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Looking for Innovation Opportunity Areas in the Value Chain in the Agri-food Sector

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Abstract

Agricultural producers know their business very well, through daily practice they know the best way to carry out their processes; however, currently, it is necessary to continually seek improvements in its production processes to remain competitive and not only survive but grow. Thus, today we speak of open innovation, which implies the establishment of networks, made up of diverse local, regional, national and international nodes and components through which small or medium-sized producers can learn about experiences from other latitudes,

which help them develop innovation projects to stay competitive. Through the review and analysis of cases of some Mexican agricultural producers and other Latin American countries based on the experience and proposals of some international organizations, which use the network innovation model, in this work a simple and synthetic proposal is developed for the opportunity areas to carry out innovation projects in the different links of the value chain of agri-food production processes.

Keywords: agricultural sector, value chains, innovation

1. Introduction

The agricultural sector is so important throughout the world because of food production. Accordingly, companies and organizations related to the sector must be efficient and competitive not only from an economic point of view, but also their processes must be clean and respect the environment to seek the sustainability of the planet in the long term. At the same time, the required quantity of healthy, good quality and affordable food must be produced.

Briz and de Felipe, (2011) state: *"The availability of food is a necessary requirement for human survival, which represents a responsibility of the agri-food sector from the producer to the consumer".*

In recent decades it has been shown that one of the management processes to improve the efficiency and competitiveness of all economic sectors, both in the macro and micro economy, is technological innovation, which goes beyond continuous improvement. Since making disruptive innovations is very complex and depends on equally disruptive and potential inventions, the objective of this work is to show that small incremental innovations can be sought by targeting the sector's value chain, addressing, environmental and energy restrictions, as well as the improvement opportunities identified in the various linked production processes.

Briz and de Felipe (2011) also state: *"The agri-food system must maintain innovation on several fronts, products, processes, organization and use of natural resources. All this must be carried out in a context of demographic growth, decrease in water resources and traditional energy sources, change in eating habits towards a more protein-rich diet and climate change."*

However, in the global context described, the situation is worrying because the food system is one of the most complex within the economy, which gives rise to problems of inefficiency, lack of transparency and abuse of dominant positions, with geopolitical impact among others.

Briz and De Felipe, (2011, op cit), argue that the basic issue of the agricultural sector is indeed the feeding of the population, a matter of great social sensitivity, in which the global socioeconomic dynamics has shown that competition between companies is a competition between the value chains of their processes.

In the last decade, with the aim of helping to achieve "Zero Hunger" and the "Sustainable Development Goals (SDG)", in most countries of the world, the promotion of international

organizations related to the agricultural and agri-food sector has been intensified. For example, The Food and Agriculture Organization of the United Nations (FAO) has proposed that companies and producers in each country *should carry out strategies, plans and projects to achieve sustainable food and agriculture*. Clarifying that, to be sustainable, agriculture must meet the needs of present and future generations while ensuring profitability, environmental health, as well as social and economic equity. Sustainable food and agriculture contribute to the four pillars of food security: (a) availability, (b) access, (c) utilization and (d) stability; as well as to the three dimensions of sustainability: environmental, social and economic (FAO, 2023).

FAO (2018) proposes that it is necessary to search for and reach the SDGs since there are a series of contrasts in the world. On the one hand, there are more than 815 million people suffering from hunger and one in three people is malnourished; likewise, migration has increased unprecedentedly over the last seventy years, and, without a doubt, we are experiencing intense effects of climate change. Rural populations are being severely affected and there is a growing number of crises, conflicts and natural disasters.

Besides, some countries have achieved certain levels of progress which has often been accompanied by social and environmental consequences, such as water scarcity, soil degradation, pressures on ecosystems, loss of biodiversity, declining fish and forest populations and high levels of greenhouse gas emissions. Notwithstanding, according to the 2030 Agenda for Sustainable Development, approved in September 2015 by the United Nations General Assembly, sustainable food and agriculture have great potential to reverse the chronic undernourishment or food shortage of millions of people around the world., as well as to revitalize rural landscapes, to generate inclusive growth in countries and to achieve positive change. To this end, FAO has suggested to decision makers a plan of five (5) principles and twenty (20) actions (FAO, 2018).

Recent research on the food challenge highlights the complex and interconnected drivers of food insecurity, including the impacts of climate change, increased frequency of extreme weather or climate events, economic shocks or crises, and conflicts (Abdullahi, 2024).

1.1 Research Objective

Since making disruptive innovations is very complex and depends on equally disruptive and potential inventions, *the objective of this work* is to show that small incremental innovations can be sought by targeting the sector's value chain, found in the experience of some Latin-American producers, emphasizing on addressing, environmental and energy restrictions, as well as the improvement opportunities identified in the various linked production processes.

2. Theoretical Framework

2.1 Agricultural Innovation

One of the most effective strategies to achieve sustainable agriculture and food is to develop innovation projects. Innovation occurs when there is social appropriation of knowledge, ideas,

practices and technologies; that is, when these are translated into useful and beneficial changes in productive or organizational activities for the society wellness. For the Inter-American Institute for Cooperation on Agriculture, IICA, (2014), agricultural innovation can be institutional, technological or social.

