biology and life sciences forum

MDPI

Proceeding Paper

Assessment of an Organic Vineyard as a Strategic Multifactorial Node in the Conservation of Natural Resources in an Intermountain Territory of the Sonoran Desert, Mexico †

Héctor Tecumshé Mojica-Zárate

Biological Sciences Division, Universidad de la Sierra, Moctezuma 84560, Sonora, Mexico; hectortecumshe@gmail.com; Tel.: +53-(634)-3453622

† Presented at the 1st International Electronic Conference on Horticulture, Online, 16–30 April 2022; Available online: https://iecho2022.sciforum.net/.

Abstract: Grape cultivation in Sonora, Mexico is one of the most notable in the world, but it is restricted to certain areas and uses a conventional production approach. The objective of this work is to evidence the development of the establishment of an organic vineyard as a novel cultivation pattern in an agrosystem of the intermontane valley of the Sonoran Desert, Mexico, from its endogenous variables and its link with the surrounding environment, to an integrated approach between the organic and the sustainable. The approach is conducted by conceptualizing the vineyard as a Strategic Multifactorial Node (SMN) with ecological influence towards its immediate environment, evaluated from endogenous variables of the vineyard itself and those linked to the agrosystem of direct influence. To measure the degree of influence between the vineyard and the surrounding ecosystems, sustainability values between 0 and 1 were assigned, derived from the activities and conditions included in SDGs 13 and 15. Among the vineyard's results, a percentage of weed cover equal to 96% stands out, as well as the presence of entomofauna and avifauna in a ratio of 78:22. In the component exogenous to the vineyard, that is, the degree of sustainable influence for the elements of the adjacent desert agrosystem, resulted in 0.98 for Soil Conservation Areas; 0.79 for edaphic organic matter, 0.97 for maintenance of water, and 0.96 for soil microorganisms. SMN promoted lateral conservation of the water-soil binomial, limited erosion, decreased soil loss, and increased soil fertilization.

Keywords: complex system; intra-ecosystemic links; integrated strategic management; agroecosystemic biodiversity; cropping pattern; sustainable development goals; edaphic fertilization; EU & NOP standards

check for updates

Citation: Mojica-Zárate, H.T. Assessment of an Organic Vineyard as a Strategic Multifactorial Node in the Conservation of Natural Resources in an Intermountain Territory of the Sonoran Desert, Mexico. *Biol. Life Sci. Forum* **2022**, *16*, 2. https://doi.org/10.3390/IECHo2022-12495

Academic Editor: Esmaeil Fallahi

Published: 15 April 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Sonora, Mexico has one of the first positions globally in grape production and export. A high percentage of the productive surface is located in the coastal area of this province, with a certain degree of deterioration due to salinity or low fertility. In addition, the conditions of the water tables also indicate a detriment in the levels of production due to excessive consumption of water for continuous use in conventional agriculture, as well as a degradation of the adjacent pristine environments [1,2].

One method that integrates grape production into sustainable development is through organic orientation. Organic grape production is promising in territories where the altitudinal, local climatic, and edaphic conditions are outside traditional conditions. Its establishment as a crop pattern, from an organic approach, strengthens a type of ecological relationship with the immediate adjacent biological and environmental systems, which reduces the possibility of affecting local biodiversity as well as avoids soil loss due to erosion and promoting efficient use of water, among other positive effects [3–6].

An endogenous condition of the production of organic grapes is not only intended to promote the characteristics of the soil, the vegetation cover, the quality and care of the water and, in general, the natural resources of the singular area of the cultivated area. Its purpose reproduces and maintains an iterative process in which the integrated strategic management applied to organic production assigns a sustainable value to the spaces and resources surrounding the cultivated area. With these considerations present, it is ensured that the cultivation of organic grapes is identified as a node of ecological influence and environmental services in continuous conservation [7–9].

Productive value is not only assignable to the generation of food suitable for human consumption. There is also a direct and positive effect on the presence of wild animal species, improvement in the health and quality of water bodies, maintenance and conservation of xeric vegetation, and increase in the fertility and abundance of soils, including an improvement in the quality of the air adjacent to the cultivation area [1,6].

