chemistry proceedings

Article

Sustainable Character of Agroproductive Nodes in Intermontane Arid Territories of Sonora, Mexico †

Héctor Tecumshé Mojica-Zárate

Biological Sciences Division, Universidad de la Sierra, Moctezuma 84560, Sonora, Mexico; hectortecumshe@gmail.com

† Presented at the 1st International Online Conference on Agriculture—Advances in Agricultural Science and Technology, 10–25 February 2022; Available online: https://iocag2022.sciforum.net/.

Abstract: The sustainability of the agroproductive nodes of the Sonoran Desert is a function of environmental and water limitations, the degree of ecotechnological inclusion, and the strategic diversification of its production processes. The objective of this work is to evaluate the inclusion of the ecotechnological approach of an agroproductive node with a sustainable trend (ANST) in Moctezuma, Sonora, Mexico, from the opening, and the adoption of strategic management through the Braden scale to interpret the changes that have occurred in an agroproductive node when it tends towards sustainability. The case study is node-oriented to the production of forage for haymaking. The global evaluation of the activity is tending towards a decrease in sustainability and a value of the environmental compatibility trait of 25 BU. The valuation of the same trait for the new productive approaches included in the node result from collateral categories that contribute to production and sustainability, among which are distinguished: (a) the definition and practice of arid tourism with 47 BU, (b) buffer areas for the protection of wildlife with 100 BU, and (c) the use of rescue grazing with 68 BU. The sustainable-ecotechnological-adoption process in the study node is a process with complex relationships, with an influence and trend towards what is defined by the SDGs as an agroproductive approach.

Keywords: complex systems; sustainable evaluation; agroproductive conversion; sustainable management; natural resources

check for updates

Citation: Mojica-Zárate, H.T. Sustainable Character of Agroproductive Nodes in Intermontane Arid Territories of Sonora, Mexico. *Chem. Proc.* **2022**, *10*, 77. https://doi.org/10.3390/IOCAG2022-12346

Academic Editor: Bin Gao

Published: 14 March 2022

1. Introduction

Sonora, Mexico, is a world reference in agriculture, and in it there are various categories of agricultural production units that are located throughout the geography of the state. The gross domestic product for this item alone for the year 2020 was 6.5%, with a total of MXN 57,669,885 million [1]. These dimensions are based on the conversion of various natural resources, which leads to a context of disturbances and pressures on the ecosystem of origin [2].

Conventional farming represents an antithesis to organic farming. In this productive plane, the use of resources is unlimited, as well as the activities that they hold against the natural environment and its components. Therefore, its long-term results represent an environmental mortgage and, in the case of the desert and its different niches, under this scenario of intensive nonecological production, environmental impacts of different intensities and a minimal resilience capacity are the double common factors in the generality of productive units [3–5].

In the new way of managing natural resources in arid Mexican territories, a complex and integrative approach that includes water as the first resource, and other factors involved in agroproductive units, cannot be postponed [4–10]. These factors are related to environmental and climatic risks or catastrophes; at the same time, decisive with effective development, one of these cases consists of revitalizing the agroproductive nodes through improvement programs and local participation [11–18]. The combination of nodes, as an interconnected network forming productive networks, and their combination of pristine spaces and the sustainable management of resources, constitutes a Sustainable Ecotechnological Agropolis [4,5,15].

The objective of this work was to apply an ecotechnological-adoption-evaluation methodology to an agroproductive node in Moctezuma, Sonora, Mexico, the orientation of which is conventional hay production. As specific research aims, the following were sought: (1) an assessment of the aptitude of new sustainable activities for the potential development of the study of the agroproductive node, and (2) a definition of the inclusion of the activity suggested to the node based on the capacity and the sustainable and ecotechnological trend from the processes inserted into that activity.

2. Methods

2.1. Location of the Study Area and Observation Site

The observations were made in a production unit concerning livestock production. The focus of this node originates from a conventional trend in the production of hay, silage, and grazing forage. The location of this node is in the vicinity of the southeast of Moctezuma, Sonora, Mexico (lat 29°42′01″ N, long 109°39′05″ W), at an average altitude of 658 m above sea level. The climate corresponds to a semiwarm dry climate with summer rains BS0hw (x′), and with maximum and minimum temperatures in the range of from −3 to 48 °C. The hottest period of the year is between June and September, and the coldest month is January.

2.2. Elements of the Agroproductive Node and Its Identification

The elements of the agroproductive node, or productive unit, are all the activities that exist in it. Therefore, the primordial activity is evaluated and compared with those activities of possible insertion into the node. To carry out this evaluation, it is necessary to:

(a) Identify the vulnerable points of the process, vulnerability traits, importance value, and numerical value;
(b) Establish the risks and respective indicators;
(c) For both cases, assign a value from 0 to 1, defined by the operator of the agroproductive node;
(d) Identify the value of the threat (VT) using Equation (1):

$$VT = PVV \times RV, \quad (1)$$

where PVV is the process vulnerability value, and RV is the risk value.

