

Scientific contributions of agroecology in Latin America and the Caribbean: a review

Contribuciones científicas de la agroecología en América latina y el Caribe: una revisión

Felipe Gallardo-López ¹, Mario Alejandro Hernández-Chontal ^{1*}, Ariadna Linares-Gabriel ¹, Pedro Cisneros-Saguilán ²

ABSTRACT

A systematization and a quantitative and qualitative analysis of scientific documents are presented, which respond: What are the main contributions of research in relation to the demands of agroecology in Latin America and the Caribbean (LAC)? What factors approaches and methods have been used in time and space? The quantitative approach predominates, followed by the qualitative one, and the mixed one to a lesser extent. The development of agroecology in LAC is distributed in: a country with greater consolidation (Brazil), a larger group in development, another with initial contributions and, finally, one with minimal contributions. The most considered factors in the investigations are the physical-biological ones, followed by the social, economic, cultural, and political ones. Two thirds of the contributions to agroecological demands were: agroecological management, maintenance of biodiversity, self-management and local self-sufficiency, and soil and water conservation. Some contributions have been intensified at present, while agroecological management has prevailed over time. The predominance of conventional research approaches, methods and techniques is evident; the challenge is to generate new ways of seeing and doing research, which allow addressing the disciplinary interfaces of the complex problem in the society-nature relationship.

Keywords

agroecology • agroecological management • biodiversity • agroecological education

1 Posgrado en Agroecosistemas Tropicales. Colegio de Postgraduados. Campus Veracruz. Veracruz 91700. Mexico. * hernandez.mario@colpos.mx
2 Departamento de Ciencias Agropecuarias. Instituto Tecnológico de Pinotepa. Tecnológico Nacional de México. Oaxaca 71600. Mexico.

RESUMEN

Se presenta una sistematización y análisis cuantitativo y cualitativo de documentos científicos, que responden ¿Cuáles son los principales aportes de las investigaciones en relación con las demandas de la agroecología en América Latina y el Caribe (ALC)? ¿Qué factores, enfoques y métodos han utilizado en tiempo y espacio? Predomina el enfoque cuantitativo, seguido del cualitativo y menormente el mixto; el desarrollo de la agroecología en ALC está distribuido en: un país con mayor consolidación (Brasil), un grupo más grande en desarrollo, otro con aportaciones iniciales y, finalmente, uno con mínimos aportes. Los factores más considerados en las investigaciones son los físico-biológicos, seguido de los sociales, económicos, culturales y políticos. Las dos terceras partes de los aportes a las demandas agroecológicas fueron: manejo agroecológico, mantenimiento de la biodiversidad, autogestión y autosuficiencia local y conservación de suelo y agua. Algunos aportes se han intensificado actualmente, mientras que el manejo agroecológico ha prevalecido a través del tiempo. Es evidente el predominio de enfoques, métodos y técnicas de investigación convencionales; el reto es generar nuevas formas de ver y hacer investigación, que permitan abordar las interfaces disciplinares de la compleja problemática en la relación sociedad-naturaleza.

Palabras clave

agroecología • manejo agroecológico • biodiversidad • educación agroecológica

INTRODUCTION

The global ecological movement emerged in the 1960s in the context of an environmental crisis triggered by economic growth and technological progress, which generated the "society of waste and pollution" years later (50). In response to this proterva relationship between society and nature, agroecology arose for the agricultural sector, which is considered as a discipline to better understand the ecological principles of traditional agricultural systems and, with it, the sustainable development of agroecosystems from an ecological and socioeconomic perspective (2, 39). Several authors highlight the importance and benefits of agroecology to ensure the well-being of humanity, as well as the balance and health of the planet's ecosystems. Among these, the systematization of agroecological science stands out as an integral innovative approach for the study, design and management of sustainable agroecosystems (8, 39, 65), as well as the documentation of productive practices that are implemented in various parts of the world (7, 51, 64), and social movements linked to the demand of small producers, peasants and indigenous people (6, 34, 53).

On the other hand, several studies have shown the contribution of agroecology to promote sustainability in agroecosystems, increasing food production in the long term, improving the diet of peasant families and maximizing economic gains. In these systems, minimum inputs are used, and practices are carried out to minimize risks by planting several species and crop varieties that provide the agroecosystem with nutrient enrichment plants, insect predators, pollinators, bacteria that decompose and fix nitrogen, as well as a variety from other organisms that perform various beneficial ecological functions (8, 28, 65).

In general terms, human welfare and the balance and health of ecosystems are aspirations of a society that currently faces the effects of global climate change and, in a certain way, maintains a constant struggle to achieve food security and sovereignty. In this sense, in a particular vision, Toledo (2011) argues that the articulation of the three innovative communities of agroecology (academic, technological and social) achieves a concrete and practical fulfillment with 10 social and ecological demands arising from critical and alternative thinking, formulated at different times and by different communities of thought.

At a global level, agroecology has had a different origin and degree of development in terms of science, movement and practice, according to Wezel *et al.* (2009) and Gallardo-López, Hernández-Chontal (2018).

In the case of Latin America and the Caribbean (LAC), its roots are mainly in social movements, explicitly directed at agrarian empowerment, which emerged as a response to the economic exclusion produced by agricultural modernization (6, 8, 59). Although this territory has been systematized and documented abundant knowledge about the origin and evolution of the concept as well as the main approaches since its re-emergence in the 70's, these have focused mainly on the considered core of development of this discipline: Brazil, the Andean Region, Central America, Mexico, and Cuba (6, 8, 11, 13, 59).

However, little has been systematized and documented on the information of the applied methodological approaches and their main contributions. Therefore, the objective of this review is to provide initial answers for the LAC case to the questions: What are the main contributions generated in scientific research in relation to the demands of agroecology? Which factors have been considered? What are the methodological and technical approaches used in time and space?

MATERIALS AND METHODS

A query was made to the Scopus database on April 3, 2018, using the word "agroecology". The search was limited to scientific research published by countries from Latin America and the Caribbean (LAC). The consulted and downloaded database into an Excel spreadsheet had a list of 429 documents, mainly scientific articles (93.3%), book chapters (0.8%), conference documents (2.2%), misprints (0.3%), and revisions (3.1%), written in English, French, Italian, Portuguese and Spanish. It also contained the name of the authors, title, year of publication, volume, number, pages, authors' affiliations, type of document, summary, link, and digital object identifier (DOI). These last two were used to download the full documents in PDF format.

After a review of documents, investigations conducted outside the LAC countries and those that did not indicate the place where they were carried out were excluded, leaving 338 documents from the period 1992-2018. For each document, a Word file was created, containing a record with the title, author(s), summary, keywords, and conclusions. A text analysis was performed on these documents, identifying the analysis categories in table 1, using the NVivo 11 Pro software for Windows, and applying the content analysis technique to textual citations (37).

