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Article

Agroecology in the Brazilian Amazon. A Review

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ABSTRACT

Agroecological practices are alternatives for valuing and conserving the biodiversity of the Amazon as well as for integrating family farmers who survive from the exploitation of natural resources in the face of the expansion of large agricultural projects that have advanced in the region. In this respect, the objective of this study was to evaluate the scientific production related to agroecology in the Brazilian Amazon, in order to identify the main research gaps and set the foundations for new studies that will strengthen the debate on and policies to encourage sustainable agriculture. Our methodology was based on a systematic review of the literature using four academic research databases. The studies were published from 2000 to 2019. Through our database research, we obtained 36 articles that focused on agroecology in the Brazilian Amazon. Our results showed a certain level of diversity in terms of the geographic distribution of the municipalities included in the studies analyzed. Additionally, we detected diversity in terms of the dimensions addressed. For instance, reference was made to sustainable production systems based on agroecological principles, with emphasis on agroforestry systems. Additionally, socioeconomic and cultural aspects, such as the valuation of traditional knowledge and the importance of women in rural areas, were analyzed. Thus, the realization of in-depth studies that will analyze the process of agroecological transition with the use of different techniques, such as the statistical treatment of data and geoprocessing, can qualify agricultural production based on the agroecological practices in the Amazon.

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Keywords: ecological agriculture; agroforestry systems; sustainable agriculture.

RESUMO

As práticas agroecológicas são alternativas para valorizar e conservar a biodiversidade da Amazônia, bem como para integrar os agricultores familiares que sobrevivem da exploração dos recursos naturais em face da expansão de grandes projetos agrícolas que avançam na região. Nesse sentido, o objetivo deste estudo foi avaliar a produção científica relacionada à agroecologia na Amazônia brasileira, a fim de identificar as principais lacunas de pesquisa e fundamentar novos estudos que fortaleçam o debate e as políticas de incentivo à agricultura sustentável. . Nossa metodologia foi baseada em uma revisão sistemática da literatura usando quatro bancos de dados de pesquisa acadêmica. Os estudos foram publicados no período de 2000 a 2019. Por meio de nossa pesquisa em banco de dados, obtivemos 36 artigos com foco na agroecologia na Amazônia brasileira. Nossos resultados mostraram um certo nível de diversidade em termos da distribuição geográfica dos municípios incluídos nos estudos analisados. Além disso, detectamos diversidade quanto às dimensões abordadas. Por exemplo, foi feita referência a sistemas de produção sustentáveis baseados em princípios agroecológicos, com ênfase em sistemas agroflorestais. Adicionalmente, foram analisados aspectos socioeconômicos e culturais, como a valorização dos saberes tradicionais e a importância da mulher no meio rural. Assim, a realização de estudos aprofundados que analisem o processo de transição agroecológica com a utilização de diferentes técnicas, como o tratamento estatístico de dados e o geoprocessamento, pode qualificar a produção agrícola baseada nas práticas agroecológicas na Amazônia.

Palavras-chave: agricultura ecológica; sistemas agroflorestais; agricultura sustentável.

1. Introduction

Over the past decades, the Brazilian Amazon has undergone a constant process of alteration in terms of the land use patterns, caused, initially, by innumerable governmental programs; the intention of these programs was the colonization of the Amazon, which was encouraged from the 1970s with the arrival of more than one million agricultural families from other regions of the country (Browder et al. 2004).

The occupation process was undertaken predominantly by small landowners who were expanding the agricultural frontier; these were subsequently replaced by owners with greater capitalization and large tracts of land (Souza et al. 2013). This dynamic caused small farmers to look for new areas to occupy, while big landowners, who were incentivized by public policies in the 1960s and the 1970s, which determined forest clearing as a criterion of land valorization, proceeded with the deforestation of the region (Buclet 2005).

The deforestation caused by the occupation of land by these farmers is also strongly associated with cattle breeding and logging, as, historically, deforestation has been directly related to a productive activity undertaken in the land in question (Hall 2008). Other factors that can also be considered fundamental in the deforestation of the region after the expansion of the local infrastructure, are private investments in soybean and palm oil crops and the low technological level adopted in the region, which affects the recovery increase of deforested areas, thereby preventing the intensification of agricultural practices on the already open border (Rebello & Homma 2009; Rebello & Homma 2017).

Despite the significant importance of the large agricultural segment in the region, especially in recent decades, it is worth mentioning that the Amazon is characterized by its rich physical and biological diversity as well as the cultural, political, and social issues associated with it (Aragon 2015). It is also noteworthy that the livelihood of many rural Amazonian families depends on natural resources and the implementation of production systems that require limited inputs and involve low risk (Pokorny et al. 2013). Thus, a discussion regarding alternative production systems that prioritize these peculiar characteristics of the Amazon biome is fundamental for the sustainable development of the region.

