ORIGINAL ARTICLE

Indicators of Agroecological Management of Urban and Periurban Agricultural Soils in Caracas, Venezuela

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Indicadores de manejo agroecológico de suelos de agricultura urbana y periurbana en Caracas, Venezuela

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ABSTRACT: Urban and periurban agriculture has been recognized as a fundamental strategy in achieving food security, which makes necessary a characterization of such systems and the implementation of evaluation systems of their sustainability, which lead to their more efficient management. Proposals are presented for indicator systems related to soil resource management, built in a participatory manner, in two peri-urban and one urban productive areas. From the previous analysis of each agroecosystem, the SWOT matrix was built and the evaluation of the soil profile was carried out. Once the information obtained by producers, students and teachers was analyzed using the MESMIS reference framework, the farm design was carried out and the system of indicators proposed for its management was established.

Keywords: Sustainability Assessment, Food Security, Participatory Action Research.

RESUMEN: La agricultura urbana y periurbana ha sido reconocida como una estrategia fundamental en el logro de la seguridad alimentaria, lo que hace necesaria una caracterización de tales sistemas y la implementación de sistemas de evaluación de su sostenibilidad, que conduzcan a una gestión más eficiente de los mismos. Se presentan propuestas de sistemas de indicadores relacionados con el manejo del recurso suelo, construidos de manera participativa, en dos áreas productivas periurbanas y una urbana. A partir del análisis previo de cada agro ecosistema se construyó la matriz FODA y se realizó la evaluación del perfil de suelo. Una vez analizada la información obtenida por productores, estudiantes y profesores empleando el marco referencial MESMIS, se procedió a realizar el diseño predial y establecer el sistema de indicadores propuesto para su gestión.

Palabras clave **:** evaluación de sostenibilidad, investigación, acción participativa.

INTRODUCTION

The terms "Urban Agriculture (UA) and Peri-Urban Agriculture" (PA) were proposed in 1999 by the FAO to describe "agricultural practices that are carried out within the limits or in the vicinity of cities throughout the world and include the production , and in some cases the processing of agricultural, fishing and forestry products", which are characterized by being practiced on small surfaces (plots, orchards, margins, terraces, containers) destined for the production of crops and the raising of small livestock for own consumption or for sale in neighborhood markets" (Mougeot, 2006; FAO, 2007; Morán-Alonso, 2010; Ribeiro *et al.*, 2015).

Peri-urban agriculture, specifically, has a broader connotation, and can range from intensive and subsistence mini-agriculture to commercial agriculture carried out in an intermediate space between the city a (FAO, 2007).

At present, the importance of vegetable production in urban and peri-urban agriculture has been highlighted as an important source of vitamins and micronutrients and its easy access to the urban population belonging to the lowest socioeconomic strata, aspects that favors the achievement of food sovereignty (Zaar, 2011; Alemán, 2019). For this reason, it is necessary to advance policies to promote and support this socio-productive activity, encouraging self-management and the empowerment of organized communities from both a legal and administrative points of view, facilitating access to technical advice, institutional support and microcredit (Hermi, 2011; Degenhart, 2016; Bellenda *et al.*, 2018; Alemán, 2019).

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In this sense, it is essential to advance in the characterization of these agroecosystems and generate management mechanisms that allow increasing the efficiency of these production systems, and that include their evaluation. Therefore, the objective of this work was the participatory design of indicator systems that allow evaluating the management of soil resources in three agroecosystems located in the city of Caracas and its surroundings.

MATERIALS AND METHODS

This research was carried out in three productive areas, one of them located in the city of Caracas ("Comunidad El Porvenir", Catia, Distrito Capital), corresponding to an urban agroecosystem and two in its surroundings ("Finca Daktari", El Hatillo and "Comunidad Las Cadenas", Los Teques, both in the State of Miranda), corresponding to peri-urban agroecosystems.