According to the Oslo Manual (2018), innovation is fundamental to improving living standards and can affect people, institutions, entire economic sectors and countries in multiple ways. Proper measurement of innovation and the use of data obtained by investigating successful innovation projects can help policy makers better understand economic and social changes; as well as to evaluate the contribution of innovation to the achievement of social and economic objectives, and to monitor and evaluate the effectiveness and efficiency of its policies. Achieving innovations is complicated, therefore, when they occur, they must be identified, measured and based on this information, those responsible for the development of the sector must formulate policies that contribute directly and/or indirectly to adjusting the direction of productive and economic processes, to promote new innovations in a positive spiral-type growing cycle and to configure how their effects should be distributed (Oslo, 2018, pp. 28).

To make the measurements, the Oslo Manual has defined the following types of innovation: (a) innovations in the production of goods or services, within which we find innovations in the areas of (a.1) distribution and logistics, (a.2) sales and marketing, (a.3) information and communications systems, (a.4) administration and management; (b) product innovations and (b.1) business process development innovations. (Oslo Manual Op. Cit, pp. 75)

It is often said that the purpose of carrying out innovation projects is to strengthen the competitiveness of a company or organization. The proposal by Arboleda et al (2020) is very interesting since they propose that innovation is a tool that seeks to achieve the growth of a sector through new technologies, models and strategies; namely, innovation can also be a driving force of sectoral macroeconomics. They propose that agricultural innovation must find the different resources that significantly improve the lives of small, medium and large farmers to, consequently, improve the productivity of the same companies in the sector.

It seems to be a virtuous chain since, by extending this thinking, in theory it could be achieved that the innovation chains of different sectors of a country's economy could improve its competitiveness and stimulate its development, at the regional or global level. According to IICA (2014), innovation in agriculture is a key process for sustainable development.

The sale of quality products obtained from agricultural innovations will produce better economic results; however, emphasizing the famous phrase attributed to Peter Drucker that, since one of the most common business strategies is to try to achieve the successful introduction of an innovative product in the market, “the test of an innovation, after all, lies not its novelty, its scientific content, or its cleverness. It lies in its success in the marketplace” (Drucker, 1985; Hesselbein et al., 1988).

Notably, nowadays, developing innovation projects requires seeking and achieving strategic technological alliances that allow for streamlining the operation, sustainability, efficiency,

and profitability of companies working within the primary agricultural sector.

Regional innovation leads to increasing the well-being of the population of a locality or region (Vásquez, 2000, p. 71). While it is true that the agricultural sector is of fundamental importance for all countries in the world and for the global population, its importance is exacerbated in third world countries that have large populations living in poverty and extreme poverty. According to the World Bank (2023), agriculture can help reduce poverty, increase incomes and improve food security for 80% of the world's poor, who live in rural areas and are mainly engaged in agricultural work. Agricultural development is one of the most important means of ending extreme poverty, promoting shared prosperity and feeding a population.

Nonetheless, Rojas-Meza (2015) points out that in addition to the fact that innovation in the different parts of the value chain of the agricultural sector is very important for the growth and competitiveness of the sector; it must be emphasized that today there are very important risks in the sector, the first of which is climate change., which is perhaps the greatest risk for the present and future of agricultural development in Latin America and in all countries around the world. The second risk is low levels of productivity, which are combined with a process of degradation of soil and water resources. The third is the end of the agricultural frontier, the pattern of agricultural growth over the past 60 years. The author points out that an increase in the demand for food is also expected due to the natural increase in population, making it imperative to innovate in the organizational, product and process dimensions.

In summary, the agri-food industry has assumed importance in terms of major societal challenges at a global level, involving multiple partners in the innovation process to address several emerging problems, such as food scarcity and the impact of the industry on climate change (Tolin and Piccaluga, 2024).

2.2 The Value Chain in The Agricultural Industry

In general terms, the use of a value chain model allows for the identification and analysis of activities that organizations perform in their production processes. As can be seen in Figure 1, in a macroeconomic scheme, the basic value chain model is conditioned by the interfaces of the economic agents and how and when customer orders are received and transmitted to the supplier.

One of the most important challenges for companies in all sectors of the economy, particularly agricultural companies, is to have a business model that involves all production processes, from the production stage to the final consumer. This business model must be closely related to the incremental value chain. In each company, the value chain must include the production processes, including those of marketing; it must also provide indicators so that decision makers can see the performance of the company and issue alerts for early decision making, preventing small businesses from going bankrupt or entering situations of instability. In this sense, the value chain can be understood as an instrument for analyzing the functioning and risk of the agri-food system (Briz and De Felipe, 2011, pp.67).

