Volume 59, January-December 2025, ISSN: 2079-3480

PASTURE SCIENCE AND OTHER CROPS

CUBAN JOURNAL OF AGRICULTURAL SCIENCE

Journal site: https://cjascience.com Cu-ID: https://cu-id.com/1996/v59e06

GEO-ECOLOGICAL ASSESSMENT OF LANDSCAPES IN RELATION TO SUSTAINABLE LAND MANAGEMENT IN JIMAGUAYÚ MUNICIPALITY

EVALUACIÓN GEOECOLÓGICA DE PAISAJES EN SU RELACIÓN CON EL MANEJO SOSTENIBLE DE TIERRAS EN EL MUNICIPIO JIMAGUAYÚ

A. J. ESPINOSA

Universidad de La Habana, Calle 25 entre I y J, Vedado, Plaza de la Revolución, CP: 10400, La Habana, Cuba.

**Email: adrian.juan82@gmail.com*

Consequences of climate change affect islands such as Cuba, where its impact on agricultural landscapes is evident. Jimaguayú municipality in Camagüey, which has long been dedicated to intensive agricultural production, has affected its landscapes due to the inadequate use of its resources and services. The implementation of tools is necessary to achieve, on a larger scale, the application of good practices, because of their effectiveness in productive sites. The objective of this study is to offer a geoecological assessment of the "*Llanura alta en suelos pardos y húmicos*" landscape, in relation to sustainable land management and climate change adaptation. Methods and techniques for obtaining, analyzing, and processing data and information were applied, such as a bibliographic review, landscape analysis method, and the use of Geographic Information Systems. The study area is analyzed, and a methodological argument is made for landscape assessment in relation to sustainable land management. An evaluation of the landscape under study is presented, resulting in severe environmental problems and an altered geo-ecological state. The need to establish management actions aimed at climate change adaptation at landscape scale was demonstrated.

Keywords: *climate change, geo-ecological analysis, sustainable development*

Las consecuencias del cambio climático afectan estados insulares como Cuba, donde se evidencian su impacto en los paisajes agrícolas. El municipio Jimaguayú, en Camagüey, al dedicarse a la producción agropecuaria de forma intensiva durante mucho tiempo presenta afecciones en sus paisajes, debido al uso inadecuado de sus recursos y servicios. Constituye una necesidad la implementación de herramientas con el propósito de lograr, a una mayor escala, la aplicación de buenas prácticas, debido a su efectividad en sitios productivos. El objetivo del trabajo es ofrecer la evaluación geoecológica del paisaje Llanura *alta en suelos pardos y húmicos* en su relación con el manejo sostenible de tierras y la adaptación al cambio climático. Se aplicaron los métodos y técnicas para la obtención, análisis y procesamiento de datos y la información, como la revisión bibliográfica, el método de análisis paisajístico y el uso de los Sistemas de Información Geográfica. Se analiza el área de estudio y se realiza la argumentación metodológica para la evaluación del paisaje en su relación con el manejo sostenible de tierras. Se presenta la evaluación del paisaje objeto de estudio, resultando en una problemática ambiental severa y un estado geoecológico alterado. Quedó demostrada la necesidad de establecer las acciones de manejo orientadas a la adaptación al cambio climático a escala de paisaje.

Palabras clave: *análisis geoecológico, cambio climático, desarrollo sostenible*

Introduction

The potential offered by integrated landscape planning and management for environmental sustainability makes these spaces ideal for scaling up sustainable land management, which is an urgent need considering environmental degradation and the challenge of climate change. A set of best practices based on sustainable land management (SLM) represents a significant contribution to reversing the ecological footprint of humans on the planet. Essential analyses in SLM address the impact of climate change and variability on ecosystems, natural resources, and social and economic sectors (Primelles *et al.* 2020).

Received: October 10, 2024
Accepted: February 28, 2025
Conflict of interests: The author declares that there is no conflict of interest.
CRediT Authorship Contribution Statement: A. Juan Espinosa: Conceptualization, Investigation, Formal analysis, Writing-original draft.

In the agricultural sector, SLM is primarily applied in a very small area, known as an agroecosystem, where the resources belonging to a specific landscape are properly used and managed. Since the agroecosystem is considered a relatively small unit within the geographic space that constitutes the landscape, sustainability problems outweigh the possibilities of solutions within the agroecosystem itself, without taken into account holistic and integrative approaches, the ability to understand the problem as a whole to implement solutions in larger spatial units, and the participation of social actors and decision-makers. Likewise, the implementation of policies oriented toward greater equality and inclusion, with an emphasis on social protection proposals, is a necessity on the path toward achieving sustainable development (Henry and Hodson de Jaramillo 2021 and de Mesa and Cecchini 2022).

