

## CHARACTERISTICS, RISKS, AND REVALUATION OF THE VALUE NETWORKS OF AN AGRICULTURAL LAND

Zaira Sarahi **Sánchez-Sánchez**<sup>1</sup>, Jorge **Cadena-Iñiguez**<sup>1\*</sup>, Victor Manuel **Ruiz-Vera**<sup>1</sup>,  
Victor Manuel **Cisneros-Solano**<sup>2</sup>, Francisco Javier **Morales-Flores**<sup>2</sup>,  
Ernesto **Peredo-Rivera**<sup>1</sup>, Brenda I. **Trejo-Téllez**<sup>1</sup>

<sup>1</sup>Colegio de Posgraduados Campus San Luis Potosí. Posgrado en Innovación en Manejo de Recursos Naturales. Iturbide 73, Salinas de Hidalgo, S.L.P., México. C.P. 78600.

<sup>2</sup>Universidad Autónoma Chapingo. Centro Regional Universitario Oriente. Carretera Federal Huatusco-Xalapa Km. 6.5, Huatusco, Veracruz, México. C.P. 94100.

\* Author for correspondence: jocadena@gmail.com

### ABSTRACT

Several crops generate local employment and drive the economy in the High Mountain Region (RAM: Región Altas Montañas) of Veracruz. However, changes in sale price, oversupply, natural disasters, new pests, and scarce or lack of training regarding agricultural activities can lead producers to the abandonment of crops, unemployment, and migration. Consequently, identifying the type of value networks and risks and developing revaluation proposals is fundamental to foster the consolidation and permanence of products, both in domestic and international markets. Surveys –based on socioeconomic, environmental, commercial, and technological variables, as well as on the integration of links from internal logistics– were applied to crop (n=15) producers (n=131). The RStudio v. 4.3.3 software was used for the analysis. Six types of value networks were identified; none of them fell into a single classification type (primary, emergent, or potential). The percentage of the distinctive features indicated that the networks were dynamic and that their common features establish them as mixed and evolving. To facilitate their study, risks were classified per social segments. The products of the network have an accumulated dependency on the domestic, local, regional, and Mexico City (CDMX) markets (86%). Only chayote and banana leaves are exported. Chayote is included in the six value networks and has the highest consolidation level as primary network. The explained cumulative variance (73.95%) is divided into four main components. It frequently includes technical support, unauthorized agrochemicals, and raw manure. In order to consolidate the networks, risky activities that limit the dynamics and evolution of crops should be taken into account.

**Keywords:** raw materials, self-consumption, agroindustry, sustainability, agriculture.

### INTRODUCCIÓN

Agriculture is an activity that gathers rural producers (INEGI, 2023), who grow crops, provide raw material to the agroindustry, and generate local and self-employment

**Citation:** Sánchez-Sánchez ZS, Cadena-Iñiguez J, Ruiz-Vera VM, Cisneros-Solano VM, Morales-Flores FJ, Peredo-Rivera E, Trejo-Téllez BI. 2025. Characteristics, risks, and revaluation of the value networks of an agricultural land.

**Agrociencia.** <https://doi.org/10.47163/agrociencia.v59i3.3336>

**Editor in Chief:**

Dr. Fernando C. Gómez Merino

Received: October 29, 2024.

Approved: April 10, 2025.

**Published in Agrociencia:**

May 06, 2025.

This work is licensed under a Creative Commons Attribution-Non-Commercial 4.0 International license.



(SIAP, 2022). In Mexico, Veracruz is an agricultural region with annual and perennial crops (Almaraz-Vidal, 2016; INEGI, 2023; SIAP, 2022) and is divided into ten strategic regions. One of these regions is the High Mountain Region (RAM), 48% of whose area is used for agricultural activities (INEGI, 2023; Rivera-Hernández, 2018; SIAP, 2022). In RAM, exportations generate income to producers. Crops such as chayote (*Sechium edule* (Jacq.) Sw.), coffee (*Coffea arabica* L.), and sugarcane (*Saccharum* spp.) provide raw materials to the agroindustry (Bada Carbajal *et al.*, 2010). Other regional producers grow crops as food for the rural population and their produce is sold locally (Beltrán-Morales, 2022). Their activities are not structured and their operations are not consolidated (Gómez-Núñez *et al.*, 2019; INEGI, 2024b; SIAP, 2022). The value networks of agricultural activities include the following characteristics: field production, packaging (Sánchez-Galván *et al.*, 2020), and technical support in areas such as phytosanitary control, nutrition, waste management, shelf life, food safety, transfer of business, marketing, and sales (Rosa and de Paredes, 2017). However, the structure and operation of some crops have not reached the same maturity level (Vargas-Canales *et al.*, 2020) and, consequently, not all of them can be classified as primary or consolidated value networks. Although value networks in agricultural areas are not highly consolidated, they play a major role in food security (Urquía-Fernández, 2014), trade, input supply, and local employment (Sánchez-Sánchez *et al.*, 2023).

In order to produce or promote additional economic development poles in the region, the emergent or potential value networks should be reevaluated or reorientated through the improvement of technology aimed to guarantee their socio-economic consolidation, competitiveness, and permanence (Torre, 2020). These proposals would help certain local or ancestral products to reach domestic and international markets (Cañarte *et al.*, 2021). This objective can be reached through the identification of limitations, the level of adoption of local practices, and the compliance with the quality and safety regulations and standards demanded by international markets (Carenzo, 2007).

Consequently, the types of value networks, their structural and operational levels, and their socio-economic, environmental, technological, trade, and public health risks, as well as their integration of internal logistics must be identified (Singh *et al.*, 2018).

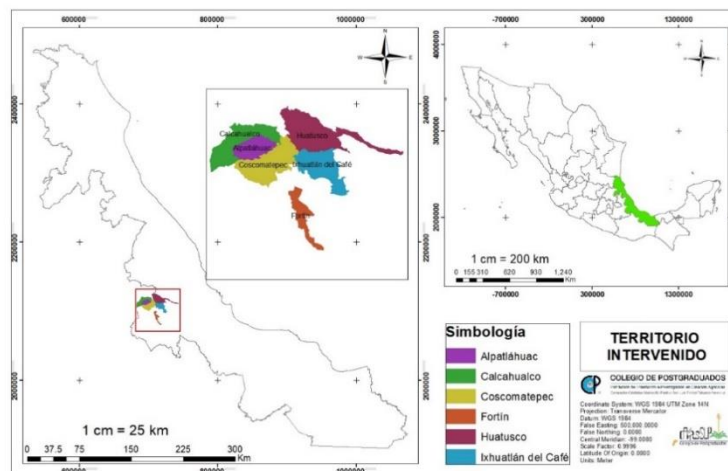
Therefore, primary, emergent, and potential value networks of crops in the High Mountain Region of Veracruz were identified and characterized. The objective was to determine the limitations and advantages in order to propose a reevaluation and consolidation. These findings will help to predict or avoid failures in the region, caused by unemployment, migration, and oversupply. In addition, they would help producers to achieve long-term sustainability for their crops.