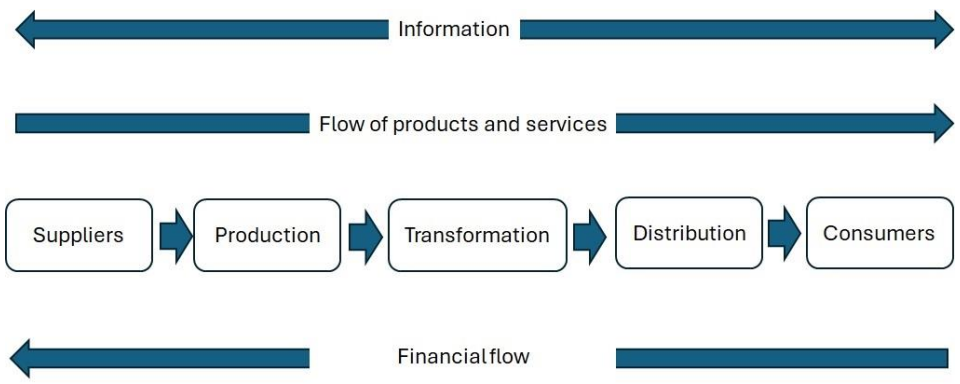

Figure 1. Value Chain in the Macroeconomy

Source: modified from Briz and De Felipe (2011, pp.75)

One of the most important challenges for companies in all sectors of the economy, particularly agricultural companies, is to have a business model that involves all production processes, from the production stage to the final consumer. This business model must be closely related to the incremental value chain. In each company, the value chain must include the production processes, including those of marketing; it must also provide indicators so that decision makers can see the performance of the company and issue alerts for early decision making, preventing small businesses from going bankrupt or entering situations of instability. In this sense, the value chain can be understood as an instrument for analyzing the functioning and risk of the agri-food system (Briz and De Felipe, 2011, pp.67).

In particular, the value chain of the different processes carried out by the modern agricultural sector has at least the following main components: (a) direct sowing, (b) transgenic crops, (c) agrochemicals, (d) sowing machinery, (e) harvesting, forage management and quality control of products, (f) marketing, sales and distribution of products. The technological platform is made up of the product, process and service technologies required in each link of production. Thinking in financial terms, each of these processes or links adds value to the sector's production. Therefore, in terms of its added value, the technological platform is directly related to the value chain.

By introducing any innovation, no matter how small, some type of competitive advantage is obtained over other organizations in the market. Poma-Hidalgo et al. (2022) designed a value chain model for agribusinesses of the main agricultural products produced in the province of El Oro, Ecuador, which are bananas, cocoa and coffee. Notably, in this case many of the innovations are introduced in the services link.

Figure 2 shows that the process of increasing value in the agribusiness value chain can have both disadvantages and opportunities for innovation in different areas.

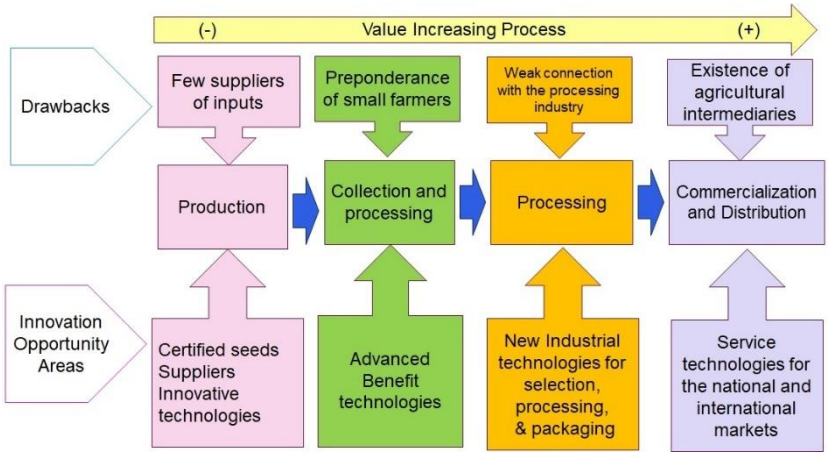

Figure 2. Disadvantages vs. areas of opportunity for innovation in the agricultural value chain

The modern definition of chain value includes the use of networks Like the WORLD BANK – FAO – GIZ – OIT -USAID definition: "Describes the full range of value-added activities necessary to bring a product or service through the different phases of production, including the acquisition of raw materials and other inputs."; The United Nations Industrial Development Organization– UNIDO's definition: "Actors connected along a chain that produce, transform, and bring goods and services to end consumers through a sequenced set of activities."., and International Center for Tropical Agriculture – CIAT definition: "A strategic network between a number of independent business organizations, where members of the network engage in extensive collaboration" (Albarracín-Gutiérrez et al., 2024).

Scardino and García (2024) mention that within the network approach, it is necessary to take into account that there are substantial differences in space, time and complexity in the number of actors in the concepts of regional production circuits, the cluster approach and global value chains.

3. Methodology

Taking as a reference framework the value chain in the agroindustry of Figure 1 and the areas of opportunity for innovation in Figure 2, after a deep discussion and analysis, it was determined that the opportunity areas for innovations in the value chain of agricultural and food production processes can be grouped into four different groups, which are: agricultural products technology, technology devices and transformation processes, organizational technologies and capabilities, technologies for distribution and marketing and relational capital. Subsequently, as a pilot test and validation of the methodology for identifying areas of innovation, a search was carried out in a sample of some representative cases of agricultural innovation in Latin American countries reported in the literature. Once the cases of interest were selected, the innovative projects in each case were identified according to the following criteria: 1. Projects that clearly present improvements in the agricultural value chain. 2. Projects in which deficiencies recognized in the different links of the productive value chain, since they represent opportunities for innovation.

