













Evolution of conventional to diversified livestock production systems in the Mexican tropics



Evolución de los sistemas de producción ganaderos convencionales a diversificados en el trópico Mexicano

Evolução dos sistemas de produção pecuária convencionais para diversificados nos trópicos Mexicanos

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Abstract

Cattle ranches in Mexico have demonstrated a remarkable ability to adapt to changing economic, environmental, and social conditions. In a context where traditional cattle ranches were being replaced by conventional technologies, diversification has become a fundamental strategy to ensure their sustainability and resilience. The term “ranch” used to encompass various agribusiness units with different forms of ownership and management. However, today, a conventional cattle ranch is characterized by its focus on the core activity of grazing. The central objective of the article was to analyze the evolution of cattle ranches in Mexico, focusing on how diversification became a fundamental strategy to address challenges over time and adapt to changing economic, environmental, and social conditions. To achieve this, a bibliographic search and comprehensive analysis of the state of the art related to the organizational structure of cattle ranches were conducted. This process provided the necessary theoretical foundations for the conceptualization of cattle ranches based on their structure, diversity of functions, products, and activities. Ultimately, it was concluded that the evolution of cattle ranches in Mexico reflected their continuous adaptation to changing economic, environmental, and social conditions, with diversification being a key strategy to ensure the sustainability and resilience of livestock farms.



Resumen

Los ranchos ganaderos en México han demostrado una notable capacidad de adaptación a las cambiantes condiciones económicas, ambientales y sociales. En un contexto donde los ranchos ganaderos tradicionales, con un enfoque arraigado en prácticas históricas y culturales que resaltan métodos naturales y extensivos, eran sustituidos por tecnologías convencionales orientadas hacia la eficiencia mediante métodos modernos, la diversificación emergió como una estrategia esencial para asegurar la sostenibilidad y resiliencia del sector ganadero. El término “rancho” solía abarcar diversas unidades agropecuarias con diferentes modalidades de tenencia y gestión. No obstante, en la actualidad, un rancho ganadero convencional se caracteriza por su enfoque en la actividad principal de pastoreo. El objetivo central del artículo fue analizar la evolución de los ranchos ganaderos en México, centrándose en cómo la diversificación se convirtió en una estrategia fundamental para enfrentar los desafíos a lo largo del tiempo y adaptarse a las condiciones económicas, ambientales y sociales cambiantes. Para ello, se realizó una búsqueda bibliográfica intensa y un análisis exhaustivo del estado del arte relacionado con la estructura organizativa de los ranchos ganaderos. Este proceso proporcionó las bases teóricas necesarias para la conceptualización de los ranchos ganaderos en función de su estructura, diversidad de funciones, productos y actividades. En última instancia, se concluyó que la evolución de los ranchos ganaderos en México reflejó su continua adaptación a las diversas condiciones cambiantes del contexto productivo de México, destacándose la diversificación como estrategia esencial para garantizar la sostenibilidad y resiliencia de estos.

Palabras claves: diversificación, explotaciones ganaderas, resiliencia agricultura convencional.

Resumo

As fazendas de gado no México têm demonstrado uma notável capacidade de adaptação às condições econômicas, ambientais e sociais em constante mudança. Em um contexto em que as fazendas de gado tradicionais estavam sendo substituídas por tecnologias convencionais, a diversificação se tornou uma estratégia fundamental para garantir sua sustentabilidade e resiliência. O termo “rancho” costumava abranger várias unidades agropecuárias com diferentes modalidades de posse e gestão. No entanto, atualmente, uma fazenda de gado convencionais é caracterizada pelo foco na atividade principal de pastoreio. O objetivo central do artigo foi analisar a evolução das fazendas de gado no México, concentrando-se em como a diversificação se tornou uma estratégia fundamental para enfrentar os desafios ao longo do tempo e se adaptar às condições econômicas, ambientais e sociais em constante mudança. Para isso, foi realizada uma pesquisa bibliográfica e uma análise abrangente do estado da arte relacionado com a estrutura organizacional das fazendas de gado. Esse processo forneceu as bases teóricas necessárias para a conceptualização das fazendas de gado com base em sua estrutura, diversidade de funções, produtos e atividades. Em última análise, concluiu-se que a evolução das fazendas de gado no México refletiu sua contínua adaptação às condições econômicas, ambientais e sociais em constante mudança, destacando a diversificação como uma estratégia essencial para garantir a sustentabilidade e resiliência as fazendas de gado.