## MATERIALS AND METHODS

### Study Area

The following municipalities of Veracruz were included as agricultural areas: Alpatláhuac, Calchualco, Coscomatepec, Fortín, Huatusco, and Ixhuatlán del Café

(Figure 1) They are located from 19° 07" to 18° 58' 39" N and from 97° 06" to 96° 57' 25" W, at 987-1,860 m.a.s.l. The weather of the area is mainly humid, semi-warm, and temperate (INEGI, 2000, 2024a).



**Figure 1.** Location of the municipalities included in the study area of the High Mountain Region, Veracruz. Figure developed by Mayra Aragón Magadán, based on the layers of CONABIO (2024).

The crops identified in the study area included: avocado (*Persea americana*), coffee (*Coffea arabica*), zucchini (*Cucurbita pepo* L.), sugarcane (*Saccharum* spp.), chayote (*Sechium edule*), chilacayote (*Cucurbita ficifolia*), manzano pepper (*Capsicum pubescens*), prune plum (*Prunus domestica*), peach (*Prunus persica* L.), tomato (*Solanum lycopersicum* L.), prickly pear (*Opuntia ficus-indica*), potato (*Solanum tuberosum* L.), pear (*Pyrus communis*), tomatillo (*Physalis philadelphica*), and banana leaf (*Musa acuminata*).

### Research Method

The study was conducted through a structured survey, that included questions about social, economic, technical, environmental, biosafety, trade, and risk issues. In order to determine the size of the sample, producers from the RAM were identified, based on the data available for 2019, 2021, and 2022, from the Programa para el Bienestar “Corte a junio 2022, beneficiarios del Programa Producción para el Bienestar 2022” (SADER, 2022) and the *Anuario Estadístico de la Producción Agrícola* (SIAP, 2022). The Brenlla-Martínez (1997) formula was applied to the universe of producers (N= 1,131). This author suggested that a >107 >145 sample size provides a 97% confidence level. The operation and structure of value networks poses several risks. Meanwhile, their impact can be related to factors such as public health (authorized agrochemicals, use

of manure), environment (agrochemical application, water, soil), socio-economic (job offer/lack of) and technological (lack of training) issues. These factors also include trade (oversupply/missing products), maintenance — as a consequence of the displacement of local genetic resources by other highly-successful commercial resources —, and, finally, generational change for each crop and network (Table 1). Table 2 and 3 shows the activities that set primary (consolidated), emergent, and potential value networks apart (Sánchez-Sánchez *et al.*, 2023; Porter, 1985).

In order to identify the consolidation level of the regional value networks, acceptance criteria and acceptable ranges, based on the percentage value, were adopted from Porter (1985) and Sánchez-Sánchez *et al.* (2023). Since a consolidated primary network must have evolved from a potential and emergent value network (3), the percentage of primary, emergent, and potential characteristics was codified to determine the status and level of the features that are mixed in or define a network.

In order to understand the acceptance criteria and the acceptable ranges of the characteristics that define agricultural value networks, a location triangle was developed. The percentages of the networks are drawn with different colors: orange for the emergent-potential-mixed value network, purple for the primary-mixed value network, and green for the primary value network (Figure 2).

A breakdown of the answers was structured to confirm the level of each network, based on their activities (Table 4).

**Table 1.** Study variables included in the survey to identify the value networks of crops.

Variable	Description
Social	Land ownership, cultivation, surface area, irrigation, rainfed, technical assistance. Rural stakeholders: age, gender, education, economic activity.
Economic	Local employment (number and gender, week, month, year). New crop pests.
Environmental	Type of agrochemicals, fertilizers, organic and biological inputs, biosecurity: use of raw or composted manure.
Commercial	Markets (local, regional, national, and export). Direct sales, local or national intermediary, central supply center, or self-service stores. Product presentation (fruit, packaging: box, with or without refrigeration). Product destination: local, regional, national, or export. National or international certification (field and packaging).
Technological	Agronomic, nutritional, and sanitary management, harvesting, and post-harvest. Monoculture, associated, extensive ( $\geq 1.0$ ha), backyard.
Integration of links in the internal logistics of the value chain	Producers, suppliers in general, collectors, distribution (local, regional, national, and export), consumers, processors.

**Table 2.** Activities that distinguish the value networks adapted from Porter (1985) and Sánchez-Sánchez *et al.* (2023).

Value network	Crterios de definición	Rango de aceptación
Primary mixed	40%Prim-33%Emer-27%Pote	45%-35-%Prim-38%-28%Emer-32%-22%Pote
Emerging mixed	28%Prim-39%Emer-33%Pote	28-26% Prim-39%Emer-33%Pote
Potentially emerging mixed	21%Prim-45%Emer-34%Pote	25%-16%Prim-50%-40%Emer-39%-19%Pote
Primary prevalence	50%Prim-30%Emer-20%Pote	55%-45% Prim-35%-24%Emer-25%-15%Pote
Transition to primary	65%Prim-25%Emer-10Pote	69%-59%Prim-26%-23%Emer-15%-12%Pote
Primary	75%Prim-18%Emer-7%Pote	80%-70%Prim-22%-13%Emer-11%-1%Pote

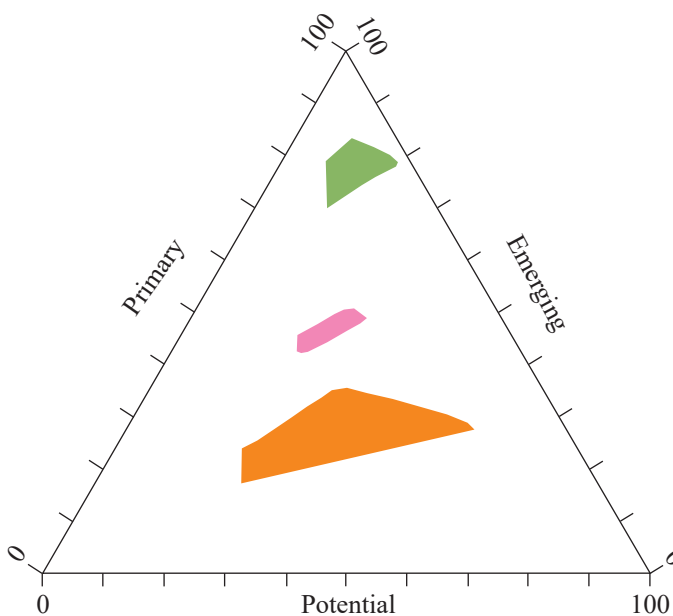
**Table 3.** Agricultural value networks, acceptable ranges, and acceptance criteria.