Table 1 presents the different innovation opportunities or projects mentioned in the different cases analyzed. We concluded that all of them belong to the following categories of the agroindustry value chain: Agricultural Products Technology, Technological devices and transformation processes, Organizational Technologies and Capabilities, Technologies and relational capital Distribution-Marketing, Technology transfer.

Table 2 was built and complemented with the agricultural innovation projects reported in the theory and practice of agricultural production literature. The headings in Table 2 match the types of innovation projects in the central stage of the value chain in Figure 2. The process can be repeated and new cases were analyzed to obtain a general table of innovation areas. It can be consulted as a first approximation by practitioners and theoretical researchers of the Agri-production sector.

4. Analysis of Some Latin-American Producer Cases

Below, we will study a sample of the situation of the agricultural sector in different Latin American countries. Based on these descriptions, we will propose some examples of how areas of opportunity have been found for innovation in the value chain of the agricultural producers studied.

4.1 Corn Cultivation in El Salvador

In Latin-American countries, family-level agriculture has received strong support from the Food and Agriculture Organization of the United Nations (FAO). The culture of basic grains has been crucial in the development of El Salvador, as well as in the history of many other Latin American countries (Ayala, 2021). For corn, the Ministry of Agriculture and Livestock (MAG, from Spanish) of that country conducted an analysis of its value chain at the national level in 2012, finding that in general there is a high cost associated with agricultural inputs, inefficient practices, little technology transfer, low access to financing and little organization among producers. Clearly, inefficiencies and/or disadvantages in the value chain become opportunities for innovation.

In the same study, but from the perspective of value chains, the following disadvantages were identified: a small number of input suppliers, a predominance of small farmers, high use of hybrid seeds, a weak connection with the processing industry, and the existence of agricultural intermediaries. In previous Figure 2 we can see that these disadvantages can be addressed through small incremental innovations at each stage of the value chain.

4.2 The Agricultural Sector in Mexico

Mexico has great potential in the agricultural sector, even though the total share of this sector in the total national Gross Domestic Product (GDP) is very low. From 2008 to 2012, agricultural activity in the country showed an average annual growth rate of 6.5%, with Jalisco, Michoacán, Veracruz, Sinaloa, Sonora and Chihuahua being the main states contributing to the national GDP in this sector in the same period (Conacyt, 2014-2).

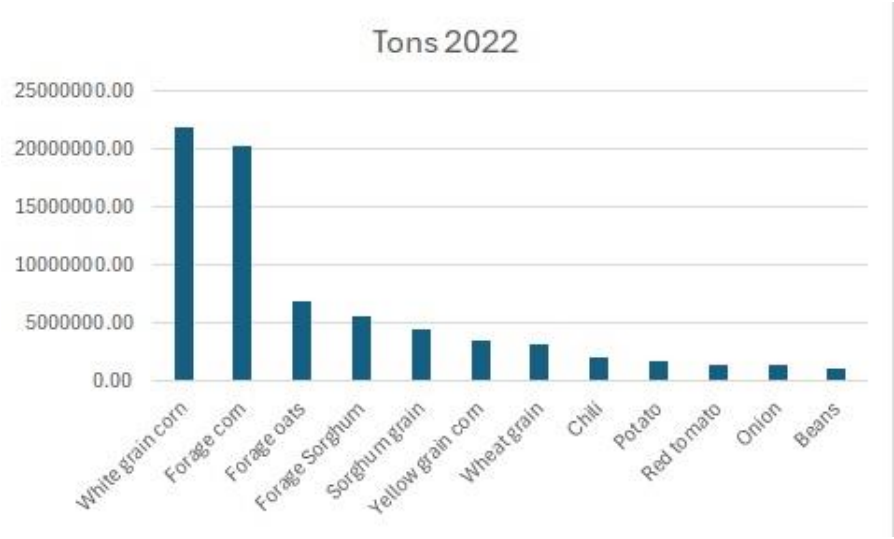

Figure 3. Production of main agricultural products in Mexico in 2022

Source: Modified from INEGI, (2022).

The field for agricultural innovation is made up of cultivation and production methods, within the set of activities that make up the agri-food value chain

The main products that contribute to the agricultural GDP are forage and grain corn, forage and grain sorghum, forage oats, grain wheat, chili, potatoes, red tomatoes, onions, beans, watermelon, pumpkin, cotton, broccoli, husk tomatoes, grain barley, melon, rice, soybeans and amaranth.

Figure 3 shows that corn production in its various varieties represented approximately 56.8% of the total tons of agricultural products produced in 2022, making it the main agricultural product that contributed to the annual GDP.

4.3 Agricultural Innovation in Corn Cultivation: The Case of Yucatan, Mexico

The state of Yucatán is in the southeast of Mexico, on the Yucatán Peninsula, and is bordered to the north by the Gulf of Mexico, to the east by Quintana Roo, and to the west by Campeche. The state is also a natural bridge between the Central American countries, the Caribbean islands, and the southwest of the United States.