The SDGs represent a transversal axis of analysis for the exercise of sustainability in agroproductive territories in which a relationship with food security and at the same time with the different biological-environmental systems with which it coexists stands out, without taking into account aspects such as decent work, among other fundamentals derived from the SDGs [3,4].

The tendency of agriculture is to align itself with the precepts of sustainability and increasingly close the gap between the conventional way of producing and the organic trend, following and considering the existing regulations and at the same time complying with the different indicators emanating from local experience, articulated in the SDGs. This intricate relationship is feasible within a complex agroproductive and intraecosystem system, which for the case study is made up of a vineyard and the Sonoran desert ecosystem [2,8,10,11].

The objective of this work is to evidence the development of the establishment of an organic vineyard as a novel cultivation pattern in an agrosystem of the intermontane valley of the Sonoran desert, Mexico, from its endogenous variables and its link with the surrounding environment to an integrated approach between the organic and the sustainable.

2. Materials and Methods

2.1. Location of the Study Area and Observation Site

The study was developed in a site prepared for the cultivation of grapes of the Perlette variety with one year of establishment from cuttings. The crop is located in the southeast of Moctezuma, Sonora, Mexico, at an altitude of 658 m above sea level (29°42′01″ N and 109°39′05′ W). A semi-warm, dry climate prevails with summer rains BS0hw (x′), and with temperatures within the range of −3 to 48 °C. The hottest period is between June and September, and the coldest is between December and February.

The study area corresponds to a low area of fluvial runoff surrounded by native vegetation with a medium to high degree of pristineness, inserted in the Sonoran desert landscape and located in an intermontane valley. It presents vertisol soils from late volcanism, in the emerging area ferrosols and arenosols are immediately present due to deposition. The vegetation adjacent to the vineyard consists of thorny scrub, cacti, and medium-sized endemic legume trees. Distinguishable vertebrates in the area include deer, hares, wild boars, pigeons, toads, and rattlesnakes [12].

2.2. Definition of Endogenous—Exogenous Variables and Identification of the SDGs Linked to the NME

For the determination of the various indices in this work, we start from a concentration of variables or indicators, which give dimension to the effect generated by the vineyard as a complex system of influence, defined as a Strategic Multifactorial Node (SMN) [13–15]. These elements of the complex system are identified in three categories:

2.2.1. Exogenous Components

Exogenous components are systems, elements, or conditions exogenous to the vineyard that are located in the surrounding area and that receive direct influence from it in a circumference of no less than 400 m. The main functions, systems, conditions, or elements of an environmental and biological nature are distinguished.

2.2.2. Recognition of the SDGs Involved

In this part, the SDGs that are involved and that will be the starting point to define both endogenous and exogenous variables of the vineyard are identified and prioritized. Its understanding, from this complex adaptive platform, updates the practical configurations from an organic—ecological approach [12].

2.2.3. Detection of Indicators or Variables Typical of the Vineyard Such as Those from Exogenous Components

In order to introduce an interpretation as close to the impact that the vineyard has on the surrounding natural systems or components clearly, from the results with their consequent precise conclusions, these components must be accepted as a part of variables that provide reliable data. Therefore, the variables are extracted from field observation, as well as from the expert opinions of grape growers and scientists involved who recognize the relationship, influence, and impact of production on the organic practice of grapes in the natural environment [6].

2.3. Construction of Sustainability Indices from the SDGs Identified

Once the variables involved have been outlined, considering as a reference the fundamentals present in the SDGs identified and related to the cultivation of grapes and/or the ecological spatial surroundings, they are organized according to the approach and its degree of influence and assign target values to each variable [13–16]. Once this is done, proceed to:

2.3.1. Carry Out Statistical Tests of Normality to Eliminate the Extreme Values of the Distribution

It is possible to use asymmetry, kurtosis test for normality, and Shapiro-Wilk and Shapiro-France tests to determine if the variables considered in the ODS Index are normally distributed.