Activities	Primary network	Emerging network	Potential network
Operations	Product packaged under refrigeration	Bulk product	Packaged and unrefrigerated product
Product Presentation			
Marketing and Sales	The producer has a certificate that guarantees good food safety practices	The producer does not have a certificate that endorses good practices and does not deliver product selected and packaged according to quality.	The producer delivers product selected and packaged according to quality
Sales requirements			

Source: Table developed by the authors.

### Statistical Analysis

The data obtained from the surveys were systematized and codified using Google Forms and Excel, respectively. The codification integrated dichotomous, polytomous, ordinal, and continuous qualitative variables. Subsequently, the RStudio v.4.3.3 software, with a similarity matrix based on Gower’s distance (Palacio *et al.*, 2020), was used for the cluster analysis. The `fviz_nbclust` function of the `factoextra` package was used to determine the optimal number of the cluster. Once the number of clusters was determined, Ward’s method was used to develop a scatter plot and to determine the cluster groups. Afterwards, Excel was used to identify the networks, taking into account the acceptable ranges and the acceptance criteria (Table 3). The risks of the networks were established using the distinctive features of each network (Table 2) and Statistics. Finally, the revaluation proposal was developed through an analysis of their main elements.



**Figure 2.** Location triangle of an agricultural value network, based on the percentage obtained from the acceptable ranges and acceptance criteria.

**Table 4.** Breakdown of the answers based on the characteristics of the crop value networks.

Feature Name	Value network	Feature component
Activity	Primary Emerging Potential	Grow, Sell, and Store Grow and Buy Grow, Sell, and Distribute
Crops	Primary Emerging Potential Primary Potential	Coffee, sugarcane, and chayote Zucchini, wax pepper, plum, tomato, peach, potato, pear, chilacayote, and nopal (vegetables) Tomato, avocado, banana leaf, or velillo No crops grown during dry weather
JanEmp, FebEmp, MarEmp, AprEmp, MayEmp, JunEmp, JulEmp, AugEmp, SeptEmp, OctEmp, NovEmp, DecEmp	Emerging Potential Potential	Year-round employment generation Job creation for 3 to 6 months of the year Year-round employment generation
Leave Someone	Primary Emerging Potential	I've already solved it I haven't thought about it I haven't solved it
ATReceives	Primary Emerging Potential	I frequently receive technical support I rarely receive technical assistance I rarely receive technical assistance
New Plague	Primary Emerging Potential	There are many new pests New pests are present There are no pests

**Table 4.** Continued.

Feature Name	Value network	Feature component
I apply	Primary Emerging Potential	Permitted agrochemicals or composted manure; Unregulated agrochemicals or Raw manure
Use equipment	Primary Emerging Potential	No application I use it every time I rarely use it
DeliveryWho	Primary Emerging Potential	I don't use it I sell it to a distributor I sell it on the lot
Post-Practice	Primary Emerging Potential	Extending shelf life and managing product volumes Product volume management I don't do this
Destination	Primary Emerging	Export (US, Canada, UK) Local market (Coscomatepec-Huatusco) or domestic market
	Potential	Metropolitan area supply center (CDMX, Guadalajara, Jalisco, Monterrey, NL)
Delivery Requirements	Primary Emerging	Regional market (Córdoba-Orizaba-Puebla) He doesn't ask me for anything
	Potential	Deliver my product selected and packaged according to quality
ReasonReturn	Primary Emerging Potential	Presence of pesticides My product is not inspected Inert objects

## RESULTS AND DISCUSSION

Six types of agricultural value networks were identified (Table 5) based on the typical activities of each type of network (Table 2) and the acceptable ranges and acceptance criteria (Table 3). Sánchez-Sánchez *et al.* (2023) mentioned that networks with different consolidation levels can be found within a region and that they can generate a combination of distinctive features.

**Table 5.** Consolidation level of agricultural value networks, based on the integration (%) of the characteristics of primary, emergent, and potential networks.

Value Network (acronym)	Description	Valuation (%)	Level of consolidation
MixtEmer	Emerging mixed	Prim (33), Emer (43), and Pote (23)	Emerging
MixtPoteEmer	Potentially emerging mixed	Prim (21), Eme (45), and Pote (34)	Emerging
PrevPrim	Primary prevalence	Prim (52), Emer (29), and Pote (19)	Primary
MixtPrim	Primary mixed	Prim (36), Emer (33), and Pote (30)	Primary
TPrim	Transition to primary	Prim (62), Emer (23), and Pote (15)	Primary
Prim	Primary	Prim (75), Emer (14), and Pote (11)	Primary

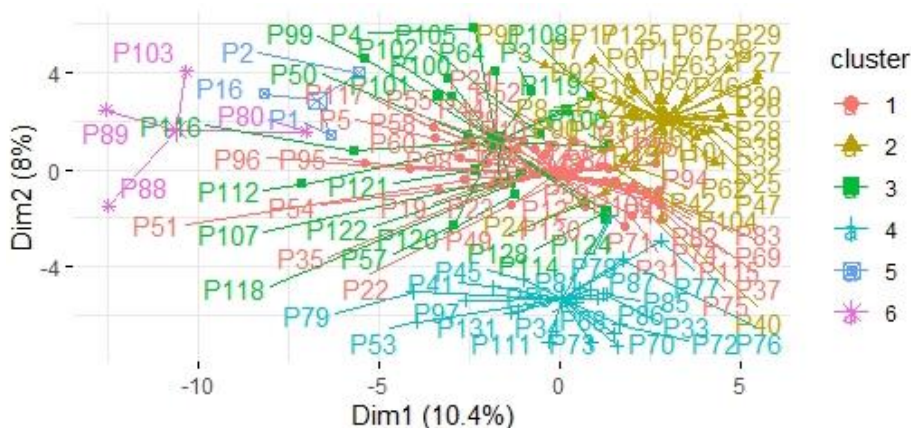
The dynamics of value networks depend on the supply, demand, and importance of the input supply link; consequently, they have multi-level features. For example, the emergent mixed network (EmerMix) recorded 33% of the features of a primary network, 43% of an emergent network, and 23% of a potential network. These percentages showed that the dynamics of the structural and operational levels of the agricultural networks depend on the requirements of the markets.

