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Article

The Main Agroecologycal Structure (MAS) of the Agroecosystems: Concept, Methodology and applications

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Abstract: This document presents, from environmental thinking (ecosystem - culture relations), the concept of the Main Agroecological Structure of Agroecosystems (MAS, EAP, for its acronym in Spanish), considered as a dissipative cultural structure. It discusses its possible applications (resilience, production, diversity) both inside and outside the farms. The MAS can be useful in the land planning on the farms, based on the concept of potential MAS that allows the quantification of the management of internal and external corridors, including natural vegetation. At the same time, it can be useful in the context of landscape management because it shows a series of cultural relations (economic, social, symbolic and technological) hidden from the partial analysis of landscape ecology.

key words: agrobiodiversity; environment; ecosystem; culture; farms; planning.

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1. Introduction

Environmental thinking in essence raises and recognizes that humanity built a system of adaptation to the ecosystems, different from that of other living beings, based primarily on culture. The culture has been defined as the non-biological heritage of humanity (1) or as all those theoretical and practical processes that are expressed in the symbolic structures, human organization and technological platforms of humanity (2,3,4). From this point of view, food production systems can be understood as sets of activities that human groups organize, direct and carry out according to their objectives and resources, influencing and being influenced by the ecosystem and biophysical environment where they are located (5). This aspect denotes the relevance and complexity of the interaction ecosystem-culture in the agrarian field (4).

On the other hand it is widely accepted that agriculture is the result of the cultural modification of ecosystems, when these transformations apply to satisfy the basic needs of food, fibers and other materials and are amplified according to the conditioning factors of ecosystem coevolution - culture (6, 7). The study of these complex relationships is the object of agroecology (8), a science that focuses on the environmental analysis of agroecosystems (9, 10), recognizing in them multiple biophysical, symbolic, social, economic, political and technological interactions (11).

Agroecology studies and proposes answers to complex problems, through agrarian practices based on traditional or ancestral knowledge, the promotion of biological and cultural diversity, the

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autonomy of producers and the conservation and proper management of natural resources. It also propose an interdisciplinary approach in scientific research and successfully stimulating biological regulations even in large-scale agriculture (12, 13, 14, 15, 16).

Within these practices or strategies that arise from agroecology, León-Sicard (11) proposes to study what he called the Main Agroecological Structure of the major agroecosystems (MAS). This concept refers to the arrangements of the internal and external connectors of the farms (fences, hedges, living fences or patches of forest) and can relate to the probability of resilience or adaptation of agrarian systems to disturbances of different nature. The MAS could be associated theoretically with a Dissipative Structure (ED), with possible beneficial effects on the establishment and development of crops in different scales, from subsistence agriculture in small areas to intensive productive processes of agro industrial character. Likewise, the MAS could allow the design and implementation of adaptation and mitigation options to the changing climate, as a contribution to risk management.

This document presents the theoretical bases of the concept, the general methodology for its calculation and the description of some preliminary applications made in Colombia.

2. Theoretical bases of the MAS

The agroecosystem is an ecosystem deliberately modified by human beings in order to obtain goods and services, with different purposes and therefore it is the place where dynamic relations between the culture and its physical-biological environment are presented (17, 18).

Various authors considered agroecosystems as units of analysis where different types of ecosystem processes and socio-economic relationships converge (energy flows, material cycles) (9, 10).

The agroecosystem has been define as "…the set of relationships and interactions between soils, climates, cultivated plants, organisms of different trophic levels, adventitious plants and human groups in certain physical and geographical spaces. Its study includes their energy flows and information, their material cycles and their symbolic, social, economic and political relations, which are expressed in different technological forms of management within specific cultural contexts… "(12). The interactions between the components are presented within diffuse limits that can go beyond the farm (11).

The origin of the MAS derived from the works of van der Hammen and Andrade (19, 20) in Colombia, who proposed the idea of the Ecological Support Structure of the Nation (ESS), to facilitate the comprehension, at the country level, of the current state of its plant cover. In this ESS the authors recognized two components: the Main Ecological Structure of the Landscape (MES) and the Ecological Infrastructure (EI) and in the latter they included the remnants of vegetation in the agroecosystems, although they did not deepen in their meaning and applications.

With these concepts the authors gave meaning to the study of landscape ecology and provided a background to articulate, in theory and practice, the management of relicts and patches of natural vegetation, including biological corridors and wooded masses. In the concept of Ecological Infrastructure, they introduced the existing natural vegetation in the agroecosystems, but did not advance in the formulation of this idea.