The principles of agroecology can form the basis of a viable agricultural production alternative. According to Altieri (2004), agroecology is the science that seeks to reconcile environmental, economic, and social aspects, thereby stimulating diversified agricultural systems that maximize ecological interactions, in order to guarantee independence from external inputs and food sovereignty for producers.

Furthermore, Assis (2006) considers that agroecology adapts more easily to the reality of family farming, as it involves diversified production structures and has a desired level of complexity, without involving prejudice regarding the application of supervision activities and the control of the work process. Therefore, the use of agroecological models of production presents itself as an important tool for the development of family farms, especially those with a lower level of capitalization, as is the case in the Amazon. In this respect, this review aimed to evaluate the scientific production related to agroecology in the Brazilian Amazon through a systematic literature review, in order to identify the main research gaps and set the foundations for new research that will enrich this debate in the region.

2. Literature Review

This research was classified, according to Prodanov and Freitas (2013), as exploratory and bibliographic with respect to its objectives and the technical procedures that were followed, respectively. Cronin et al. (2008) classify the bibliographic research or literature review process into two types: a traditional review of the literature, which consists of a survey of relevant studies in a given thematic area, but without specifying for the reader the criteria based on which the research sources were selected, and a systematic literature review, which, in turn, employs a more rigorous and well-defined technique for the bibliographic review of a given subject; thus, the latter was the method used in the present study.

To guarantee the reliability and legitimacy of the systematic review, Sampaio and Mancini (2007) established five steps: (i) define the research question, (ii) identify the databases and define the search strategies, (iii) review and select studies based on specific inclusion and exclusion criteria, (iv) critically analyze the studies included in the review, and (v) present the results by summarizing the information available in the selected articles.

Therefore, the procedures adopted in this study were as follows:

1. Research question: which agroecology research topics are being pursued in the Brazilian Amazon?
2. Researched databases and search strategies: we researched four academic research databases: Scopus, Scielo, the Web of Science, and the Portal de Periódicos CAPES. The publication dates researched covered the 2000–2019 period in an effort to review the most recent research on our study topic. Next, we determined the search descriptors; these were Agroecolog* AND Amazon*, Permacultur* AND Amazon*, (Syste* AND Agroforestr* AND Amazon*) OR (Sistema* AND Agrofloresta* AND Amazon*), ("Agricultura Sustentável" OR "Sustainable Agriculture") AND Amazon*, ("Agricultura Ecológica" OR "Ecological Agriculture") AND Amazon*, ("Agricultura Alternativa" OR "Alternative Agriculture") AND Amazon*, and ("Serviços Ambientais" OR "Environmental Services" OR "Serviços Ecossistêmicos" OR "Ecosystem Services") AND Agricultur* AND Amazon*. It is worth mentioning that in Scopus, Scielo, and the Web of Science, where only titles, abstracts, and keywords can be searched, this filter was used. In the Portal de Periódicos CAPES, the search was carried out for entire articles.
3. Inclusion and exclusion criteria: in order to select the articles relevant to the research question, the title, summary, and keywords of all articles from the search results of each database were read and those that tackled the topic of agroecology in the Brazilian Amazon were selected. Articles that were repeated in more than one database were excluded, and the search sequence used was Scopus, Scielo, the Web of Science, and the Portal de Periódicos CAPES.
4. Critical analysis of the studies included in the review: the articles selected according to the previous step were read in full, in order to assess more accurately the objectives, methodology, results, and conclusions of each study.
5. Results summarizing the information available in the selected articles: our aim in organizing the results of the selected articles was to expose the regions of the Amazon where the studies were carried out, the methodologies used, and the main focal points of the studies in view of the diversity of dimensions addressed in agroecology.

3. Analysis of agroecology studies in the Brazilian Amazon

3.1 Quantitative in databases, regions studied and methodologies used

After researching the four electronic databases, we obtained a total of 13,737 results, as is shown in Table 1. The vast majority of the results were obtained from the Portal de Periódicos CAPES, as it allowed us to search entire articles. The number of studies selected

for analysis (36) was much lower than the overall search results. This discrepancy was attributed to the repetition of certain results in the different databases and with the use of different descriptors and to the abundance of publications regarding other countries covered by the Amazon biome.

Table 1. Quantitative data of search results and selected articles from the databases covering the 2000–2019 period.