2.3.2. Assign Scales to the Data in Order to Compare

This comparison must be possible in the same or another vineyard over time for both endogenous and exogenous conditions. Upper and lower limits consistent with the SDGs are defined. The scale is assigned in values from zero to 100. Zero represents the worst performance and 100 the best performance in Equation (1):

$$X' = \frac{X - lower}{upper\ (x) - lower\ (x)} \quad (1)$$

2.3.3. Index Formation by Including Indicators within and among the SDGs

This section is based on the premise that each SDG has the same weight in the concept of sustainability. It consists of adding to each SDG the various variables or indicators previously identified, using the value of their arithmetic mean as a numerical reference, thus constituting the composite indices. Equation (2) can be written as:

$$l\ (N,\ l_j,\ p) = \left[\sum_{j=1}^{N} \frac{1}{N}\ lj^{-p}\right]^{-\frac{1}{p}} \quad (2)$$

where N denotes the number of variables to be aggregated per SDG. The substitution parameter p describes the substitutability across components of the indicator with a permissible range of $-1 \leq p \leq \infty$.

2.4. Analysis and Interpretation of the Link and Impact of the Degree of Sustainability of the Vineyard on the Adjacent Environment

From the values obtained in the previous step, a value of degree of influence of the vineyard is assigned to the different components that surround it. The ODS and the variable that is influencing the exogenous components are considered main elements to identify the degree of influence on the sustainability of the vineyard to the adjacent environment [17].

3. Results and Discussion

3.1. Components Dependent on the Variables Defined in the Vineyard as NME Articulated to the SDGs

Objectives 15, 13, 12, and 08 were identified as influencing SDGs. The main external components from which the variables or indicators were extracted were those referring to natural resources, ecosystem conditions, responsible consumption, and decent work. In the agronomic and ecological approach, components are distinguished that promote the conservation of the hydric-edaphic binomial and the ecological maintenance of ecosystem users of the vineyard such as wildlife, xeric, and weed vegetation [16]. The variables related to the exterior components valued as essential are shown in Table 1.

Table 1. Definition of endogenous and exogenous variables based on the SDGs identified in relation to the NME: vineyard and its adjacent systems or elements.

SDG	Indicator and Component [1]	Exogenous/Endogenous to SMN	Source [2]
15	Species of flora and fauna in protection categories (0–1)	Ex/En	[18]
	Change in forest area (%)	Ex/En	Producer
	Spaces dedicated to wildlife conservation in the area (%)	Ex	Scientist
13	Vulnerability to climate change (0–1)	En	Producer
	Use of safe agricultural practices (0–1)	En	Producer/Technician
	Oxygen generation (%/ha)	Ex	Scientist
12	Consumption of electrical energy for irrigation (kWh)	En	Federal Electricity Commission
	Generation of organic waste in pruning (0–1)	En	Producer
	Water consumption in irrigation (liters/cycle)	En	Producer
08	Employment for the local population (Journals/day/year)	En	Producer
	Inclusion of adult workforce (%)	En	Scientist

[1] It refers also to the exogenous elements of the agrosystem in which the indicator influences; [2] Represented by: producer, technician, scientist, or authority related to the indicator.

The endogenous variables were also valued, articulating these with the objectives of sustainable development. One of the aspects with the greatest impact on the vineyard was related to the management of weeds, which will be considered as essential for the growth of the branches and main stem [19]. The indicators evaluated in a period of one year are shown in Table 2.

Table 2. Endogenous indicators added for each of the SDGs involved in the study vineyard.

SDG	Endogenous Indicators
15	Weed control: Manual with the use of a hoe; Presence of wild fauna: entomofauna, avifauna, herpetofauna (0–1); Percentage of organic matter coverage in summer of the surface: 96%; Soil texture: Clay—sandy; Soil type: ferrosol—vertisol; Weed species in the vineyard: (0–1), Percentage by species; Branch length of the plant in winter: 57 ± 7.4; cutting diameter at planting: 12 ± 6.5 mm; Number of nodes in cuttings (4 ± 2); Root length at planting 16 ± 4.2; Postsummer diameter of main stem 21 ± 3.2 mm; Percentage of coverage with weeds: 96%; Longest guide length: 1.6 m
13	Water Pollution Level: (0–1); Type of seeds: Cuttings developed for two and a half months
12	Duration of drip irrigation in summer of 2.5 ± 1.7 h/day/week; Drip irrigation duration in autumn—winter 2.7 ± 0.6 h/week
08	Wages/day: 2 for 15 days a year
06	Spacing between drop dispenser: 70 cm