Singh *et al.* (2018) pointed out that, as a result of globalization, agricultural networks made up of small producers have modified their operations and structures, in order to achieve competitiveness in international markets. Likewise, the highest percentage determines the consolidation level of other networks. Therefore, the emergent-potential-mixed network (EmerPotMix) would be classified as an emergent network (45%), while the transition consolidated primary network (TConsPrim) and the primary consolidated network (ConsPrim) are transition (62%) and primary (75%) networks.

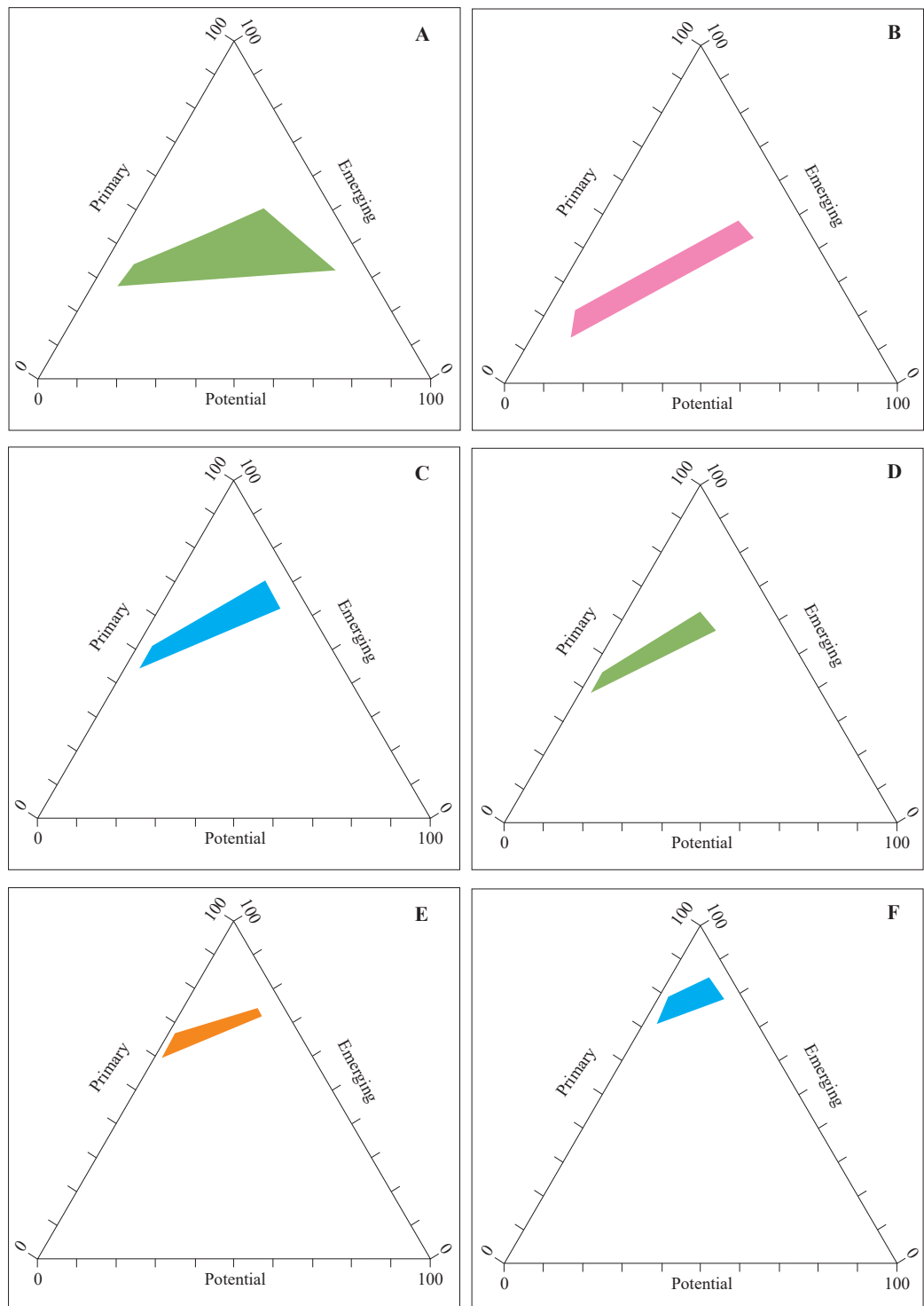
A mixed primary (MixPrim) network is integrated with 36, 33, and 30% features; these percentages indicate that their activities, operations, and structures are balanced. However, the small difference between these percentages suggests which characteristics require assistance or support in areas such as product packaging, additional markets, life shelf, etc.

Figure 3 shows a low statistical weight of the features of the value network. Dimensions 1 and 2 recorded 10.4 and 8%, respectively, in a wide range of groups, suggesting that neither network is completely consolidated and that they share primary, emergent, and potential features.

The characteristics of some value networks (e.g., emergent mixed and emergent potential mixed) can overlap (Figure 4). The diverse crops that make up each network suggest the existence of a sustainable rural employment, local commerce, external commerce (regional, domestic, and exportation), diversification of activities,



**Figure 3.** Scatter plot of value networks of crops, based on the features of primary, emergent, and potential networks.



**Figure 4.** Value networks identified in the High Mountains Region (RAM) of Veracruz: A) EmerMix; B) EmerPotMix; C) PrimPrev; D) PrimMix; E) TPrim; and F) Prim.

differences in offer throughout the year, and the number of exploited local genetic resources (Table 6).

The diversified agricultural activities reported in the territory suggest that producers that participate in the value networks do not depend on a single activity (Waha et al., 2018). These results match the findings of Rojas and Saavedra-Mera (2022), who reported that having several crops guarantees the sustainability of the producers. Being able to distribute their economic dependency between multiple sources of income allows them to overcome the risks involved by changes in market prices, the effects of climate change, or the impact of new pests.

Productive and economic diversity can help to reduce the risks posed to certain crops by employment loss and climate change displacement, particularly those crops involved in primary networks, such as chayote in TConsPrim (100%) and ConsPrim (75%). Chayote is included in the six networks, followed by avocado, tomato, peaches, manzano pepper, and coffee. Sugarcane has a restricted surface and depends on the capacity of the sugar mill. Meanwhile, price instability and new pests have caused a loss of interest in coffee, which has been substituted by chayote. Regardless of their consolidation level, value networks may face diverse threats (Figure 4).