Descriptor		Scopus	Scielo	Web of Science	Portal de Periódicos CAPES	Total
Agroecolog* AND Amazon*	Total results	36	8	39	1,615	1,698
	Selected articles	8	2	2	7	19
Permacultur* AND Amazon*	Total results	1	0	1	84	86
	Selected articles	0	0	0	0	0
(Syste* AND Agroforestr* AND Amazon*) OR (Sistema* AND Agrofloresta* AND Amazon*)	Total results	216	90	282	3,378	3,966
	Selected articles	10	1	1	4	16
("Agricultura Sustentável" OR "Sustainable Agriculture") AND Amazon*	Total results	32	6	68	1,695	1,797
	Selected articles	0	0	0	0	0
("Agricultura Ecológica" OR "Ecological Agriculture") AND Amazon*	Total results	0	0	0	101	101
	Selected articles	0	0	0	0	0
("Agricultura Alternativa" OR "Alternative Agriculture") AND Amazon*	Total results	33	1	0	126	160
	Selected articles	0	0	0	0	0
("Serviços Ambientais" OR "Environmental Services" OR "Serviços Ecossitêmicos" OR "Ecosystem Services") AND Agricultur* AND Amazon*	Total results	109	6	167	5,647	5,929
	Selected articles	0	0	0	1	1

Source: research data.

The 36 studies were published in 13 different years of the 20 included in the review, as can be seen in Figure 1. As of 2009, publications have become more frequent, with the exception of 2011, and more abundant. From 2009 to 2019, approximately 92% of the studies related to agroecology were concentrated in the Amazon territory. This result may be associated with the creation of 12 undergraduate and five postgraduate courses in the field of agroecology in the states of the Legal Amazon as of 2008, with emphasis on the Federal Institutes that created five technological undergraduate courses in the Amazonas, Acre, and Pará states, and all postgraduate courses in the Maranhão, Mato Grosso, and Pará states.

The Amazon Institute of Family Farms [Instituto Amazônico de Agriculturas Familiares (INEAF)] of the Federal University of Pará [Universidade Federal do Pará, (UFPA)], can also take credit for this rise in studies. In recent years, the Center for Agroecological Studies has developed its human resources in a manner that influences strongly the approach to agroecological practices and has created research groups associated with agroecology in various institutions, such as in agronomy courses in the Federal University of the South and Southeast of Pará [Universidade Federal do Sul e Sudeste do Para (UNIFESPA)], Marabá, and UFPA on the campus of the Cametá municipality.

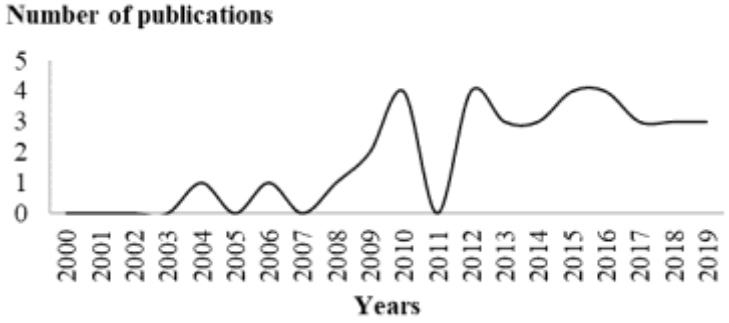

Figure 1. Evolution of the publications referring to agroecology in the Amazon (2000–2019). Source: research data.

When analyzing the selected studies, a certain diversity was observed in terms of the researched regions; more specifically, studies were conducted in six of the nine states of the Legal Amazon, namely, Pará, Amazonas, Rondônia, Acre, Maranhão, and Mato Grosso, with emphasis on the state of Pará, which garnered the focus of 61% of the articles.

Among the municipalities surveyed, it is important to highlight the presence of 13 belonging to the mesoregion of northeast Paraense. Tomé-Açu is located in this region, which is relevant to the introduction of agroecological practices through the dissemination of agroforestry systems. Additionally, the strong presence of the PROAMBIENTE program at the Rio Capim Pole (São Domingos do Capim, Irituia, Mãe do Rio, and Concórdia), which was in operation between 2000 and 2008, should be highlighted. Ouro Preto do Oeste, in the state of Rondônia, also appeared in the search results, as this municipality was the focus of three studies examining the presence of the Association of Alternative Producers [Associação dos Produtores Alternativos (APA)], an institution that promoted the adoption of several sustainable technologies in the 1990s and the 2000s (Sills & Caviglia-Harris 2015).

Regarding the methodologies used, many studies employed triangulation and a qualitative approach to collecting data by conducting interviews and undertaking field observations. The techniques employed other than bibliographic reviews included the use of remote sensing for the analysis of land use and occupation as well as ethnofloristic and fauna surveys. The use of quantitative methods based on multivariate analysis, a tool that could demonstrate more clearly the progress of the agroecological transition in the Amazon, was not detected in our systematic review.