Landscape potential makes it an ideal environment for expanding sustainable land management practices, as natural and economic factors can coexist without conflict to ensure system sustainability. The combination of anthropogenic and natural factors has resulted in a situation of great impact. Currently, erosion caused by human action on nature is occurring at a faster pace (United Nations Convention to Combat Desertification 2022). Landscape potential is determined by a combination of geomorphological, hydroclimatic, biological, and social factors (Martínez 2022).

In Camagüey province, Jimaguayú is a very important municipality for the agricultural production of the area. Its productivity is affected by severe soil degradation, poor water availability despite its numerous reservoirs of this resource, the presence of invasive plants in large areas, declining agricultural production yields, and the exodus of workers, among other factors. Therefore, the introduction of good SLM practices is insufficient for the territory compared to the rapid degradation of natural resources in the context of climate change, which affects the sustainability of the landscape.

The objective of this study is to offer a geo-ecological assessment of the "*Llanura alta en suelos pardos y húmicos*" landscape, in relation to SLM and climate change adaptation. This is part of the SLM Action Plan, aimed at adapting and addressing climate change in the aforementioned landscape of Jimaguayú municipality, which includes eight key result areas.

Materials and Methods

Jimaguayú municipality, belonging to Camagüey province (figure 1), has a surface area of 783.43 km^2 and it is located between 21° 05' 00" and 21° 22' 00" North and 77° 36' 00" and 78° 03' 00" West. It limits with Camagüey municipality to the North, Sibanicú to the East, Vertientes and Camagüey to the West, and Najasa to the South (National Office of Statistics and Information [ONEI] 2019).

The physical and geographical features of Jimaguayú are not significantly different from the vast plain of Camagüey, in terms of climate and relief, with small heights and residual hills. There is a network of rivers and streams, as well as reservoirs and micro-reservoirs with good-quality water. Underground water is less abundant and presents some quality problems, such as salinity and nitrification, resulting from inadequate management. Soils are genetically diverse and have adequate agricultural productivity, which can support agricultural and livestock activity, despite having a group of limiting factors. Forest cover is scarce, as a result of the widespread economic assimilation of the territory, which, in turn, is reflected in its biodiversity, although some remnants of valuable flora, vegetation, and fauna, including endemic species, are preserved (Environmental Bases for Local Food Sustainability [BASAL] 2013).

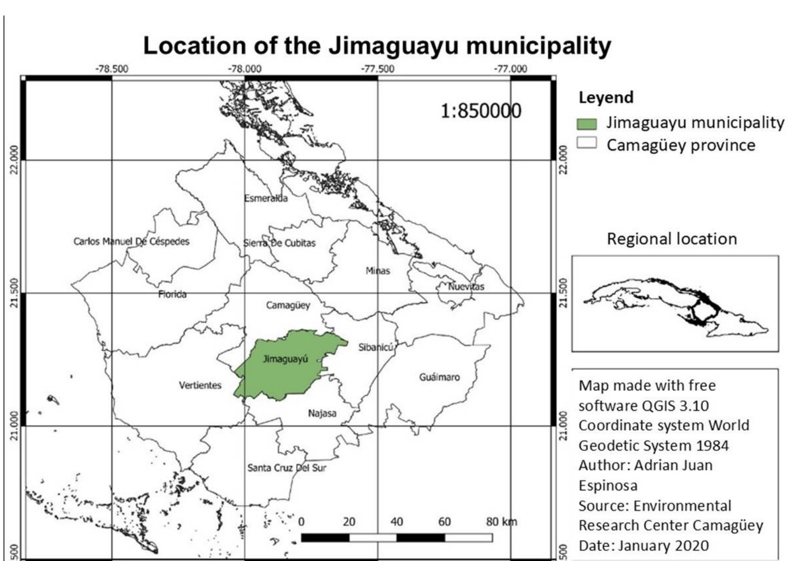

Figure 1. Location map of Jimaguayú municipality

With a population of 20,581, a population density of 26.3 inhabitants/km^2, and modest population growth (ONEI 2019), Jimaguayú has historically lacked the availability of labor resources to guarantee the workforce for the productive and service activities of the municipality. This population resides primarily in small rural settlements that generally lack good services, housing, and adequate access.