In this way, the concept of the Main Agroecological Structure of agroecosystems is born to accommodate this unfinished relationship proposed by professors van der Hammen and Andrade and to provide a frame of reference for agroecology in terms of a natural property of the Agroecosystems: its own structure.

Then the MAS was defined as "…the internal configuration or spatial arrangement of the farm and the connectivity between its different sectors, patches and corridors of vegetation or productive systems. The MAS allows the movement and exchange of different animal and vegetable species, offers shelter, habitat and food, provides microclimatic regulations and affects the crops yield and the conservation of natural resources and other ecosystem and cultural aspects of the major agroecosystems " (12).

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The major agroecosystem (farm) has an ecosystem content expressed in minor agroecosystems (lots, plots, cultivation sites, forest areas, agroforestry sites or silvopastoral systems). The way in which these relate to forests or other types of tree, herbaceous or scrub vegetation cover within the major agroecosystem, gives specific characteristics to the farm's MAS. This concept, which aims to describe the structural and functional relationships of major agroecosystems, in light of the cultural factors that determine them, can be used for different applications (relations with production, plant health, food autonomy, resilience) including future uses as taxonomic criterion of agroecosystems (8).

In the processes of designing agroecosystems resilient to different types of disturbance, it is necessary to understand the complexity inherent in agroecosystems (21). In this sense the MAS accounts for both functional (unintentional) and planned agrobiodiversity, offering possibilities for planning through the potential MAS, with repercussions at farm level (crops yields) and also at the level of agroecosystem matrices in landscape units at smaller scales (sidewalks, river basins, municipalities, regions) (12).

In agroecosystems, while they are considered as systems far from equilibrium, there are constant exchanges of matter, and energy and information flows with the environment, and it is impossible to obtain final and permanent equilibria, due to the continuous entropy generated in their transformation processes. However, these systems evolve adapting to their environment, until they reach the weakest possible dissipation through mechanisms of self-organization or autopoiesis (22, 23, 24).

When these systems face disturbances or fluctuations, for example, when agroecosystems are subject to changes in temperature, rainfall or attacks by insects or pathogens and when these disturbances, instead of disappearing, increase, agroecosystems can undergo an organized structural transformation, which would allow maintaining its functionality in time and space, towards a new passenger state called "dissipative structure". This structure is the amplified fluctuation, stabilized by the interactions with the environment, maintaining itself because it is continuously nourished by the energetic flow coming from the disturbance (23, 25). The formation and maintenance of the dissipative structure requires at least three conditions: (1) the system must be open and can continuously exchange matter and energy with the external environment. (2) The system must be in a state of no equilibrium or far from equilibrium; because non-equilibrium is the source of order (3) Non-linear interactions as well as certain nonlinear dynamic equations must exist in the system (26,).

Since its promulgation, the theory of dissipative structures has shown a wide scope, currently achieving support for several theoretical frameworks in engineering, medicine, psychology, agriculture and human sciences (27, 28, 26, 29, 30, 31, 32). For this reason, this Theory is becoming an important reference in the modern scientific system (33).

The concept of dissipative structure was applied in ecology, since the seventies of the last century, to explain the relationships that exist between predators and their prey (34) and in the study of biological structure and functions at the genetic level (35). In the 1980s, it was used to study the evolution of ecosystems (36) and explain the relationships between species and ecosystems (37). While for the late twentieth century it was applied to the analysis of the distribution of plants (38) and in the design of processes to manage and control weed plants (39), to name just a few examples.

In summary, the theoretical approach of dissipative structures can be applied to explain the behavior of biological, physical, chemical and social systems and to study the evolution of their structures in terms of a certain "order acquisition" (24) and for the analysis of systems resilience.

If the agroecosystem is considered an open system that interacts constantly with the environment (physical, biotic, social, economic and cultural), the MAS can also be considered as a dissipative structure, which allows the system to increase or improve the possibilities of maintaining its functionality, incorporating, dissipating or using the matter, energy or information coming from the disturbance. In this sense, for example, the greatest available agrobiodiversity in a farm allows the different plants located in diversified strata and with diverse phenotypes and genotypes, to have greater physical resistance to climatic disturbances, but also wide ranges of response in economic and social terms to disturbances of different origins and class.