The categories of analysis of the contributions of agroecology were established *a priori* according to the Toledo's classification (59), identifying two more after the review (the emerging ones) (table 1). In the same way, the year (1992-2018), country, factors of analysis of agroecology (physical-biological, social, cultural, economic and political) and approaches (quantitative, qualitative or mixed). Methods were considered (introspective reflection, hermeneutics, conceptual modeling, futures scenarios, intensive interviewing, Delphi, historical analysis, case studies, action research, laboratory experimentation, physical modeling, survey research, structural interviewing, field experiments and field studies) according to Meredith, *et al.* (1989).

Table 1. Categories of research analysis in Latin America and the Caribbean.

Tabla 1. Categorías de análisis de investigación en América Latina y el Caribe.

Contributions to the demands of agroecology (55)	Maintenance of biodiversity
	Conservation of forest cover
	Soil and water conservation
	Carbon capture
	Suppression of agro-toxic and transgenic
	Agricultural equity
	Food sovereignty and healthy food
	Local self-management and self-sufficiency
	Fair and organic markets
Dialogue of knowledge and participatory research	
Contributions to the demands based on the review	Agroecological education
	Agroecological management

The number of textual citations for each document was determined by the categories of analysis. In this sense, the documents might contain textual citations of a category of analysis, multiple or null. To answer the questions that guided this research, the results and discussion were obtained from the systematization and quantitative and qualitative analysis of the textual citations, including it in the results some as examples that contextualize the qualitative terms.

The quantitative analysis and the spatial distribution of the researches were carried out according to the country where the methodological approach, the techniques, and the contributions to the demands were undertaken.

The first of these was carried out with the program Statistica[®] version 7 (2004) through two multivariate techniques to identify groups of countries according to the percentage distribution of the methodological approaches applied in the research (quantitative, qualitative and mixed) and the total number of these by country, for which a dendrogram was made using the Euclidean distances and a complex ligament algorithm (21). As this technique showed the conformation of four groups of countries, the second technique, k-means, was applied to identify the countries that made up these four groups and their descriptive statistics. For the spatial distribution (figure 1), the number of researches by country and the percentage distribution of methodological approaches were used.

RESULTS AND DISCUSSION

Spatial distribution of research approaches and methods in agroecology

Based on the analysis carried out, the researches in agroecology in LAC have a different spatial distribution. The majority applies a quantitative research approach, followed by the qualitative, and a mixed one to a lesser extent (figure 1). The multivariate techniques identified four groups of countries according to the total number of researches and the percentage distribution of the methodological approaches applied.

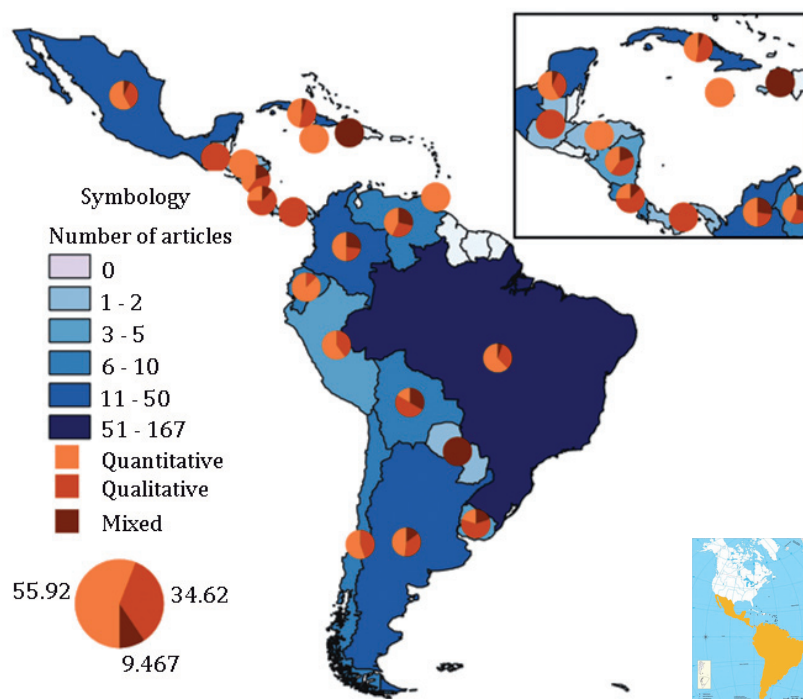


Figure 1. Spatial distribution of publications and methodological approaches in LAC countries.
Figura 1. Distribución espacial de publicaciones y enfoques metodológicos en los países de ALC.

The first group is considered as consolidated, made up only by Brazil with the largest number of researches (n=167), mostly applying a quantitative approach (62.2%), followed by a qualitative approach (32.3%) and a mixed approach to a lesser extent (5.3%). A second group in development consisting of Mexico, Argentina, Colombia, Cuba, Chile, Ecuador, Venezuela, Nicaragua, Perú, Honduras, Jamaica and Trinidad & Tobago with an average of 12 researches, mostly under a quantitative approach (65.7%), followed by a qualitative one (25.6%) and a mixed approach to a lesser extent (8.6%).

The third group with initial and inverse contributions in relation to the first two groups integrated by Costa Rica, Bolivia, Uruguay, Guatemala and Panamá with an average of four researches mostly under a qualitative approach (74.5%), followed by a mixed approach (13.1%) and a quantitative approach to a lesser extent (12.3%). The fourth and last group with incipient contributions composed of Haiti and Paraguay, with an average of one research completely under a mixed approach (100%).

Figure 2 shows the distribution of research methods used in LAC, where Brazil stands out with the highest number of publications and a diversity of research methods, followed by Mexico, Argentina, Colombia, and Cuba. The predominance of conventional research methods is evident. However, agroecology requires research methods from different disciplines to face the complex social and environmental dynamics present in rural areas (18), trying to reverse the reductionist vision of agriculture by alternative research approaches (3). In general, agroecological research should guide researches within a broader context, which not only considers agronomic and biophysical attributes of the farming system, but it also considers socio-economic and political aspects (5); this suggests more and new methods of agroecological research.

Temporary distribution of researches

A slight increase in agroecology research in LAC is observed in recent years (figure 3, page 220), highlighting Brazil with the greatest increase. The decrease observed in the last year is due to the fact that this review only considered the information until April 2018. Mexico, Argentina, and Colombia have also had a moderate increase, although it does not compare to Brazil. On their behalf, Nicaragua and Ecuador have begun to make contributions in recent years.

