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Evaluating University Gardens as Innovative Practice in Education for Sustainability: A Latin-American Case Study

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Abstract: The aim of this study was to define a protocol for evaluating university gardens as innovative practice in Education for Sustainability and to apply it to a Latin-American study case, that of the Agroecological Garden in the Faculty of Biology at the Veracruzana University (Mexico). A comparative evaluation was conducted between two different moments (December 2018 and January 2021) based on sustainability indicators that were adapted from the SAEMETH-G methodology, using three levels of increasing complexity. These levels were the selection of sustainability dimensions, the individuation of the components, and the selection of the appropriate indicators. At the beginning of 2021, the selected Agroecological Garden showed high sustainability, with an accumulated score of 84.04 out of a total of 100 points, with the agro-environmental dimension being the best positioned (93.74), followed by the socio-educational (91.99) and the economic-administrative (66.4) domains. A significant robustness at the socio-environmental level was evidenced. However, it is necessary to address the substantial deficiencies evidenced at the economic-administrative level, especially in relation to financing and institutionalization, in order to make this innovative didactic resource sustainable and thus contribute to education for sustainability among university students.

Keywords: indicators; university gardens; SAEMETH-G; sustainability

Citation: Fontalvo-Buelvas, J.C.; Eugenio-Gozalbo, M.; de la Cruz-Elizondo, Y.; Escalona-Aguilar, M.Á. Evaluating University Gardens as Innovative Practice in Education for Sustainability: A Latin-American Case Study. *Sustainability* **2023**, *15*, 3975. https://doi.org/10.3390/su15053975

Academic Editors: Pilar Azcárate Goded, Rocío Jiménez Fontana and Esther García-González

Received: 3 January 2023
Revised: 14 February 2023
Accepted: 15 February 2023
Published: 22 February 2023

1. Introduction

At present, higher education institutions in Latin America face different challenges that test their prestige in the education sector. To obtain the recognition of society, several aspects require strengthening and improvement on a permanent basis [1]. The main challenges are to fulfil substantive functions, build a fair society, strengthen cultural identity, transform educational systems, make effective use of new technological resources, conduct research that meets local needs, create links with companies, resolve funding issues, innovate in processes, tirelessly pursue educational quality, and promote sustainable development [2].

To deal with these challenges, some Latin-American universities have made use of gardens, both for educational and productive purposes, as these resources enjoy increasing popularity throughout the world and in all stages of education from Early Childhood and Primary Education to Secondary and Higher Education [3–5]. Gardens are real-life contexts which can promote learning in a wide variety of fields [6], being particularly useful in relation to scientific and environmental education [7–9]. They facilitate an active, experiential, and integrated approach [10], and the use of participatory methodologies addresses real needs.

Vegetable gardens (The term garden is wide; an instructional garden may include ornamental plants and other elements, such as a pond and its associated fauna). In this work, we refer to a space where mainly edible plant species are cultivated, and where compost heaps and/or vermicompost heaps are also found. Thus, we will use the term "garden" as synonymous with "vegetable garden" throughout the text) have recently been found to be highly valuable educational resources for addressing issues related to agriculture, food, and the environment at universities, within the framework of the sustainability issues raised by the 2030 Agenda and the SDGs [11–14]. These spaces are, thus, valuable instruments of environmental education for sustainability, through which it is possible to raise awareness by generating spaces for dialogue and reflection [15], especially on issues such as food security and sovereignty, solid waste management, consumerism, healthy lifestyles, and sustainability [14,16]. In this sense, to talk about sustainability and promote it through university gardens, it is strictly necessary that these spaces present sustainable features and that they remain over time [17]. However, it is important to note that these areas face challenges, such as a transient and inexperienced student population, that may affect their management. In addition, administrative and funding problems exist that threaten their permanence [18,19].

As a result, special attention has been paid in recent years to assessing the sustainability of urban agriculture and gardens as units within this phenomenon, using multiple methods and tools. Studies have used differing methods, such as in-depth interviews, participant observation [20], surveys [21], landscape metrics [22], life cycle assessment [23], and footprint metrics [24]. However, an important limitation has been the inability of these assessment methods or tools in capturing the multidimensional nature of urban agriculture. This challenge has been addressed by the MESMIS methodology [25] and the SAEMETH-G methodology [26], as well as by recent work testing indicators that are increasingly easy to use and interpret [27,28]. At this point, it is worth noting that these instruments have been applied to home and neighborhood gardens, but very rarely to school [29] or university gardens.

The aim of this study was to evaluate, by means of comparison and indicators, the sustainability of the Agroecological Garden of the Faculty of Biology of the Veracruzana University (Mexico), with the intention of measuring progress after an intervention process to enhance the garden that took place between 2019 and 2021 [30]. This assessment is expected to allow for identifying deficiencies and strengths, a basic input for establishing a continuous improvement plan in the future. Overall, this work shows a case study in which the sustainability of a selected garden is assessed in two key moments, before and after an intervention, by applying a pre-existing methodology which was adapted.

2. Materials and Methods

2.1. Study Area

The scope of intervention of this study is the Faculty of Biology, Campus Xalapa, belonging to the Veracruzana University. This academic institution, founded in 1968, regularly has 745 students enrolled on its Degree Course in Biology, 43 academics, and 35 support workers (administrators, secretaries, cleaners, gardeners, and others). Meanwhile, the space used since 2010 as a garden within the Campus Xalapa is a green area of 323 m^2, considered a classroom laboratory with various areas (Table 1) that provide different learning opportunities [30]. This garden was selected to conduct this study based on two main criteria: on the one hand, it treasures a long and continuous use from 2010. On the other, it has the largest number of evaluable components, which makes it ideally positioned to obtain a broader notion of its state of sustainability. An average of 15 students in different semesters work in this garden, forming a group that provides agroecological maintenance for the garden vegetables [31]. The representative of the garden and the main promoter of this initiative is a full-time teacher of the Faculty of Biology, who uses this space as a didactic resource, along with other colleagues. Since its inception, the project leader and the students who form the collective of the garden have conceived agroecology as the central axis of the management of the garden. Agroecology is a multidimensional discipline that applies the concepts and principles of ecology to the design, development, and management of sustainable agricultural systems. Within its approaches, agroecology presents a holistic vision of the agro-food system, from agroecosystems to the plate; it is also conceived as a socio-political resistance movement; finally, at the plot level, it provides a set of management practices that seek sustainability.