Palavras chave: diversificação, fazendas de gado, resiliência, pecuária tradicional.

Introduction

Despite the challenges posed by the pandemic and other factors, global meat production increased by 5 % in 2021, reaching approximately 339 million tons (OECD/FAO, 2022). In addition, global meat production is projected to continue to increase and reach about 377 million tons by 2031 (OECD/FAO, 2022). However, livestock farming, being dependent on chemical and energy inputs, presents significant challenges in terms of its negative impact on the environment and society (Paleologos *et al.*, 2017). These challenges derive from traditional paradigms in agricultural sciences (Sarandón *et al.*, 2014), which highlight the need to adopt a multidisciplinary approach that goes beyond productivist strategies and comprehensively addresses the evaluation, design and management of livestock systems (Lermanó and Sarandón, 2016).

Historically, agriculture and livestock have been studied in a fragmented manner, by analyzing their components separately. However, this perspective limits the global understanding of their functioning and the emergent properties resulting from their interaction. Bertalanffy's systems theory offers a holistic view by recognizing that the whole is more than the sum of its individual parts, which facilitates the identification of aspects that could go unnoticed (Paleologos *et al.*, 2017; Sarandón *et al.*, 2014). Therefore, this study aims to analyze the evolution of traditional cattle ranches towards diversification in Mexico to face economic, environmental and social conditions.

Methods

This review article was based on a comprehensive literature search and analysis process focused on the organizational structure of cattle ranches in Mexico. A comprehensive strategy involving recognized academic search engines, such as Scopus and Scholar Google, was employed using relevant keywords such as “Diversified Ranches,” “Conventional Cattle Ranching,” and “Cattle Ranching in Mexico”. The process was divided into several stages, and started with general searches and some filters were applied to focus on the evolution and diversification of cattle ranches in Mexico. The abstracts and titles of 80 papers were identified and examined in detail to ensure their relevance. In addition, a manual search of the references cited in the initial sources was performed. The selection and review of the papers was carried out in a systematic manner, from recording the important details of the relevant sources, to the extraction of key information for the corresponding conceptualization. This methodology was implemented to ensure a diverse inclusion of perspectives and reliable sources to support the historical analysis of cattle ranches and their relationship to diversification.

Integration of livestock in agroecosystems

Agroecosystems are environments transformed by human activity for the production of food and raw materials (Hidalgo, 2020). In the Mexican context, they stand out as centers of domestication and evolution of cultivated species (Severo *et al.*, 2020). These complex systems, which include components such as soil, crops, pastures, weeds, trees and beneficial fauna, are analyzed from the perspective of agroecology to understand their intricate ecological processes (Mansilla *et al.*, 2020).

Agroecosystems are managed in an ecological and sustainable manner by promoting the interactions of plants, animals and the environment (Luliano *et al.*, 2021). Management involves regulating energy flows, nutrient cycles and population mechanisms to optimize natural resources and minimize non-renewable inputs (Pretty,

2007). Sustainable practices can improve food production, reduce pesticide use and balance carbon (Pretty, 2007). In livestock farming, agroecological approaches are associated with environmental and productive benefits (Herrero *et al.*, 2010).

Current situation of livestock farming in Mexico

Mexico devotes 55 % of its territory, equivalent to 177 million hectares, to extensive cattle raising, and is the seventh largest producer of animal protein in the world. It also contributes significantly to the domestic consumption of animal-based foods. In terms of exports, Mexico has experienced remarkable growth in the sale of beef and live cattle. The Mexican livestock sector is composed of 817,000 producers and more than one million livestock production units, which generates about 23.78 million tons of animal protein in 2020, which includes milk production (SADER, 2023).

Origin and concept of the term cattle ranches

“Agriculture and livestock system” refers to individual farm systems, where “farm” encompasses the household and its resources (Muñoz-González *et al.*, 2017). In Latin America, “*finca*” and “*ranchos*” are used interchangeably, although with different meanings: a ranch is dedicated to livestock grazing, while a farm involves more diverse agricultural and livestock activities (González, 2015; Altieri, 1999).