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Sizing the MAS as a dissipative structure allows us to analyze the components of the agroecosystem and strengthen those that can dissipate the disturbance. For example, in the event of a disturbance related to the increase in evapotranspiration or the decrease in available water, it is possible to use species that are more resistant, to use green cover to protect the soil or other strategies, which are themselves the consequence of social or economic processes. It would also make it possible to direct efforts to propose solutions of a cultural nature such as saving water or collecting rain, mediated by the cultural characteristics of particular agrarian societies.

Assuming this theoretical approach to thermodynamics, MAS could be considered as a cultural dissipative structure that, insofar as it increases, improves the possibilities of interaction and adaptation to different types of disturbances, due to the inherent complexity of greater agrobiodiversity and connectivity between sectors of agroecosystems. In this way, the greater MAS (structured) would help to dispel the negative effects of external factors, whether cultural or ecosystemic.

3. Methodology approach

The criteria proposed by the authors of the methodology (40, 41), aimed at evaluating the MAS, corresponds to the sum of the parameters indicated in Table 1.

Table 1. Evaluative parameters to estimate the Main Agroecological Structure (7)

Parameter	Acronym	Description
Connection with the main ecological structure of the landscape	CMES	It assesses the distance of the farm in relation to the nearby fragments of natural vegetation, mainly forest cover and bodies of water.
Extension of external connectors	EEC	Evaluates the percentage of the linear extension of live fences, present in the perimeter of the farms.
Diversification of external connectors	DEC	Evaluates the diversity of live fences or hedges located on the perimeter of the major agroecosystem.
Extension of internal connectors	EIC	Evaluates the percentage of the linear extension of the rows of vegetation, but internally.
Diversification of internal connectors	DIC	Evaluates the diversification of internal live fences.
Uses and conservation of the soil	US	This parameter evaluates the percentage distribution of different coverages.
Management of weeds	MW	Evaluates the management practices and systems of weed plants.
Other management practices	OP	Is an indicator that expresses the types of production systems (ecological, conventional, or in transition) of each farm.
Perception-Awareness	PA	Evaluates the degree of conceptual clarity and awareness of producers regarding agrobiodiversity.

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Level of capacity for action	CA	Evaluates the capacities and possibilities of farmers to establish, maintain or improve their MAS

Each of the aforementioned indicators are evaluated in scales from 1 to 10, according to the following tables and criteria developed by León (8):

Connection of the farm with the Main Ecological Landscape Structure (CELS)

This parameter assesses the relationships of the agroecosystem with the elements of the surrounding landscape through some metrics such as the density of patches or fragments of natural vegetation and bodies of water, as well as the distance between them and their average distance to the center of the agroecosystem. It is determined from any type of image of remote sensors (aerial photographs, satellite or drone images) with the following procedure (Figure 1):

1. Define the area of influence of the landscape on the farm, starting from a circle whose center coincides with the center of the major agroecosystem. The circle has a radius that is twice the longest side of the farm.

2. Outside the major agroecosystem, but within the area of influence of the circle and using the categories proposed by the Coordination of Information System on Environment and Coverage of Land (Corine Land Cover) separate types of plant cover, especially fragments of forests, shrubs, crops and bodies of water.

3. Determine the average distance of the types of vegetation cover identified to the center of the farm (the same point taken as the center of the area of influence).

4. All the percentages obtained are weighted and added, on a scale of 1 to 10. The resulting value represents, in this numerical scale, the connectivity of the major agroecosystem with the main ecological landscape structure (ELS), which then direct is added to the calculation of the MAS.

For the interpretation of the distances and qualification of attributes analyzed in the determination of the ELS, the scales indicated in Table 2 were proposed.

Table 2. Connection with the Main Ecological Landscape Structure (ELS).

Metric	Description	Connectivity	Value
1. **DFF.** Distance between forest fragments.	The greater the distance, the less chance of harboring a greater degree of biological connectivity.	High (0-150 m.)	10
		Medium High (150-300 m.)	8
		Medium (300-450 m.)	6
		Medium Low (450-600 m)	4
		Low (≥ 600 m.)	2
2. **DFFCF** Distance of forest fragments to the center of the farm.	Related to exchanges of organisms between forests and crops.	High (0-150 m.)	10
		Medium High (150-300 m.)	8
		Medium (300-450 m.)	6
		Medium Low (450-600 m.)	4
		Low (≥ 600 m)	2