From an economic and productive perspective, the land is predominantly used for pastures and large, uncultivated areas, mainly covered with marabou grass (*Dichrostachys cinerea*), which negatively impacts agricultural production. However, the area is a significant dairy and beef production contributor at province and national levels (BASAL 2013).

Methods and techniques used for data collection, analysis, and processing: At the empirical level, the landscape analysis method (Hersperger *et al.* 2021) was applied through its technical and analytical procedures, which made it possible to understand and explain the regularities of the structure and functioning of landscape, study its properties, and determine the indices and parameters on the dynamics, development history, states, formation and transformation processes, as well as aspects related to sustainable landscape management. Functional approach to landscape analysis was used to clarify its structure and functional relationships among its elements.

From this perspective, the genesis of the landscape was analyzed by determining its origin, based on the characteristics and evolution of physical-natural and economic-social factors. Its functioning and structure were evaluated. The landscape environmental status assessment matrix proposed by Sigarreta (2000) was used, with adjustments for characterizing the landscape in its relationship to the MST and analyzing the factors that comprise the landscape. The geo-ecological function of the landscape contributed to the analysis of functional dynamics and degrading geo-ecological processes.

To deep into the functional approach to the landscape, elements of the geo-ecological analysis of the landscape were used: the structural, horizontal and vertical approach (Mateo 1991) to determine the processes that degrade it and the geo-ecological state in which it is. In turn, environmental planning was taken as a basis. In this case, actions for scaling the TDM with a focus on adaptation to climate change were considered.

The spatial analysis method was applied to geographic information management for landscape assessment in relation to SLM and climate change adaptation. Geographic location techniques and various map-based tools were used, with QGIS program version 3.10, at different scales based on the World Geodetic System of 1984 (WGS84) coordinate system.

In the assessment of environmental problems in the landscape under study, an adaptation of the environmental problem assessment matrix (Sigarreta 2000) was used, adjusted by the author, to consider the situations within the landscape. In this sense, and in accordance with BASAL (2013) and Primelles (2018), the environmental problems identified and assessed were deforestation, the impact of climate variability, soil degradation, biodiversity loss, impact of environmental conditions on settlements, the deterioration of savanna and grassland ecosystems, and the insufficient availability of surface and groundwater.

Results and Discussion

As part of the geo-ecological analysis of the landscape, environmental problems and processes that degrade the landscape, along with the geo-ecological state of the landscape and the efficiency of its use by society, were identified. The seven environmental problems of the landscape evaluated coincide with those identified by the environmental planning model for the municipality: deforestation, impact of climate variability, soil degradation, biodiversity loss, impacts on environmental conditions in settlements, deterioration of savanna and grassland ecosystems, and insufficient water availability.

Environmental problems were assessed in the landscape unit using the environmental problem assessment matrix (table 1). Insufficient water availability (28 total points), soil degradation (26 total points), the deterioration of savanna and grassland ecosystems, and impact of climate variability (24 total points) are the main problems of landscapes.

Table 1. Results of the environmental problem assessment matrix (source: author)

"Llanura alta en suelos pardos y húmicos" landscape								
Environmental problem	**I**	**A**	**E**	**MD**	**U**	**TP**	**C**	**T**
Deforestation	3	3	2	2	2	12	1	12
Impact of climate variability	2	3	3	2	2	12	2	24
Soil degradation	3	3	2	2	3	13	2	26
Biodiversity loss	2	2	1	2	2	9	2	18
Environmental conditions in settlements	2	2	3	1	2	10	1	10
Deterioration of ecosystems	3	3	2	2	2	12	2	24
Water availability	3	3	3	2	3	14	2	28
TOTAL								142

Legend: (I) intensity, (A) reach, (E) effect, (MD) dysfunctionality magnitude, (U) urgency, (TP) partial total, (C) character, (T) total

In the overall total, 142 points were obtained, and since this value was in the range of 110 to 212, it was determined that this landscape has a severe environmental problem and an altered geo-ecological state, which corresponds to the adaptation made to the Sigarreta matrix (2000). This is also related to the approach of Urquiza *et al.* (2011), who stated that an agricultural ecosystem that presents some indicator that affects soil, vegetation cover, water availability and life quality will evidently be a degraded ecosystem to a different extent.