Table 1. Areas of the Agroecological Garden of the Faculty of Biology.

Area	Dimension	Description
Storage	48 m^2	Tool shed.
Seedbed	15 m^2	Five seedbeds.
Seed bank	1 m^2	Three-shelf drawer with 15 groups of seeds.
Compost	48 m^2	Two compost piles, a circular and a worm.
Educational	45 m^2	Area covered with slate and down.
Experimental	116 m^2	Eight grow beds and a *milpa* (a traditional Mexican crop-growing field).
Medicinal and aromatic	50 m^2	Three triangular beds and one square, with 25 species.

2.2. Methodology for Assessing Sustainability

The sustainability of the Agroecological Garden was evaluated using the adapted application of an interpretive structure called "Sustainable Agrofood–Garden Assessment Methodology" (SAEMETH-G), derived from an analogous model built for small-scale agriculture [26]. This methodology includes sustainability indicators that are built through three levels of increasing complexity. First, the dimensions of sustainability are selected (Table 2); then, the components are individualized; finally, several indicators are defined as described in Tables A1 and A2. The selection of socio-educational and agro-environmental dimensions, together with their indicators, was adapted from the SAEMETH-G method for school gardens [29]. Meanwhile the economic–administrative dimension and its indicators were mostly of our own preparation, considering the university context of the garden to be evaluated. However, all levels of indicators and their proportional values were of their own making.

Table 2. Dimensions, components, and the number of indicators of sustainability.

Dimensions	Socio-Educational	Agro-Environmental	Economic-Administrative
Components	Internal relations and external relations.	Biodiversity and agricultural practices.	Financing and institutionalization.
Number of indicators	16	16	6

Note: To compensate for the imbalance in the number of indicators per dimension, the weight per indicator for the economic-administrative dimension is 16.6, while for the others, it is 6.25.

Regarding the weight of the dimensions, equal importance (value = 100) was attributed to each of the three dimensions in the total sustainability measure, considering that no dimension is more important than another dimension, but all are complementary in fulfilling of the functions of the university garden. The definition of the components and the attribution of weights to the components of the various dimensions with the system of equal weights were as follows: (a) for the socio-educational dimension, we selected two components (internal and external relations) with a weight equal to 50 each; (b) for the agri-environmental dimension, we chose two components (biodiversity and good agricultural practices) with a weight equal to 50 each; and (c) for the economic-administrative dimension, two components (financing and institutionalization) were selected, also weighing 50 each.

Several indicators were tested for each component, as well as several maximum and minimum values for the indicators. Quantitative and qualitative data were considered for the selection of indicators. In addition, for each of the indicators chosen, a minimum threshold (0 = for the worst situations) and a maximum threshold (10 = the best situations) were defined and then adapted to the weights defined in each dimension. The reference values were derived from the direct observation of the agroecosystem and, in some cases, from the rapid techniques available. Finally, a set of 38 indicators grouped into the three dimensions was established to evaluate, as described, the sustainability of the university garden. In addition, individual levels and values (depending on the weight of the indicator) were defined for all indicators—for example, two levels (dichotomous: presence–absence), as well as three levels and four levels (ranges: proportions and percentages).

2.3. Collection and Processing of Data

The data were collected collectively by a commission of four students and one teacher, belonging to the collective of the Agroecological Garden, who had the task of recording the information in retrospect for two specific moments of the garden, the first in December 2018 and the second in January 2021 (for indicators in Tables A1 and A2). To this end, a total of thirteen meetings were held from 9 a.m. to 3 p.m. to record the data in the scoreboards: six in January 2019 to collect the information, six in February 2021, and an additional one in March 2021.

Data related to the socio-educational and economic-administrative dimensions were collected through documentary research, a qualitative research technique that collects and selects information through the targeted reading of documents of interest. In this case, administrative and academic documents such as attendance logs, social service and volunteer cards, theses, articles, and book chapters related to the Garden were reviewed. Regarding data related to the agro-environmental dimension, data on the biodiversity component were collected by using field techniques (total plant population count, photographic record, visual soil assessment) and recorded on a record sheet. The above information was supplemented with data from the sowing calendar and from biweekly monitoring (10 a.m. and 3 p.m.) that the Agroecological Garden has. On the other hand, data on the agricultural practices' component were collected by direct observation and recorded in a checklist. Finally, all collected data were transformed into point values, according to the levels of indicators (Tables A1 and A2).

Once the data were recorded, they were graphed in radar form to show, together, the components of total sustainability, regardless of their size. This was possible thanks to the approach of using equal weights with respect to the size of each. The values of the indicators for each component analyzed were placed along the axes of the scaled radial diagram from 0 to 50, from the worst (0) to the best (50). Therefore, the outer ring of the diagram represents the optimal values measured for each component. All data processing and graphing were performed in Microsoft Excel, version 2019.