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3. **DBW** Distance between bodies of water.	The greater the distance, the less water available and the less biotic interrelations.	High (0-150 m.)	10
		Medium High (150-300 m.)	8
		Medium (300-450 m.)	6
		Medium Low (450-600 m)	4
		Low (≥ 600 m.)	2
4. **DBWCF.** Distance of bodies of water to the center of the farm.	Related to the living conditions of different organisms	High (0-150 m.)	10
		Medium High (150-300 m.)	8
		Medium (300-450 m.)	6
		Medium Low (450-600 m.)	4
		Low (≥ 600 m)	2

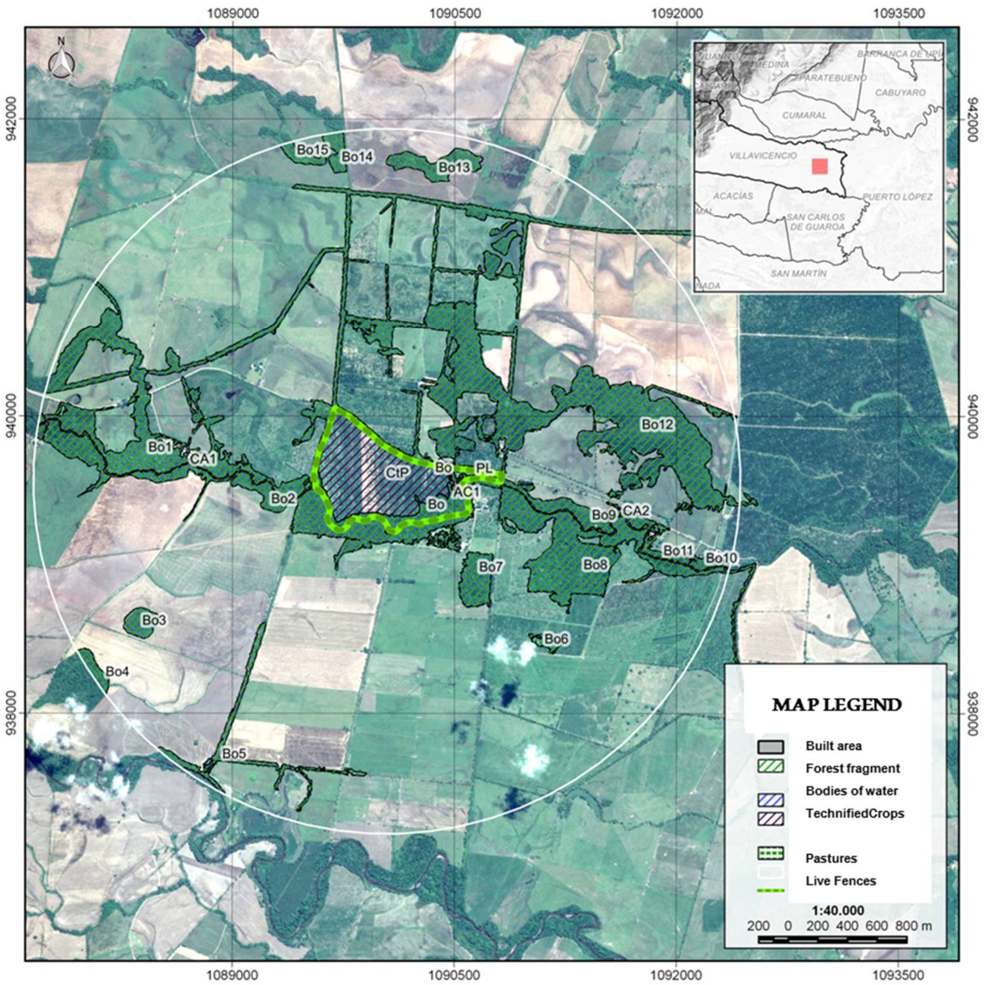

Figure 1. Farm "Agrícola El Naranjal", showing its connectivity with the Main Ecological Structure of the Landscape

Extension of the External Connectors (EEC).

Evaluates the linear extension and the surface of live fences, present in the perimeter of the farms (Table 3). For its determination, any type of remote image is also used.

Table 3. Extension of the External Connectors (EEC).