The analysis of the existing relationship, significant or non-significant, among the environmental problems identified in the landscape unit and the key result areas of SLM, allowed to recognize the significant relationship that exists among the environmental problems, especially the impact of climate variability, soil degradation and the deterioration of savanna and grassland ecosystems with respect to the key result areas of SLM.

The study of the performance of indicators per key results areas of SLM at the BASAL Project intervention sites, located in the landscape under study (figure 2), which are 13 in total, confirmed the analysis outlined above. At each intervention site, the eight areas proposed by Urquiza *et al.* (2011), and their indicators, were independently evaluated.

As a result of this analysis, La Victoria farm is recognized as an *advanced* intervention site, with 75 % compliance with the requirements. It is also the only one with an SLM plan at the time of this research. The other farms are distributed within the *advanced* (five sites) and *initiated* category (eight). The total calculation of these areas as a whole, places them in the "*initiated*" category, with 49.4 % of the surface of intervention sites.

Total area of the 13 intervention sites is 9,656 km^2, representing 2.45 % of the total area of *Llanura alta en suelos pardos y húmicos,* which is 394,630 km^2. Although the existence of other small areas, where good agroecological practices are implemented, is not ruled out, there is a clear need to increase the area under SLM as a guarantee of landscape sustainability (table 2).

This information was useful in developing the Sustainable Land Management Plan for the "*Llanura alta sobre suelos pardos y húmicos*" landscape of the Jimaguayú Municipality, as well as its eight key result areas described below.

The first group of key result areas for SLM is aimed at environmental management of the landscape segment. For this group, these actions allow decision-making in the development and implementation of management plans for the farms involved. In this regard, Urquiza *et al*. (2011) point out that the selection of management units responds to farmer needs, area characteristics, and selected technology.

Other elements related to this first group are aimed at ensuring the application of technologies in accordance with the characteristics identified for the landscape, appropriate location of spaces for the reception and treatment of solid and liquid residues, as well as an increase of the area in the landscape where good SLM practices are applied, based on the updating and deepening of the integrated diagnosis in productive units. This is one of the most important aspects that would favor the progressive scaling up to the landscape. In this regard, Planos *et al.* (2012) point out the need to establish a set of policies and regulations for territorial planning that contribute to safeguarding human and economic resources of society, reducing accumulated vulnerability, and adapting to climate change. This process, aimed at the sustainable development of the territory, must be cyclical, based on a diverse system that integrates public relations, economic activities, and environmental relations (Salazar *et al.* 2021).

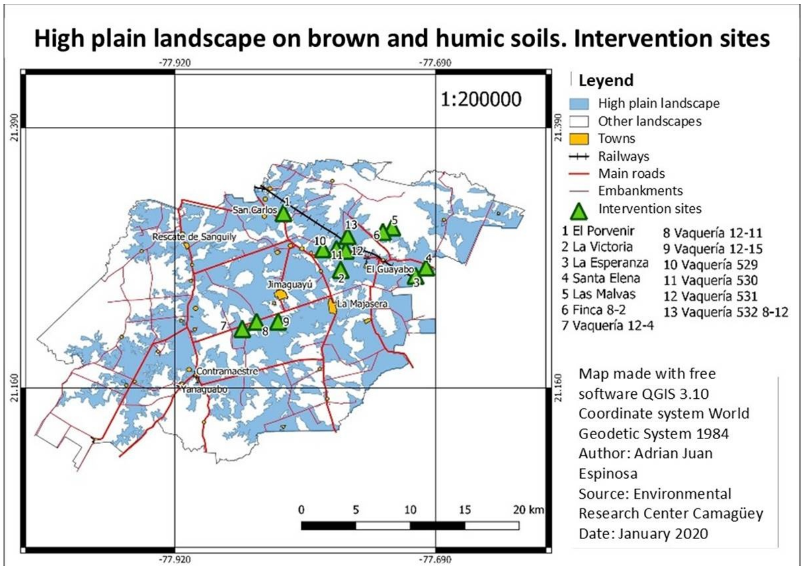

Figure 2. Map of location of intervention sites of "*Llanura alta sobre suelos pardos y húmicos"* landscape

Table 2. Calculation of key results for the SLM, surface under SLM and potential reach of transformation in intervention sites