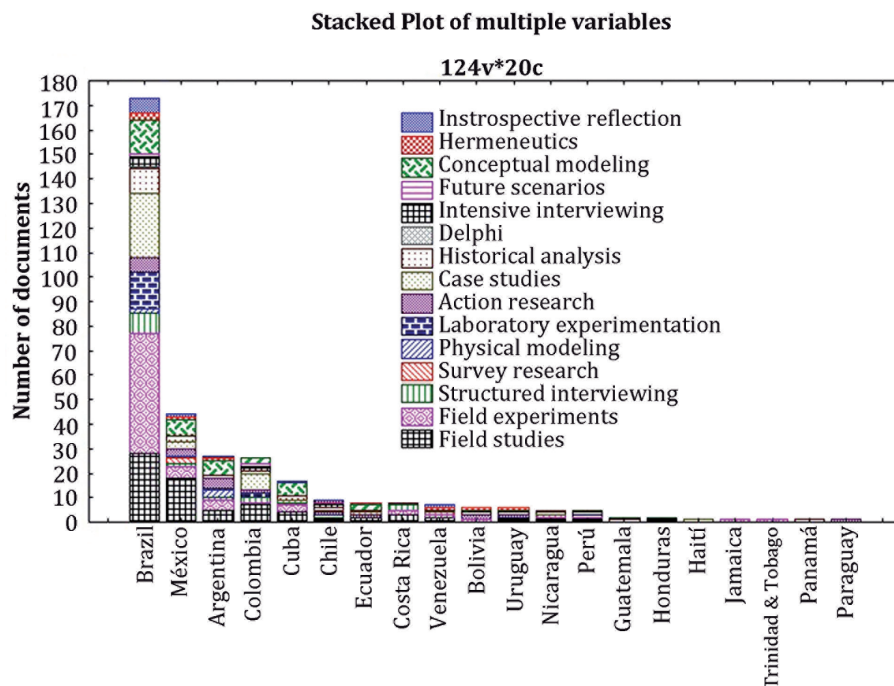


Figure 2. Research methods in publications from LAC countries.
Figura 2. Métodos de investigación en publicaciones de países de ALC.

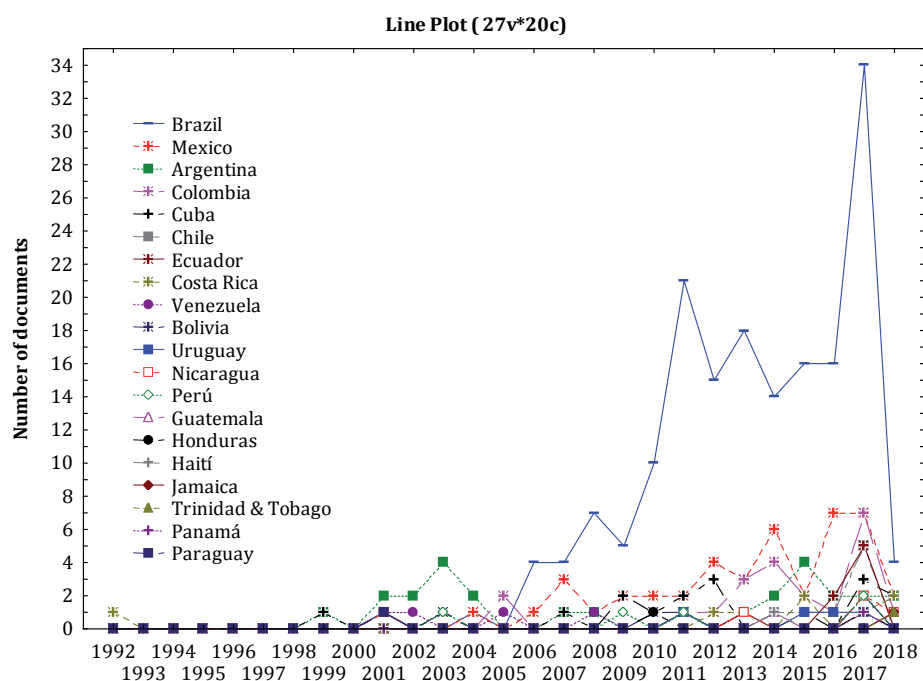


Figure 3. Temporary distribution of publications in the LAC countries.

Figura 3. Distribución temporal de publicaciones en los países de ALC.

Factors of analysis of agroecology

Based on the total number of coded text citations ($n=493$), the predominant factors in the researches are physical-biological (45.2%), social (29.4%), economic (11%), cultural (7.9%), and political (6.5%) in a lesser proportion. The results regarding the factors are similar for the case of the countries of Europe, where the main factor of analysis is the physical-biological. However, social, economic and cultural factors have become relevant, in the same way that political factors have been included in the studies (11, 25). The historical process of agroecology reflects a constant in the physical-biological factor in light of the origin of this discipline since it was focused on the application of ecological principles, the design, and management of sustainable agroecosystems, taking into account the agricultural system as an ecosystem (28).

Contributions of research to the demands of agroecology

According to the citations codified in the documents, it was found that 33.2% corresponds to agroecological management, 15.9% maintenance of biodiversity, 14.7% local self-management and self-sufficiency, 10.2% soil and water conservation, 6.2% agroecological education, 4.7% food sovereignty and healthy food, 4.3% suppression of agro-toxic and transgenic, 2.8% conservation of forest cover, 2.4% fair and organic markets, 2.1% carbon capture, 1.9% agricultural equity, and 1.7% dialogue of knowledge and participatory research. In the review, two more categories emerged (agroecological management and agroecological education) to those determined *a priori*.

In figure 4 (page 221), the distribution of research contributions according to the demands of agroecology in relation to countries is shown, displaying a wide heterogeneity in terms of number and type of contribution. The particular case of Brazil has the highest number of contributions due to the greater number of publications. In this sense, Brazil is a benchmark for agroecology in LAC. It has catalyzed, propped up and stimulated agroecology as a science, movement, and practice thanks to the application of public policies at various levels of government, such as support for family farming, communication and dissemination programs, the creation of organic markets and the training of rural extension workers (59), which has supported the generation of research and, therefore, scientific contributions to agroecology.

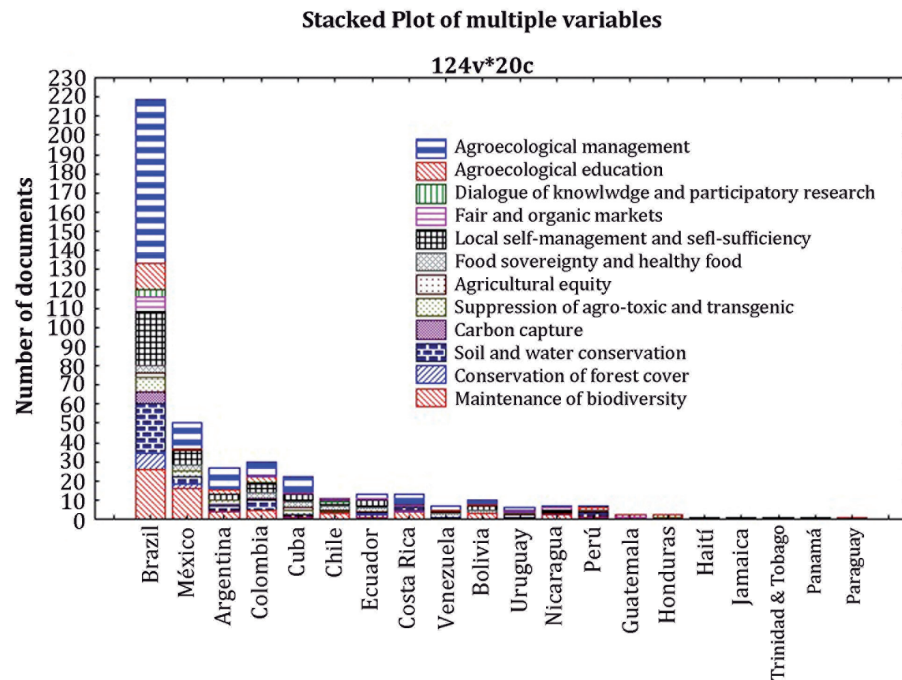


Figure 4. Contributions of research from LAC countries to the demands of agroecology.