The geographical position of the Yucatan Peninsula, surrounded by sea, as well as its proximity to the Tropic of Cancer and the lack of significant orography, gives the region a very particular climate. In the case of Yucatan, the weather is affected by sea currents, trade winds, tropical waves, tropical storms and cold fronts.

One of the natural attractions that distinguish the State of Yucatan are the cenotes, deep natural wells, around which large Mayan settlements were built. In Yucatan, more than half of the population belongs to the indigenous population, mostly of Mayan descent, and it is one of the states with the largest number of indigenous people in the entire country.

Its capital, Mérida, has been the development hub for the entire peninsula. Historically, the city has concentrated the best educational and health services in the entire region. This has allowed the development of the city and the State in an economy distributed between services, primary and transformation sectors (CONACYT, 2014).

According to Gamboa-Cimé et al. (2023) corn, beans and squash are the crops called the "Mesoamerican triad", other crops are also harvested, but the milpa represents the main source of food for families in rural communities in the south and east of Yucatan.

Bautista (2021) comments that the people of Yucatan commonly say that there is no soil there. The reason for these comments is that 80% of the surface of the Peninsula is made up of leptosols, which are shallow soils of little depth, with very little fine soil and a large quantity of stones or rock outcrops. This makes farming activities difficult because, due to the stony soil, it is practically impossible to use agricultural machinery or animals for farming work, so the milpa is cultivated using the slash-and-burn system. This is a shifting agriculture system that involves disturbing the forest to prepare the land before planting, working it for about three consecutive years, and then abandoning it to allow the soil to regenerate for 20 to 30 years. The soil is fertile for only three years and very quickly the organic matter disappears and with it the corn yields.

The use of fertilizers and insecticides is also impractical due to their high cost; furthermore, these products are harmful to the environment and human health. For this reason, an optional innovative procedure to conserve and improve the soil in its physical, chemical and biological components is to strengthen the cultivation of milpa, through agroecological management with Conservation Agriculture (CA) practices (Gamboa-Cimé et al, Op cit, pp.56).

Due to the type of soil, tillage machinery cannot be used in Yucatan, as this procedure favors the destruction of soil macroparticles that become compacted and eroded. The alternative is the use of zero-tillage practices introduced in the 1970s in Brazil. This production system is now known as Conservation Agriculture (CA). It has three principles: zero tillage, permanent soil cover and crop diversification.

Permanent cover consists of using residues such as stubble and depositing them on the surface for soil conservation and improvement. The stubble that is deposited on the soil comes from the previous crop, it is cut and crushed to facilitate decomposition and sowing of the next cycle. Thus, the organic matter content is increased, the availability of nutrients increases and the biological activity in the soil improves. It is a no-till crop, where only a hole is opened through the decomposing residues of the previous harvest, in which the seed will be deposited, trying to minimize the breaking of the soil and guarantee its protection, and the planting positions with the vegetal cover. This type of crop is diversified by including, in addition to corn, pumpkin. The benefits of diversification are the reduction of pests and diseases, weed control, and the proper distribution of nutrients in the soil.

Legumes such as beans can also be used, as they are resistant to drought, inhibit weed growth and are very important for human consumption.

In this case, Conservation Agriculture is an innovation opportunity area in the production

phase of the agricultural value chain.

4.4 The Municipality of Angostura in the State of Sinaloa

Numerous authors discuss and analyze the determining elements of innovation in various regions of Mexico. Accordingly, Zayas (2018) states that, in the agricultural sector of the Municipality of Angostura in the State of Sinaloa, Mexico, innovative projects are, among others, those who seek to achieve greater resistance of plants to pests and diseases; increase crop productivity, improve crop quality through the design and creation of new modern equipment and machinery that involve information technologies for their use and management. Also, the development of innovations in seed varieties that allow for greater production and resistance to pests, allowing producers to benefit from the results in the yield of their production per hectare, reducing production costs and therefore improving their profits.

Naturally, one of the fundamental variables in the performance of agricultural production is the proper management of irrigation water. Many producers obtain the water they need from irrigation modules by paying fees per hectare for crops such as corn when there are no rainfed crops. In cases such as vegetables that require more water for production, the cost of water is higher, which increases production costs, so it is essential to make innovations in the irrigation water management system, canals, gates and machinery, which would significantly reduce production costs (Zayas, op. cit., pp.876).

Besides, there are attitude problems regarding the possibility of problems since, according to the study by Lucero et al., (2023), as the age of producers increases, the possibility that they choose to take out insurance decreases.

4.5 Sonoran Farmers

Continuing with the study of innovation opportunities, let us now look at the interesting study carried out by Hernández-Pérez, (2019) on innovation in export agriculture in the state of Sonora in northwestern Mexico. The author mention that some Sonoran producers undertook a process of reconversion and modernization of their agricultural activities to take advantage of the “comparative-natural advantages” of the region.