Participatory action research (PAR) methods were used in all cases. To design the indicator system, the MESMIS framework (Framework for the Evaluation of Natural Resource Management Systems incorporating Sustainability Indicators) was used as a methodological reference (Astier *et al.*, 2008). This system proposes a continuous evaluation cycle where the system of indicators allows monitoring management measures (Figure 1).

In the application of MESMIS, the "critical points" of the agroecosystem are identified, which constitute aspects of it that limit the scope of the sustainability attributes (Productivity, Diversity, Equity, Stability and Resilience). In this way, the indicators that will constitute the evaluation system allow quantifying the progress towards achieving the sustainability of the agroecosystem expressed in terms of overcoming its "critical points".

On the other hand, SWOT matrices Geilfus (2002) were also made jointly by researchers, professors, students and producers to include sociocultural and economic aspects. Since the objective of this analysis was centered on the soil resource, the description of a representative profile was also made in each of the production spaces, in order to identify limiting factors in production from its state.

With the data obtained, a farm design proposal was carried out, also in a participatory manner, accompanied by its respective system of indicators, with the intention of converting the latter into an effective management system for the soils of the agroecosystem, which allows the evaluation of the production process and subsequent management and design adjustments.

In Figure 2, the work scheme developed is shown.

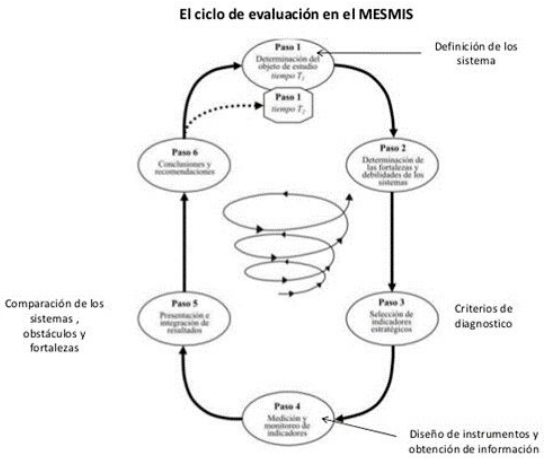

FIGURE 1. Evaluation cycle. MESMIS framework Masera *et al.* (2008).

RESULTS AND DISCUSSION

CASE 1. "EL PORVENIR" COMMUNITY, CATIA, SUCRE PARISH, LIBERTADOR MUNICIPALITY. CAPITAL DISTRICT.

This agroecosystem is located in one of the areas with the highest population density in the city of Caracas. Table 1 shows the SWOT matrix (Weaknesses-Opportunities-Strengths-Threats) carried out in a participatory manner.

In this case, the main problems identified by producers in relation to soil resource management are the scarcity of organic matter and biodiversity, as well as the high presence of pests and diseases, which directly affects the decrease in vegetable production.

This perception of the producers was confirmed when characterizing the soil profile, where a reduced depth and an A horizon with little organic matter and poor aggregation were found, as well as marked drainage problems evidenced by the presence of mottles in the BC horizon. That characterization is expressed in Table 2 and in Figure 3.

Based on this information, the farm design and the management plan were carried out, and using the MESMIS reference framework according to Astier *et al.* (2008), the "critical points" of the agroecosystem in relation to the soil resource were identified and the system of indicators to evaluate its management was established and it is shown in Table 3.

Case 2. "Daktari" Farm, El Hatillo Municipality

This productive space corresponds to a peri-urban environment. At the time of this study, there was only vegetable garden production in beds in a small area, as well as a seedbed and nursery, but the community intended to expand and diversify such production, so the agroecosystem analysis was carried out in function of this purpose. The SWOT matrix obtained is shown in Table 4.