Intervention sites	Key result areas of SLM											Farm Surface (km²)	Landscape Surface (km²)	Percentage APT
	1	2	3	4	5	6	7	8	TP	Percentage	Category			
La Victoria	3	2	2	2	2	2	2	3	18	75.00	Advanced	1,251	394,630	0.32
Las Malvas	2	1	1	1	2	1	1	2	11	45.83	Initiated	1,303	394,630	0.33
Finca 8-2	2	1	2	1	1	1	1	2	11	45.83	Initiated	0,882	394,630	0.22
Santa Elena	2	2	2	1	2	1	1	2	13	54.17	Advanced	0,614	394,630	0.16
La Esperanza	2	2	2	1	2	1	1	2	13	54.17	Advanced	0,343	394,630	0.09
El Porvenir	2	2	2	1	2	1	2	2	14	58.33	Advanced	0,067	394,630	0.02
Vaquería 12-4	2	2	1	1	2	1	1	2	12	50.00	Advanced	0,663	394,630	0.17
Vaquería 12-11	2	1	1	1	2	1	1	2	11	45.83	Initiated	0,090	394,630	0.02
Vaquería 12-15	2	1	1	1	1	1	1	2	10	41.67	Initiated	1,196	394,630	0.30
Vaquería 529	2	1	2	1	1	1	1	2	11	45.83	Initiated	0,804	394,630	0.20
Vaquería 530	2	1	2	1	1	1	1	2	11	45.83	Initiated	0,538	394,630	0.14
Vaquería 531	2	1	1	1	1	1	1	2	10	41.67	Initiated	0,818	394,630	0.21
Vaquería 532 8-12	1	1	1	1	1	1	1	2	9	37.50	Initiated	1,087	394,630	0.28
Total										49.36	Initiated	9,656	394,630	2.45

Legend: (TP) partial total, (APT) potential reach of transformation:

1- Environmental ordering of landscape segment, 2- Agroecological preparation alternatives of the seminatural site, 3- Selection of crops, plantations, species and their varieties, 4- Alternatives for sustainable water management, 5- Proper agricultural techniques, 6- Adequate methods for ecosystem management, 7- Economical proper use of residues, 8- Energy and economic control

The second group focuses on agroecological alternatives for preparing semi-natural sites. Therefore, it is important to avoid the uncontrolled use of fire as an alternative for waste disposal, weed control, exotic plants, and invasive species, due to the direct and indirect effects it has on flora and fauna, including soil biota, as well as the emission of toxic gases into the atmosphere. However, the application of eco-friendly alternatives is proposed as control. This group also suggests the use of agroecological cultivation techniques and the use of soil improvement and conservation measures with the use of biofertilizers.

Hermida and Manté (2019) state that cover crops and green manures protect the soil against degradation processes, such as erosion and compaction. The use of permanent measures prevents soil and water loss. Among the most widely used, according to the aforementioned authors, are the construction of living barriers, ponds and terraces with plowing, sowing on contour or perpendicular to the direction of the greatest slope, management of cover crops and water independence of fields, minimal tillage, stone collection, and subsoiling.

Hernández *et al.* (2018) also warn that adequate management practices for soil preservation are urgently needed due to the deterioration of the quality of this resource as a consequence of the use of conventional agricultural practices, which do not allow the soil to maintain its long-term viability, resulting in an imbalance of the ecological processes that help maintain sustainability.

For the third group, related to the selection of crops, plantations, species, and their varieties, it is necessary to update and deepen the study on the agricultural productivity of the soil in question. Its results have a significant influence on the selection of crops and plantations that are more resistant to water and heat stress, in accordance with soil suitability, and the use of recommended areas for growing pastures and forages as feed for livestock, mainly cattle. Likewise, the application of techniques related to rotation, alternation, and intercropping of various crops is suggested, with the introduction of up to 10% of new varieties per year.

The above coincides with what was stated by Planos *et al.* (2012), when they express that the recommended actions should be aimed at crop diversification, improving soil conditions, introducing and developing varieties resistant to the new temperature scenario, pest control, protecting production, and soil management. Quispe (2022) suggests that these integrated conditions have a favorable impact on livestock development, based on agro-ecological alternatives. Grassland cultivation leads to the creation of ecosystem services such as carbon sequestration, water availability, soil degradation reduction, and biomass production, which are advantageous for conserving and boosting livestock productivity and improving soil quality.

