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The regenerative and multifunctional livestock value network in La Antigua Basin, Veracruz, Mexico

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ABSTRACT
Objective: To identify and to characterize production units (PUs) and economic and non-economic stakeholders that belong in the regenerative and multifunctional livestock value network in La Antigua Basin, Veracruz.
Design/methodology/approach: Farmers with regenerative and multifunctional livestock production, who were selected by directed and snowball sampling, were interviewed with semi-structured interviews with key actors, and review of documental information was carried out.
Results: Producers who manage their livestock systems based on agroforestry, with water management were identified, both in harvesting, storage, caring for water springs and efficient use; and who, in addition, promote composting of organic residues and grassland management. Livestock feeding is carried out in grasslands with support of electric fencing. In general, the PUs present 20 years since their production began, with a size of 11 ha; decision makers are 57 years old, and education profile of undergraduate and graduate studies, 57% with agrarian sciences orientation; and they employ 4 people. The value network is characterized by non-economic actors, mainly those that complement, who promote regenerative and multifunctional livestock production through consultancy, training and financing of projects.
Limitations on study/implications: The need to promote a participative innovation agenda is identified.
Findings/Conclusions: In La Antigua Basin, various economic actors were found that apply regenerative and multifunctional livestock production as their productive system, where they have found strengths to maintain or recover their natural resources, and based on the characteristics of their products they recognize the market segments where they must be destined.

Keywords: value chain, silvopastural grazing, agroforestry, rotational grazing, associativity.

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INTRODUCTION

In La Antigua Basin (Veracruz, Mexico), various agriculture and livestock activities have emerged and evolved, from conventional productive systems to those that seek to be more friendly with nature (Torres-Rivera and Palma-García, 2021), such as regenerative and multifunctional livestock production systems.

Regenerative livestock production has demonstrated benefits such as improvement in the soil structure, increase in organic matter contained, and reduction of erosion, which are reflected in better soil health, more biodiversity by providing habitat for plants and

animals, improved water quality, reduction in nutrient and sediment contamination, climate regulation, reduction in greenhouse gas emissions by sequestering carbon in the vegetation and in the soil (Schreefel *et al.*, 2020; Spratt *et al.*, 2021).

When regenerative livestock production is combined with multifunctional agriculture, the income of livestock farmers increases with the production of quality meat and milk that can be sold at a higher differentiated price, and the conservation of their production units (PUs) is strengthened with a holistic view that allows them to detect new products to be traded (Alquiler *et al.*, 2009). Therefore, regenerative and multifunctional livestock production requires analysis with an approach of economic and social assessment that brings together the views of protagonist actors in the activity and of those who also participate indirectly.

Based on this, the value network analysis proposed by Nalebuff and Brandenburger (2005) is a tool that allows visualizing the interactions of the network's actors: producers-agroindustry, those who complement, competitors, clients and suppliers, in addition to economic and non-economic actors, with the objective of identifying the actions that contribute to the creation of value or wealth and in order to generate strategies to strengthen the production units in the territories (Muñoz and Santoyo, 2011). Thus, the objective of this study was to identify and to characterize production units and economic and non-economic actors that participate in the regenerative and multifunctional livestock value network in La Antigua Basin, Veracruz, Mexico.

MATERIALS AND METHODS

The study was carried out in La Antigua Basin, Veracruz, which occupies an approximate surface of 2 176 km^2 and originates in the Sierra Madre Oriental at an altitude of 3350 masl. In central Veracruz, it covers 20 municipalities; the municipalities of Calcahualco and Huatusco include a small portion of La Antigua Basin.

The methodological process consisted of the following phases: 1) PUs with regenerative and multifunctional livestock production were identified and characterized, and their value network was determined through the methodology proposed by Nalebuff and Brandenburger (2005), adapted by Muñoz and Santoyo (2011). The analysis of key actors was carried out to have a view of the environment; stemming from this, the dynamic of the value network was developed through the analysis of the role of those who integrate it. 2) The procurement of information from stakeholders was conducted from June to September, 2023, with interviews performed in situ (livestock ranches, government offices, among others). 3) A questionnaire was applied, which included two sections: i) Profile of the actor: name, date of birth, location, level of education, contact information; and ii) Dynamics of the activity in the network (producers-agroindustry, those who complement, competitors, clients and suppliers): years of experience in production, animal and agricultural species, economic importance of the activity, percentage of income, staff that supports in the activity, data from the farm, type of production, market or markets, advantages and disadvantages both of the activity and of the PU, and opinions about associativity and cooperation.

The systematization and analysis of information from the value network was carried out through qualitative processes, as well as through quantitative processes (Santoyo *et al.*, 2002).