Public health risks were detected, particularly as a result of the application of raw chicken manure in crops from the emergent mixed, emergent potential mixed, and consolidated primary networks, exposing the product and the consumer to *Escherichia coli* (Luna-Guevara et al., 2019) and *Salmonella sp.* These findings match the reports of Rosas-Martínez and Aguilar-Rivera (2022), who identified *E. coli* and *Salmonella sp.* (Natarén Velázquez et al., 2020) in chicken manure (Table 7), a situation that is penalized in international audits.

The socioeconomical risks reported show the presence of new pests that impact crops (Rojas and Saavedra-Mera, 2022; Skendžić et al., 2021). The application of agrochemicals impacts the financial costs involved in the emergent mixed, emergent-potential-mixed,

**Table 6.** Percentage value that each crop contributes to the value network.

Value network	Crops
MixtEmer	Chayote (30%), avocado (21%), plantain veil (21%), peach (14%), tomato (7%), wax pepper (5%), and plum (2%)
MixtPoteEmer	Avocado (22%), coffee (14%), potato (11%), nopal (11%), tomato (8%), zucchini (5%), plum (5%), peach (5%), pear (5%), tomato (5%), chayote (3%), wax pepper (3%), and chilacayote (3%)
PrevPrim	Coffee (61%), sugarcane (9%), plum (9%), chayote (5%), tomato (4%), zucchini (4%), peach (4%), and avocado (4%)
MixtPrim	Chayote (19%), plum (14%), peach (14%), wax pepper (9%), potato (9%), avocado (10%), tomato (10%), plantain veil (10%), and chilacayote (5%)
TPrimCons	Chayote (100%)
PrimCons	Chayote (75%) and avocado (25%)

**Table 7.** Risks associated with the activities of the crop value networks.

Variable	Risk and related network
Public Health	Application of raw manure exposes crops and people to microorganisms ( <i>Escherichia coli</i> and <i>Salmonella sp.</i> ) representing a high risk to marketing and health (MixtEmer), (MixtPoteEmer) and (PrimCons).
Socioeconomic	<p>The business transfer to the next generation (MixtPoteEmer) and (MixtPrim) has not been completed.</p> <p>The value chains are experiencing new pest organisms, leading to increased application of agrochemicals (MixtEmer), (MixtPoteEmer), (MixtPrim), (TPrimCons), and (PrimCons).</p> <p>Worker shortages occur in the months of January, February, March (PrevPrim), (MixtPrim), July, August (TPrimCons), (PrimCons), September, October, and December (PrimCons).</p> <p>Worker shortages due to migration (MixedPrim), (TPrimCons), (PrimCons), high demand, or other agricultural activity (PrimCons).</p> <p>Presence of fungi in crops affecting leaves (PrevPrim), stems (MixedPrim) (PrimCons), and fruits (PrimCons).</p>
Environmental	<p>Unregulated agrochemicals are used, putting personnel at risk and negatively impacting the environment (MixtEmer).</p> <p>The network is vulnerable to natural disasters (frost, hail and drought) that affect crops and reduce supply to the market (MixtEmer), (MixtPoteEmer), (PrevPrim) and (PrimCons).</p>
Technological	<p>It does not have technical assistance in health, nutritional, biosecurity and post-harvest management (MixtPoteEmer) and (MixtPrim).</p> <p>They do not receive technical assistance after natural disasters (MixtEmer).</p> <p>By delivering their produce to a buyer (intermediary), they earn less during peak supply periods (MixtEmer).</p>
Comercial	There is no certification for field and post-harvest activities (MixtPoteEmer).
Conservation	<p>Coffee monoculture, producers have been cultivating the crop for a long time (PrevPrim).</p> <p>The price of avocado fruit has influenced the establishment and substitution of potatoes, chayote and coffee (PrimCons)</p>
Integration of links in internal logistics	Producers cultivate without expanding purchasing, selling and distribution activities of their product along the agri-food chain to be more competitive (MixtEmer), (MixtPoteEmer), (PrevPrim) and (MixtPrim).

primary mixed, in transition to a consolidated primary, and consolidated primary networks (Tudi *et al.*, 2021). According to Shrestha (2019), this situation diminishes production and impacts the quality of the product in the destination market. Likewise, it impacts producers who lack economic solvency to support an increase in the long-

term production costs (Acevedo-Suárez *et al.*, 2012; Natarén Velázquez *et al.*, 2020; Skendžić *et al.*, 2021).

Rana *et al.* (2022), Rojas and Saavedra-Mera (2022) and Raza *et al.* (2019) pointed out that the vulnerability of emergent, potential emergent, and primary value networks to frost, hail, and droughts poses a third environmental risk, affecting income and the creation of employment (Erokhin *et al.*, 2020).

The lack of training in the health, nutritional, biosafety, and postharvest handling poses a technological risk (Njoroge *et al.*, 2019). Fonseca-Carreño *et al.* (2020) and other authors report that good agricultural practices should be applied in the management of a specialized agricultural production (Leong *et al.*, 2020).

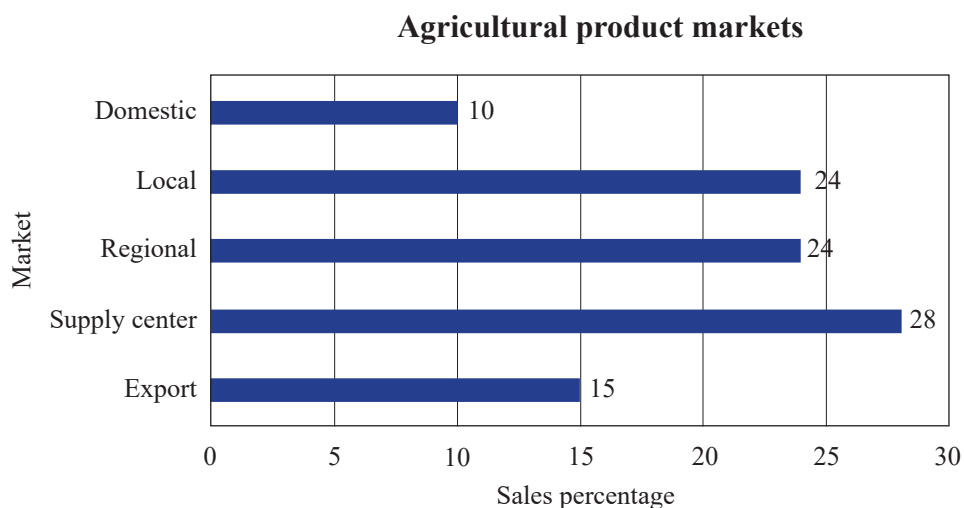
The low consolidation of chain links poses a risk to commercialization. Those risks include middlemen and the lack of integration of producers into the purchase, sale, and commercialization links. This situation puts the producers at a disadvantage in markets that require processed or added-value products. Producers who do not put into practice entrepreneurial measures will not have a greater participation in specialized markets with high quality and competitiveness standards (Durham and Mizik, 2021). The displacement of chayote by avocado endangers the conservation of local genetic resources, as a consequence of the price increase in the market. A distinctive feature of the type of value network is its activity, which can suggest the consolidation level of its structure and operation. Table 8 shows the main activity of the identified network, highlighting that the raw material (RM) supply is a priority for the first four networks, whose classification includes emergent, potential, and primary features. Meanwhile, the last two integrate the raw material (RM) supply links: the purchase and sale of agricultural products (PAP and SAP). This situation suggests that the inner logistics in the network have a higher level of consolidation.