“*Ranchos*” in Mexico have historical and economic significance rooted in national identity and the preservation of traditions and customs (Ultras and Isais, 2018). In Latin America, “*ranchos*” refers to informal settlements in urban and peri-urban areas (Ultras and Isais, 2018). Differences in the perception of “*ranchos*” are due to socioeconomic realities and regional contexts (González, 2015). In Mexico, the term “*ranch*” is associated with various agricultural units with different tenure and management modalities. In this sense, ranches transcend the mere category of properties, as they embody a symbol of cultural identity and a historical legacy.

Cattle ranches, concept and challenges

A conventional cattle ranch in Mexico is distinguished by its primary dedication to grazing, and because it uses continuous and rotational approaches, each with its own implications rooted since Spanish colonization. Over time, this practice has evolved driven by modern technologies and sustainable policies (González-Padilla *et al.*, 2021; Guareros and Pichardo, 2019).

The integration of livestock in agroecosystems not only influences the choice of animal and plant species, but also directly impacts their productivity and diversity (Carreño *et al.*, 2019). Factors such as relief and climate exert a significant influence on system dynamics (Hidalgo, 2020).

Livestock systems face a series of challenges that affect their sustainability and productivity. One of the most significant problems is the projections of reduced precipitation and the associated limitation in water availability (Keyserlingk *et al.*, 2013). Land disconnection has been identified as a problem that threatens livestock sustainability (Dumont *et al.*, 2018). The integration of crops and livestock poses challenges in management and organization that may explain implementation problems (Martin *et al.*, 2016). In addition, human-wildlife conflict generates public alarm and political pressures that often lack scientific basis (Margalida *et al.*, 2014). Also climate change negatively influences these systems, which, has a direct manifestation on net income and food security (Nhemachena, 2014).

The COVID-19 pandemic has also had an impact on the livestock sector, leading to changes in consumer behavior that influence agricultural production (Saravanan, 2022). Management of the

livestock-wildlife interface poses challenges in disease transmission between wild and domestic mammals (Ward *et al.*, 2006). Finally, waste management, which includes animal manure, plant residues, agricultural packaging, contaminated cleaning water, and animal feed containers, represents an environmental challenge for ranches in Mexico, both in rural and urban areas. Currently, alternatives for the reuse and recycling of solid waste are being explored as a measure to address this challenge (Patiño and García, 2022). This problem has direct implications on the health of livestock, crops and the human population, which demands proper management (López-Ramírez and Cuevas-Cardona, 2022).

Diversification and key factors for the sustainability of ranches in Mexico

Diversification is important for the sustainability of ranches in Mexico, as it represents an alternative source of income while reducing the environmental impacts of ranching (Ostrom, 2009). Factors such as intergenerational transfer of ownership, knowledge sharing and social innovation also contribute to the success of conventional ranches (Chiswell, 2016; Špaček *et al.*, 2022). Sustainability on cattle ranches involves adopting practices that balance meat or dairy production with natural resource conservation and animal welfare by considering the financial needs of farmers and the local community. These ranches are closely linked to four critical factors: natural resources, economics, technology and management (figure 1). Environmental resources, such as soil and land, play a critical role in providing the necessary space for livestock rearing and forage production. Sustainable management of these resources becomes imperative to ensure long-term productivity and preserve the environment.

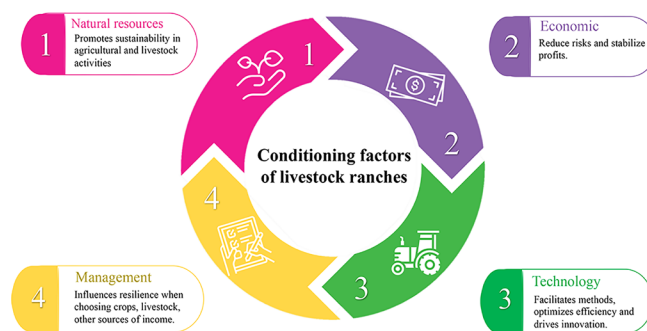


Figure 1. Contextual factors that condition cattle ranches. Source: Own elaboration.