3. Results

The results obtained from the final sustainability evaluation applied to the Agroecological Garden showed a cumulative score of 84.04 out of a possible total of 100 points (see Tables 3, A1 and A2). The agro-environmental dimension was the best positioned (93.74), followed by the socio-educational (91.99) and economic-administrative (66.4) domains. This reflects a significant strength at the socio-environmental level and a significant shortfall at the economic and administrative levels, especially regarding internal financing and institutionalization. After two years, it was possible to progress from an initial state of 44.06 to a final one of 84.04, reflecting an advance of 39.76 points. In this sense, the socio-educational dimension was the most highly enhanced, increasing from 34.36 to 91.99, accounting for a rise of 56.98 points. Likewise, the agro-environmental and economic-administrative dimensions also improved, with one-off gains of 12.52 and 49.8, respectively.

Table 3. Comparative assessment of the sustainability of the garden by dimensions and components.

Dimensions	Components	Initial Score by Components	Final Score by Components	Initial Score by Dimensions	Final Score by Dimensions	Final Balance
Socioeducational	Internal relations	17.18	41.99	34.36	91.99	+56.98
	External relations	17.18	50			
Agro-environmental	Biodiversity	43.74	46.87	81.22	93.74	+12.52
	Agricultural practices	37.48	46.87			
Economic-administrative	Financing	16.6	33.2	16.6	66.4	+49.8
	Institutionalization	0	33.2			
Sustainability score				44.06	84.04	+39.76

Note: Initial score for December 2018 and final score for January 2021.

The radar graph (Figure 1) shows the distribution of the various components evaluated for each sustainability dimension. It is particularly interesting that four of the six components show values of more than 41 out of 50. In contrast, the funding and institutionalization components showed the lowest scores (32.2). Visually, some differences in the agro-environmental dimension can be seen in Figure 2, which are the results of redesigning, including a redistribution of areas and crops, considering functional diversification.

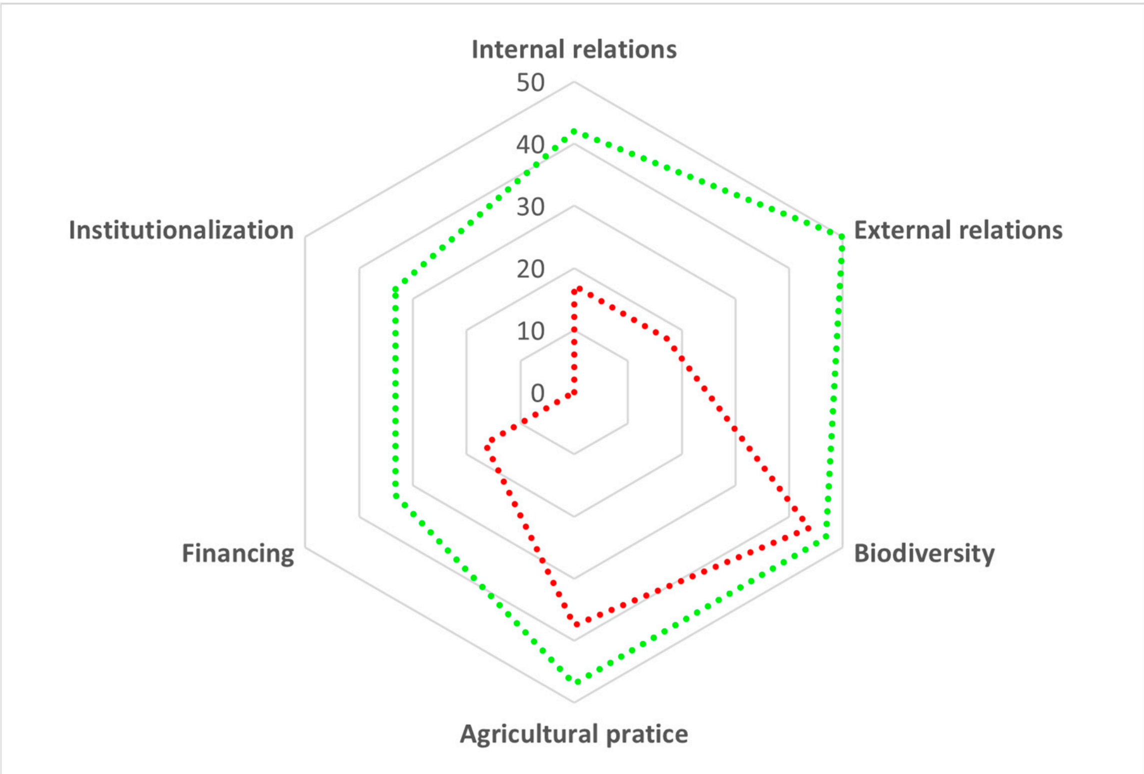

Figure 1. Visual representation of the comparative sustainability assessment of the Agroecological Garden of the Faculty of Biology at the Veracruzana University (Mexico). Note: Red shows the initial situation (December 2018), and green shows the final situation (January 2021).

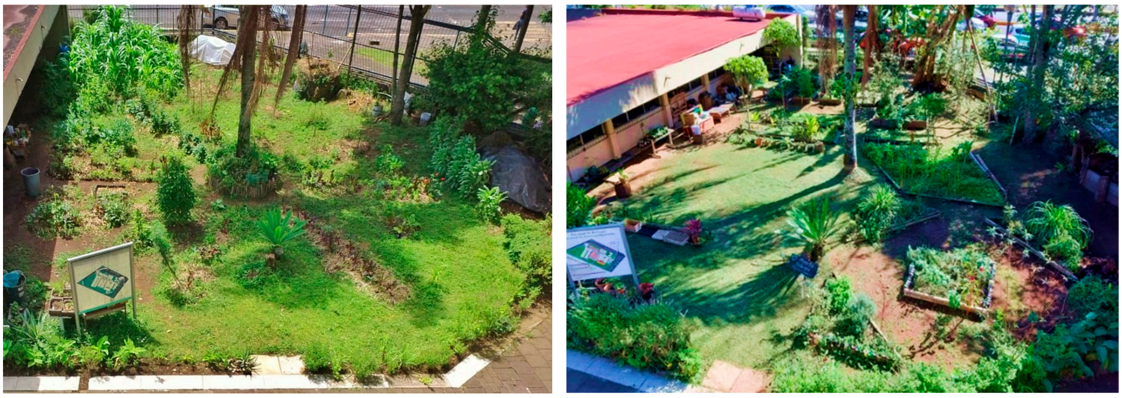

Figure 2. View of the vegetable garden in December 2018 (**left**) and January 2021 (**right**). More pictures are available at: https://www.facebook.com/HuertoAgroecologicoBiologiaUV/photos (accessed on 14 February 2023).