**Table 8.** Value networks and their integration into the supply chain.

Value Network	Activity (%)	Description of the priority activity
MixtEmer	SM (98)	SM: Supply of raw materials
MixtPoteEmer	SM (100)	SM: Supply of raw materials
PrevPrim	SM (96)	SM: Supply of raw materials
MixtPrim	SM (100)	SM: Supply of raw materials
TPrimCons	SM (100), PAP (100) and SAP (67)	SM: Supply of raw materials, PAP: Purchase of agricultural products, SAP: Sale of agricultural products
PrimCons	SM (100), PAP (75) and SAP (75)	SM: Supply of raw materials, PAP: Purchase of agricultural products, SAP: Sale of agricultural products

MixtEmer (EmerMix): emergent mixed network. MixtPoteEmer (EmerPotMix): emergent potential mixed network. PrevPrim (PrimPrev): primary prevalence network. MixtPrim (PrimMix): primary mixed network. TPrimCons (TConsPrim): transition to consolidated primary network. PrimCons (ConsPrim): consolidated primary network.

Revaluation proposals for local or endogenous products are established to strengthen territorial development, seeking to overcome several limits, including scale and adaptation to the quality standards established in international commercialization regulations. Figure 5 shows the destination market of the by-products of each network that has been identified in the territory.



**Figure 5.** Destination markets for the agricultural products from the High Mountains Region of Veracruz. Figure developed by the authors based on producer surveys.

The Central de Abasto of Mexico City has the highest value, followed by regional and local destinations, suggesting the involvement of middlemen in commercialization. This is also the case of informal and traditional sale points that operate two or more days per week, in Coscomatepec, Orizaba, and Iztaczoquitlán, Veracruz, as well as the Central de Abasto of the city of Puebla, Puebla. Only chayote and banana leaf are exported and 15% of their production is sold to the United States and Canada. The surveyed socioeconomic sector does not generally export coffee. Producers only sell their production to middlemen who specialize in coffee cherry (direct from the field), In their turn, middlemen sell coffee cherries to processing and exporting companies. Since the territory does not have a North American pest free area certificate, producers only sell their avocados in their hometowns and in the region. Some of the limitations to the exportation of manzano pepper (*Capiscum pubescens*) is the presence of the Mexican fruit fly (*Anastrepha* spp.). The remaining crops, including tomatillo (*Physalis* sp.) and tomato (*S. lycopersicum*), are commercialized in the local and regional markets. Risk characteristics were selected to identify the activities of the revaluation proposal (Carenzo, 2007). A principal component analysis revealed that nine characteristics of the networks are key for the said proposal (Tables 9 and 10).

**Table 9.** Activities required to reevaluate the value networks of crops.

Value Network Characteristics	Description	Activity in the value chain
AT Frequency	Frequency of technical assistance	Purchasing
ApplyAgroPermitted	Applies permitted agrochemicals	Logistics
ApplyCompost	Applies organic compost	Logistics
ApplyAgroNotRegulated	Applies prohibited agrochemicals	Logistics
ApplyRawManure	Applies manure without composting	Logistics
UseEquipment	Uses used equipment	Purchasing
PostPractice	Applies post-harvest techniques	Operations
DeliveryRequirements	Proper product delivery	Marketing and sales
ReturnReasonNotReviewed	Applies product traceability	Marketing and sales

**Table 10.** Integrated variables of the principal components (PC) that account for the cumulative variance for the revaluation of crops.

Component Structure	Variables (number)	Cumulative explained variance (%)
CP1 = -0.75 Equipment Use -0.73 Post-Practice -0.68 ATFrequency. Technical Assistance and Post-Harvest Handling Asistencia técnica y manejo postcosecha	2.9	32.57
CP2 = 0.63 ApplyAgroPermit -0.63 ApplyAgroNoRegulate + 0.47 DeliveryRequirements + 0.32 ReturnNoReview Requirements for Product Sale	4.4	49.81
CP3 = 0.78 ApplyCompost -0.54 ApplyRawManure +0.15 Equipment Use +0.10 ATFrequency +0.07 Post-Practice Field Training	5.6	63.23
CP4 = -0.86 ReturnNoReview +0.29 ATFrequency -0.22 ApplyRawManure -0.18 ApplyAgroNoRegulate +0.05 ApplyAgroPermit -0.01 DeliveryRequirements	6.7	73.95

After grouping the activities according to their statistical weight, a 73.95% cumulative variance was recorded in four principal components (PC) which determine the priority of the activities (Table 10).

To boost network consolidation and bring producers into the supply chain, purchase activities must be improved (Dias *et al.*, 2019), along with logistics, operations, marketing, and sales. This approach matches the proposal of Bada Carbajal *et al.* (2010) and Carengo (2007), who reported that the problems must be identified before local products are reevaluated; likewise, quality standards must be adapted to international regulations to facilitate the participation of producers in domestic and foreign markets.

Likewise, Singh *et al.* (2018) point out that globalization has changed the structure and operation of agricultural networks; therefore, they suggest improving competitiveness to comply with the standards of the international market. In summary, value networks are characterized by their activities, structure, and operation. The type of value network and its consolidation depend on structural differences and the ratio between its economic, logistical, social, technological, and risk values. Improvements for the consolidation of value networks can be suggested, as well as action strategies aimed at the less structured activities of each network.

Value networks harbor local genetic resources of great importance. These resources preserve agrobiodiversity, as well as productive and economic diversity. Likewise, they boost and support the local economy, mitigating migration and promoting local employment.