In his study he highlights that, to improve their competitiveness, Sonoran producers developed a series of product, process, organizational and marketing innovations, collaborating in global value chains through networks of companies or agricultural producers who, through specific tasks, grouped around the production and marketing of an agricultural product, even making administration innovations by implementing new marketing methods, making changes in product design and packaging and in methods for finding the right price for their goods and services.

The author emphasizes that, as proposed by the OECD (2013), agricultural innovation arises from the interaction between the different actors related to the sector: producers, processors, packers, distributors, consumers, organizations and government. From this premise defines the Agricultural Innovation System (SIA) as: "a network of actors who, together with their

institutions and policies supporting the agricultural sector, put into social and economic use new or existing products, processes and practices" (Hernández-Pérez, Op Cit, pp.10).

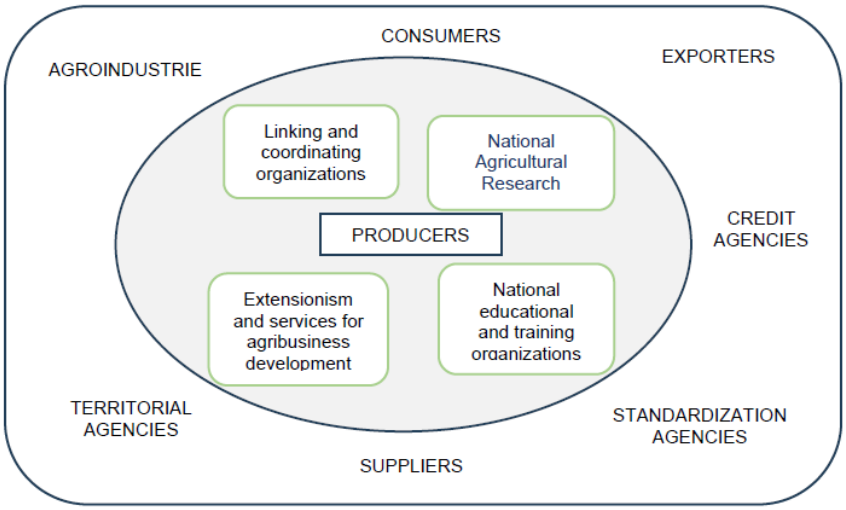

Figure 4. Agricultural Innovation System

Source: Modified from IICA, 2017, taken from Hernández-Pérez, op cit, page 10

Figure 4 shows the conceptual diagram of a holistic agricultural innovation system, consisting of a system of internal and external networks that producers must establish to develop their innovation processes. It includes all the key actors in the agricultural research and innovation core proposed by Rojas-Meza (2015, p. 45).

4.6 The Agroindustry of Tequila in Jalisco State of Mexico

In his research, Rojas (2024) finds that agave tequila producers and tequila industrialists in the state of Jalisco in Mexico face the dilemma of whether or not to address the prevention and mitigation of socio-environmental impacts on water and social inequality and the achievement of profitability schemes inherent to market inertia. Since the 1990s, there has been a great exploitation of water resources supported by economic aspects that entail the intensification of production and consumption through the exploitation of resources and increasing technological advancement. This has caused a technological lag in the management of water resources.

The agro-industrial processes for the production of tequila are affected by the profitability demanded by international markets with free market economic schemes, which do not take into account environmental regulations, which has led to privileging profitable monoculture in order to be able to subject them to market demands. This type of monoculture causes water stress in the western region of Mexico. To correct this problem, it is necessary to carry out Water Management and Environmental Management, in accordance with the Regulations of the Ministry of Environment and Territorial Development (Semadet Jalisco). Monocultures, from the point of view of the ecosystem, also cause homogenization of the landscape and the

constant fragmentation and loss of habitats, microclimatic changes and losses of important species and populations of fauna and flora (Staduto et al, 2024).

5. Technology Transfer and Innovation

Undoubtedly, agricultural and farming systems are based on modern and ancestral knowledge held by farmers and members of the companies and organizations that are part of it. Agricultural universities and some governmental and private organizations are also part of this ecosystem since they are continually developing new product and process technologies for the sector. All of them constitute the National Agricultural Research System (Fig. 4). In this sense, the transfer of knowledge and technology in commercially usable forms is increasingly important. The role of universities has ceased to be solely that of teaching and since the 1980s their responsibility has been extended in practically all countries, to contribute to social development and economic growth (Faccin et al., 2015).

Today, agricultural universities and their research institutes and centers must ensure that their research brings social and economic benefits, transforming knowledge into useful technologies. The transfer of technology and knowledge is also expected to translate into jobs, wealth, career and growth opportunities for young people, as well as creating the foundations for reducing social disparities.

The idea is to improve the value chain through the application of innovative new or ancestral technologies, which implies optimizing or improving the production sequence that goes from obtaining the product to its commercialization with the consequent economic and social impact.

Traditionally, the transfer of technology developed by the different entities of the National Innovation Systems is carried out to companies or agricultural producers through the signing of Technology Transfer Agreements. However, this is a very complicated process for small producers. To address this problem, Herrera-Toscano (2023) stresses that the social network approach currently constitutes a best alternative method for technology transfer and innovation, since small producers can be grouped into societies or cooperatives.