The economic factor is crucial, since financial investment and access to funds are necessary for the growth and improvement of ranches, and their lack affects the ability to adopt advanced technologies and improve management practices. Technology, properly adopted, can transform ranch management, increase efficiency and reduce the environmental impact of livestock production.

Finally, livestock management, ranging from genetic selection to veterinary care, is vital to animal health and productivity, with a positive impact on economics and sustainability. However, these interconnections can have negative consequences if not properly managed, such as overexploitation of resources and indiscriminate adoption of technology, which could cause damage to the environment and livestock health.

Diversification strengthens the rural economy and preserves traditions and the local environment, but requires adequate policies to support small producers (Špaček *et al.*, 2022). Environmental considerations, agricultural policies and wildlife conservation programs are essential for long-term sustainability (Short and Dwyer, 2012). Cooperation, fair trade, technical efficiency, and water management are critical to ranch success (Folch and Planas, 2019).

Conventional versus diversified ranches

The distinction between conventional and diversified ranches highlights the importance of income diversification in the agricultural economy. Conventional ranches are highly dependent on climate and have limited income, while diversified ranches are characterized by their varied production of crops and livestock species (Meert *et al.*, 2005; Kremen and Miles, 2012; Khanal and Mishra, 2014). Mexican ranchers have adopted diversification strategies, as illustrated in figure 2.

Mexican cattle ranchers have faced challenges that have led them to seek new routes and make strategic decisions to ensure the sustainability of their operations. These routes are strongly influenced by the four critical factors mentioned above, where they leverage their assets to strengthen their economy. However, it is important to keep in mind that these routes face challenges, such as the loss of traditions and the need to acquire new skills. In addition, the implementation of appropriate policies is required to prevent social inequalities and support small producers in their quest for diversification and sustainability.

Diversification is manifested in the incorporation of perennial crops, food and vegetables into land use systems. Examples in

Cameroon demonstrate how cocoa farmers diversify their land use systems with citrus, safou, oil palm, cassava, bananas, tomatoes and other vegetables, although this has led to biological simplification (Schroth and Ruf, 2013). In other regions, diversification improves the relationship between *acequia* cultivation and pasture grazing (Garcia-Martinez *et al.*, 2016). In Latin America, multiple benefits have been demonstrated with the implementation of agroforestry practices, as a viable strategy, it offers social and ecological benefits, which contribute to the protection of the environment and its biodiversity (Marinidou *et al.*, 2018). For example, extensive production with indigenous breeds has been shown to contribute significantly to this (Pardos *et al.*, 2022).

The diversification of economies and financial development also has differentiated impacts on the benefits of regional integration processes (Romero *et al.*, 2021). Furthermore, in livestock production it is essential for the survival of farms (Casasús, 2014), and facilitate access to government resources and investment opportunities (García and Cancino, 2022).

Reasons and benefits of diversification in Mexican cattle ranches

In the Lake Patzcuaro Basin Region, in Central-Western Mexico, significant transformations have been experienced in peasant farming systems, characterized by an increasing diversification combining agriculture, livestock and forest. In addition, a transition towards beef production has been observed, where the use of hybrid maize is prioritized over native varieties for animal feed (Astier *et al.*, 2020).

Income diversification has become fundamental for livestock farming households, accounting for 49 % of total income (Astier *et*

