 2013.

DUARTE, A. P. **Calagem e sistemas de rotação de culturas:** efeitos nas características e propriedades da matéria orgânica do solo. Jaboticabal, Universidade Estadual Paulista, 1994. 165p. (Dissertação de Mestrado)

DUTRA, R. M. S.; SOUZA, M. M. O. de. Cerrado, revolução verde e evolução do consumo de agrotóxicos. **Revista Sociedade & Natureza**, v.29, n.3, p.469-484, 2017.

LEFF, E. Agroecologia e saber ambiental. **Revista Agroecologia e Desenvolvimento Rural Sustentável**, v. 3, n. 1, p. 36-51, 2002.

MASERA, O. R.; ASTIER, M.; LOPEZ-RIDAURA, S. **Sustentabilidad y manejo de recursos naturales**: el marco mesmis. Mexico: Mundiprensa, 1999.

MAZOYER, M.; ROUDART, L. **História das agriculturas no mundo**: do neolítico à crise contemporânea. São Paulo: UNESP, 2010.

Observatório ABC. **Propostas para revisão do Plano ABC**. São Paulo: GVces/FGV, 2015.

PANTERA, A., MOSQUERA-LOSADA, M. R., HERZOG, F., HERDER M. D. Agroforestry and the environment. **Agroforestry Systems**, n.95, p. 767-774, 2021.

PAVLIDIS, G.; TSIHRINTZIS, V. A. Environmental Benefits and Control of Pollution to Surface Water and Groundwater by Agroforestry Systems: a Review. **Water Resource Management**, v. 32, p. 1-29, 2018.

PIGNATI, M. G.; SOUZA E LIMA, F. A. N. de; LARA, S. S. de; CORREA, M. L. M.; BARBOSA, J. R.; LEÃO, L. H. C.; PIGNATTI, M. G. Distribuição espacial do uso de agrotóxicos no Brasil: Uma ferramenta para a Vigilância em Saúde. **Revista Ciência & Saúde Coletiva**, v. 22, n. 10, p. 3281-3293, 2017.

REZENDE, S. R. **Planejamento participativo e desenvolvimento sustentável em áreas de reforma agrária do INCRA. O caso do projeto de assentamento Dandara dos Palmares – Camamu- BA**. 2004. Dissertação. (Mestrado em Ciências Agrárias). Universidade Federal da Bahia, Salvador, 2004.

SANGALLI, A. R.; SILVA, H. C. H. da; SILVA, I. F. da; SCHLINDWEIN, M. M. Associativismo na agricultura familiar: contribuições para o estudo do desenvolvimento no assentamento rural Lagoa Grande, em Dourados (MS), Brasil. **Revista Organizações Rurais & Agroindustriais**, v. 17, n. 2, p. 225-238, 2015.

SETENTA, W. C.; LOBÃO, D. E.; SANTOS, E. S.; VALLE, R. R. **Avaliação do sistema cacau-cabruca e de um fragmento de Mata Atlântica. 40 Anos do curso de economia**: memória. Ilhéus: Editus, UESC, 2005. p. 605-628.

SOUSA, R. da P. Educação em agroecologia: reflexões sobre a formação contra-hegemônica de camponeses no Brasil. **Ciência e Cultura**, v. 69, n. 2, p. 28-33, 2017.

UDAWATTA, R. P.; RANKOTH, L. M.; JOSE, S. Agroforestry and Biodiversity. **Sustainability**, v. 11, n. 10, p. 2879, 2019.