3.2. Degree of Influence on Components Exogenous to the Vineyard

Organic agriculture in some scenarios has been erroneously considered as agriculture that does not use inputs because it is an alternative for those who do not have the financial capacity to develop conventional agriculture. However, in this case it is not an option considered in this way, and goes beyond the concept of organic agriculture, since it establishes a direct relationship with the SDGs [20–22].

In the exogenous component of the vineyard system, the degree of influence for the elements of the desert agrosystem was 0.98 for Soil Conservation Areas; 0.79 for edaphic organic matter, 0.97 for maintenance of water bodies, 0.96 for soil microorganisms. The birdlife was an element of the environment that was modified by the presence and abundance of local birds. The vineyard provided feeding services for insects as well as shelter [23,24].

4. Conclusions

The components with the most influence on the vineyard as SMN for the surrounding areas were the soil, the amount of organic matter, water maintenance, and microorganisms in soil.

The SDGs in which the vineyard was most influenced as a node were 15, 13, 12, 08, and 06 with a total of 11 exogenous variables and 20 related endogenous variables.

The endogenous characteristics, in particular, the productive parameters that increased in the vineyard, influenced by the organic management of the vineyard such as SMN, were branch length, basal diameter, number of leaves, presence of weeds, and conservation of irrigation water.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this research work are available on request with the authors of this study.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Jayaraman, S.; Dang, Y.P.; Naorem, A.; Page, K.L.; Dalal, R.C. Conservation Agriculture as a System to Enhance Ecosystem Services. *Agriculture* **2021**, *11*, 718. [CrossRef]
2. Byomkesh, B.; Blay-Palmer, A.; Gary, W. VanLoon, G.; Hipel, K. Towards complexity of agricultural sustainability assessment: Main issues and concerns. *Environ. Sustain. Indic.* **2020**, *6*, 10038. [CrossRef]