The fundamental elements of the social network approach are the nodes, which can represent not only individual producers, but also companies, industries, government entities, non-governmental organizations (NGOs), universities, institutes and research centers, associations, suppliers, industries, consumers, standardization agencies, state-owned companies, among many others. The second element is the interactions that occur between actors or nodes in the networks.

Communication is crucial, because through specialized communication systems, interactions can materialize in joint research projects, strategic alliances, business mergers, research internships, joint patents, joint purchase or use of equipment, and both, or purchase of inputs. Over time and with the development of joint projects, interactions generate links. The main objective of social network analysis is the study of established links, which over time become structures. Old person-to-person communication is reinforced using specialized computer programs which are very convenient for this type of collaborations.

In other words, this means that innovation processes depend more on the existence of many agents innovating in their daily activities than on a few institutes that research at the frontier of science, but with many difficulties in carrying out the processes of knowledge transfer.

On the other hand, government entities that establish public policies for the sector, such as the Secretariat of Agriculture and Rural Development (SADER) of the Mexican Federal Government, must establish support programs so that companies in the agricultural sector can solve the different problems of the sector related to innovation to achieve regional development; in other words, they must act as accelerators or catalysts.

5.1 Case Tlaxcala Farmers

Amaro-Rosales and de Gortari-Rabiela, (2016), describe a case that occurred in Mexico some years ago, between 1980 and 2015, the technology transfer and innovation policies for the agricultural sector in Mexico were mainly supported by the actions of the so-called "extensionism", which has basically included technical assistance, training and technological support for the use of inputs and machinery.

The extensionism operation was focused on the operational public policy instrument called: Comprehensive Innovation and Extension Projects Program of the then Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA).

An example of this extensionism was the transfer of genetically modified wheat technology created at the National Institute of Forestry, Agriculture and Livestock Research (INIFAP) to farmers in Tlaxcala, Mexico (Sangerman–Jarquín et al., 2009).

Between 1995 and 2000, INIFAB, using financing from the Agricultural and Rural Development Program (PADR), also developed the following programs: Alliance for the Countryside, Kilo by Kilo, Grains of the South, Coconut Palm, Agricultural Mechanization, Coffee and Training and Extension. During this period, the Autonomous University of Chapingo, the College of Postgraduates, and the Antonio Narro Autonomous Agrarian University of Coahuila also contributed to the emergence of Mexico's agricultural research system and the training of extension workers. It is notable that, in their bibliometric study, Tolin and Picalluga (op cit, p. 5) mention that universities in general can interact with producers and agri-food companies in the sector, through the transfer of knowledge.

5.2 Value Generation in Sustainable Agro-industrial Chains

Through a systematic literature review in the Scopus database, Albarracín-Gutiérrez et. al., (2024) reviewing more than two thousand documents, found that that activities associated with operational skills and the integration of network agribusiness are the most relevant. However, in recent years value has been given to activities associated with marketing and innovation, making new strategies for the use of resources visible, which directly impacts the increase in the competitiveness of agro-industrial chains. On the other hand, sustainability must be based on three main axes: economic, social and environmental (Staduto et al., 2024).

6. Results

The findings of the areas of innovation in the value chain in Mexican agricultural producers in Yucatan, Sinaloa and the extraordinary table of agricultural innovations in the Coast of Hermosillo Sonora, proposed by Hernández-Pérez, (op cit, pp. 20-21); are summarized, integrated and shown in Table 2. The header of this table shows the four technological levels of the agri-food industry value chain.

The first column of Table 2 breaks down the fundamental technological research and development topics for the agricultural sector, which are the following:

Soil science. Maximizing use of atmospheric nitrogen in crops and trees through plant selection and the achievement of optimal plant-bacteria conditions; and optimizing the use of nitrogen and phosphate fertilizers and water to obtain the highest level of productivity and yield while minimizing their negative impact on the environment.

Phytotechnology. Creation of crop varieties with higher yields and resistance/tolerance to diseases.

Agrochemical compounds. Development of new pesticide formulas for specific uses and long-term effects that have minimal consequences on the environment.

Entomology: reduction of the indiscriminate use of insecticides against agriculturally important insect pests by creating and promoting an environmentally friendly and targeted system: the sterile insect technique.

Livestock production. Increasing livestock productivity by proposing other management strategies in livestock feeding and genetic selection; defining the incidence and prevalence of the main livestock diseases and monitoring the effectiveness of vaccination or other disease eradication and control campaigns.

Under the organizational technologies heading, Table2 also includes innovation opportunities in the agribusiness gender issues as the one pointed out by Cassia Da Silva et al. (2023), Agribusiness is male-dominated: professional discrimination of women in the sector. A summary of the innovation opportunities drawn from the analysis of the cases presented is found in Table 1. These problems could be addressed with the projects and activities on Table 2.