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Description	Value	Remark
Continuous perimeter	10	Between 75% and 100% of the perimeter of the major agroecosystem surrounded by live fences of native and / or exotic species.
Moderately continuous perimeter.	8	Between 50% and 75% of the perimeter of the major agroecosystem surrounded by live fences of native and / or exotic species.
Discontinuous perimeter.	6	Between 25% and 50% of the perimeter of the major agroecosystem surrounded by live fences of native and / or exotic species.
Perímetro fuertemente discontinuo.	3	Between 12% and 25% of the perimeter of the major agroecosystem surrounded by live fences of native and / or exotic species.
Perímetro extremadamente discontinuo.	1	Less than 12% of the perimeter of the major agroecosystem is surrounded by live fences of native and / or exotic species

Extension of the Internal Connectors (EIC).

It measures the linear extension of the rows of vegetation, but at the internal level of the agroecosystem (Table 4). The extension of the external and internal connectors is also determined

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with the images of remote sensors.

Table 4. Extension of internal connectors (EIC).

Description	Value	Remarks
High connectivity	10	Between 75% and 100% of the internal areas of the major agroecosystem connected with live fences or hedges of native and / or exotic species.
Medium connetivity	8	Between 50% and 75% of the internal areas of the major agroecosystem connected with live fences or hedges of native and / or exotic species.
Low connectivity	6	Between 25% and 50% of the internal areas of the major agroecosystem connected with live fences or hedges of native and / or exotic species.
Very Low connectivity	3	Between 12% and 25% of the internal areas of the major agroecosystem connected with live fences or hedges of native and / or exotic species..
No connectivity or extremely low connectivity.	1	Less than 12% of the internal areas of the major agroecosystem connected with live fences or hedges of native and / or exotic species.

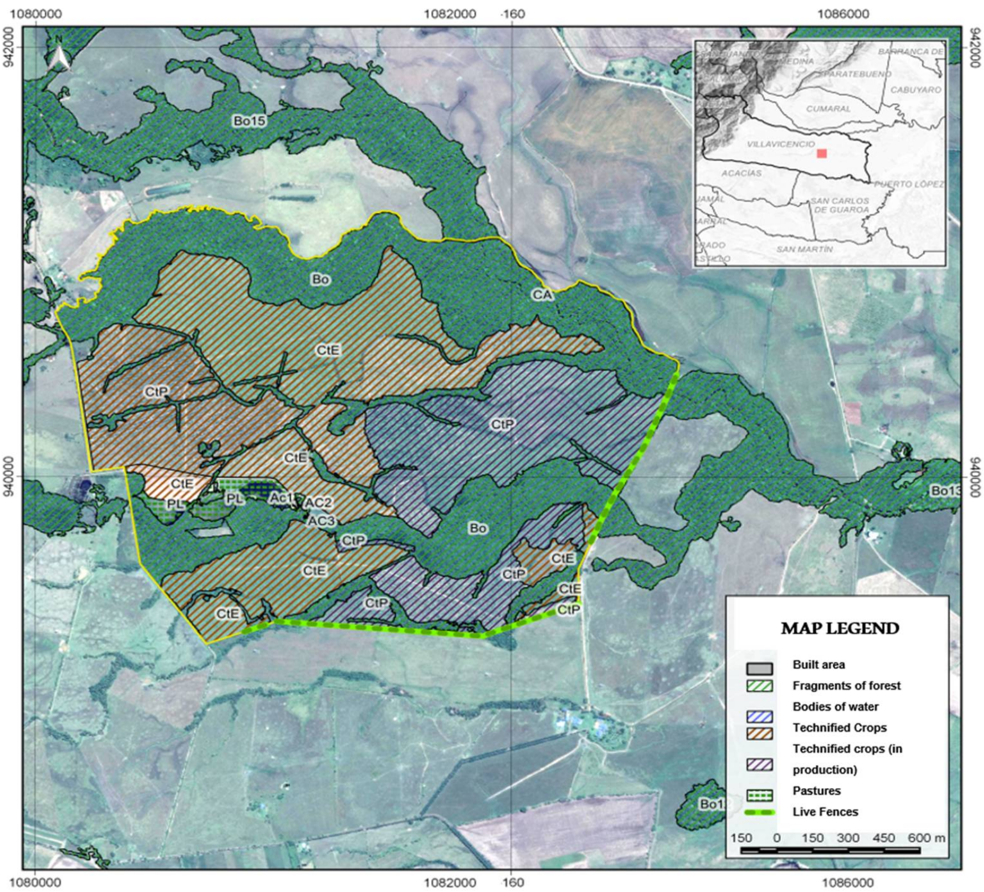

Figure 2. "Cítricos del Milenio" farm showing its external and internal connectors. Note the connection with gallery forests.

