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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 †

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† 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 but it is restricted to certain areas and with 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 from an integrated approach between the organic and the sustainable. The approach is conducted 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 ecosystem elements, 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

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. **2022**, *1*, x. https://doi.org/10.3390/xxxxx

Academic Editor:

Published: 6 April 2022

1. Introduction

Sonora, Mexico has one of the first places 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 level due to excessive consumption of water in line for to 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 possible 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 avoiding 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 the foregoing, 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].

The relationship between the productive value is not only assignable to the generation of food suitable for human consumption. There is 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 agro-productive 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 the local experience itself, articulated in the SDGs. This intricate relationship is feasible within a complex agro-productive and intra-ecosystem 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 from 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, variety Perlette 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′), with temperatures within the range of −3 to 48 °C. The hottest period is between June and September, the coldest 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. They are distinguishable vertebrates among deer, hare, wild boar, 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

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, part of variables that provide reliable data. Therefore, the variables are extracted from field observation, as well as from the expert opinion of grape growers and scientists involved who recognize the relationship, influence and impact of production oriented from the organic practice of grapes to 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 to 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, as well as 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 through time and space that is, 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 0 to 100. Zero represents the worst performance and 100 the best performance. 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

It 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.

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

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 as 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 and xeric and weed vegetation [16]. The different 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 agrocultural 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 that had the greatest impact on the vineyard

was related to the management of weeds, which will be considered 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), % 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: 1.6m
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 from insects and also shelter [23,24].

4. Conclusions

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

The SDGs in which the vineyard 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.

Author Contributions: Conceptualization, H.T.M.-Z.; methodology, H.T.M.-Z.; software, H.T.M.-Z.; validation, H.M; formal analysis, H.T.M.-Z.; investigation, H.T.M.-Z.; resources, H.T.M.-Z.; data curation, H.T.M.-Z.; writing—original draft preparation, H.T.M.-Z.; writing—review and editing, H.T.M.-Z.; visualization, H.T.M.-Z.; supervision, H.T.M.-Z.; project administration, H.T.M.-Z. 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: The Data presented in this research work are available on request with the authors of this study

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

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