In the case of the fourth group, which deals with sustainable water management alternatives, it is important to broaden studies aimed at evaluating the water resources available in the landscape and their relationship to resource availability, potential use, recommended exploitation standards, and water quality. It is also a priority to analyze how to guarantee access to a secure supply source, whether for agricultural irrigation, animal intake or social needs. This aspect is one of the greatest challenges facing the landscape and the municipality, as a result of multiple factors that threaten the proper management of this resource, which is largely underutilized due to the volume stored in more than 600 dams and micro-dams located in this area. Emphasis is placed on utilizing the information provided by the Camagüey Meteorological Center regarding weather forecasting to perform proper irrigation operations. There is also an emphasis on good practices in sustainable water management, aimed at building water collection systems, reservoirs, functional drainage systems, reforestation of the surrounding areas of water bodies and water sources, the development of hydro-regulatory strips, and the implementation of various measures to retain soil moisture.

Morales *et al.* (2016) explain that changes in the structure and composition of livestock systems contribute to the water cycle, because plant stratification reduces soil evaporation, improving its texture and structure, which regulates water infiltration, facilitates aquifer recharge, reduces surface runoff and erosion processes.

The fifth group, which corresponds to appropriate agricultural technology, proposes creating conditions for local assurance of certified seed production or its acquisition, if it is not possible to obtain them through local management in the landscape. Planting of crops that are suited to soil characteristics, climate behavior, and respect for the cultural traditions of producers and communities should be promoted.

In this group, the application of integrated alternatives for pest and disease control is suggested by combining different types of treatments (mechanical, chemical, manual, and biological) as long as they do not contradict specific landscape guidelines or SLM procedures. Finally, the implementation of alternatives for the conservation, processing, and marketing of food and products grown in the landscape is proposed. In this regard, Díaz (2019) asserts that the impact on biodiversity generated by various agricultural practices will depend on the use of agrochemicals, pesticides, and their management.

In the sixth group, identified with appropriate methods for ecosystem management, it is important to achieve increased sustainability of environmental goods and services in the landscape through the implementation of good SLM practices. These should be aimed at protecting and promoting biodiversity, increasing soil preservation and improvement measures, and reforesting the areas. The construction of layered living fences and windbreaks, hydro-regulatory forest strips, natural corridors, and agroforestry systems is also proposed, as the ecological advantages and services each offers to the landscape as a whole and to the economic benefit of the areas that host them are widely recognized. Therefore, the integrated management of the landscape's forest resources must also be guaranteed, and the use of non-timber resources that can be obtained should be encouraged.

It is advisable to reforest the hydro-regulatory belt with different fruit and forest species to ensure food and economic benefits. By developing a mix of forage shrubs, trees, and grasses with cattle production, silvopastoral systems represent a good alternative to help mitigate the impact of livestock activity on the environment. Because each landscape has its own dynamics, its management shapes the landscape, and the changes made should be in accordance with its purpose, taking temporary or permanent form, depending on land use (Miranda *et al.* 2022).

According to Morales *et al.* (2016), trees on farms improve connectivity among landscapes and serve as biological corridors for various species, constituting buffer zones along grasslands. Forest restoration is a fundamental strategy for recovering the ecological functions of the landscape. Calle *et al*. (2014) made some recommendations for agroforestry systems, which were the inclusion of at least 10 tree species, the use of native trees that retain a minimum of 40% shade throughout the year, maintain a height of 12 to 15 m in different strata, and the creation of the greatest possible diversity.

Regarding the seventh group, the economic use of waste, the proposal is to build systems or plants for the treatment of solid and liquid waste, biodigester and biomass systems, and the use and marketing of products obtained from the treatment of these residues, particularly livestock waste, biomass obtained from invasive plants, and the recovery of raw materials, which can generate income for producers and institutions. The use of crop residues as animal feed is proposed. Practices using different agroecological techniques should be developed, involving the use of solid and liquid waste generated, primarily those resulting from agricultural activities carried out in the landscape.

Ascanio (2017) considers the need to design and promote a plan so that the management of the components and the final disposal of residues is a controlled activity, with joint participation of the local government and the citizens. Díaz (2019) also proposes identifying and analyzing the indicators and the polluting characteristics generated by the productive actions in each of the stages of the process, such as the management of soil, water and air, in addition to solid vegetable waste, as well as plastic containers that have a negative impact on the environment.