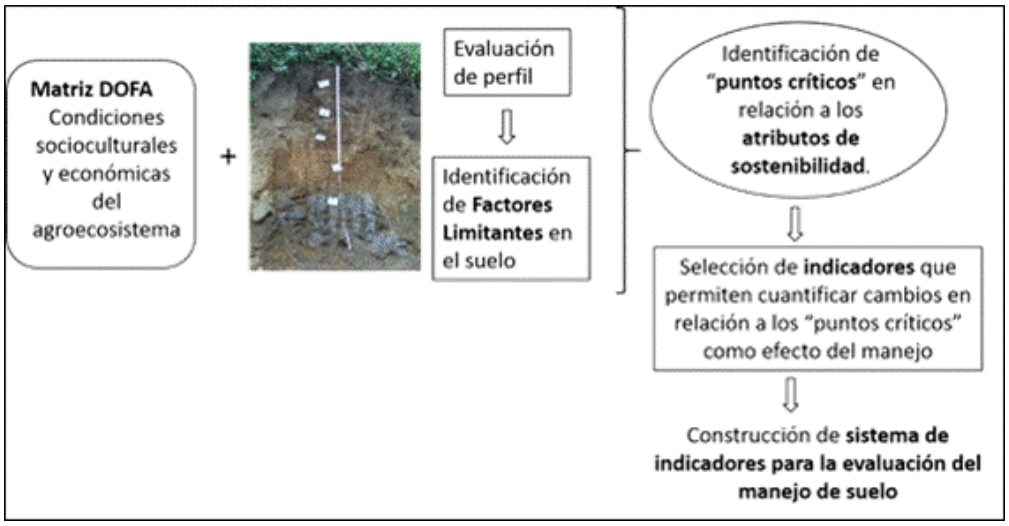

FIGURE 2. Scheme of work developed for the construction of indicator systems.

TABLE 1. SWOT Matrix ("El Porvenir" Community, Catia)

STRENGTHS	WEAKNESSES
Water availability. Seedbeds and nurseries established. Vermiculturist and composter established. High diversity of crops. Knowledge acquired. High participation and interest in the training workshops	Physical and biological degradation of the soil. Seed deficiency. Insufficient irrigation equipment. Dispersion in tasks. Difficulty in unifying management criteria.
OPPORTUNITIES	**THREATS**
Legal framework that favors agricultural activity. Institutional support (Ministry of Agriculture and Bolivarian University of Venezuela).	Possibilities of invasion in the plots. Personal insecurity. Difficulty in weed control. High presence of pests and diseases in the plots.

TABLE 2. Characterization of the soil profile ("El Porvenir Community", Catia)

Horizon	Depth	Borders	Structure	Aggregate size	Degree of aggregation	Color	Texture
A	1 - 12 cm	-	Granular	Fine	Weak	7.5 YR 4/3	Clayey Sandy
B	13 - 26 cm	Definite	Platy	Medium	Weak	2.5 Y 5/4	Clayey
BC	27 - 33 cm	Diffuse	Platy	Medium	Weak	2.5 Y5/3 (mottled 5 Y 5/1)	Sandy
C	34 - 52 cm	Diffuse	Massive	-	-	Color 2.5 YR 6/3	Sandy

Table No. 5 shows the characterization of the soil profile, corresponding to one of the hillside areas where no agricultural activities have been carried out. The presence of an O horizon and good structure stands out, as well as evidence of biological activity (presence of deep root systems). Figure 4 shows the soil profile of "Daktari" Farm, El Hatillo, Miranda State.

From the analysis of these data, the critical points and the system of indicators were established, as shown in Table 6.

Case 3. "Las Cadenas" Community. Los Teques, Miranda State.

This community is also located in a peri-urban environment, and it is a productive space associated with a cooperative made up of community residents with the aim of achieving organic production. This plot has been previously subjected to conventional management and is surrounded by other plots dedicated to the cultivation of vegetables and flowers, with a high application of agrochemicals. The SWOT matrix obtained in a participatory manner is presented in Table No. 7

Table No. 8 presents the description of the soil profile, highlighting the coloration observed in A and AB horizons, which shows a lack of organic matter. The A horizon, for its part, shows signs of compaction and loss of structure. The B horizon presented artifacts of anthropic origin. Such characteristics, together with the limitations evidenced in the SWOT matrix, were considered in the farm design and the indicator system.