4. Discussion

The adaptation of the SAEMETH-G methodology appears to be a useful monitoring tool for university gardens when the final objective is to seek continuous improvement in sustainability. This study constitutes the first occasion on which the SAEMETH-G method has been adapted, applied to a university garden, and used to comparatively evaluate two specific moments. Thus, some differences and similarities arise in this study with respect to the assessment developed by Sottile et al. [29] for 15 school gardens in Kenya. For example, the school gardens showed an average sustainability of 56.66, with values ranging from 50.00 to 63.33, which are values higher than the initial evaluation (44.06) of the Agroecological Garden but lower than its final one (84.04). The agro-environmental dimension was predominantly low (values less than 40) in school gardens, especially due to deficiencies in agricultural practices, whereas at the Agroecological Garden, it remained high at both considered times (values of 81.22 and 93.74, respectively). Regarding the social dimension, all school gardens scored high values (above 70), whereas an intermediate value between 34.36 and 91.99 was obtained in our comparative assessment, indicating the need to strengthen external relations and to learn to communicate results. Regarding the economic dimension, school gardens presented high values thanks to funding from government institutions, local non-governmental organizations, as well as NGOs and foreign associations. In our case, this was the dimension that scored the lowest, and, although this did not compromise sustainability in general, it would be advisable to look for external financing to optimize processes and have a greater scope.

In the case of the Agroecological Garden, the results of the evaluation provide a comprehensive overview of the dimensions in which significant progress has been made and point to the areas in which improvement is still necessary. In the following paragraphs, we aim to address the reasons underlying the progress observed for each sustainability dimension.

4.1. Socio-Educational Dimension

On the one hand, the good internal relations largely respond to the recent establishment of a horizontal organization of the team leading the garden community. This allowed for the design and implementation of various awareness-raising activities, in which the integration of the various community actors was achieved [32]. At the beginning of the period evaluated, a call for volunteering and social services was opened, which attracted students in different semesters, including many women who began to play a leading role in the organization of the garden community. These students quickly became spokespersons for the activities of the garden and began to collaborate with great enthusiasm in the tasks around the garden.

On the other hand, a process of a direct approach with teaching staff enabled them to find links between the Agroecological Garden and the subjects they teach. This led to them offering the course "The garden as a didactic resource in support of university teaching", from which a teaching session planner and a manual for school practices were generated. Both documents are essential in guiding students and teachers about using the garden through the development of planned pedagogical processes, with the garden as the core teaching–learning context. These issues also involved the implementation of research processes, mainly related to environmental education and composting.

Similarly, the outstanding qualification of the external relationship is due to the planning and implementation of a process of the dissemination of information on Facebook and a web page on the university portal. Additionally, broadcasts on state radio and television programs were facilitated, as well as reports in local newspapers. Such communication channels were key to achieving community outreach and to promoting the transfer of knowledge. In this way, needs in the educational and productive sector were perceived, a subsequent response was provided through the implementation of school gardens, and advice was given to small farm holders in the area on how to move towards sustainable agriculture.

An aspect of great importance is the links and alliances established between a university garden and the external community. In our case, there were different participations in the Network of Gardens of the Veracruzana University, the Network of Urban and Peri-urban Agriculture of Xalapa, the Network of School and Community Gardens of Xalapa, the Network of Educational Gardens of Colombia, and the International Network of School Gardens. These articulations provide spaces for participation, exchanging experiences, and learning [33] but also allow related goals to be set, progress to be recognized, shortcomings to be identified, common mistakes to be avoided, and continuous improvement to be achieved. Similarly, collective activities were registered with different departments of the City Council, including the Department of Agroecology and Environmental Education and the Solid Waste Management Sub-directorate [34], as well as with the Government of Xalapa, through the Social Welfare Secretariat, to support social projects. These alliances allowed for the exchange of seeds and seedlings, specialized talks for the internal community, and the visibility of the activities conducted. However, it is still necessary to establish alliances with the private sector to meet specific needs, transfer knowledge and obtain financing [35].

In general, the outstanding results of the socio-educational dimension are due to the social management processes generated in the internal and external community [36]. To strengthen this aspect, it is essential to develop organizational and pedagogical management capacities in the garden community so that they can overcome the complexity involved in the varying interests of actors, sectors, and powers of the university environment [37]. At this point, practical and methodological conceptions of social management are fundamental to generating dynamic, fair, and empathetic relationships [38], as well as to building a learning community around the garden that can maintain the principles of participation, cooperation, agreement, and coexistence [39].

Under this scenario, one of the final aims of social management in the university garden should be that related individuals have a strong sense of appropriation both with one another and with the location [40]. In particular, the ties that individuals establish with gardens can be analyzed from multiple perspectives, such as the attachment to public space, place identity, social identity, or symbolic space [41,42]. However, it has already been evidenced that social appropriation allows for the collective construction of public space, the emancipation of communities, and the promotion of sustainable initiatives [43]. In the case of our Agroecological Garden, this appropriation has likely been promoted by the definition of clear aims that respond to local needs, the support for substantive functions of the Faculty of Biology, the opening-up to free participation, and the increase in urban gardens in the city of Xalapa.