Figura 4. Contribuciones de la investigación de los países de ALC a las demandas de la agroecología.

The contributions of the researches found and according to their qualitative importance are described below: with the most relevant citations in relation to the categories of analysis.

Agroecological management: Here contributions are reflected in relation to organic and agroecological production systems which include high yields that include control of pests and diseases, soil quality, cultivars adapted to the environment, use of compost, family gardens, achieve an impact in rural and urban areas in order to increase profitability and seek an insertion in differentiated markets. An agroecological approach to agricultural development goes beyond the yields of crops; it contemplates the complexity of the set of factors that contribute to the sustainability of agroecosystems. It is necessary to obtain indicators of sustainability of agroecosystems that operate conceptually and empirically from a multidimensional and systemic approach (60). In this sense, traditional local agroecosystems have evolved over time, in other words, they are doing more agroecological practices with little dependence on commercial inputs, a greater reliance on renewable resources and management strategies based on ecology (29).

In Ecuador ... *"the productive diversification of cocoa farms and their access to markets are key elements to increase and diversify the income of small producers, while contributing to the improvement of energy efficiency indicators of cocoa farms"* Pérez Neira (2016).

When we talk about agroecological management, it is important to highlight that agroecology works with principles that adopt multiple technological forms according to the local socioeconomic needs of farmers and their biophysical circumstances (8), as in the case of livestock producers in a protected region in Uruguay, where it was found that response capacity is related to the use of agroecological principles and agroecological criteria that guide strategies among producers and within the protected area in which they practice livestock (26).

Maintenance of biodiversity: The contributions mentioned here are mainly shown by the conservation of natural resources, which improve or meet human needs. Research has often been found in terms of the diversification of production areas and associations between species and combinations of land use, as well as resort to seed banks.

Therefore, in order to promote a sustainable agricultural system, progress must be made towards protecting the environment and the rational use of natural resources, based on the management of local resources, in order to stimulate the transition to more economic systems, with a greater family character and a high level of biodiversity (57).

It is important to maintain biodiversity in agriculture to improve the ecological balance of agroecosystems and to achieve a sustainable production. In Brazil, the diversification of the areas of tobacco production is effective, so it needs a socio-environmental/territorial management approach, which shifts the diversification of an instrumental business or state profile, for an instrumental/substantive way that values agricultural multifunctionality (55).

"Coffee agroforestry had a lower proportion of conservation trees, a higher proportion of pioneer trees were dominated by Inga spp., they harbored a lower diversity of tree species at plot level and were composed of different tree species compared to native forests" Rover, *et al.* (2017).

Local self-management and self-sufficiency: In this category the findings show a line that guides self-management and self-sufficiency, this is "social reproduction strategies" in the face of the climate change, food, economic income, use of seeds as an alternative to monopoly crops, among others. In the latter, problems arise that affect the family values associated with religiosity and cosmologies in which movements are triggered by individual and collective affectations, mostly of the peasants. In these contributions, local campesino autonomy is reflected in the events of intervened and/or coerced globalization that throw them into the capitalist markets in which they have not managed to insert themselves due to the very nature of the peasantry. According to Blandi *et al.* (2018), "contextual factors" (social, political and economic) can exert pressure for farmers to choose to incorporate unsustainable technological innovations, such as greenhouses.

In the light of all that, agroecology presents several challenges such as the existence of contradictory interests within the peasantry as a result of social differentiation, the role of the State in the development of conventional development models relatively favorable to small producers, the prevalence of ideologies of modernization in many rural areas, and the need for this paradigm to recognize the importance of small farmers when engaged in industrial agriculture (10). To achieve self-management and local self-sufficiency, farmers carry out their own strategies, in Brazil we can emphasize that local production is... *"a path based on an insurgency to the subordination of dominant capitalism, whose tradition must be rescued as a way to evoke the local values: popular knowledge for the effectiveness of autonomy and independence"* Paulino and Gomes (2015).

In Mexico, *"farmers see goats as a source of income, security, credit, prestige, independence, food, manure and apprentices for young children. Interest is present in all socioeconomic strata. For the poor, goat breeding was one of the main livelihood strategies. The richest and middle households had a wider range of activities"* Oseguera Montiel, *et al.* (2014).

Soil and water conservation

The contributions are oriented to agroecological practices such as soil conservation, soil fertility and soil quality, integrating them to agroforestry systems, conservation agriculture, and intercropping. In other works, comparisons have been made about the before and after of agricultural practices, mostly to reflect the damage that has impacted the soils.

On the other hand, it is discussed on achieving a water balance so as not to waste water, since in agricultural practices a significant percentage is used for production. The use of bioremediation for the use of water in a second moment is also discussed. It is clear that research in Nicaragua is helping to understand soil conservation, an example is expressed in the following quote: *"Agricultural expansion and common practices of land management contribute to the degradation of soil resources in the dry tropical forest region of Central America. We find the conversion of the forest to traditional agricultural systems to reduce biodiversity and to increase the compaction of soils on the slopes of the region"* Rousseau, *et al.* (2013).

In the case of water conservation in Mexico... *"The Mexican agricultural sector is the main consumer of water resources whose availability is scarce in some areas, so it is necessary to direct bioremediation techniques to reuse wastewater from municipal sources. However, it is advisable to treat wastewater before using it, but it is used without prior treatment in reality"* Mora-Ravelo, *et al.* (2017).

To achieve soil and water conservation and achieve sustainability, agroecological strategies such as crop diversification, maintenance of local genetic diversity, integration of animals, organic soil management, conservation and harvesting of water are required as a way to understand the agroecological characteristics of traditional systems (44).

Specifically, soil conservation has more complex implications. The case of the conservation of agricultural land in Mendoza, Argentina, shows that the contributions of land use to plan and regulate land uses can contribute to maintaining the conditions of urban and rural sustainability (32).

Agroecological education

This section shows the use of tools and workshops used in different social actors such as extension workers, families, schools, farmers, peasants, indigenous people, among others; in some works, it is presumed the need for the intervention of programs directed to these actors, especially those from the rural contexts, in areas of organic agriculture, medicinal plants, empowerment and production of knowledge, changes in their own habits, PET bottles recycling, sustainable supplies of food, and environmental education, to guide these pedagogical results to sustainability as the main objective. According to Boza *et al.* (2018), when evaluating the "Education and Training Program for Rural Women" of the Chilean National Institute of Agricultural Development (NIAD), they found three groups of women, "reticent participants", "participative associative" and "empowered participants", these authors conclude that the characteristics and individual circumstances impact on the perception that the beneficiaries have about the programs, hence the identification of the groups.

"The complementary knowledge of rural inhabitants and indigenous production systems or local knowledge has a transcendental importance not only theoretical, but also to solve the gaps in agroecology as a practice. This contribution is the basis of the alternative agricultural movement in Latin America" Arguello and Cueva (2009).