3.2 Agroecological dimensions of studies

Within the context of analyzing the objectives (i.e., the main focal points) of each article, we aimed to fit them within the agroecology dimensions proposed by Sevilla Guzmán (2013), namely, the ecological (technical-productive), socioeconomic and cultural (endogenous, local development), and politics (of socio-environmental transformation) dimensions, as can be seen in Table 2. It is important to highlight that agroecology is a multidimensional science, as the same study can encompass one or more dimensions, as they complement each other.

The studies cited in Table 2 verify the diversity in the mentioned dimensions. It should be highlighted that two articles encompassed all three dimensions and 16 addressed two dimensions.

The ecological or technical-productive dimension that was the topic of 20 studies, characterized the productive systems used, with emphasis on the existing species diversity and the agroecological practices employed. In 15 of the 20 studies, agroforestry systems were cited as agroecological alternatives in the Amazon. This suggestion was justified considering that biodiversity is favored more in this type of land management system than in traditional agricultural systems; additionally, native species are included, which leads to greater landscape heterogeneity (Haggar et al. 2019).

Table 2. Agroecology dimensions addressed in the selected articles.

Dimensions	Definition	No. of articles	Authors
Ecological (technical-productive)	Management and promotion of biodiversity and the generation and diversity of ecological dynamics that reduce the use of external inputs	20	Ribeiro et al. (2004); Miller and Nair (2006); Scoles (2009); Castro et al. (2009); Raiol and Rosa (2012); Martins et al. (2012); Noda et al. (2012); Bonaudo et al. (2014); Quaresma et al. (2015); Cardozo et al. (2015); Sills and Caviglia-Harris (2015); Abreu and Watanabe (2016); Tricaud et al. (2016); Lavelle et al. (2016); Valente et al. (2017); Pompeu et al. (2017); Rego and Kato (2017); Resque et al. (2019); Braga et al. (2019); Rayol et al (2019).
Socioeconomic and cultural (endogenous, local development)	Alternative market niches, cultural diversity, and valuing local knowledge	24	Ribeiro et al. (2004); Miller and Nair (2006); Scoles (2009); Castro et al. (2009); N. Oliveira et al. (2010); J. Oliveira et al. (2010); Roces and Montiel (2010); Raiol and Rosa (2012); Pompeu et al. (2012); Noda et al. (2012); Costa et al. (2013); Vieira et al. (2012); Britto et al. (2013); Tremblay et al. (2015; Roces et al. (2014); Hora et al. (2015); Quaresma et al. (2015); Cardozo et al. (2015); Sills and Caviglia-Harris (2015); Abreu and Watanabe (2016); Tricaud et al. (2016); Pompeu et al. (2017); Resque et al. (2019); Rayol et al (2019).
Policy (of socio-environmental transformation)	Movements of resistance to class, gender, and modernization processes and the establishment of socio-environmental transformation policies	12	Hall (2008); P. Oliveira (2010); Roces and Montiel (2010); Costa et al. (2013); Britto et al. (2013); Roces et al. (2014); Meek (2016); Tricaud et al. (2016); Almeida et al. (2018); Kohler and Negrão (2018); Centrone et al. (2018); Resque et al. (2019).

Source: research data.

Braga et al. (2019) also highlighted that agroforestry systems are an important option for agricultural land in the Amazon region, owing to the production of cocoa (*Theobroma cacao* L.), a species cultivated by small farmers in the region, mainly under this type of production system, and with strong market value. Other alternative system types mentioned in the studies were the integrated crop-livestock system, the silvopastoral system, and the vegetation management in slash-and-mulch. In this dimension, there was a lack of depth in the analysis of the production systems, as this was carried out using only simple characterizations with the aid of descriptive statistics, thereby lacking methodological enrichment, which may be related to the lack of human resources employing more robust techniques in the area.

In terms of the socioeconomic and cultural dimension, 24 of the 36 selected articles focused on the creation of alternative markets and on the empirical knowledge of family farmers, traditional populations, and indigenous peoples. Pompeu et al. (2017) highlighted the importance of organizing producers in cooperatives and/or associations in the municipality of Tomé-Açu (PA) in order to disseminate knowledge regarding agricultural practices and farmer experiments.

On the other hand, the presence of communities that have a weak link to the market and the difficulties related to this producer organization, as their relationships are based on kinship and ethno-knowledge, as evidenced by Noda et al. (2012), were apparent from our results. However, according to Altieri and Nicholls (2017), this traditional knowledge, combined with scientific research, is a key element for the rural development of small-farm areas, by valuating a "bottom-up" approach in which the available local resources are valued both in terms of knowledge and of natural resources.