### CONCLUSIONS

Six types of value networks with different consolidation levels were identified in the territory in question. None of them had a single classification type (e.g., primary, emergent, and potential). The percentage value of distinctive characteristics pointed out that these dynamic networks share features that classify them as mixed and evolving. Different risks were identified and classified per social group to facilitate their study. The network by-products recorded a cumulative dependency ( $\leq 85\%$ ) on the domestic, local, regional, and Mexico City markets. Only chayote and banana leaf are exported. Chayote is the most widespread crop in the six networks and it has the highest consolidation level as a primary network. Both crops and risks that can limit their dynamics and evolution should be reevaluated and reorientated to strengthen the networks. The most frequent factors were technical support and the application of banned agrochemicals and raw manure.

### ACKNOWLEDGMENTS

To CONAHCyT, for the economic support provided for the education of the MSc candidate. To COLPOS, particularly the SLP campus, for the education opportunities and their advice for this research. To the agricultural producers of the High Mountains Region of Veracruz, Mexico, for their information and trust.

### REFERENCES

- Acevedo-Suárez, J. A., Gómez-Acosta, M. I., & López-Joy, T. (2012). Análisis de la cadena de valor hortofrutícola del municipio Marianao en La Habana, Cuba. XXXIII (2), 200–2013.
- Almaraz-Vidal, D. (2016). Las serpientes venenosas de importancia médica de la región de Las Grandes Montañas de Veracruz, México: Aspectos ecológicos y accidentes ofídicos. *Revista mundo de investigación*, 2(1). [https://web.archive.org/web/20210716165252id\\_/https://mundoinvestigacion.es/wp-content/uploads/2017/03/5-SERPIENTES-VENENOSAS\\_Almaraz.pdf](https://web.archive.org/web/20210716165252id_/https://mundoinvestigacion.es/wp-content/uploads/2017/03/5-SERPIENTES-VENENOSAS_Almaraz.pdf)

- Bada Carbajal, L. M., Rivas Tovar, L. A., Bada Carbajal, L. M., & Rivas Tovar, L. A. (2010). Los clusters agroindustriales en el estado de Veracruz. *Investigación administrativa*, 39(105), 73–100.
- Beltran-Morales, N. N. (2022). La etnografía en los estudios turísticos, el caso del tianguis tradicional de Coscomatepec de Bravo, Veracruz; México [Colegio de Postgraduados]. [http://colposdigital.colpos.mx:8080/xmlui/bitstream/handle/10521/4998/Beltran\\_Morales\\_NN\\_MP\\_PTR\\_2022.pdf?sequence=1&isAllowed=y](http://colposdigital.colpos.mx:8080/xmlui/bitstream/handle/10521/4998/Beltran_Morales_NN_MP_PTR_2022.pdf?sequence=1&isAllowed=y)
- Brenlla-Martínez, M. (1997). Calculo tamaño de muestra. Universidad de Granada, España. <https://www.ugr.es/~ecordon/master/docus/calculotama%C3%B1omuestra.xls>
- Cañarte, J. S. R., García, J. G. M., Intriago, M. A. L., & Moreira, J. A. F. (2021). El desarrollo territorial y el pensamiento económico. *Sociedad & Tecnología*, 4(3), Article 3. <https://doi.org/10.51247/st.v4i3.145>
- Carenzo, S. (2007). Territorio, identidades y consumo: Reflexiones en torno a la construcción de nuevos paradigmas en el desarrollo.
- Dias, C. S. L., Rodrigues, R. G., & Ferreira, J. J. (2019). What's new in the research on agricultural entrepreneurship? *Journal of Rural Studies*, 65, 99–115. <https://doi.org/10.1016/j.jrurstud.2018.11.003>
- Durham, T. C., & Mizik, T. (2021). Comparative Economics of Conventional, Organic, and Alternative Agricultural Production Systems. *Economies*, 9(2), Article 2. <https://doi.org/10.3390/economies9020064>
- Erokhin, V., Diao, L., & Du, P. (2020). Sustainability-Related Implications of Competitive Advantages in Agricultural Value Chains: Evidence from Central Asia—China Trade and Investment. *Sustainability*, 12(3), Article 3. <https://doi.org/10.3390/su12031117>
- Fonseca-Carreño, N. E., González Moreno, M. R., & Narváez Benavides, C. A. (2020). Asociatividad para la administración los sistemas de producción campesina. *Revista Estrategia Organizacional*, 9(1). <https://doi.org/10.22490/25392786.3644>
- Gómez-Núñez, J., Gómez-Martínez, E., Morales, H., González-Santiago, M. V., & Aiterwegmair, K. (2019). Construcción social de la soberanía alimentaria por la organización campesina OCEZ-CNPA en Chiapas, México. *Estudios Sociales. Revista de Alimentación Contemporánea y Desarrollo Regional*, 29(54). <https://doi.org/10.24836/es.v29i54.799>
- INEGI (Instituto Nacional de Estadística y Geografía). (2000). Espacio y datos de México. Instituto Nacional de Estadística y Geografía. INEGI. <https://www.inegi.org.mx/app/mapa/espacioydatos/default.aspx>
- INEGI (Instituto Nacional de Estadística y Geografía). (2024a). Climatología. <https://www.inegi.org.mx/temas/climatologia/#mapas>
- INEGI (Instituto Nacional de Estadística y Geografía). (2024b). Directorio Nacional de Unidades Económicas. DENU. Censos Económicos 2014; Instituto Nacional de Estadística y Geografía. INEGI. <https://www.inegi.org.mx/app/mapa/denu/default.aspx>
- INEGI, I. N. de E. y. (2023). Censo Agropecuario (CA) 2022. <https://www.inegi.org.mx/programas/ca/2022/>
- Leong, W.-H., Teh, S.-Y., Hossain, M. M., Nadarajaw, T., Zabidi-Hussin, Z., Chin, S.-Y., Lai, K.-S., & Lim, S.-H. E. (2020). Application, monitoring and adverse effects in pesticide use: The importance of reinforcement of Good Agricultural Practices (GAPs). *Journal of Environmental Management*, 260, 109987. <https://doi.org/10.1016/j.jenvman.2019.109987>
- Luna-Guevara, J. J., Arenas-Hernandez, M. M. P., Martínez de la Peña, C., Silva, J. L., & Luna-Guevara, M. L. (2019). The Role of Pathogenic *E. coli* in Fresh Vegetables: Behavior,