The transfer of agroecological knowledge is not enough to guarantee a sustainable agriculture, but it is essential to broaden the perspectives of farmers so that they have a position on agroecological practices. These practices are carried out because they have personal issues and reasons; to broaden the perspective can boost the process of internalization, externalization, and objectification of farmers (58). Education is central to the agroecological extension, in the case of Brazil, the importance of considering the political and institutional environments in extension reforms is highlighted, and it indicates the need for an additional reflection on the strategies to expand an agroecological and oriented extension to sustainability proposals (23).

Food sovereignty and healthy food

The contributions highlight three important points, first nutrition, the demand for fast food and, finally, local food production. What is proposed in these contributions is the empowerment of the communities, the foregoing reflects the idea that under these headings the achievement of food sovereignty is geospatially linked to local consumption. On the other hand, armed conflicts in agriculture have intrinsically affected LAC, since these directly disrupt the peasant community, causing a change in the strategies of the producers in the realization of their activities and therefore in the acquisition of food. In LAC, organizations such as Vía Campesina and the Latin American Coordination of Farm Organizations (CLOC, in its Spanish acronym) are struggling to transform global and regional agro-food conditions; in addition, they are fighting for the reintegration of peasants as producers of staple foods. This leads to a crisis that constitutes a historic opportunity for the transformation of the decadent neoliberal model, but it requires a great deal of strength to achieve it (56).

In the Darien region of Colombia, in less than 35 years, changes in leasing and land use have transformed a settlement of self-supply, in a place dependent on the external market (9), unlike Uruguay, where agroecology emerges as a critique of the dominant industrial agriculture model and linked to the development of alternative thinking by multiple actors ... "Its objective is to strengthen ecological processes in agricultural systems while the phenomena of concentration, alienation and access to land, along with the problems of family farming and food sovereignty" Gazzano and Gómez Perazzoli (2017).

The case of the Dominican Republic shows the sustainable agricultural value chain model (SAVCM), shows how different factors determine the access of producers to the SAVCM, as well as the potential of the subsectors (organic bananas and avocados), but also to know the stage in which producers are to adopt the expectations of consumers (31).

In a research carried out in Ecuador, the authors mention that... *"we find a continuous promise in the heterogeneity of the practices small-holder farms, particularly in small farms, where agrobiodiversity appears to increase nutritionally important species, as they maintain a relatively high profile in production systems and family diets"* Oyarzun, *et al.* (2013).

Suppression of agro-toxic and transgenic

The contributions in this category marked two items. First, the qualities of transgenics are perceived in the face of pests, diseases, climatic alterations, as well as high yields. It also alludes to mestizo producers who are the ones to access the purchase of commercial seeds. Second, a mention is made on the conservation of wild seeds, the culture of the peasants, and it is emphasized that the indigenous producers are those who maintain local races of seeds and a mixture of colors. In this sense, the authors emphasize the repercussions brought by agriculture based on the green revolution and compare it with local agroecological practices.

Therefore, it is stated that public policies are in favor of conventional agriculture, which have been unleashing a series of social movements of non-governmental organizations and groups of ecologists. In LAC, transgenic crops represent a recent and powerful threat to biodiversity, ecological integrity and food security, which is why it is necessary to implement an integral agrarian reform that assures farmers access to water, seeds and other productive resources, as well as to undertake national agrarian and food policies that respond to the needs of peasants and consumers, especially of the poor ones (4).

"The budgetary resources destined to this type of public policies are unfortunate in comparison with those destined to the conventional agriculture. This indicates that despite some important advances in the public policies of organic agriculture and agroecology, the Brazilian government continues to prioritize agribusiness, pesticides, and uses of GMOs" Candiotto (2018).

In the case of Brazil, the use of agro-toxics is greater in systems of production of transgenic maize in relation to the conventional one, which leads to the need for technologies and practices that contribute to reduce the nitrogen fertilization of chemical synthesis and the application of agro-toxics in those systems (17). Unlike transgenics, in Mexico, it is argued that local races of corn are probably better than transgenic crops to adapt to climate change...

"These autochthonous varieties could be lost with rapid climate change if they cannot evolve fast enough (through natural and farmer-mediated selection) or respond plastically to climate change" Mercer, *et al.* (2012).

Conservation of forest cover: This section shows contributions related to agroforestry, agrosilviculture and agrosilvopastoral systems, which have the purpose of conserving native species, replacing monocultures, contributing to the nutrient cycle and moderating extreme temperatures. The former as a response to problems of deforestation and forest fires that result in the abandonment of peasant lands.

In the same way, it is proposed to carry out public policies that address the aforementioned problems. It is important to emphasize the conservation of vegetation cover, because in tropical regions the extensive conversion of forests to pastures and agricultural intensification are typically identified as the most important drivers of change in land use, with consequent loss of quality and biodiversity (62). There are several proposals, as in the case of Brazil research results mention the following... *"we propose the establishment of rows of agroforestry systems in the surrounding crops as hedges and additional sources of food and products that contribute to the food security of small farmers"* Harterreiten-Souza, *et al.* (2014).

In this sense, *"Brazil should develop a science-based forestry code that requires an adequate restoration to guarantee the resilience of forests and the provision of essential ecosystem services, while at the same time preventing non-compliance"* Trevisan, *et al.* (2016).

Fair and organic markets: The contributions in this category are inclined to an integral trade, in other words, to achieve a specialized market where the agreements in the prices

are favorable mainly for producers who are evolving in local dynamics. Since this sector is more vulnerable to food prices, certification of their organic products and most are those that cushion environmental problems. In this sense, the contributions propose policies related to local markets. In relation to fair and organic markets, Latin America stands out initiatives linked to social, economic, political, and environmental claims that arise in indigenous communities, Afro, peasants and other groups, and excluded populations that have been fighting for recognition. This poses challenges in terms of recreating ways of satisfying human needs beyond the material, questioning the logic of capitalist accumulation and its effects on nature and human relationships (52). In the case of Brazil, the rules of fair trade and organic markets have contributed to the institutional strengthening of organic agriculture and agroecology, however..

"The budgetary resources destined to this type of public policies are regrettable in comparison with those destined to the conventional agriculture. This indicates that despite some important advances in the public policies of organic agriculture and agroecology, the Brazilian government continues to prioritize agribusiness, pesticides and uses of GMOs" Candiotto (2018).

Unlike Brazil, in the case of Ecuador, *"direct marketing in Pachano Square has allowed the partners' agricultural and livestock work to be revalued, to persist in their decision of production under the principles of agroecology, to reduce the costs of transaction, to receive training, to access credit and to acquire political prominence through integration with other producer organizations and with local state institutions, which was not possible as each one of them individually delivered their products to the wholesaler"* Contreras Díaz, et al. (2017).