This value allows the threat to be classified into three ranges:

1. Low or tolerable: between 0 and 5. The threat is tolerable. Change 10% of the processes that seem fragile or unsuitable for the development of the activity;
2. Medium or latent: between >5 and <10. The threat is latent. Identify and assess possible activities to be carried out that are complementary to the main activity of the node in 50% of these;
3. High or imminent: >10. The threat is imminent. The main activity requires a transformation in more than 50% of its processes.

2.3. Selection Criteria of the Elements or Activities of the Agroproductive Node

To choose the activities or elements of the agroproductive node in transition, the following conditioning criteria were taken into account, which are applicable to the processes that constituted them:

- That there are vulnerable processes or potential risks that represent a threat to the existence of the node;
- That the options for the use of natural resources generate sustainable activity;
- That the results are products or services within a sustainable category;

- That they contribute to the development and food security of the community and/or region with minimal environmental impact.

Finally, the biophysical, vision or projection, and technical and financial characteristics are identified to propose a technical alternative.

2.4. Definition of the Scale of Ecotechnological and Sustainable Adoption

To assess each productive activity of the node in an integrated way, it is essential to recognize the emerging attributes of the agroproductive process. Table 1 shows a modified Braden scale. This scale is applicable in the agroproductive production process. The pressure exerted must result in a change in the processes of the agroproductive node, which thereby induces an ecotechnological transition of the node. The change moves from a conventional approach to an ecotechnological state, which reduces the vulnerability and risk of the agroproductive node.

Table 1. Fundamentals of the Braden scale adapted for the ecotechnological insertion into the elements of the agroproductive node.

Score [1]	1	2	3	4
Process versatility	Completely rigid	Rigid in some parts	Rigid but open to change	Completely innovative and open to change
Water requirement	More than 24 h	Between 12 and 24 h	One hour a day	Rarely, once a month
Resilience in natural resources involved	Nil	Low resilience in all	Partial resilience	Full resilience
Consumption dynamism	Consumed more than twice per week	Consumed more than twice per season	Consumed twice per season of the year	In one season of the year
Contribution to the ecosystem, economy, or food security	Does not offer immediate contribution	Only to the ecosystem	To the ecosystem and flow in the local economy	Total contribution
Environmental compatibility	Not compatible	Moderate	High	Very high

[1] Each value represents a quartile of ecotechnological adoption in the agroproductive-node process.

The degree of adoption from a conventional agricultural production system to an ecotechnological one is established through an evaluation of each aspect represented in the quartiles, for which an end sum of no more than 100 points is obtained.

3. Results

3.1. Analysis of the Agroproductive Process of the Original Activity

The original activity is oriented towards the production of hay from alfalfa and sorghum, and the vulnerable stages of the process and their respective scores Table 2.

Table 2. Identification of vulnerable stages of the process.

Process Vulnerability	Vulnerability Trait	Importance Value	Assigned Value *
Planting	The seed loses its germinative capacity	High	0.85
Irrigation	Water is not available due to lack of electricity	Very high	0.95
Growth—Development	Lack of water/nutrients	High	0.85
Cut—baled	Machinery in bad condition or lack of fuel	Middle	0.50
Storage	Putrefaction or combustion	Middle–high	0.5–0.85

* Assigned by the operator of the agroproductive node.

3.2. Identification of Risk Indicators and Threat Quantification

Those directly linked to the main activity of hay production were identified as the main risks. The faults, shortcomings, or deficiencies of the inputs in some parts of the process stand out. The assigned values ranged, according to the operator, from 0.23 for germination failure to 0.97 for the necessary irrigation water for growth; from 0.95 for hours of irrigation with electricity to 0.62 for a low prevalence of plants in the meadow. Once the equation is applied, it is considered that there is a high or imminent threat to the existence of the node with a value greater than 10.59, and so it is essential that the main activity performs a transformation in more than 50% of its processes.

3.3. Conditioning Criteria for the Adoption of Potential Productive Activities

The main attributes identified according to the criteria defined in the methodology were: (a) **Biophysical characteristics:** In this category are soils with 73% fertility levels; the existence of native vegetation (pristine in 95% of the area); a 5% slope of the land; the presence of faunal diversity. (b) **The projection of the node:** being a diverse node in the activities aimed at fulfilling the SDGs. (c) **Technical capacity:** sufficient enough to moderate, with necessary technical support for the development of low-energy ecotechnologies. (d) **Financial capacity:** sufficient for the development of ecological projects that require low investment.