Finally, the eighth group, which refers to economic and energy control, requires control and measurement of the costs of productive activities, as well as the resulting economic benefits, whether in products, the productivity generated by the land itself, and the monetary assets acquired as a result of the previously mentioned activities. It is also proposed to implement measures that promote energy savings, such as the use of biodigesters based on animal manure and contributing to the reduction of fuel imports.

It is important to focus on the economic, social, and political dimensions, as the interaction among these processes is still not systematically understood. In this regard, Casimiro (2016) believes that pricing policy should be adjusted to the costs of agroecological farm production to encourage better prices for import-substituting products, while also contributing to the quality and freshness of products offered in the local market. Furthermore, this expands the collective benefit, especially for developing nations, where job opportunities require the creative capacity, leadership, and resilience of disadvantaged sectors of the rural population (Jurado 2022).

Conclusions

As a result of the evaluation of the *Llanura alta en suelos pardos y húmicos* landscape in its relationship with the SLM, it is evident that there are severe environmental issues and an altered geo-ecological state, which compromise the sustainability of this large geographical area.

The landscape assessment conducted is the basis of the SLM Plan, which is directed toward adaptation and response to climate change, in line with the challenges posed by its impact on the sustainability of this geographic area.

Acknowledgements

Thanks to the Faculty of Agricultural Sciences of the University of Camagüey for hosting this study and to CIMAC and the BASAL Project for their collaboration and provision of information.

References

Ascanio, F.H. 2017. Plan de manejo de residuos sólidos urbanos para el distrito de El Tambo según las recomendaciones de la Agenda 21 Available at: http://repositorio.uncp.edu.pe/-bitstream/handle/UNCP/4130/Ascanio%20Yupanqui.pdf?sequence=1&isAllowed=y [Consulted: February 27, 2021].

Bases ambientales para la sostenibilidad alimentaria local [BASAL]. 2013. Modelo de Ordenamiento Ambiental. Municipio Jimaguayú. Editorial AMA. La Habana, Cuba.

Calle, A., Calle, Z., Garen, E. & Del Cid-Liccardi, A. 2014. Experiencias de fortalecimiento de capacidades para la restauración ecológica en America Latina. Simposio sobre Restauración Ecológica y Agropaisajes Sostenibles. Iniciativa de Liderazgo y Capacitación Ambiental. New Haven, CT: Universidad de Yale; Ciudad de Panamá: Instituto Smithsonian de Investigaciones Tropicales. Available at: https://www.researchgate.net/profile/Severino_Pinto2/publication/309618686_Experiencias_de_fortalecimiento_de_capacidades_para_la_restauracion_ecologica_en_America_Latina/links/581a206608ae3c82664c17e9.pdf [Consulted: February 15, 2017].

Casimiro, L. 2016. Necesidad de una transición agroecológica en Cuba, perspectivas y retos. *Pastos y Forrajes*. 39 (3): 81-91, ISSN: 2078-8452. http://scielo.sld.cu/scielo.php?script=sci_serial&pid=0864-0394&lng=es&nrm=iso.

De Mesa, A. & Cecchini, S. 2022. Igualdad y protección social: claves para un desarrollo inclusivo y sostenible. *El Trimestre Económico*, 89(353): 257-309, ISSN: 2448-718X. https://www.eltrimestreeconomico.com.mx/index.php/te/article/view/1407.

Díaz, C.J. 2019. Implementación de un plan de manejo ambiental al sistema de producción de aguacate Hass en la finca Jireh, vereda La Claridad, municipio de Popayán. Available at: https://repository.unad.edu.co/bitstream/handle/10596/33267/cjdiazp.pdf?sequence=4&isAllowed=y [Consulted: February 27, 2021].

Henry, G. & Hodson De Jaramillo, E. 2021. Bioeconomía, modelo para un desarrollo territorial sostenible e inclusivo. Available at: https://agritrop.cirad.fr/597552/7/ID597552.pdf [Consulted: May 20, 2023].

Hernández, C.E., Carrazana, Y.B., Quintana, L.J. & Vega, M. 2018. Prácticas de conservación de suelos en la Finca Eliecer del municipio Cumanayagua, Cuba. *Revista Científica Agroecosistemas,* 6(2): 112-120, ISSN: 2415-2862. https://ceema.ucf.edu.cu/index.php/aes/article/view/200/229.