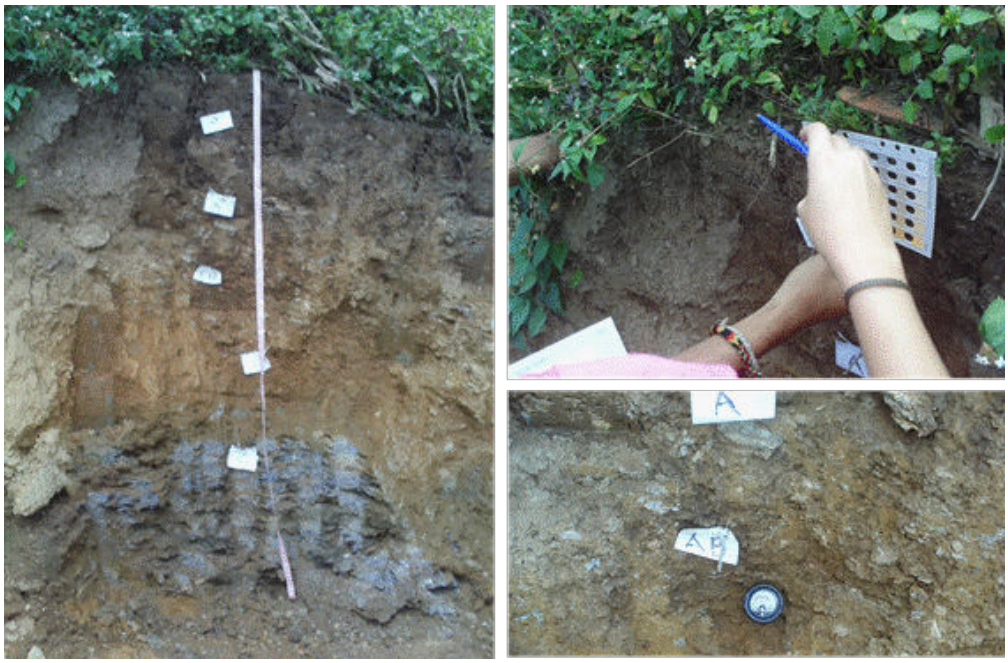

FIGURE 3. Characterization of soil profile in "El Porvenir" Community, Caracas, Capital District.

TABLE 3. System of indicators ("El Porvenir" Community, Catia)

Sustainability attributes	"Critical points" diagnosed in the system	Proposed indicators
Stability	Compaction	Soil penetration. Root length.
Resilience	Poor drainage	Infiltration rate.
Biodiversity	Little biodiversity	Macrofauna observed.
Stability	Severe damage from pests and diseases	Percentage of affectation of plants by pests and diseases.
Stability	High number of weeds	Visual indicators of nutrient deficiency. Crop growth curve.
Resilience	Little organic matter	Organic matter (as property inferred).
Productivity	Regular yield	Agronomic yield

TABLE 4. SWOT Matrix ("Daktari Farm", El Hatillo Municipality, Miranda State)

STRENGTHS	WEAKNESSES
Soil quality and appropriate climate. Water availability. Seedbed and nursery established. Extension of virgin areas.	Lack of proper tools. Lack of composter and vermiculturist. Insufficient irrigation equipment. Dispersion in tasks. Little community involvement.
OPPORTUNITIES	**THREATS**
National and municipal legal framework that favors agricultural activity. Institutional support (MPPA - UBV).	Beliefs associated with the agroecological model. Possibilities of invasion due to property conflicts. Difficulty in weed control. High presence of pests in harvested vegetables.