3.4. Alternatives for the Transition of Node of Study

The alternative activities identified, as suggested, use options for the ecotechnological conversion of the node, which, according to the values obtained through the Braden scale, were three: the practice of arid tourism (14–93 BU), the creation of areas for the protection of wildlife (12–100 BU), and rescue grazing use (36–86 BU). Figure 1 shows a comparison between the original activity and the activities suggested for the transition to the ecotechnological and sustainable management of the Moctezuma node, Sonora, Mexico.

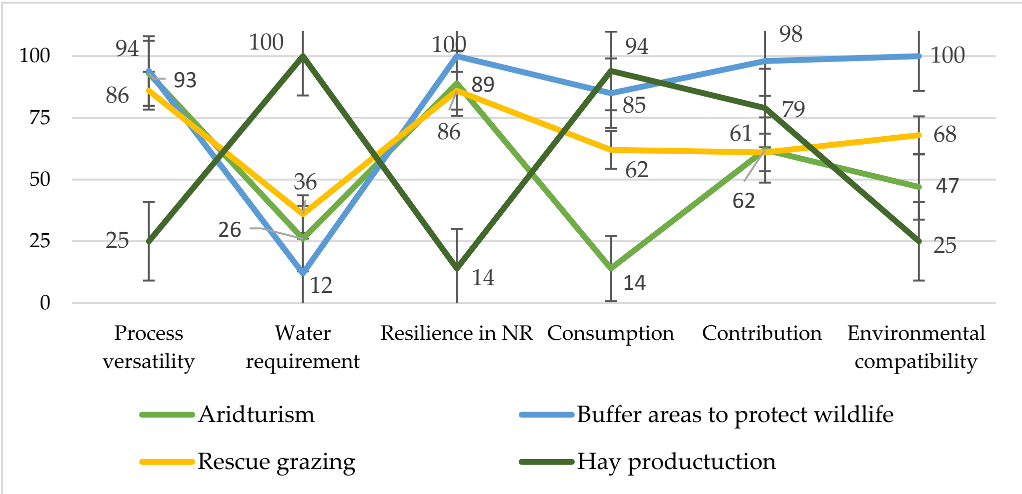

Figure 1. Comparison of the levels of ecotechnological inclusion in the activities of the agroproductive node under study.

4. Discussions

The importance of agricultural production systems in arid Mexican territories represents an alternative for food security and for local–regional self-consumption, guaranteeing the existence of inputs and food for local users under a production approach of an ecotechnological nature. The level of ecotechnology adoption is partially influenced by the physical-climatic conditions of the productive environment and the climatic emergency. These severe conditions of a climatic nature occur in various ways during the seasons of the year in the arid territories of the Sonoran Desert, Mexico [5,6,8,15,17].

5. Conclusions

In the node for hay production in Moctezuma, Sonora, Mexico, diversity traits were identified in the existence of resources, capacities, and biophysical aptitudes. This diversity gave rise to other sustainable productive activities, which were parallel to but independent from each other, with different ecotechnological processes. The complex integration, as well as the link in the optimal and sustainable use of the natural resources of the node, derive from the implementation of the integrated strategic management.

The activity identified as arid turismo refers to the care and development of buffer areas to protect wildlife, as well as rescue grazing, and they were included as integration elements. Its planning and operational development are within sustainability. These activities generate a contribution to the ecosystem with environmental services and, simultaneously, have positive effects on the local users of other agroproductive nodes by acting as primary suppliers.

Both the sustainable and ecotechnological capacity of the node, as well as its gradual changes in the processes over time, were determined in Braden units. The importance of the pragmatism of sustainability was valued, with the various strategies applied in the activities included in the agroproductive node.

The rational use of and the sustainable and ecotechnological tendencies of endemic natural resources in the activities of the node have the following particularly relevant features:

(a) Arid tourism values spaces that are direct to the environment and that are focused on the appreciation of nature, without population overcrowding. It promotes inner peace, as well as the use of xeric landscapes for therapeutic walking and connecting with the biology of the desert;
(b) The purpose of the buffer areas to protect wildlife is to conserve undisturbed spaces on the site for the maintenance of migratory and local species, or both, such as vertebrates and other native organisms;
(c) The use of rescue grazing provides a healthy soil cover, without pressure from trampling or soil erosion. This generates protein from the rescue of livestock, which suffer the consequences of prolonged droughts in the region and the low availability of forage.