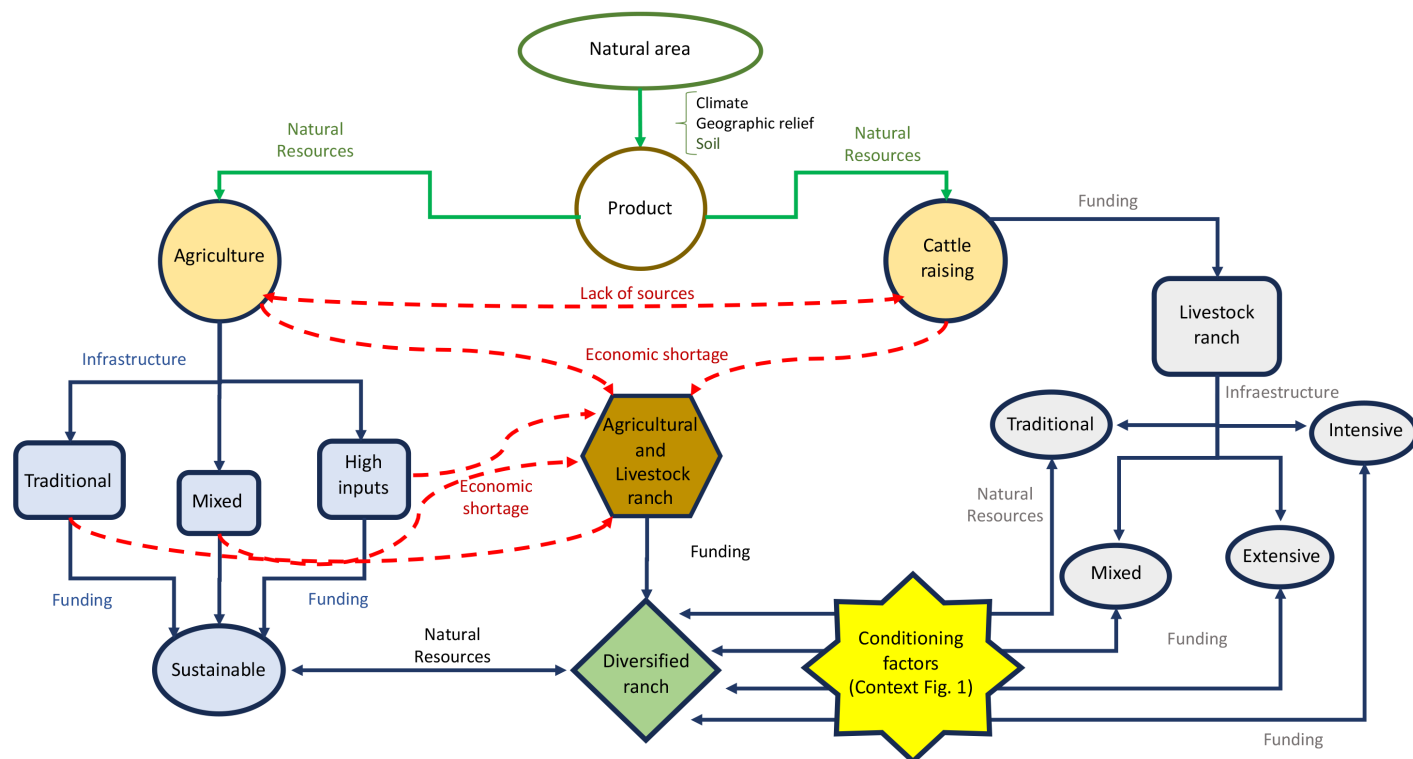


Figure 2. Livestock ranch diversification route. Source: Own elaboration.

al., 2020). In addition, the service sector, with tourism as the main focus, has emerged as a key source of income for rural communities (Avila-Foucat *et al.*, 2021).

On Mexican ranches, diversification has become a response to economic volatility, to minimize the risks associated with dependence on a single source of income (Rivera-Huerta *et al.*, 2019). Changes in government policies and tax incentives have also encouraged agricultural diversification and investment in renewable energy by encouraging cattle ranches to adopt new activities (Avila-Foucat *et al.*, 2021).

Changing consumer preferences for local and organic products have motivated cattle ranches to diversify, supported by technological advances that facilitate the adoption of new activities (Astier *et al.*, 2020; Avila-Foucat *et al.*, 2021).

Diversification not only brings economic benefits, but also improves environmental sustainability, productivity and long-term resilience (Rivera-Huerta *et al.*, 2019). In particular, biomass accumulation in forests has become crucial in regions under pressure from fuelwood extraction, such as in Chiapas (Astier *et al.*, 2020). Silvopastoral systems have demonstrated great capacity to effectively store carbon and contribute to climate change mitigation (Valenzuela *et al.*, 2022). Another advantage is the adoption of improved seeds, which has also contributed to increased crop productivity and resistance to pests and diseases (Astier *et al.*, 2020). Furthermore, in Chiapas, the importance of strengthening ranchers' capacities in sustainable practices has been recognized for a successful transition to organic livestock farming (Rivera-Huerta *et al.*, 2019).