Diversity of External Connectors (DEC)

Evaluate the diversity and functionality of live fences or hedges located on the perimeter of the major agroecosystem (Table 5). Their analysis includes sampling the types of herbaceous, shrub, or tree vegetation that are part of these living fences. Samples can be take using the same fences as transects or random sampling in plots of different areas. The collected material is then identified with its vernacular and scientific names (with the support of botanists and local inhabitants) and is classified within the taxonomic categories of family, gender and, as far as possible, species. Depending on the economic resources and the objectives of each research, other indices of biodiversity (abundance, wealth, equitability) can be used.

Table 5. Diversity of External Connectors (DEC).

Description	Value	Remarks
Highly diversified perimeter.	10	Between 75% and 100% of the fences and hedges are dense, with a high diversity of tree species, with two or more strata and two or more rows.
Moderately diversified perimeter.	8	Between 50% and 75% of the fences and hedges are dense, with a high diversity of tree species, with two or more strata and two or more rows.
Slightly diversified perimeter.	6	Between 25% and 50% of the fences and hedges are dense, with a high diversity of tree species, with two or more strata and two or more rows.
Little diversified perimeter.	3	Less than 25% of the fences and hedges are dense, with a high diversity of tree species and at least two strata and two rows.
Perimeter not diversified.	1	100% of live fences have a single tree species and a single row.

Diversity of the Internal Connectors (DIC).

Evaluate the diversification of live fences, inside the farm (Table 6). The same methodology described for the determination of the diversity of external connectors is suggested.

Table 6. Diversity of Internal Connectors (DIC).

Description	Value	Remarks
Highly diversified internal connector.	10	Between 75% and 100% of the fences and hedges are dense, with high diversity of plant species, with two or more strata and two or more rows.
Moderately diversified internal connector.	8	Between 50% and 75% of the fences and hedges are dense, with high diversity of plant species, with two or more strata and two or more rows.
Slightly diversified internal connector.	6	Between 25% and 50% of the fences and hedges are dense, with high diversity of plant species, with two or more strata and two or more rows.
Internal connector little diversified.	3	Less than 25% of fences and hedges are dense, with a high diversity of plant species and at least two strata and two

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		rows or any percentage of internal hedges and fences that have only one species, not very dense and in one row.
Internal connector not diversified.	1	Divisions of areas made up of any non-living material (barbed wires or electric fences).

Land Uses (LU)

This parameter based on the Corine Land Cover methodology evaluates the percentage distribution of different coverages, associated with the productive activities of the farm (Table 7).

Table 7. Land Uses (LU)

Description	Value	Remarks
Polycultures and agrosilvopastoral systems in total coverage.	10	100% of the farm used with polycultures or tree coverages in silvopastoral systems or others that guarantee high productive diversity.
Polycultures and agrosilvopastoral systems in high coverage.	8	Between 75% and 100% of the farm used with polycultures or tree coverages in silvopastoral systems or others that guarantee high productive diversity
Polycultures and agrosilvopastoral systems in medium high coverage.	6	Between 50% and 75% of the farm used with polycultures or tree coverages in silvopastoral systems or others that guarantee high productive diversity
Polycultures and agrosilvopastoral systems in low coverage.	5	Less than 50% of the farm used with polycultures or tree coverages in silvopastoral systems or others that guarantee high productive diversity
Monocultures, livestock and plantation forest systems.	3	The farm owns the three components in different percentages.
Monocultures or livestock.	1	The farm uses only one type of coverage.

Weed management (WM).

Values practices and management systems of weed plants (Table 8).

Table 8. Weed Management (WM).

Description	Value	Remarks
Weed managed in maximum coverage.	10	The major agroecosystem presents fringes, stripes, spots, rows or random weed surfaces as an intentional management practice.
Weed managed in medium coverage.	5	Only in some sectors of the major agroecosystem are intentionally managed strips, spots, rows or random surfaces of weeds.
Weeds not managed	1	The mechanical, physical or chemical control of weeds predominates on the farm.

Other Management Practices (OP).

It is an indicator that expresses the types of management (ecological, conventional, or in the process of transition or reconversion) of each farm (Table 9).

Table 9. Other management practices (OP).