Carbon capture: The contributions are aimed precisely at carbon capture basically in silvopastoral practices, family gardens, use of legumes, as well as the importance of soil in the structure of the landscape, in public policies and their impact on the use of renewable energies. Various agroecological practices can contribute to increase the carbon sequestration in vegetation and soil, for example, the restoration and recovery of disturbed areas through agroforestry (20). In this sense, ecological agriculture in LAC began to develop as a strategy aimed at addressing the rural crisis based on three objectives: family food self-sufficiency, the care of natural resources, and the reduction of production costs. Initiatives carried out by peasant and indigenous groups, usually accompanied by community and non-governmental organizations (19).

"The agrosilvopastoral system contributes to the nutrient cycle through the constant supply of nutrients through the litter, the weeding of the herbaceous vegetation and the cutting of the legumes, which produces the return of a large part of the nutrients extracted by the crops to the system" Aguiar, et al. (2014).

Agrarian equity: Regarding the contributions of research to agrarian equity, we find that the empowerment of women and men in the struggles for land, the strategies of their use in conservation areas and the importance of ecological processes are relevant in relation to concentration, alienation, and access to land. Therefore, in LAC, agroecology is now understood and practiced as the approach for the unification of the peasant movement and the struggle for land, constituting a movement of political organization, a recovery of self-esteem, and an affirmation of sociocultural identities (24). In the case of Uruguay, agroecology has been considered as a criticism of the dominant industrial agriculture model and oriented to the alternative thinking of different actors...

"The different actors drive the development of a National Agroecology Plan. A process of agroecological transition is proposed through the construction of sustainable development options, which emerges from agriculture and extends to the whole society" Gazzano and Gómez Perazzoli (2017).

When referring to Ecuador... *"the adoption of agroecology as a form of resistance on the part of indigenous and peasant movements played a key role in its development"* Intriago, et al. (2017).

Dialogue of knowledge and participatory research: Contributions in this category are based on local knowledge, mainly of farmers, represented in dialogue spaces of knowledge applied to agroecological practices and movements. They show how the actions can arouse the interest of the inhabitants for the techniques and practices friendly to the environment.

The social movements of small farmers show great interest in developing agroecology as an integral alternative, which responds to the education of rural men and women and in this way to build a dialogue of knowledge, a pedagogy that values the knowledge of ancestral peoples and peasant cultures present in the rural world (42). This is a necessary proposal to face, from the local space, the effects of the current planetary ecological crisis and the culturally homogenizing capacity of the current model of globalization, based on economic growth and the unsustainable and inequitable accumulation of material wealth (12).

In the case of Brazil, dialogical spaces have an educational function that supports the transformation of society... *"the creation of dialogical spaces results in learning within the movements, the movement of rural workers without land learned, after the occupation of Syngenta, that many organizations abandoned the Agroecology Day because they would not support direct confrontation with Agribusiness"* Meek and Simonian (2017).

These dialogues also have to do with the strategies of action and cultural transmission, we give as an example the case of the ethnobotanical use of plant resources in Chile, where it is established that ... *"the main mechanism of cultural transmission, referred to the use and properties of resources floristic is vertical type, with the family being the main socialization agency"* Peredo and Barrera (2017).

CONCLUSIONS

This review allowed us to explore the main contributions generated in scientific research in relation to the demands of agroecology, the factors considered, their approaches and methods, as well as their spatial and temporal distribution. In this context, it was possible to identify that most of the agroecological research in LAC is carried out under the quantitative approach, followed by the qualitative approach, and the mixed approach to a lesser extent; according to the number of publications and approaches applied, there is a differentiated degree of distribution in these countries, identifying a country with greater consolidation (Brazil), a larger group in development, another with initial contributions and finally one with minimal contributions. Most of these publications have been developed in recent years (2011-2018).

The most considered factors in research are the physical-biological, followed by social, economic, cultural and, to a lesser extent, political. Regarding the contributions of research to the demands of agroecology, Brazil has the largest contribution given to the largest number of publications and, along with Mexico, Argentina, Colombia, Cuba, Ecuador, Costa Rica, and Venezuela, is mainly in relation to agroecological management, maintenance of biodiversity, self-management and local self-sufficiency, and conservation of soil and water. In a smaller proportion, the contributions of the research are in relation to the remaining of the categories analyzed.

It is worth stressing that these contributions in LAC countries have intensified in recent years, mainly regarding the elimination of agro-toxic and transgenic, soil and water conservation, maintenance of biodiversity and local self-management and self-sufficiency, while the contribution in agroecological management has prevailed over time. It is evident that the research in agroecology in LAC, the predominance of conventional research approaches, methods and techniques, so the challenge should not be just a simple diversification, as a mere juxtaposition of these, but generating new ways of seeing and doing research that allow addressing the disciplinary interfaces of the complex problem in the relationship between society and nature.

REFERENCES

1. Aguiar, M. I.; Fialho, J. S.; Campanha, M. M.; Oliveira, T. S. 2014. Carbon sequestration and nutrient reserves under different land use systems. *Revista Árvore*. 38: 81-93.
2. Altieri, M. A. 1989. Agroecology: A new research and development paradigm for world agriculture. *Agriculture, Ecosystems & Environment*. 27(1):37-46. Available in: [https://doi.org/10.1016/0167-8809\(89\)90070-4](https://doi.org/10.1016/0167-8809(89)90070-4)
3. Altieri, M. A. 2003. Dimensiones éticas de la crítica agroecológica a la biotecnología agrícola. *Acta Bioethica*. IX(1): 47-61.