Table 3. Journals with publications referring to agroecology in the Brazilian Amazon (2000–2019).

Journal	Number of articles
Agroforestry Systems	6
Revista Verde de Agroecologia e Desenvolvimento Sustentável	3
Sustentabilidade em Debate	3
Acta Amazônica	2
Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas	2
Revista Brasileira de Ciências Agrárias	2
Agricultural Economics	1
Agriculture and Human Values	1
Ambiente y Desarrollo	1
Brazilian Journal Development	1
Cahiers Agriculture	1
Confins	1
Dialectical Anthropology	1
Espacios	1
European Journal of Agronomy	1
Global Environmental Change	1
Investigaciones Feministas	1
Novos Cadernos NAEA	1
Philosophical Transactions of The Royal Society B	1
REDES Revista do Desenvolvimento Regional	1
Relaciones Internacionales	1
Revista de Economia e Sociologia Rural	1
Sustainability (Basel)	1
Tropical and Subtropical Agroecosystems	1

Source: research data.

It is worth mentioning that our results showed that even though the authors of the studies analyzed in this review demonstrated the importance of alternative markets for the rise of family farming, they did little research on the relationship between organic certification and agroecology; the former could add value to products derived by agroecological practices.

Studies have shown that out of the diversity of species produced, such as those highlighted by Cardozo et al. (2015), the cocoa (*T. cacao*), banana (*Musa* spp.), black pepper (*Piper nigrum*), açaí (*Euterpe oleracea*), Brazil nut (*Bertholletia excelsa*), and cupuaçu (*Theobroma grandiflorum*) cultures stand out. This could be attributed to the adoption of agroecological practices, which provide farmers with greater security with regard to market changes, in addition to allowing them to sell their products directly at fairs, which, according to Roces and Montiel (2010), strengthens their contact with consumers who value agroecological production.

In the political dimension, which is substantially associated with socio-environmental transformation, three main themes were discussed in the 12 studies analyzed: gender equity, the influence of government programs, and the rejection of conventional agriculture.

In these surveys, agroecology was treated as an important means that guarantees greater autonomy for women in rural areas. For instance, Centrone et al. (2018) concluded that the agroecological systems developed in the municipality of Santa Luzia do Pará, northeast Paraense, strengthen the independence of women, both economically and in terms of allowing them to participate actively in decision-making.

In relation to government programs, the National School Meal Program [Programa Nacional de Alimentação Escolar (PNAE)], the Food Procurement Program [Programa de Aquisição de Alimentos (PAA)], and the Proambiente program were cited as government actions that promote sustainability in rural areas, thereby stimulating the adoption of agroecological practices. According to Resque et al. (2019), although the programs have great potential to promote biodiversity on a local scale, they are still considered fragile because of the marked political instability in the country.

Regarding the divergence between conventional agriculture and sustainable agriculture based on agroecological principles, studies have demonstrated the importance of native peoples resisting to the imposition of "modernization" processes; this can be seen in Tricaud et al. (2016) who emphasized the efforts of guarana (*Paullinia cupana* Kunth var. sorbilis) producers from Amazonas to value family-based and agroecological production in order to conserve agrobiodiversity.

Another relevant point regarding research on agroecology in the Brazilian Amazon concerns the journals the studies examined in our review were published in. As is shown in Table 3, our analysis showed that the studies were published in a significant number of journals linked to sustainability and interdisciplinarity; this demonstrated the characteristics of studies related to agroecology, which, according to Altieri (2004), is a science that encompasses agronomic principles as well as ecological and socioeconomic aspects for the development of agricultural systems and society in general. Thus, it could be suggested that several journals are open to discussing the topic, thereby indicating that scientific production regarding agroecological practices in the Amazon has the potential to grow.

4. Conclusion

Our systematic literature review showed that only 36 studies were related to agroecology in the Brazilian Amazon, despite the great international appeal of the environmental crisis, which has led to the growth of studies focused on sustainable production alternatives. However, we also identified a consolidation of production systems based on agroecological practices in the region, such as agroforestry systems. Additionally, our analysis showed that there are discussions about the role of women in agriculture, traditional knowledge is valued, and alternative markets have been created. The aforementioned topics were discussed in length, in terms of agroecology, in the studies analyzed in our review.

Thus, the realization of in-depth studies that analyze the process of agroecological transition with the use of different techniques, such as the statistical treatment of data and geoprocessing, can qualify agricultural production based on the agroecological practices in the Amazon.

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