Description	Value	Remarks
Ecological management practices.	10	Farmers use ecological (organic) management practices, which may or may not be certified.
Management practices in the reconversion process.	5	The farm is totally or partially in processes of ecological reconversion.
Conventional management practices.	1	The farm uses only conventional farming practices

Perception - Consciousness (PC).

It assesses the degree of conceptual clarity and awareness of producers in relation to the use and management of agrobiodiversity (Table 10).

Table 10. Perception-Consciousness (PC)

Description	Value	Remarks
High degree of environmental awareness and knowledge of the roles of biodiversity.	10	Farmers are aware of the importance of environmental factors and biodiversity in their farms and know the role of links, hedges and living fences.
High degree of environmental awareness - low or medium knowledge of biodiversity roles.	5	Farmers are aware of the importance of environmental factors and biodiversity in their farms, but they are unaware of the role of live fences, hedges and fences.
Low or no degree of environmental awareness and roles of biodiversity.	1	Farmers do not give importance to environmental or biodiversity factors or know the role of links, hedges and living fences.

Level of Capacity for Action (CA).

In addition to the commitment, it assesses the capacities and possibilities of farmers to establish, maintain or improve the MAS of their productive units (Table 11). The evaluation of parameters: weed management, other management practices, perception-awareness and capacity for action, are determined through surveys or interviews conducted with the owners, owners or managers of the respective farms.

Table 11. Capacity level for action (CA).

Description	Value	Remarks
High possibilities of action.	10	Farmers have the means of infrastructure, financial, economic, family, social and technological to establish the functional and complete MAS on their farm.

Medium possibilities of action.	5	Farmers have some means of infrastructure, financial, economic, family, social and technological to establish the functional and complete EAP on their farm.
Very low to null chances of action.	1	Farmers do not have any cultural means to establish functional and complete EAP on their farm, or some key factor fails to prevent their establishment

The final value of the Main Agroecological Structure of the major agroecosystems is obtained by adding each of the aforementioned indicators, according to the following equation (unweighted)

MAS = CELS + EEC +EIC + DEC + DIC + LU + WM + OP + PC + CA. (1)

The scale of interpretation of the MAS is indicated in the next table.

Table 12. Interpretation of the Main Agroecological Structure (8)

Value	Interpretation
80 - 100	Strongly developed
60 - 80	Moderately developed
40 - 60	Slightly developed
20 - 40	Weakly developed, with cultural potential to complete it
< 20	No structure or weakly developed structure, no cultural potential to establish it

4. Applications of the MAS

The MAS was applied for the first time in Colombia in an study conducted in a high Andean horticultural area (40) which compared 6 ecological farms (from 20 to 0.16 hectares), in the savannah of Bogotá using the ten general criteria exposed. They found values of MAS between 47 (slightly developed) and 81 (strongly developed), which revealed substantial differences in management between the farms studied and a high degree of isolation from them with the ecological structure of the landscape. This first exercise indicated that the index could be applied in different socioeconomic conditions and in different natural regions of the country. To this end, new studies were carried out in other areas of peasant production in Colombia (Anolaima, Quipile and Pulí in the department of Cundinamarca), in coffee agroecosystems with greater biodiversity.

In this sense, we studied the ecosystem and cultural resilience of six coffee agroecosystems (three ecological and three conventional) in Anolaima (Colombian Andes), regarding climate variability (41). All the ecological farms presented better MAS conditions and greater resilience than the conventional ones, although all were located in a region characterized by the soil susceptibility to mass movements and responded to a common history of settlement and similar socioeconomic conditions. In another study conducted in coffee agroecosystems of Quipile and Puli (Cundinamarca) (42), the MAS was tested in an area with different degrees of agricultural intensification, comparing the results with the typing methodology of Moguel and Toledo (43). In different types of coverage, the authors measured local variables associated with agricultural management (richness, density and average height of trees, average density and height of coffee, weed richness, percentage of canopy

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cover and distance to the nearest forest as a factor of the landscape) and determined the types and frequency of application of agrochemicals and other cultural management variables.

The authors found out good correlation of the classification of Moguel and Toledo with the classification proposed in the study. In addition, they determined that the floral diversity and natural spaces close to the crop substantially affect the richness of the visiting bees of the coffee. They proposed that the MAS, through diversified productive arrangements with high internal and external connectivity, propitiates synergistic effects that increase the wealth of bees within the coffee field and enhance their conservation and ecological function of pollination.