4. Altieri, M. A. 2009. Transgénicos y agrocombustibles en América Latina. In: F. R. Funes-Monzote y E. F. Freyre Roach, editor. *Cultivos transgénicos ¿Qué se gana? ¿Qué se pierde? Textos para un debate en Cuba*. La Habana. Cuba: Centro Félix Varela. p. 235.
5. Altieri, M. 2013. Construyendo resiliencia socio-ecológica en agroecosistemas: algunas consideraciones conceptuales y metodológicas. *Agroecología y resiliencia socioecológica: adaptándose al cambio climático* (Nicholls, C. I.; Ríos, L. A.; Altieri, M. A., eds) Proyecto REDAGRES Medellín, Colombia. 94-104.
6. Altieri, M. A.; Toledo, V. M. 2011. The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. *The Journal of Peasant Studies*. 38(3): 587-612. 10.1080/03066150.2011.582947
7. Altieri, M. A.; Funes-Monzote, F. R.; Petersen, P. 2012. Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agronomy for Sustainable Development*. 32(1): 1-13. 10.1007/s13593-011-0065-6
8. Altieri, M. A.; Nicholls, C. I. 2017. Agroecology: a brief account of its origins and currents of thought in Latin America. *Agroecology and Sustainable Food Systems*. 41(3-4): 231-7. 10.1080/21683565.2017.1287147
9. Álvarez-Salas, L.; Gálvez-Abadía, A. 2014. Food Sovereignty in a Socioecological Transformation Context in the Caribbean Darién of Colombia. *Agroecology and Sustainable Food Systems*. 38(7):812-38. 10.1080/21683565.2014.881951
10. Antonio, C. N.; Kees, J. 2018. Is oil palm expansion a challenge to Agroecology? Smallholders practising industrial farming in Mexico. *Journal of Agrarian Change*. 18(1): 132-55. doi:10.1111/joac.12195
11. Argüello, A. H. 2015. Agroecology: scientific and technological challenges for agriculture in the 21st century in Latin America. *Agronomía Colombiana*. 33: 391-8.
12. Arguello, M.; Cueva, K. 2009. La revalorización de la Agroecología andina: estrategia local de diálogo de saberes para enfrentar problemas globales. *Letras Verdes Revista Latinoamericana de Estudios Socioambientales*. (5): 12-4.
13. Astier, M.; Quetzal Argueta, J.; Orozco-Ramírez, Q.; González, M. V.; Morales, J.; Gerritsen, P. R. W.; Escalona, M. A.; Rosado-May, F. J.; Sánchez-Escudero, J.; Martínez Saldaña, T.; Sánchez-Sánchez, C.; Arzuffi Barrera, R.; Castrejón, F.; Morales, H.; Soto, L.; Mariaca, R.; Ferguson, B.; Rosset, P.; Ramírez, H.; Jarquin, R.; García-Moya, F.; Ambrosion Montoya, M.; González-Esquivel, C. 2017. Back to the roots: understanding current agroecological movement, science, and practice in Mexico. *Agroecology and Sustainable Food Systems*. 41(3-4): 329-48. 10.1080/21683565.2017.1287809
14. Blandi, M. L.; Rigotto, R. M.; Sarandón, S. J. 2018. Influencia de factores contextuales en la adopción de modelos de agricultura insustentables. La incorporación del invernáculo en agricultores platenses. *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina*. 50(1): 203-216.
15. Boza, S.; Muñoz, T.; Cortés, M.; Rico, M.; Muñoz, J. 2018. Development programs for female farmers: identifying clusters for the case of Chile's "Education and training program for rural women". *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina*. 50(1): 141-155.
16. Candioto, L. Z. P. 2018. Organic products policy in Brazil. *Land Use Policy*. 71:422-30. <https://doi.org/10.1016/j.landusepol.2017.12.014>
17. Capellesso, A. J.; Cazella, A. A. 2013. Indicador de sustentabilidade dos agroecossistemas: estudo de caso em áreas de cultivo de milho. *Ciência Rural*. 43:2297-303.
18. Cárdenas Grajales, G. I. 2009. Investigación participativa con agricultores: una opción de organización social campesina para la consolidación de procesos agroecológicos. *Revista Luna Azul*. (29): 95-102.
19. Casado, G. G.; Hernández, J. M. 2011. Agroecología y agricultura ecológica. Aportes y sinergias para incrementar la sustentabilidad agraria. *Agroecología*. 6: 55-62.
20. Casanova-Lugo, F.; Petit-Aldana, J.; Solorio-Sánchez, J. 2011. Los sistemas agroforestales como alternativa a la captura de carbono en el trópico mexicano. *Revista Chapingo serie ciencias forestales y del ambiente*. 17: 133-43.
21. Chalate-Molina, H.; Gallardo-López, F.; Pérez-Hernández, P.; Paul Lang-Ovalle, F.; Ortega-Jiménez, E.; Vilaboa Arroniz, J. 2010. Características del sistema de producción bovinos de doble propósito en el estado de Morelos, México. *Zootecnia tropical*. 28(3): 329-39.
22. Contreras Díaz, J.; Paredes Chauca, M.; Turbay Ceballos, S. 2017. Circuitos cortos de comercialización agroecológica en el Ecuador. *Idesia (Arica)*. 35: 71-80.
23. Diesel, V.; Miná Dias, M. 2016. The Brazilian experience with agroecological extension: a critical analysis of reform in a pluralistic extension system. *The Journal of Agricultural Education and Extension*. 22(5): 415-33.
24. Fernandez, G. B.; Romano, J. O. 2016. Alianza por la agroecología en América Latina: potencialidades y desafíos. *LEISA Revista de Agroecología Edición especial*. 4-9.
25. Gallardo-López, F.; Hernández-Chontal, M.; Cisneros-Saguilán, P.; Linares-Gabriel, A. 2018. Development of the Concept of Agroecology in Europe: A Review. *Sustainability*. 10(4): 1210.
26. Gazzano, I.; Altieri, M. A.; Achkar, M.; Burgueño, J. 2015. Holistic Risk Index: A case study of cattle producers in the protected area of Farrapos Estuaries-Uruguay. *Agroecology and Sustainable Food Systems*. 39(2): 209-23.