The evolution of cattle ranches is focused on continuous adaptation to improve both profitability and sustainability. This process involves incorporating new practices and technologies, the key strategy is diversification, making the most of their available natural resources and exploring new markets. The diversification of a cattle ranch is a natural process consisting of three key stages: the first focuses on geographic and climatic aspects, such as pastures, water and livestock structures. The second stage involves specialization and

financial planning. The third stage seeks to maximize profitability and sustainability, take advantage of local natural resources, implement the use of advanced technology and expand into activities beyond cattle ranching, such as dairy production, processed meat marketing, rural tourism and agricultural education, to ensure the long-term viability of the ranches (figure 3).

Negative impacts of diversification

Diversification in cattle ranches can have negative consequences. Ramírez-Juárez (2022) mentions the possibility of resulting in the loss of local agricultural traditions and practices, which would impact social cohesion. In addition, it could generate social inequalities, since those producers with more financial resources can more easily access new technologies and markets, which indirectly encourages migration.

Increased complexity in the production system could also lead to increased energy consumption and a larger carbon footprint (Thornton and Herrero, 2010). In addition, the introduction of new species or practices could require higher water consumption, which would more directly affect arid or semi-arid regions (Oliveira *et al.*, 2019). On the other hand, Rendon *et al.* (2022) explains that these types of practices contribute to soil degradation and biodiversity loss. Therefore, frontier research with innovative approaches is required to understand in a holistic way, the implications of these environmental disadvantages in the long term.

Conclusion

Cattle ranches in Mexico have evolved in response to economic, environmental and social challenges. Diversification has become a key strategy to ensure the sustainability and resilience of these operations. It offers economic, environmental and social benefits, but also poses challenges such as loss of traditions and inequalities. The implementation of sustainable diversification policies is essential to balance these aspects and ensure a prosperous future for both producers and the environment in which they operate their livestock agroecosystem.

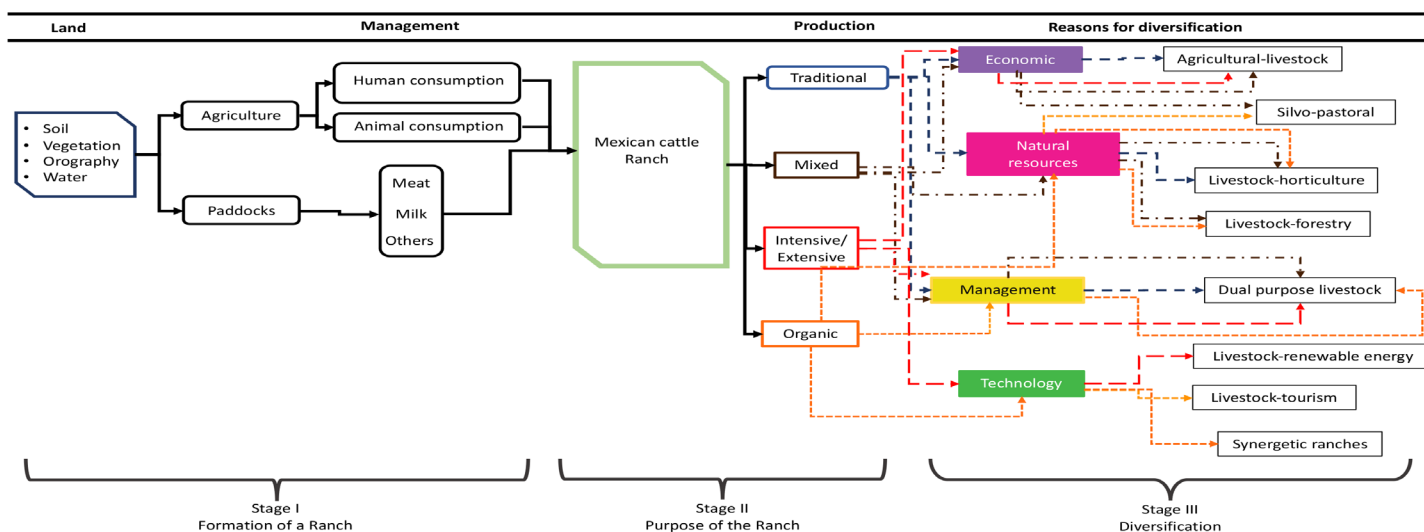


Figure 3. Stages of diversification of a cattle ranch. Source: Own elaboration.

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