RESULTS AND DISCUSSION

Identification and characterization of regenerative and multifunctional livestock production cases

Five cases of PUs with regenerative and multifunctional livestock production were detected in the basin, which have an interrelation of livestock production with agriculture, allowing them to be multifunctional, since they do not depend solely on one type of product to trade (Table 1).

In the first link, generally the PUs practice agroforestry, protection and improvement of the soil, and moisture retention in their plots. All of them carry out water management, both through harvesting, storing and caring for natural springs, and with an efficient use. Animal excretes are used, where wastes are reincorporated into the soil through composting of organic residues and the management of grasslands; this is linked to what was described by Schreefel *et al.* (2020).

On average, PUs started their production 20±13.3 years ago and have 11±17.3 ha, and decision makers have undergraduate and graduate studies; 57% are oriented toward the area of agrarian sciences, age of 57±17.3 years, and employ 4±1.7 people constantly.

In animal species, laying hens stand out in every PU; 50% of them have Mexican Creole hairless pigs or crosses with this breed; 50% have milk-producing goats; and in a smaller proportion there is livestock for meat, Melipona bee, sheep and tilapia. Feeding in every PU is based on grassland rotation with the support of an electric fence, protein banks and use of grains or concentrate as complement; 50% of the PUs use residues or silage.

Table 1. Main activities developed in the links of the regenerative and multifunctional livestock value chain in La Antigua Basin, Veracruz, Mexico.

Linkage	Livestock products	Agricultural products
Primary Production	Range-fed pork Range-fed beef Stable-produced goat milk Range-fed chickens for eggs Bee honey Aquaculture	Planting forage and protein banks Coffee Fruit trees: orange, lychee, macadamia, banana Vegetables Aromatic and medicinal plants Spices Production and sale of seeds
Processing	Cuts of meat Sausages Goat milk cheeses: matured, semi-ripe and unconventional Milk cheeses: semi-ripe and fresh Goat-bovine, goat-sheep milk mixture cheeses Recipes made with pork and goat meat Typical goat milk desserts	Preserves: jams, jellies, pickles, and more Dehydrated Essence extracts Primary coffee transformation, coffee roasting and grinding processes Sale of seedlings and cuttings Humus and lixiviate Compost
Market	Products Local: on-site, repeat buyers, referrals, tourists Regional: agroecological markets (Xalapa, Coatepec), specialized stores, social networks State and national: specialized stores, sales through digital platforms Services Farm tours, tastings or product pairings	

All the PUs process part of the production and some systems stand out where 100% of the production is processed for its sale as differentiated meat, transformed into cold meats or regional dishes, and in the case of milk into cheeses from semi-mature to mature with fungus cover. Egg is the only product that is destined to fresh sale or for subsistence.

In terms of agricultural products, a part is sold fresh, such as cherry coffee, macadamia, litchi, and fruits in general. In every PU, at least one product is elaborated as a preserve, such as jam, jelly, pickles, ferments, extracts or dehydrated products; and for coffee, 33% of the PUs applies processing, drying and toasting. As complement to the activity, plants and cuttings are produced, which provide extra income to the PUs for their management or as material to reincorporate into the farms.

From the total PUs, 66% manage agricultural residues, livestock excretes or other organic residues, through the elaboration and use of composts or vermicompost and the use of lixiviate. In all the PUs with grazing livestock, there is a preference not to use agrichemical products that affect soil biodiversity, and the ecosystem services that macro and microorganisms provide are recognized to reincorporate residues to the soil, as well as the advantages to incorporate nutrients to the soil and air and water infiltration.

In general, the PUs have a well-defined market or segment to which they send their product, and recognize the existence of markets in Xalapa and Coatepec, Veracruz, which add value to the products with agroecological and organic management; however, the PUs also place their products outside the region, in cities such as CDMX, Guadalajara, Monterrey, Puebla, Oaxaca, Estado de México, among others, where they have found allies to enter these markets through specialized trading companies in agroecological or organic products. Of the PUs, 66% receive support from trading companies to place their products, the rest depend on the positioning that they presently have and their products are sold directly to the consumer.

The value network

The regenerative and multifunctional livestock value network in La Antigua Basin, Veracruz, is presented in Figure 1. The five PUs with regenerative and multifunctional production in the basin are identified as trailblazing companies, which are next described in general.

Agrosol-Educación activa, servicios y producción, S. C. de R. L. de C. V. Located in Zoncuantla, municipality of Coatepec, Veracruz, is characterized by promoting animal production with grazing with electric fence. Since 1982, Agrosol was defined as a training organization for producers, students and apprentices, through dual education (Dual German training system), with the topics of agroecology, agroforestry, participant research, importance of livestock equipment, and agroecological products as its main themes. It has hired staff, labor from cooperative partners, interns and apprentices. This PU is an example of integration of agricultural, livestock and forestry production, multi-species and multi-plant. The main products that they trade are training (dual training), project elaboration, counseling and facility visits; sale of dairy, meat products and fruit preserves, with their main clients being producers in general, students and research centers.