4.2. Agro-Environmental Dimension

The outstanding results of the agri-environmental dimension largely respond to the recent adoption of agroecology as part of the design and management of our university garden, which eventually became a distinctive characteristic. During 2019, the garden was redesigned based on the principles of functionality and practicality [44], for which an agroecological design was chosen [45,46], and the indications of methodological guides on establishing educational gardens were followed. This process consisted of optimizing spaces and resources so that the garden could be transformed into a dynamic green area capable of responding to the substantive functions of the Faculty of Biology. In other words, after the redesign, the garden was expected to have the basic operational elements allowing it to function as a classroom–laboratory suitable for teaching sessions consisting of educational experiences, school practices, and community outreach activities.

The collective redesign was achieved thanks to the implementation of a volunteer and social service program, in which 23 students of Biology, Agronomy, Pedagogy, and Psychology participated, in collaboration with the gardening staff of the faculty. For this process, different agroecological practices that were intended to maintain soil and plant health were considered [47]. Such practices include reduced tillage, organic fertilizer, crop association and rotation, live barriers or fences, the use of native seeds, and the agroecological management of pests and diseases. Additionally, although cultivation beds are mulched to retain soil moisture, it is still necessary to integrate a water collection system and to design an irrigation system that permits the responsible use of water. All the above-mentioned elements favor the establishment of synergies and biomass recycling, which increases energy efficiency and promotes the agroecosystem's resilience [7,47].

In this sense, to maintain the agro-environmental dimension of university gardens, they must be managed by using alternative models to those offered by conventional agriculture, especially in relation to the dependence on external inputs [48]. Therefore, it is recommended that these educational spaces are managed based on permaculture [49], organic [17], agroforestry [50], or agroecological [51,52] approaches, all of which are grounded in the imitation of natural ecosystems. In our case, agroecology was chosen because it is a multi-epistemological discipline that is closely related to the content of the degree in Biology and because it offers a holistic vision of agri-food systems [53]. Agroecology is considered a science and a set of practices but also a social, environmental, and political movement of resistance [52,54], which provides more elements of reflection for an integrated education.

Under this scenario, the principles of agroecology provide a sustainability model that can be applied through various techniques and strategies in university gardens [55]. However, the appropriation of agroecology in these cultivated spaces greatly depends on the availability of resources, the interests of the group that undertakes it, and its institutionality [56]. When the conditions at the university are favorable, the agroecological proposal involves collectively designing and managing an agroecosystem and maintaining the structure and function of the surrounding natural ecosystems [57]. During this process, awareness is raised regarding our relationship with the environment through more responsible farming systems that have a favorable impact on the health, nutrition, and well-being of the educational community [58].

4.3. Economic-Administrative Dimension

The economic-administrative dimension presented, on the one hand, a great advance in terms of institutionalization and, on the other hand, a substantial challenge in terms of financing. However, self-financing has enabled us to maintain the garden in operation for five years. This has been possible thanks to the exchange of plant material with other gardens and government entities, the sale of self-made books, the teaching of certified courses, and donations in exchange for training. However, it is necessary to obtain external financing sources, a matter that has already been attempted, but without success as yet. On the other hand, the achievement of internal sources of financing is being advocated for, given the growing institutional recognition of the Agroecological Garden.

Regarding the institutionalization component, great progress was achieved: from 0 to 33.2. This is due to the progressive recognition both at the university and faculty levels. In this sense, the steps that allowed for the establishment of a website for the Agroecological

Garden (web 1) on the university portal and an institutional email (mail 1) are outstanding; both aspects offer greater credibility and support to each administrative process conducted. Similarly, the registration of the Agroecological Garden project in the Research Registration and Evaluation System (SIREI) and the Information System for University Linkage (SIVU) was achieved. These processes make it possible to inform the Faculty of Biology and the Veracruzana University of the contributions of the garden in terms of research and links with the community, which constitutes a crucial issue of transparency.

It is also worth highlighting that the group responsible for the Agroecological Garden has proposed the road map or administrative steps necessary for the rest of the gardens of the Veracruzana University to achieve institutional recognition. These comprise a set of guidelines that have the purpose of guiding the institutionalization process, achieving operability, and maintaining permanence in academic institutions or university facilities. This constitutes one of the main contributions of this group, since institutionalization is one of the main challenges of educational gardens [59]. These guidelines, although specific to the internal community of the Veracruzana University, provide guidelines for this type of process in other universities with a similar structure.

Finally, to strengthen the economic-administrative dimension, it is essential to visualize new mechanisms for achieving the financing and institutionalization of educational gardens [60]; working on them as funded research projects or managing them as university programs that contribute to campus sustainability are some viable strategies [61–64]. In any event, the activities generated in these spaces should not be a burden for teachers and students but rather tools for promoting comprehensive education [60]. For this reason, the awareness of the university authorities is key, as well as the awareness and appropriation of the university garden by teachers, students, and other members of the community. Curricular greening [65] and the consolidation of research lines around the processes generated in the garden [66] are other issues that could bolster the institutionalization of these cultivated spaces. All this would help in achieving the administrative recognition of these spaces, which effectively contribute to educational quality [3].