- Contamination Factors, and Preventive Measures. *International Journal of Microbiology*, 2019(1), 2894328. <https://doi.org/10.1155/2019/2894328>
- Nataren Velazquez, J., Del Ángel Pérez, A. L., Megchún-García, J. V., Ramírez Herrera, E., & Meneses Márquez, I. (2020). Caracterización productiva del aguacate (*Persea americana* Mill.) en la zona de alta montaña Veracruz, México. *Rev. iberoam. bioecon. cambio clim.*, 6(12), 1406–1423. <https://doi.org/10.5377/ribcc.v6i12.9941>
- Njoroge, A. W., Baoua, I., & Baributsa, D. (2019). Postharvest Management Practices of Grains in the Eastern Region of Kenya. *Journal of Agricultural Science (Toronto, Ont.)*, 11(3), 10.5539/jas.v11n3p33. <https://doi.org/10.5539/jas.v11n3p33>
- Palacio, F. X., Apodaca, M. J., & Crisci, J. V. (2020). Análisis multivariado para datos biológicos: Teoría y su aplicación utilizando el lenguaje R (1a ed.). Fundación de Historia Natural Félix de Azara. <https://fundacionazara.org.ar/img/libros/analisis-multivariado-para-datos-biologicos/analisis-multivariado-para-datos-biologicos.pdf>
- Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*.
- Rana, V. S., Sharma, S., Rana, N., Sharma, U., Patiyal, V., Banita, & Prasad, H. (2022). Management of hailstorms under a changing climate in agriculture: A review. *Environmental Chemistry Letters*, 20(6), 3971–3991. <https://doi.org/10.1007/s10311-022-01502-0>
- Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of Climate Change on Crops Adaptation and Strategies to Tackle Its Outcome: A Review. *Plants*, 8(2), Article 2. <https://doi.org/10.3390/plants8020034>
- Rivera-Hernández, J. E. (2018). El ecoturismo y el turismo rural en la región de las altas montañas de veracruz, méxico: Potencial, retos y realidades. *Agro Productividad*, 11(8), Article 8. <https://doi.org/10.32854/agrop.v11i8.1108>
- Rojas, F. E., & Saavedra-Mera, K. A. (2022). Diversificación de Cultivos y su Impacto Económico en las Fincas Ecuatorianas. *Revista Científica Zambos*, 1(1), 51–68. <https://doi.org/10.69484/rcz/v1/n1/21>
- Rosa, O., & de Paredes, M. (2017). Rentabilidad de la producción agrícola desde la perspectiva de los costos reales: Municipios Pueblo Llano y Rangel del estado Mérida, Venezuela.
- Rosas-Martínez, V., & Aguilar-Rivera, N. (2022). Compostaje para la reducción de excretas de aves (*Gallus gallus domesticus*). *Agronomía Mesoamericana*, 33(1), 1–19.
- SADER (Secretaría de Agricultura y Desarrollo Rural). (2022). Corte a junio 2022. Beneficiarios del Programa Producción para el Bienestar 2022. - Corte a junio 2022. Beneficiarios del Programa Producción para el Bienestar 2022 en Veracruz de Ignacio de la llave. - Datos. [gob.mx/busca](https://datos.gob.mx/busca). [https://datos.gob.mx/busca/dataset/corte-a-junio-2022-beneficiarios-del-programa-produccion-para-el-bienestar-2022/resource/efe4c7cd-9891-4568-a5bfd70bfdc4cdcd?inner\\_span=True](https://datos.gob.mx/busca/dataset/corte-a-junio-2022-beneficiarios-del-programa-produccion-para-el-bienestar-2022/resource/efe4c7cd-9891-4568-a5bfd70bfdc4cdcd?inner_span=True)
- Sánchez-Galván, F., Bautista-Santos, H., Martínez-Flores, J. L., Ireta-Paredes, A. del R., & Sánchez-Partida, D. (2020). Cadena de suministro de productos agrícolas de traspatio. *Agro Productividad*, 13(8), Article 8. <https://doi.org/10.32854/agrop.vi.1705>
- Sánchez-Sánchez, Z. S., Cadena-Íñiguez, J., Morales-Flores, F. J., Cisneros-Solano, V. M., & Ruiz-Vera, V. M. (2023). Método para identificar redes de valor en un territorio con vocación agrícola. XXVI Congreso Internacional de Dirección e Ingeniería de Proyectos. Donostia, España, 2023.
- Scheiterle, L., Ulmer, A., Birner, R., & Pyka, A. (2018). From commodity-based value chains to biomass-based value webs: The case of sugarcane in Brazil's bioeconomy. *Journal of Cleaner Production*, 172, 3851–3863. <https://doi.org/10.1016/j.jclepro.2017.05.150>

- Shrestha, S. (2019). Effects of Climate Change in Agricultural Insect Pest. *Acta Scientific Agriculture*, 3(12), 74–80. <https://doi.org/10.31080/ASAG.2019.03.0727>
- SIAP (Servicio de Información Agroalimentaria y Pesquera). (2022). Anuario Estadístico de la Producción Agrícola. <https://nube.siap.gob.mx/cierreagricola/>
- Singh, G., Budhiraja, P., & Vatta, K. (2018). Sustainability of Farmer Producer Organisations under Agricultural Value Networks in India: A Case of Punjab and Gujarat. *Indian Journal of Agricultural Economics*, 73, 70–85.
- Skendžić, S., Zovko, M., Živković, I. P., Lešić, V., & Lemić, D. (2021). The Impact of Climate Change on Agricultural Insect Pests. *Insects*, 12(5), Article 5. <https://doi.org/10.3390/insects12050440>
- Torre, A. (2020). Nuevas propuestas para analizar el desarrollo territorial. *Eutopía. Revista de Desarrollo Económico Territorial*, 17. <https://doi.org/10.17141/eutopia.17.2020.4549>
- Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., & Phung, D. T. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment. *International Journal of Environmental Research and Public Health*, 18(3), Article 3. <https://doi.org/10.3390/ijerph18031112>
- Urquía-Fernández, N. (2014). La seguridad alimentaria en México. *Salud pública de México*, 56, 92–98.
- Vargas-Canales, J. M., Guido-López, D. L., Rodríguez-Haros, B., Bustamante-Lara, T. I., Camacho-Vera, J. H., & Orozco-Cirilo, S. (2020). Evolución de la especialización y competitividad de la producción de limón en México. *Revista Mexicana de Ciencias Agrícolas*, 11(5), 1043–1056. <https://doi.org/10.29312/remexca.v11i5.2218>
- Waha, K., van Wijk, M. T., Fritz, S., See, L., Thornton, P. K., Wichern, J., & Herrero, M. (2018). Agricultural diversification as an important strategy for achieving food security in Africa. *Global Change Biology*, 24(8), 3390–3400. <https://doi.org/10.1111/gcb.14158>

Agrociencia