Table1. Summary of the innovation opportunities from cases presented

Case	Location	Problem detected and described in the case narration
1	El Salvador	Agricultural inputs (a small number of input suppliers); agricultural inputs (high use of hybrid seeds), predominance of small farmers; weak connection with the processing industry; existence of agricultural intermediaries; little organization among producers, little technology transfer; low access to financing.
2	Mexico's corn	Cultivation and production methods
3	Yucatan peninsula	Farming activities are difficult because, due to the stony soil, the soil is fertile for only three years and very quickly the organic matter disappears
4	La Angostura Sinaloa	seek to achieve greater resistance of plants to pests and diseases; increase crop productivity, improve crop quality through the design and creation of new modern equipment and machinery that involve information technologies for their use and

		management. Proper management of irrigation water
5	Sonora farmers	modernization of their agricultural activities, organizational and marketing innovations, organizational and marketing innovations, new marketing methods, agricultural innovation system
6	Tlaxcala farmers	Extensionism as technical assistance, training and technological support for the use of inputs and machinery. transfer of genetically modified wheat technology created at the National Institute of Forestry, Agriculture and Livestock Research
7	Tequila production in Jalisco	Socio-environmental impacts of water and water stress offer opportunities for innovation with the automation of groundwater pumping

Table 2. Innovation opportunity areas in the agricultural value chain

Agricultural Products Technology	**Technological devices and transformation processes**	**Organizational Technologies and Capabilities**	**Technologies and relational capital Distribution-Marketing**
Traditional techniques: conservation agriculture, reforestation with desert vegetation.	Design and creation of modern equipment and machinery	Departmentalized companies with an innovative vision and financial diversification. Specialized personnel with ongoing training	Establishment of internal and external networks in the marketing processes. Attention to international markets
Proper handling of agrochemical compounds and fertilizers. Land edging, genetic, biological and chemical control.	Information technologies for the use of machinery	Use of computer systems to manage all business processes. Innovation on Gender inequalities.	Specialized refrigerated transportation. Improvements in bags, packaging and box presentation
Proper management of irrigation water with dams. Automation of groundwater pumping, machinery	Agro-industrial processing, juices, jams, sweets, etc.	Technology intelligence systems for monitoring new technologies, forums, fairs and research seminars	Direct marketing without a contract. Market research and business plan. Distributor development
Soil science, optimization of the use of nitrogen and phosphate fertilizers. Use of atmospheric N	Organic production with biotechnology, drip irrigation, fertigation	Companies with social responsibility, social management and services in agricultural fields	Trading houses for small and medium-sized distributors
Phytotechnology: New varieties of improved seeds with greater plant resistance to diseases and pests	Modern pruning methods, new fruit ripening techniques; packaging and sorting	Linkage with research centers and institutes and government organizations. Development of suppliers and code of ethics	Trade partnerships and technology alliances. Contract farming (Parral Quintero, 2022)
Generation of seedlings in greenhouses and propagation of new organic species	Safety, quality and health Cold rooms and storage chambers	Inventory control systems, audit implementation, ongoing staff training plan	National and international advertising, promotional campaigns and fairs
Use of worm compost for fertilization. Fumigation with bio-insecticides. Integrated disease management.	Agroclimatic monitoring of soil moisture and pests and diseases. Agroecological management.	New flexible forms of hiring agricultural workers (day laborers): hiring by day or by task	Management of website and social networks: Facebook, Twitter, Blogs, Instagram, etc., with company information

7. Conclusion

The importance of the agri-food sector in all countries of the world is fundamental, as it provides food for its own population, for export and to alleviate hunger among both the poor population of developed countries and those of third world countries. This sector has always been affected by atmospheric phenomena and the availability of irrigation water. In fact, many authors and international organizations consider that climate change is perhaps the greatest risk for the present and future of agricultural development in Latin America and in all countries around the world (Rojas-Meza, 2015., López, Hernández, 2016).

BASF (2024) notes that by 2055, maize yields could be reduced by 10% due to rainfall fluctuations and temperature changes. The European Environment Agency EEA (2019) notes that soil erosion may be accelerated by extreme weather events and to increase the land's capacity to capture carbon dioxide from the air.

For decades, the agri-food sector, like all economic sectors, has been subject to an intense dynamic of global change. With technological change, the means of communication have changed, automation systems and production control are based on computer systems, all these changes have led to an exorbitant increase in competition from the local to the international level. The most appropriate way to face this great competition is to increase the competitiveness of producers, whether individual or grouped in companies and/or various associations. Finally, the key to increasing competitiveness lies in innovation. For this reason, the objective of this work was to offer a synoptic overview of the different areas of the value chain of agri-food processes in which innovation projects can be developed.

The method used was to study and analyze various cases of innovation projects carried out by Mexican and Latin American producers, identifying their place of incidence within the links that make up the value chain of the production processes. Subsequently, using the elements of the agri-food innovation system and the different innovation modalities reported in the literature, Table 1 was developed, which is a synthetic summary of the areas of opportunity to carry out innovation projects in the different links of the value chain of agri-food production processes. The resulting information can be used by the different actors in the production processes of the agri-food sector as a very general aid for diagnosing (Moreno et al, 2017), and planning their innovation projects, through a quick look for producers to select and innovation projects seeking effective value chain cost management that allows them to face the challenges of today's intense competition (Pérez et al, 2018).

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The Publication Ethics Committee of the Macrothink Institute.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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No additional data are available.

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