Hermida, M. & Manté, M. 2019. Los indicadores ambientales para la medición del desarrollo sostenible de Tierra del Fuego. *Informes Científicos Técnicos (UNPA),* 11(1): 1-27, ISSN: 1852-4516. https://131.161.88.152/index.php/ICTUNPA/article/view/590.

Hersperger, A.M., Grandinaru, S.R., Pierri Daunt, A.B., Imhof, C.S. & Fan, P. 2021. Landscape ecological concepts in planning: review of recent developments. *Landscape Ecology*, 36(8): 2329-2345, ISSN: 1572-9761. https://link.springer.com/article/10.1007/s10980-021-01193-y.

Jurado, I.M. 2022. Emprendimiento rural como estrategia de desarrollo territorial: una revisión documental. *ECONÓMICAS CUC*, 43(1): 257-280, ISSN: 2382-3860. https://revistascientificas.cuc.edu.co/economicascuc/article/view/3510/3929.

Martínez, A. 2022. Paisaje cafetero de la montaña de Ibagué, Colombia: un estudio ecológico a escala de geofacies y geotopos. *Cuadernos de Geografía: Revista Colombiana de Geografía,* 31(1): 65-87, ISSN: 2256-5442. https://doi.org/10.15446/rcdg.v31n1.80997.

Mateo, J.M. 1991. Geoecología de los paisajes. Apuntes para un curso de postgrado. Universidad de los Andes, Mérida. 256 p.

Miranda, L., Peñaherrera, O. & Jorge, A. 2022. Paisajes rurales: Identificación y caracterización de componentes de paisaje. Parroquia Cotaló. Tungurahua. *MÓDULO ARQUITECTURA CUC*, 28: 157-188, ISSN: 2389-7732. https://revistascientificas.cuc.edu.co/moduloarquitecturacuc/article/view/3931/3904.

Morales, S., Vivas, N.J. & Teran, V.F. 2016. Ganadería eco-eficiente y la adaptación al cambio climático. *Biotecnología en el Sector Agropecuario y Agroindustrial*, 14(1): 135-144, ISSN: 1692-3561. https://doi.org/10.18684/BSAA(14)135-144.

Oficina nacional de estadísticas e información [ONEI]. 2019. Anuario Estadístico 2018 Jimaguayú. Edición 2019. Available at: http://www.one.cu [Consulted: February 03, 2020].

Planos, E., Rivero, R. & Guevara, V. 2012. *Impacto del cambio climático y medidas de adaptación en Cuba*. La Habana, Cuba. Available at: http://revistaccuba.sld.cu/index.php/revacc/article/view/247. [Consulted: April 25, 2018].

Primelles, J. 2018. El Modelo de Ordenamiento Ambientalen sitios de intervención del Proyecto Bases Ambientales para la Sostenibilidad Alimentaria Local. CCS Evelio Rodríguez. CIMAC, Camagüey, Cuba.

Primelles, J., Iglesias, R. & Cabezas, R. 2020. Manejo sostenible de tierras en la adaptación al cambio climático en la comunidad La Gloria, Camagüey. *Revista Agrisost,* 26(2): 1-11, ISSN: 1025-0247. https://core.ac.uk/download/pdf/288205815.pdf.

Quispe, T. 2022. La agroecología como alternativa para el desarrollo sostenible y sustentable. *CIENCIAMATRIA*, 8(14): 33-45, ISSN: 2610-802X. https://cienciamatriarevista.org.ve/index.php/cm/article/view/605/923.

Salazar, J., Vergara, A., Sorhegui, R. & Garnica, L. 2021. Repensando el Desarrollo Sostenible en el territorio. *RES NON VERBA: Revista Científica*, 11(1): 19-33, ISSN: 2661-6769. https://3.14.189.95/index.php/rnv/article/view/500/324.

Sigarreta, S. 2000. Diagnóstico Geoecológico del Municipio de Holguín. Tesis de Maestría, Facultad de Geografía, La Habana, Cuba.

United Nations Convention to Combat Desertification. 2022. The Contribution of Integrated Land Use Planning and Integrated Landscape Management to Implementing Land Degradation Neutrality. Available at: https://www.unccd.int/sites/default/files/2023-09/UNCCD%20Integrated%20Land%20Use%20Planning-rev.pdf [Consulted: November 10, 2023].

Urquiza, M.N., Alemán, C., Flores, L., Paula, M. & Aguilar, Y. 2011. Manual de procedimientos para el Manejo Sostenible de Tierras. La Habana, Cuba. CIGEA.