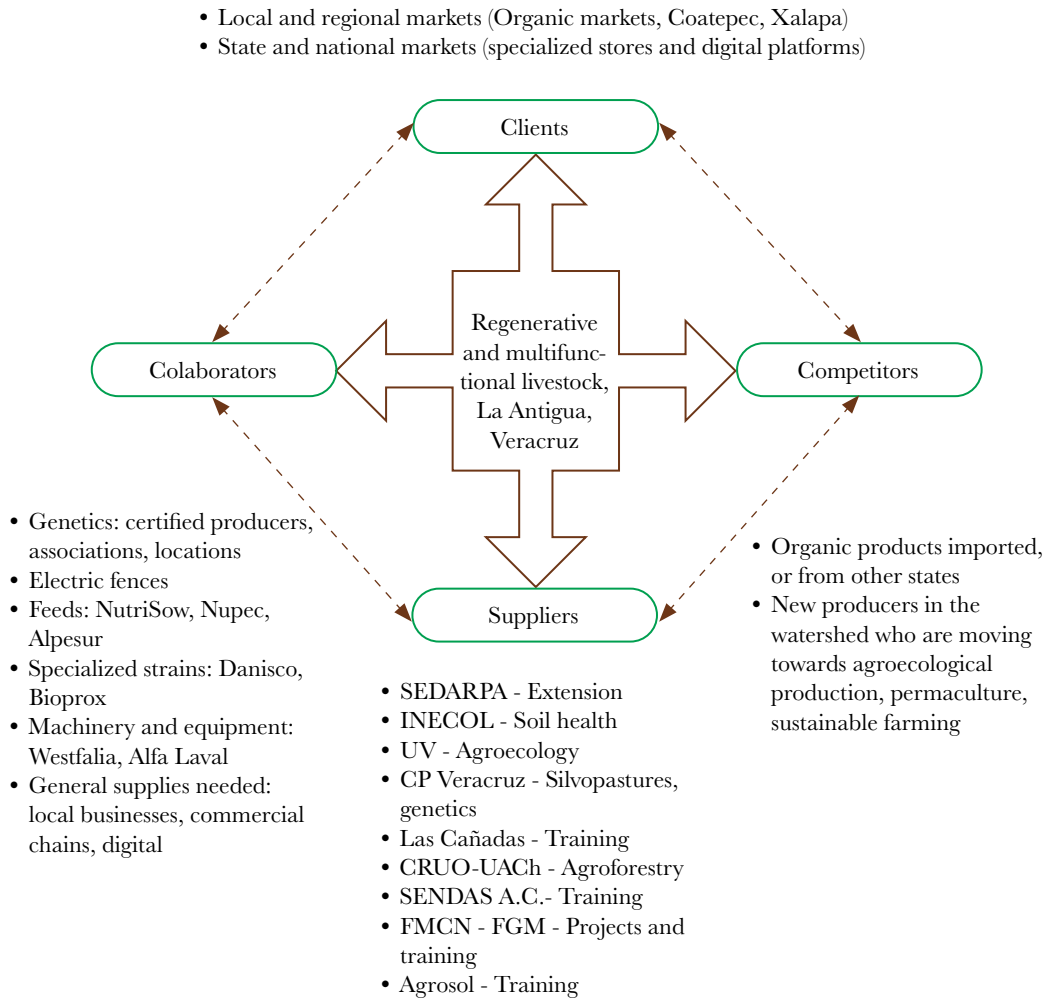

Figure 1. Schematic representation of the regenerative and multifunctional livestock value network in La Antigua Basin, Veracruz. SEDARPA: Secretariat of Agricultural, Rural and Fisheries Development of the state of Veracruz; INECOL: Institute of Ecology; UV: Veracruzana University; CP: Postgraduate College; CRUO-UACh: Eastern Regional University Center-Chapingo Autonomous; SENDAS A.C.: Civil Association Paths and Meetings for Sustainable Autonomous Development; FMCN-FGM: Mexican Fund for Nature Conservation-Gulf Mexico Fund.

Granja "Don Nelo". It is located in Pacho Viejo, municipality of Coatepec, Veracruz. The PU emerged in 2004 with goat dairy livestock, to produce mature cheeses. The milking goats are stabled and fed with fodder banks, primarily mulberry (*Morus alba*), fodder cane (*Saccharum* spp.), cuba 22 grass (*Pennisetum purpureum* × *Pennisetum glaucum*), use of residues from citrus juice-makers, brewery and bakery. As a service, it offers guided visits in the farm, which end with tasting and pairing of their products; another income is from offering training courses inside and outside their facilities.