3. Balanay, R.; Halog, A. A Review of Reductionist versus Systems Perspectives towards 'Doing the Right Strategies Right' for Circular Economy Implementation. *Systems* **2021**, *9*, 38. [CrossRef]
4. Blaće, A.; Čuka, A.; Šiljković. How dynamic is organic? Spatial analysis of adopting new trends in Croatian agriculture. *Land Use Policy* **2020**, *99*, 105036. [CrossRef]
5. Dhaliwal, S.; Naresh, R.; Agniva, M.; Ravinder, S.; Dhaliwal, M. Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. *Environ. Sustain. Indic.* **2019**, *1*, 100007. [CrossRef]
6. Wiśniewski, Ł.; Biczkowski, M.; Rudnicki, R. Natural potential versus rationality of allocation of Common Agriculture Policy funds dedicated for supporting organic farming development—Assessment of spatial suitability: The case of Poland. *Ecol. Indic.* **2021**, *130*, 108039. [CrossRef]
7. Guerra, J.; Cabello, F.; Fernández, C.; Peña, J.; Dorado, J. How weed management influence plant community composition, taxonomic diversity and crop yield: A long-term study in a Mediterranean vineyard. *Agric. Ecosyst. Environ.* **2022**, *326*, 107816. [CrossRef]
8. Kwadwo, M.I.; Tronstad, R.; Guo, J.; Shaner, L.D.; Idowu, O. On-farm land management strategies and production challenges in United States organic agricultural systems. *Curr. Res. Environ. Sustain.* **2021**, *3*, 100097. [CrossRef]
9. Cogato, A.; Pezzuolo, A.; Sozzi, M.; Marinello, F. A sample of Italian vineyards: Landscape and management parameters dataset. *Data Brief* **2020**, *33*, 106589. [CrossRef]
10. Shongwe, M.I.; Bezuidenhout, C.N.; Sibomana, M.S.; Workneh, T.S.; Bodhanya, S.; Dlamini, V.V. Developing a Systematic Diagnostic Model for Integrated Agricultural Supply and Processing Systems. *Systems* **2019**, *7*, 15. [CrossRef]
11. Armenia, S.; Pompei, A.; Castaño Barreto, A.C.; Atzori, A.S.; Fonseca, J.M. The Rural-Urban Food Systems' Links with the Agenda 2030: From FAO Guidelines on Food Supply and Distribution Systems to a Dairy Sector Application in the Area of Bogota. *Systems* **2019**, *7*, 45. [CrossRef]
12. Dane, A.; Johnson, M. Effects of habitat on prey delivery rate and prey species composition of breeding barn owls in winegrape vineyards. *Agric. Ecosyst. Environ.* **2021**, *312*, 107322. [CrossRef]
13. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Durand-Delacre, D.; Teksoz, K. An SDG Index and Dashboards—Global Report. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN). 2016. Available online: https://www.sustainabledevelopment.report/reports/sdg-index-and-dashboards-2017/ (accessed on 3 February 2022).
14. Cods, 2020. Índice ODS 2019 para América Latina y el Caribe. Centro de los Objetivos de Desarrollo Sostenible para América Latina y el Caribe: Bogotá, Colombia, 2020. Available online: https://cods.uniandes.edu.co/wp-content/uploads/2020/06/%C3%8Dndice-ODS-2019-para-Am%C3%A9rica-Latina-y-el-Caribe-2.pdf (accessed on 3 February 2022).
15. Sachs, J.; Kroll, C.; Lafortune, G.; Fuller, G.; Woelm, F. *The Decade of Action for the Sustainable Development Goals: Sustainable Development Report 2021*; Cambridge University Press: Cambridge, UK, 2021.
16. Kostas, B. A bioeconomic approach to sustainability with ecological thresholds as an operational indicator. *Environ. Sustain. Indic.* **2020**, *6*, 100027. [CrossRef]
17. Chabert, A.; Marchand, D.; Sarthou, J. Data from extensive comparative measurements of conventional, conservation and organic agricultures in southwestern France. *Data Brief.* **2020**, *31*, 105827. [CrossRef] [PubMed]
18. SEMARNAT. Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección Ambiental. Especies Nativas de México de Flora y Fauna Silvestres. Categorías de Riesgo y Especificaciones Para su Inclusión, Exclusión o Cambio. Lista de Especies en Riesgo. Diario Oficial de la Federación 30 Diciembre. 2010. Available online: https://www.gob.mx/profepa/documentos/norma-oficial-mexicana-nom-059-semarnat-2010 (accessed on 3 February 2022).
19. Guerra, J.G.; Cabello, F.; Fernández-Quintanilla, C.; Dorado, J. A trait-based approach in a Mediterranean vineyard: Effects of agricultural management on the functional structure of plant communities. *Agric. Ecosyst. Environ.* **2021**, *316*, 107465. [CrossRef]
20. Alotaibi, B.; Yoder, E.; Brennan, M.; Hazem, S. Perception of organic farmers towards organic agriculture and role of extension. *Saudi J. Biol. Sci.* **2021**, *28*, 5. [CrossRef] [PubMed]
21. Kroll, C. *Sustainable Development Goals—Are the Rich Countries Ready*; Bertelsmann Stiftung: Gutersloh, Germany, 2015.
22. Nikol, L.; Jansen, K. Rethinking conventionalisation: A view from organic agriculture in the Global South. *J. Rural Stud.* **2021**, *86*, 420–429. [CrossRef]
23. Assandri, G.; Bogliani, G.; Pedrini, P.; Brambilla, M. Insectivorous birds as "non-traditional" flagship species in vineyards: Applying a neglected conservation paradigm to agricultural systems. *Ecol. Indic.* **2017**, *80*, 275–285. [CrossRef]
24. Muñoz, A.; Heaton, E.; Reynolds, M.; Merenlender, A. Agricultural adapters from the vineyard landscape impact native oak woodland birds. *Agric. Ecosyst. Environ.* **2020**, *300*, 106960. [CrossRef]