5. Conclusions

The adaptation and application of the SAEMETH-G methodology allowed us to evaluate the sustainability of the Agroecological Garden of the Veracruzana University (Mexico) over a period of two years and to determine the advances made by dimensions and components, following an intervention process, highlighting those that occurred in the socio-educational and agri-environmental dimensions. In addition, it is essential for the group to participate together to build a plan for continuous improvement that strategically prioritizes economic-administrative issues, thus reinforcing the other dimensions. Based on this experience, to build sustainability in university gardens, it is advisable to adopt social management processes in a planned manner to favor both social appropriation and the development of capacities in the communities. In addition, it is important to implement agroecological practices that promote functional biodiversity and maintain the overall health of the agroecosystem. Finally, it is essential to obtain a secure source of financing that allows such gardens to be operable, hand in hand with a coordinated process of institutionalization that leads to administrative recognition. Thus, all dimensions have equal weights for sustainability; since the purpose of this kind of garden is educational, socio-educational aspects are key to shaping sustainability but are supported by agro-environmental and economic-administrative structures.

Some advantages of this evaluation methodology are that it has been built from a real garden experience, it is easy to use, and it does not involve high costs for operationalization. Most of the techniques used to gather information are qualitative and can be used by people with basic knowledge to follow simple instructions. The results that are obtained by applying this set of indicators can assist not only in diagnosing the departing point or the final state garden after an intervention but also in the long-term monitoring of the sustainability. It is key to follow up on this type of project but also to establish processes and actions for continuous improvement that lead to the sustainability of the garden and, therefore, to sustainability education activities at the university level.

Regarding the limitations of this study, the first one would be reducing the sustainability of university gardens with regard to several dimensions, components, and indicators. It could be that the context in which the methodology was applied may have other key indicators contributing to sustainability. This is important when aiming to adapt this methodology to assess the sustainability of other university gardens. In this study, we are considering relatively short periods of time between the initial and final assessments; however, during this time, changes may occur that can condition the measurement with the same indicators and values. The used indicators are oriented towards evaluating the sustainability of a particular case of a garden that has the clear objective of supporting the substantive functions of the Faculty of Biology, which includes promoting education for sustainability, which involves addressing context-specific needs. Therefore, the evaluation of other types of university gardens (for marketing, leisure, therapeutics, etc.) may involve reviewing and changing some indicators. Finally, note that, for data collection, the methods that were used could be complemented and combined to obtain more accurate and reliable results.

Author Contributions: Conceptualization, Y.d.l.C.-E. and M.Á.E.-A.; methodology, J.C.F.-B.; software, J.C.F.-B.; validation, Y.d.l.C.-E. and M.Á.E.-A.; formal analysis, J.C.F.-B., Y.d.l.C.-E. and M.Á.E.-A.; investigation, J.C.F.-B.; resources, J.C.F.-B.; data curation, J.C.F.-B., Y.d.l.C.-E. and M.Á.E.-A.; writing—original draft preparation, J.C.F.-B. and M.E.-G.; writing—review and editing, J.C.F.-B. and M.E.-G.; visualization, J.C.F.-B.; supervision, Y.d.l.C.-E. and M.Á.E.-A.; project administration, J.C.F.-B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Evaluation of the sustainability of the Agroecological Garden (December 2018).

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Socio-educational	Internal relations	Group organization	Presence/absence of a group organization	6.25	No group organization (0) If there is group organization (6.25)	0
		Transparency	Presence/lack of accountability to the Faculty and/or University	6.25	There is no accountability (0) Whether there is accountability (6.25)	0
		Women's participation	Percentage of women participating in the organizing group	6.25	Between 0 and 10% are women (0) Between 11 and 20% are women (1.56) Between 21 and 39% are women (3.12) Between 40 and 60% are women (6.25)	6.25
		Differentiated participation	Proportion of students from different semesters in the organizing group	6.25	Less than 1/4 of students (0) 1/4 of students (1.56) 1/3 of students (3.12) 1/2 of students or more (6.25)	6.25
		Links with subjects	Percentage of subjects in the educational program linked to the garden	6.25	Between 0 and 5% of subjects (0) Between 6 and 20% of subjects (1.56) Between 21 and 39% of subjects (3.12) 40% or more of subjects (6.25)	1.56
		Teaching sessions	Monthly number of school sessions and practices developed in the garden	6.25	Between 0 and 3 monthly sessions (0) Between 4 and 6 monthly meetings (1.56) Between 7 and 10 monthly meetings (3.12) 11 or more monthly sessions (6.25)	1.56
		Research sessions	Annual number of research works	6.25	No annual research (0) 1 annual inquiry (1.56) Between 2 and 3 investigations per year (3.12) 4 or more annual investigations (6.25)	0
		Knowledge production	Annual number of scientific literature and outreach publications	6.25	No annual publication (0) 2 annual publications (1.56) Between 3 and 5 annual publications (3.12) 6 or more annual publications (6.25)	1.56

Table A1. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Socio-educational	External Relations	Articulation with other gardens	Annual number of collaborative actions with other gardens	6.25	No annual collaboration (0) Between 1 and 2 collaborations per year (1.56) Between 3 and 5 collaborations per year (3.12) 6 or more annual collaborations (6.25)	3.12
		School support	Presence/absence of support for basic or secondary schools	6.25	No support for schools (0) If there is support for schools (6.25)	6.25
		Government linkage	Presence/absence of government ties	6.25	No government involvement (0) If there is governmental linkage (6.25)	0
		Links with the private sector	Presence/absence of association with companies	6.25	No involvement with the private sector (0) If there is a link with the private sector (6.25)	0
		Link with the agri-food system	Presence/absence of ties with farmers, markets, consumers, etc.	6.25	No association with system agrifood (0) If linked to system agrifood (6.25)	6.25
		Communicating	Presence/absence of the transmission of knowledge to society	6.25	No communication with society (0) If there is communication with society (6.25)	1.56
		Communication systems	Presence/absence of different channels of information dissemination	6.25	No different broadcast channels (0) If there are different broadcast channels (6.25)	0
		Events	Presence/absence of participation in academic and non-academic events	6.25	No participation in events (0) Participation in events (6.25)	0