Its market is regional to national, its clients and referred ones attend the PU directly, and the commercial evolution of the "Don Nelo" Farm has been strengthened by its collaboration with education and research institutions, participation in communication media, and presence in pairing events. This farm is an example of multifunctional

livestock production, since in addition to goats, it produces Mexican Creole hairless pig meat, takes advantage of organic residues to generate compost, leaf fertilizers and biogas, sells seedling and cuttings from their fodder banks, among other products, which agrees with the concept of a multifunctional farm (Torres-Rivera and Palma-García, 2021).

El Risueño Ganadería Regenerativa. It is located in the localities of Jalcomulco and Coatepec, Veracruz. The PU started activities in the year 2018, it has Tropical Creole Dairy (TCD) and Romosinuano cattle, Mexican Creole Hairless (MCH) pigs, and Creole laying hens; it has a certificate as supplier of organic products farmed in rotational grazing, management of endemic plant species, restoration of the ecosystem, water harvest and use of electric fencing. El Risueño currently processes beef and pork, it sells specialized cuts, cold cuts and finished meat products. Its market is local to national, with support from specialized stores that trade gourmet and organic products with private customers and in restaurants.

Tentlanman Chantico cooperative edible forest. It is a PU organized as a cooperative society, located in Tlanalapan, in Coatepec, Veracruz. It keeps various livestock and agricultural species in 1.4 ha. From its main products, goat milk and unconventional cheeses stand out, as well as vegetable production, hen eggs, coffee, and fruit trees, all produced agroecologically. Its main markets are the agroecological ones in Coatepec and Xalapa. The promotion of the production system is done through visits for the public in general, staff from institutions or organizations.

Finca Rey Luna. This PU is found in the locality of Baxtla, municipality of Teocelo, Veracruz, and it has two hectares of space. It self-defines as an agroecological farm, which uses animal species such as sheep, laying hen and tilapia, in addition to cultivating coffee, banana, vegetables, various fruit trees, spices, aromatic plants, among others. The main products it trades are: sheep meat, egg, roasted and ground coffee, and banana, primarily in the agroecological market of Coatepec and with clients that go directly to the farm.

In the surrounding areas of La Antigua Basin there are other PUs that are part of the actors referred, one of them being Las Cañadas, Centro de Agroecología y Permacultura, located in Huatusco, Veracruz. Another one is Mandumed Granja Ecológica, located in Lechuguillas, Vega de Alatorre, Veracruz. Both PUs maintain ties of cooperation and collaboration through the sale or exchange of animals, plant species, ecological technologies, and training.

Actors who complement: Among those who complement, a series of institutions, organizations, and other actors were detected, which are recognized by the PUs as actors that promote, drive and provide support to maintain a regenerative and multifunctional livestock production system (Figure 1).

It was possible to perceive recognition among economic and non-economic actors, where they distinguish the advances and evolution of their PUs, as well as the interactions with other actors such as research centers or civil associations. In addition, unspoken associativity by the PUs is observed, where technologies and animal and plant species are shared, among others, which can be improved through plans and strategies with specific actions for cooperation (Granados-Sánchez *et al.*, 2016). Cervantes-Escoto *et al.* (2013) recommend consolidating the articulation of the various actors, to strengthen the

values of reciprocity, solidarity, assertive communication, and trust, and to identify their areas of opportunity and strategies. The relationships between producers and those who complement can also be observed by the actions of technology transference, research studies, and their dissemination (Ireta-Paredes *et al.*, 2020).

To promote regenerative and multifunctional livestock production in La Antigua Basin, the recommendation is to elaborate an innovation agenda, with the collaborative participation of the network's actors (García-Rodríguez *et al.*, 2022), where actors such as those who complement propose ordered actions. For example, the adequate legal figure of the PUs in the basins to decrease the discouraging factors of associativity, due to the requirements and obligations that are acquired and the promotion of inter-institutional collaboration with state programs of Secretariat of Agricultural, Rural and Fisheries Development of the state of Veracruz (SEDARPA) and federal ones from Secretariat of Agricultural and Rural Development (SADER), such as the Milk Technical Support Strategy (EATL) in the central zone of Veracruz and the research institutions.

CONCLUSIONS

In La Antigua Basin, there are economic actors that apply regenerative and multifunctional livestock production in their systems, where they have found the strengths to maintain or recover their natural resources, and due to the characteristics of their products, they recognize the segments of the market where they should be destined. The value network is characterized by an interaction between owners of the production units and those who complement; through technology transference, counseling, training, and financing of projects, they promote the activity of regenerative and multifunctional livestock production, which allows documenting the degree of connection between actors.

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