27. Gazzano, I.; Gómez Perazzoli, A. 2017. Agroecology in Uruguay. *Agroecology and Sustainable Food Systems*. 41(3-4):380-400. 10.1080/21683565.2017.1286533
28. Gliessman, S. R. 1986. The ecological element in farm management. *Proceedings of a Conference on Sustainability of California Agriculture University of California*. Davis.
29. Gliessman, S. R. 1992. Agroecology in the tropics: Achieving a balance between land use and preservation. *Environmental Management*. 16(6):681-9. 10.1007/bf02645658
30. Gliessman, S. 2011. Transforming food systems to sustainability with Agroecology. *Journal of Sustainable Agriculture*. 35(8): 823-5. 10.1080/10440046.2011.611585
31. Gómez-Luciano, C. A.; De Koning, W.; Vriesekoop, F.; Urbano, B. (en prensa). A model of agricultural sustainable added value chain: The case of the Dominican Republic value chain. *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina*.
32. Gudiño, M. E. 2018. Regulación del mercado para conservar suelo agrícola. Interfaz urbano-rural, zona metropolitana de Mendoza, Argentina. *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina*. 50(2): 155-172.
33. Harterreiten-Souza, É. S.; Togni, P. H. B.; Pires, C. S. S.; Sujii, E. R. 2014. The role of integrating agroforestry and vegetable planting in structuring communities of herbivorous insects and their natural enemies in the Neotropical region. *Agroforestry Systems*. 88(2): 205-19. 10.1007/s10457-013-9666-1
34. Holt-Giménez, E.; Altieri, M. A. 2013. Agroecology, Food Sovereignty, and the New Green Revolution. *Agroecology and Sustainable Food Systems*. 37(1): 90-102. 10.1080/10440046.2012.716388
35. INC, S.S. *Statistica (data analysis software system) version 7*. 2004.
36. Intriago, R.; Gortaire Amézcuca, R.; Bravo, E.; O'Connell, C. 2017. Agroecology in Ecuador: historical processes, achievements, and challenges. *Agroecology and Sustainable Food Systems*. 41(3-4): 311-28. 10.1080/21683565.2017.1284174
37. Kaefer, F.; Roper, J.; Sinha, P. 2015. A Software-Assisted Qualitative Content Analysis of News Articles: Example and Reflections. *Forum: Qualitative Social Research* 16(2). 10.17169/fqs-16.2.2123
38. Meek, D.; Simonian, L. T. 2017. Transforming space and society? The political ecology of education in the Brazilian Landless Workers' Movement's. *Jornada de Agroecologia. Environment and Planning D: Society and Space*. 35(3): 513-32. 10.1177/0263775816667073
39. Méndez, V. E.; Bacon, C. M.; Cohen, R. 2013. Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems*. 37(1): 3-18. 10.1080/10440046.2012.736926.
40. Mercer, K. L.; Perales, H. R.; Wainwright, J. D. 2012. Climate change and the transgenic adaptation strategy: Smallholder livelihoods, climate justice, and maize landraces in Mexico. *Global Environmental Change*. 22(2): 495-504. <https://doi.org/10.1016/j.gloenvcha.2012.01.003>
41. Meredith, J. R.; Raturi, A.; Amoako-Gyampah, K.; Kaplan, B. 1989. Alternative research paradigms in operations. *Journal of Operations Management*. 8(4): 297-326. [https://doi.org/10.1016/0272-6963\(89\)90033-8](https://doi.org/10.1016/0272-6963(89)90033-8)
42. Minga, N. 2017. Agroecología: diálogo de saberes para una antigua y nueva propuesta para el campo. *Antropología Cuadernos de investigación*. 86-94. N 17.
43. Mora-Ravelo, S.; Alarcon, A.; Rocandio-Rodríguez, M.; Vanoye-Eligio, V. 2017. Bioremediation of wastewater for reutilization in agricultural systems: a review. *Applied Ecology and Environmental Research*. 15(1): 33-50.
44. Nicholls, C. I.; Henao, A.; Altieri, M. A. 2017. Agroecología y el diseño de sistemas agrícolas resilientes al cambio climático. *Agroecología*. 10(1): 7-31.
45. Oseguera Montiel, D.; Keilbach Baer, N. M.; van der Zijpp, A.; Sato, C.; Udo, H. 2014. 'It is better to herd than be herded': making a living with goats in the Bajío region, Mexico. *Pastoralism*. 4(1): 9. 10.1186/s13570-014-0009-2
46. Oyarzun, P. J.; Borja, R. M.; Sherwood, S.; Parra, V. 2013. Making sense of agrobiodiversity, diet, and intensification of smallholder family farming in the highland Andes of Ecuador. *Ecology of Food and Nutrition*. 52(6):515-41. 10.1080/03670244.2013.769099
47. Paulino, J. S.; Gomes, R. A. 2015. Sementes da Paixão: agroecologia e resgate da tradição. *Revista de Economia e Sociologia Rural*. 53: 517-28.
48. Peredo, S.; Barrera, C. 2017. Usos etnobotánicos, estrategias de acción y transmisión cultural de los recursos vegetales en la región del Maule, zona centro sur de Chile. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas*. 16(4): 398-409.
49. Pérez Neira, D. 2016. Energy efficiency of cacao agroforestry under traditional and organic management. *Agronomy for Sustainable Development*. 36(3): 49. 10.1007/s13593-016-0386-6.
50. Porto-Gonçalves, C. W.; Leff, E. 2015. A Ecologia Política na América Latina: a reapropriação da natureza, a reinvenção dos territórios e a construção da racionalidade ambiental. 35. 10.5380/dma.v35i0.43543.
51. Rogé, P.; Friedman, A. R.; Astier, M.; Altieri, M. A. 2014. Farmer strategies for dealing with climatic variability: a case study from the Mixteca Alta Region of Oaxaca, Mexico. *Agroecology and Sustainable Food Systems*. 38(7):786-811. 10.1080/21683565.2014.900842

52. Roldán Rueda, H. N.; Gracia, M. A.; Santana, M. E.; Horbath, J. E. 2016. Los mercados orgánicos en México como escenarios de construcción social de alternativas. *POLIS. Revista Latinoamericana*. 15(43): 1-18.
53. Rosset, P. M.; Martínez-Torres, M. E. 2012. Rural Social Movements and Agroecology: context, theory, and process. *Ecology and Society*. 17(3). 10.5751/ES-05000-170317.
54. Rousseau, L.; Fonte, S. J.; Téllez, O.; van der Hoek, R.; Lavelle, P. 2013. Soil macrofauna as indicators of soil quality and land use impacts in smallholder agroecosystems of western Nicaragua. *Ecological Indicators*. 27: 71-82. <https://doi.org/10.1016/j.ecolind.2012.11.020>.
55. Rover, O. J.; Boeira, S. L.; Birochi, R.; Follmann, T. M. 2017. Modos de gestão para a diversificação produtiva em regiões produtoras de tabaco. *Revista Brasileira de Gestão e Desenvolvimento Regional*. 13(2): 177-201.
56. Rubio Vega, B. A. 2011. Crisis mundial y soberanía alimentaria en América Latina. *Revista de Economía Mundial*. (29): 61-87.
57. Salmón, Y.; Funes-Monzote, F. R.; Martín, O. M. 2012. Evaluación de los componentes de la biodiversidad en la finca agroecológica "Las Palmitas" del municipio Las Tunas. *Pastos y Forrajes*. 35: 321-32.
58. Seminar, A. U.; Sarwoprasodjo, S.; Santosa, D. A.; Kinseng, R. A. 2017. Agroecological education aimed at achieving food sovereignty. *Journal of Developments in Sustainable Agriculture*. 12(1): 34-44. 10.11178/jdsa.12.34.
59. Toledo, V.M. 2011. La agroecología en Latinoamérica: tres revoluciones, una misma transformación. *Agroecología*. 6:37-46.
60. Tonolli, A. J. (en prensa). Propuesta metodológica para la obtención de indicadores de sustentabilidad de agroecosistemas desde un enfoque multidimensional y sistémico. *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo. Mendoza. Argentina*.
61. Trevisan, A. C. D.; Schmitt-Filho, A. L.; Farley, J.; Fantini, A. C.; Longo, C. 2016. Farmer perceptions, policy and reforestation in Santa Catarina, Brazil. *Ecological Economics*. 130: 53-63. <https://doi.org/10.1016/j.ecolecon.2016.06.024>.
62. Vallejo Quintero, V. E. 2013. Importancia y utilidad de la evaluación de la calidad de suelos a través del componente microbiano: Experiencias en sistemas silvopastoriles. 2013. 16(1): 17. 10.14483/udistrital.jour.colomb.for.2013.1.a06.
63. Wezel, A.; Bellon, S.; Doré, T.; Francis, C.; Vallod, D.; David, C. 2009. Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*. 29(4): 503-15. 10.1051/agro/2009004
64. Wezel, A.; Casagrande, M.; Celette, F.; Vian, J. F.; Ferrer, A.; Peigné, J. 2014. Agroecological practices for sustainable agriculture. A review. *Agronomy for Sustainable Development*. 34(1): 1-20. 10.1007/s13593-013-0180-7
65. Wezel, A.; Brives, H.; Casagrande, M.; Clément, C.; Dufour, A.; Vandenbroucke, P. 2016. Agroecology territories: places for sustainable agricultural and food systems and biodiversity conservation. *Agroecology and Sustainable Food Systems*. 40(2): 132-44. 10.1080/21683565.2015.1115799

ACKNOWLEDGMENTS

Authors thank the geomatics laboratory of Colegio de Postgraduados, Campus Veracruz, for support for the realization of the map.