Table A1. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Agro-environmental	Biodiversity	Richness of plant species	Number of plant species	6.25	Between 0 and 6 cultivated species (0) Between 7 and 13 cultivated species (1.56) Between 14 and 19 cultivated species (3.12) 20 or more cultivated species (6.25)	3.12
		Native plant species	Presence/absence of native plant species	6.25	No native species cultivated (0) If native species are cultivated (6.25)	6.25
		Weed species	Presence/absence of weed species	6.25	No native species cultivated (0) If native species are cultivated (6.25)	6.25
		Richness of soil fauna	Number of soil organisms (visible to the human eye) per 20 cm × 20 cm × 20 cm	6.25	Between 0 and 6 soil organisms (0) Between 7 and 13 soil organisms (1.56) Between 14 and 19 soil organisms (3.12) 20 or more soil organisms (6.25)	6.25
		Aromatic species	Presence/absence of aromatic plants	6.25	No aromatic plants (0) If aromatic plants are present (6.25)	6.25
		Medicinal species	Presence/absence of medicinal plants	6.25	No medicinal plants (0) If medicinal plants are present (6.25)	6.25
		Pollinators	Presence/absence of pollinators all year round	6.25	No pollinators all year (0) If pollinators all year (6.25)	6.25
		Species considered to be pests	Incidence level of species considered to be pests	6.25	High incidence of pests (0) Moderate incidence of pests (3.12) Low incidence of pests (6.25)	3.12

Table A1. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Agro-environmental	Agricultural practice	Use of native seeds	Presence/absence of native seed bank	6.25	No native seed bank (0) If native seed bank (6.25)	6.25
		Crop rotation	Number of crop rotations per year	6.25	No crop rotation (0) 1 crop rotation per year (1.56) 2 crop rotations per year (3.12) 3 or more crop rotations per year (6.25)	3.12
		Crop association	Number of crop associations in the garden (per 20 m^2)	6.25	No crop associations (0) Between 2 and 4 crop associations (1.56) Between 5 and 6 crop associations (3.12) 7 or more crop associations (6.25)	3.12
		Production of organic fertilizers	Presence/absence of organic fertilizer production with local materials	6.25	No production of organic fertilizers (0) Production of organic fertilizers (6.25)	6.25
		Use of organic fertilizers	Presence/absence of the use of natural fertilizers	6.25	No use of organic fertilizers (0) If organic fertilizer is used (6.25)	6.25
		Control of pests and diseases	Presence/absence of the agroecological management of pests and diseases	6.25	No agroecological pest and disease management (0) If there is agroecological management of pests and diseases (6.25)	6.25
		Responsible use of water	Number of practices implemented for responsible water use (efficient irrigation, rainwater harvesting, soil mulching)	6.25	No responsible use of water (0) 1 responsible water practice (1.56) 2 responsible water practices (3.12) 3 responsible water practices (6.25)	3.12
		Use of live fences	Percentage of garden perimeters with live fences	6.25	Between 0 and 25% live fences (0) Between 26 and 50% live fences (1.56) Between 51% and 75% live fences (3.12) 76% or more live fences (6.25)	3.12

Table A1. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Economic-administrative	Financing	Self-financing	Presence/absence of self-financing	16.6	There is no self-financing (0) If there is self-financing (16.6)	16.6
		Domestic financing	Presence/absence of internal funding	16.6	No internal funding (0) If there is internal funding (16.6)	0
		External financing	Presence/absence of external financing	16.6	No external funding (0) If there is external financing (16.6)	0
	Institutionalization	Registration at REHUV	Presence/absence of registration in REHUV	16.6	No registration at REHUV (0) If registered in REHUV (16.6)	0
		Registration in SIREI and/or SIVU	Presence/absence of registration in SIREI and/or SIVU	16.6	No registration in SIREI and SIVU (0) If registered in SIREI and/or SIVU (16.6)	0
		Institutional recognition	Presence/absence of recognition by the faculty and/ or university	16.6	No recognition by faculty and university (0) If there is recognition by the faculty and/or university (16.6)	0

Note: * indicator weights add up to 100 for each dimension.

Table A2. Evaluation of the sustainability of the Agroecological Garden (January 2021).

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Socio-educational	Internal relations	Group organization	Presence/absence of a group organization	6.25	No group organization (0) If there is group organization (6.25)	6.25
		Transparency	Presence/lack of accountability to the Faculty and/or University	6.25	There is no accountability (0) Whether there is accountability (6.25)	6.25
		Women's participation	Percentage of women participating in the organizing group	6.25	Between 0 and 10% are women (0) Between 11 and 20% are women (1.56) Between 21% and 39% are women (3.12) Between 40 and 60% are women (6.25)	6.25
		Differentiated participation	Proportion of students from different semesters in the organizing group	6.25	Less than 1/4 of students (0) 1/4 of students (1.56) 1/3 of students (3.12) 1/2 of students or more (6.25)	6.25
		Links with subjects	Percentage of subjects in the educational program linked to the garden	6.25	Between 0 and 5% of subjects (0) Between 6 and 20% of subjects (1.56) Between 21 and 39% of subjects (3.12) 40% or more of subjects (6.25)	6.25
		Teaching sessions	Monthly number of school sessions and practices developed in the garden	6.25	Between 0 and 3 monthly sessions (0) Between 4 and 6 monthly meetings (1.56) Between 7 and 10 monthly meetings (3.12) 11 or more monthly sessions (6.25)	3.12
		Research sessions	Annual number of research works	6.25	No annual research (0) 1 annual inquiry (1.56) Between 2 and 3 investigations per year (3.12) 4 or more annual investigations (6.25)	3.12
		Knowledge production	Annual number of scientific literature and outreach publications	6.25	No annual publication (0) 2 annual publications (1.56) Between 3 and 5 annual publications (3.12) 6 or more annual publications (6.25)	4.5