TABLE 5. Characterization of the soil profile. ("Daktari" Farm)

Horizon	Depth	Borders	Structure	Aggregate size	Degree of aggregation	Color	Texture
O	1-7 cm	-	Granular	Coarse	Strong	10YR 2/2	Loamy
A	8-22 cm	Definite	Granular	Medium	Strong	7.5YR 3/4	Loamy Clayey
E	23 - 30 cm	Definite	Single grain	-	-	10YR 5/6	Sandy
B	31 - 49 cm	Definite	Granular	Medium	Moderate	7.5 YR 4/6	Sandy Clayey
BC	50 - 63 cm	Diffuse	Platy	Medium	Moderate	10 YR 5/4	Sandy Clayey
C	64 - 85 cm	Diffuse	Platy	Medium	Moderate	10 YR 5/4	Sandy

FIGURE 4. Soil profile of the "Daktari" Farm, El Hatillo, Miranda State.

TABLE 6. System of indicators "Daktari" Farm, El Hatillo, Miranda State

Sustainability attributes	"Critical points" diagnosed in the system	Indicators proposed
Resilience	High number of weeds.	Weeds/m^2
Stability	Severe damage from pests and diseases.	Percentage of affectation of plants by pests and diseases
Productivity	Irregular crop development.	Visual indicators of nutrient deficiency.
Productivity	Regular yield	Crop growth curve. Agronomic yield
Resilience (*)	Need to preserve organic horizon and physical properties of soil	Organic matter (as property inferred). Apparent density. Porosity analysis

TABLE 7. SWOT Matrix ("Las Cadenas" Community, Guaicaipuro Municipality, Estado Miranda)

STRENGTHS	WEAKNESSES
Soil quality and appropriate climate. Water availability. Institutional support from INTEVEP Knowledge acquired.	Lack of proper tools. Seed deficiency. Insufficient working hours. Absence of seedbeds and nursery. Lack of irrigation equipment. Dispersion in tasks. Little participation of some students.
OPPORTUNITIES	**THREATS**
Support of the established cooperative. National legal framework that favors agricultural activity. Knowledge of the community by students. Ease of access by public transport. Group cohesion.	Agroecological ignorance of the community. Possibilities of invasion in the plots. Indiscriminate use of agrochemicals in neighboring plots. Difficulty in weed control. High presence of pests in the plots.

TABLE 8. Description of the soil profile ("Las Cadenas" Community)

Horizon	Depth	Borders	Structure	Aggregate size	Degree of aggregation	Color	Texture
A	1 -18 cm	-	Massive	-	-	2.5Y 4/2	Silty clay loam
AB	19 - 47cm	Definite	Granular	Very fine	Moderate	2.5 Y 4/4	Sandy loam
B	48 - 66 cm	Diffuse	Platy	Very fine	Strong	2.5Y 5/4	Sandy
BC	67 - 83 cm	Diffuse	Platy	Fine	Strong	2.5 Y 4/4	Sandy
C	84 - 94 cm	Diffuse	Platy	Fine	Weak	2.5 Y 5/4	Sandy

Figure 5 shows the soil profile of "Las Cadenas" Community, Miranda State.

As in the previous cases, after analyzing the DOFA matrix and the soil profile, the system of indicators was built in a participatory manner (Table 9).

FIGURE 5. Soil profile of "Las Cadenas" Community, Miranda State.

TABLE 9. System of Indicators for "Las Cadenas" Community.

Sustainability attribute	"Critical points" diagnosed in the system	Indicators proposed
Resilience	Loss of soil structure	Structure. % of stable aggregates.
Resilience	Compaction	Apparent density. Porosity Analysis
Biodiversity	Low biodiversity in the soil	Soil macrofauna. Radical biomass
Stability	High number of weeds	Weeds/m^2
Stability	Indiscriminate use of agrochemicals in adjacent plots	Percentage of affectation of plants by pests and diseases. Insect Biodiversity Index

CONCLUSIONS

The results of this work reveal the need to establish clear management mechanisms for producers through the participatory evaluation of their resources and the application of the information obtained through the farm design and the construction of indicator systems, specific for each agroecosystem. Such instruments will allow increasing productive efficiency and enhancing the performance of urban and periurban agroecosystems by focusing management on overcoming the deficient aspects identified through the "critical points", favoring in such systems the integration of methods and the dialogue of knowledge, in order to achieve simplicity and applicability in them, with the purpose of increasing their sustainability.

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