In the case of the agroproductive node under study, in order to move from a conventional mode of production to an ecotechnological–sustainable one, it is necessary to adopt, in the processes of the activities, a strategy that will: (1) attend to local priorities; (2) include in the total of the variables the various visualized changes in the local climate; (3) provide a dimension to the availability of quality water. These three are necessary agents for the development of new sustainable techniques and, at the same time, for the maintenance of a balance between production and the pristine state of the natural system where activities take place.

The above generates a design of a state of complexity, which is the basis for integrated and ecotechnological management for the creation of entities organized in the Sustainable Agropolis.

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 upon request to the author of this study.

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

References

1. Instituto Nacional de Estadístia y Geografía. Available online: https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2021/pibe/PIBEntFed2020.pdf (accessed on 6 January 2022).
2. Acebes, P.; Iglesias-González, Z.; Muñoz-Galvez, F.J. Do Traditional Livestock Systems Fit into Contemporary Landscapes? Integrating Social Perceptions and Values on Landscape Change. *Agriculture* **2021**, *11*, 1107. [CrossRef]
3. Molina Benavides, R.A.; Campos Gaona, R.; Sánchez Guerrero, H.; Giraldo Patiño, L.; Atzori, A.S. Sustainable Feedbacks of Colombian Paramos Involving Livestock, Agricultural Activities, and Sustainable Development Goals of the Agenda 2030. *Systems* **2019**, *7*, 52. [CrossRef]

4. Banson, K.E.; Nguyen, N.C.; Sun, D.; Asare, D.K.; Sowah Kodia, S.; Afful, I.; Leigh, J. Strategic Management for Systems Archetypes in the Piggery Industry of Ghana—A Systems Thinking Perspective. *Systems* **2018**, *6*, 35. [CrossRef]
5. Cowan, L.; Wright, V. An Approach for Analyzing the Vulnerability of Small Family Businesses. *Systems* **2016**, *4*, 3. [CrossRef]
6. 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]
7. 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]
8. Byomkesh Talukder, B.; Blay-Palmer, A.; Gary, W.; van Loon, G.W.; Hipel, K.W. Towards complexity of agricultural sustainability assessment: Main issues and concerns. *Environ. Sustain. Indic.* **2020**, *6*, 10038. [CrossRef]
9. Turner, B.L.; Goodman, M.; Machen, R.; Mathis, C.; Rhoades, R.; Dunn, B. Results of Beer Game Trials Played by Natural Resource Managers Versus Students: Does Age Influence Ordering Decisions? *Systems* **2020**, *8*, 37. [CrossRef]
10. Malec, K.; Gebeltová, Z.; Mansoor, M.; Appiah-Kubi, S.N.K.; Sirohi, J.; Maitah, K.; Phiri, J.; Pańka, D.; Prus, P.; Smutka, L.; et al. Water Management of Czech Crop Production in 1961–2019. *Agriculture* **2022**, *12*, 22. [CrossRef]
11. Maxwell, C.M.; Langarudi, S.P.; Fernald, A.G. Simulating a Watershed-Scale Strategy to Mitigate Drought, Flooding, and Sediment Transport in Drylands. *Systems* **2019**, *7*, 53. [CrossRef]
12. Cheng, L.; Zou, W.; Duan, K. The Influence of New Agricultural Business Entities on the Economic Welfare of Farmer's Families. *Agriculture* **2021**, *11*, 880. [CrossRef]
13. 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]
14. Ramírez-Orellana, A.; Ruiz-Palomo, D.; Rojo-Ramírez, A.; Burgos-Burgos, J.E. The Ecuadorian Banana Farms Managers' Perceptions: Innovation as a Driver of Environmental Sustainability Practices. *Agriculture* **2021**, *11*, 213. [CrossRef]
15. 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]
16. Mahamud, M.A.; Saad, N.A.; Zainal Abidin, R.; Yusof, M.F.; Zakaria, N.A.; Mohd Amiruddin Arumugam, M.A.R.; Mat Desa, S.; Md. Noh, M.N. Determination of Cover and Land Management Factors for Soil Loss Prediction in Cameron Highlands, Malaysia. *Agriculture* **2022**, *12*, 16. [CrossRef]
17. Kurdyś-Kujawska, A.; Sompolska-Rzechuła, A.; Pawłowska-Tyszko, J.; Soliwoda, M. Crop Insurance, Land Productivity and the Environment: A Way forward to a Better Understanding. *Agriculture* **2021**, *11*, 1108. [CrossRef]
18. Serrano, J.; Shahidian, S.; Machado, E.; Paniagua, L.L.; Carreira, E.; Moral, F.; Pereira, A.; de Carvalho, M. Floristic Composition: Dynamic Biodiversity Indicator of Tree Canopy Effect on Dryland and Improved Mediterranean Pastures. *Agriculture* **2021**, *11*, 1128. [CrossRef]