Table A2. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Socio-educational	External Relations	Articulation with other gardens	Annual number of collaborative actions with other gardens	6.25	No annual collaboration (0) Between 1 and 2 collaborations per year (1.56) Between 3 and 5 collaborations per year (3.12) 6 or more annual collaborations (6.25)	6.25
		School support	Presence/absence of support for basic or secondary schools	6.25	No support for schools (0) If there is support for schools (6.25)	6.25
		Government linkage	Presence/absence of government ties	6.25	No government involvement (0) If there is governmental linkage (6.25)	6.25
		Links with the private sector	Presence/absence of association with companies	6.25	No involvement with the private sector (0) If there is a link with the private sector (6.25)	6.25
		Link with the agri-food system	Presence/absence of ties with farmers, markets, consumers, etc.	6.25	No association with system agrifood (0) If linked to system agrifood (6.25)	6.25
		Communicating	Presence/absence of transmission of knowledge to society	6.25	No communication with society (0) If there is communication with society (6.25)	6.25
		Communication systems	Presence/absence of different channels of information dissemination	6.25	No different broadcast channels (0) If there are different broadcast channels (6.25)	6.25
		Events	Presence/absence of participation in academic and non-academic events	6.25	No participation in events (0) Participation in events (6.25)	6.25

Table A2. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Agro-environmental	Biodiversity	Richness of plant species	Number of plant species	6.25	Between 0 and 6 cultivated species (0) Between 7 and 13 cultivated species (1.56) Between 14 and 19 cultivated species (3.12) 20 or more cultivated species (6.25)	6.25
		Native plant species	Presence/absence of native plant species	6.25	No native species cultivated (0) If native species are cultivated (6.25)	6.25
		Weed species	Presence/absence of weed species	6.25	No native species are cultivated (0) If native species are cultivated (6.25)	6.25
		Richness of soil fauna	Number of soil organisms (visible to the human eye) per 20 cm × 20 cm × 20 cm	6.25	Between 0 and 6 soil organisms (0) Between 7 and 13 soil organisms (1.56) Between 14 and 19 soil organisms (3.12) 20 or more soil organisms (6.25)	6.25
		Aromatic species	Presence/absence of aromatic plants	6.25	No aromatic plants (0) If aromatic plants are present (6.25)	6.25
		Medicinal species	Presence/absence of medicinal plants	6.25	No medicinal plants (0) If medicinal plants are present (6.25)	6.25
		Pollinators	Presence/absence of pollinators all year round	6.25	No pollinators all year (0) If pollinators all year (6.25)	6.25
		Species considered to be pests	Incidence level of species considered to be pests	6.25	High incidence of pests (0) Moderate incidence of pests (3.12) Low incidence of pests (6.25)	3.12

Table A2. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Agro-environmental	Agricultural practice	Use of native seeds	Presence/absence of native seed banks	6.25	No native seed bank (0) If native seed bank (6.25)	6.25
		Crop rotation	Number of crop rotations per year	6.25	No crop rotation (0) 1 crop rotation per year (1.56) 2 crop rotations per year (3.12) 3 or more crop rotations per year (6.25)	6.25
		Crop association	Number of crop associations in the garden (per 20 m^2)	6.25	No crop associations (0) Between 2 and 4 crop associations (1.56) Between 5 and 6 crop associations (3.12) 7 or more crop associations (6.25)	6.25
		Production of organic fertilizers	Presence/absence of organic fertilizer production with local materials	6.25	No production of organic fertilizers (0) Production of organic fertilizers (6.25)	6.25
		Use of organic fertilizers	Presence/absence of the use of natural fertilizers	6.25	No use of organic fertilizers (0) If organic fertilizer is used (6.25)	6.25
		Control of pests and diseases	Presence/absence of the agroecological management of pests and diseases	6.25	No agroecological pest and disease management (0) If there is agroecological management of pests and diseases (6.25)	6.25
		Responsible use of water	Number of practices implemented for responsible water use (efficient irrigation, rainwater harvesting, soil mulching)	6.25	No responsible use of water (0) 1 responsible water practice (1.56) 2 responsible water practices (3.12) 3 responsible water practices (6.25)	3.12
		Use of live fences	Percentage of garden perimeter with live fences	6.25	Between 0 and 25% live fences (0) Between 26 and 50% live fences (1.56) Between 51 and 75% live fences (3.12) 76% or more live fences (6.25)	6.25

Table A2. *Cont.*

Dimension	Component	Indicator	Definition of the Indicator	Weight of the Indicator *	Levels of Indicators (Value)	Assigned Value
Economic-administrative	Financing	Self-financing	Presence/absence of self-financing	16.6	There is no self-financing (0) If there is self-financing (16.6)	16.6
		Domestic financing	Presence/absence of internal funding	16.6	No internal funding (0) If there is internal funding (16.6)	0
		External financing	Presence/absence of external financing	16.6	No external funding (0) If there is external financing (16.6)	16.6
	Institutionalization	Registration at REHUV	Presence/absence of registration in REHUV	16.6	No registration at REHUV (0) If registered in REHUV (16.6)	16.6
		Registration in SIREI and/or SIVU	Presence/absence of registration in SIREI and/or SIVU	16.6	No registration in SIREI and SIVU (0) If registered in SIREI and/or SIVU (16.6)	16.6
		Institutional recognition	Presence/absence of recognition by the faculty and/ or university	16.6	No recognition by the faculty and university (0) If there is recognition by the faculty and/ or university (16.6)	0

Note: * indicator weights add up to 100 for each dimension.

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