Another study carried out to explain the socio-environmental reasons of voluntary urban migrants towards intentional rural communities (44), assessed the ecosystemic effects of this migration at the level of the changes that occurred in the MAS of the farms. The study took place in three ecovillages of the department of Cundinamarca (Varsana located in the municipality of Granada, El Retoño in the municipality of Silvania and Aldea Feliz in the municipality of San Francisco), using ethnographic techniques and vegetation sampling.

The results showed that the migrants contributed positively in the improvement of the agrobiodiversity of the farms, measured through the MAS. Varsana (whose inhabitants arrived in 1979) went from an initial MAS of 18 (weakly developed) to values of 80 (strongly developed) in 2013. El Retoño went from 26 to 81 in 15 years (1998-2013) and Aldea Feliz of 63 to 92 in 7 years (2006-2013). Such modifications were linked to the personal motivations of migrants who seek in environments other than the urban, elements of healthy living, satisfaction of spiritual aspirations and vindication of values of solidarity and respect, accompanied by administrative and economic structures of solidarity type.

Likewise and in order to assess the role of the MAS in the general resilience of citrus agroecosystems to climatic variability in conditions of the Colombian Orinoquia, we studied this characteristic in 18 farms located in the Orinoquia foothills (45, 46). We found out high correlation between the MAS and the decrease in the number of phytosanitary controls, carried out by the growers of Orange (*Citrus sinensis* (L.) Osbeck) var. Valencia, as well as positive correlations with the productivity of the farms studied.

Finally, we conducted a preliminary exercise to include agroecosystems (beyond the Corine Land Cover classification) in the national ecosystem map of Colombia and for this they proposed to value the MAS as an agroecosystem connectivity criterion that could be represented even in maps at 1: 100,000 scale (47).

The previous examples show that the Main Agroecological Structure of the major agroecosystems can become a valuable tool for the study and planning of the use of agroecosystems, both at the level of their internal management and in matters related to the management territorial planning (48).

At farm level scale, the MAS facilitates the understanding of the interrelationships that agrobiodiversity provides. Although specific studies have not been made yet in this field, it is possible to advance the hypothesis of high and positive relationships between MAS and the abundance of pollinators or natural enemies and of varied intra - and interspecific relationships of different organisms, responsible for being agents or vectors of diseases and damage to crops. Included in this category is the soil biodiversity, which can be improved by the influence of agrobiodiversity management, via the reinforcement of the MAS.

On the other hand, as already noted by the author of the concept (8), the MAS can help in planning the use of the farm. This can achieve incorporating the notion of potential MAS, that is, the location, layout and implementation of better and more diversified internal and external corridors, including the management of patches of natural vegetation within the farms (ecosystems within agroecosystems). The MAS allows calculating the selection of flower banks and the introduction of certain shrub or forest species, which have already been proven beneficial for the production or control of insect populations, in the style of intensive silvopastoral systems (49, 50).

On the other hand, the MAS provides explanations, at the farm scale, of landscape connectivity. It is no longer a matter of considering the biological corridors or the patches of vegetation or the remaining forests as loose pieces in the landscape. The MAS allows them to be grouped around the agricultural production units themselves and therefore it makes visible a series of cultural relations (economic, social, symbolic and technological) hidden from the partial analysis of landscape ecology. In other words, the MAS is the entry of agricultural producers into the maps of the environmental planning of the territory.

Socio-ecological resilience recognizes that culture has a technological component that is incorporated by farmers in response to disturbances. From this perspective, the characterization of the MAS allows determining which cultural practices are necessary to increase agrobiodiversity (i.e. the development of agroforestry, the practice of allelopathy, the harvesting of water, the management of coverings and the use of entomopathogens). With these practices it is not only possible to increase yields, but also the quantity and variety of foods, creating strong connections with security processes, sovereignty and food autonomy, improving the nutritional processes of farmers and their communities (51).

The above points demonstrate the relevance of the evaluation of the MAS as a highly useful methodology for decision-making. It can help farmers make adjustments in their agroecosystems, so that by increasing connectivity and biodiversity, the resilience and productivity of their agricultural and livestock units can be increased and, as a consequence, their income, level of life and food autonomy.

At the administrative level, the MAS can become an important input for the design of public development policies with a territorial approach, based on local needs and the active participation of farmers. Finally, the MAS can also become a useful theoretical-practical instrument to advance the taxonomy of agroecosystems, an issue that the science of agroecology has not yet addressed.

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