# Use of Clean Technologies in Agribusiness in Mexico: A literature Review

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## Abstract

There is little research documenting the use of clean technologies (CT) in Agribusiness in Mexico. In this regard, the objective of this article is to provide an in-depth literature review that can cover this gap and help decision-makers and investors to identify opportunity areas in the industry. It also provides a good theoretical background for researchers and practitioners to further investigate applications of clean technologies in this sector or other potential ones. To conduct this research, an in-depth analysis of the literature on clean technologies and their use by agribusiness in Mexico was carried out. The databases such as Web of Science, Scopus, and Springer were used to identify the relevant international journals in the field and their research-contributions. The main results show that there is a need for financial investments on clean technologies CT that can help optimizing processes and products on the sector. The results also showed that CT is mainly used to minimize energy consumption, to optimize planting and harvesting, to enhance irrigation and water use, and to maintain the soil fertility. Despite these wide applications, the authors found that the penetration of CT is still low and policy-strategies are required with effective financial investments in the sector.

## Keywords
Clean technologies, agribusiness, Mexico, agriculture and environment.

## 1. Introduction

In the modern world, many people share a great concern for the increasing deterioration of the environment and its effects on human life. As it provides food to humans and other species and helps to sustain life on Earth, agriculture is one of the most relevant of human activities. This critical activity has been affected by water pollution, use of pesticides, emissions of greenhouse gases, soil erosion and loss of biodiversity, among other negative activities (Kirchmann and Thorvaldsson 2000). In addition, the persistent levels of hunger and malnutrition in the world, the continuing pervasive incidence of unsustainable practices and increased human activities on the Earth's capacity represents a challenge for agriculture, aggravated by the continuing growth of the world's population. According to the Food and Agricultural Organization (FAO) of the United Nations (2015), to meet the growing food demand for more than nine billion people by 2050, it will be necessary to increase food production by 60%. This underscores the urgent need to adapt technology to current production systems and to become more efficient in food production.

In this context, Pretty (2008) defines sustainable agriculture as the human activities that contribute to food security: availability, access, utilization and stability. Sustainable agriculture faces the challenge of meeting current and future consumer needs, while at the same time, for business, it has to guarantee profitability, as well as assure the lowest possible impact on the environment and provide social and economic equity. In practice, these multiple aims appear to be very difficult to achieve with current economic and production systems.

Since agriculture depends on ecosystems, sustainable agriculture should minimize the negative environmental impacts and, at the same time, it needs to optimize production and to protect, preserve and use natural resources efficiently (Dao et al. 2011). In addition, it is necessary to strike a balance between the protection of agro- ecosystems, and the satisfaction of a growing society's needs and offer people a better quality of life (Wirén-Lehr 2001). In this context, the achievement of sustainable agriculture requires strategies that involve adequate actions to achieve multiple objectives and several implementation approaches for different contexts. The strategies based on technological change and innovative processes offer opportunities to change the way in which agriculture is practiced from an environmental perspective and to promote social inclusion.

Therefore, the objective of this research is to conduct a literature review that provides a review of the state-of-the art use of clean technologies (CT) in agribusiness in Mexico. It also offers arguments for the importance of developing sustainable agriculture and presents the challenges in this field within the appropriate context for the coming years. A number of innovation models are reviewed for sustainable agriculture, and then the research methodology for conducting this study is presented. Finally, the last section discusses the main clean technologies that currently foster agribusiness in Mexico.

## 2. Sustainable Agriculture

At national levels, investment in agriculture is one the most important strategies for economic growth and to reduce poverty in rural areas in Mexico. The growth of the gross domestic product (GDP) in agriculture has proven to be at least twice as effective in reducing poverty compared to the growth in other sectors (Mundial 2008). In the case of sustainability, the first requirement is to understand the relationship with agriculture. Brunett (2004) suggests three positions for this relationship, which, in theoretical terms, are as follows:

- The first is related to the theory of neo-economists, which is based on the idea that sustainability is achieved by assigning a price to the environment and recognizing the inability of the market to respond to environmental degradation. Its conceptual framework is derived from the Marxist theory of the use value and exchange value theory, which builds a perspective known as environmental economics. This proposal considers natural resources as commodities to exploit for profit.

- The second position is classified as socio-anthropological, in which criticism is applied to technological models for their high content of capital inputs, and by excluding the population, which cannot afford to acquire technology for production. It recognizes the need to maintain the culture and traditional knowledge as necessary elements for the conservation of nature and economic production.

- The third position is techno-biologics, which establishes the importance of biodiversity and their interactions, which promotes a multidisciplinary approach. It argues that it is possible to maximize the efficiency of production systems and to get greater benefits with the use of environmentally friendly techniques. In addition, this proposition emphasizes that technology should not only be directed to the efficiency of the processes, but also have an impact on social, economic and environmental issues.

The authors of this article consider that the role of technology is critical to developing sustainable agriculture, and thus take (Brunett 2004) third approach. In this context, according to the inter-agency working group of FAO, UNCTAD (United Nations Conference on Trade and Development), IFAD (International Fund for Agricultural Development) and the World Bank, over the next 35 years, agriculture will face a number of pressures, including an increase of the world's population by 30%, intensification of competition for land, water and energy, and the consequences of climate change. So, to feed a population that is expected to reach 9.3 billion people by 2050, it is estimated that food production must pass from 8.4 billion tons to 13.5 billion tons per year (FAO 2015).

Agriculture not only experiences the effects of climate change, but it is also responsible for 14% of global greenhouse gas emissions. In spite of this dynamic, agriculture has the potential to be part of the solution, through the mitigation, reduction and elimination of significant amounts of global emissions. It is estimated that around 70% of this mitigation potential could be performed in developing countries (FAO 2014). This is the case for Mexican agriculture. In this context, a more productive and resistant agriculture will require better management of natural resources, such as land, water, soil, fertilizers and other factors. Several concepts are found in the literature that incorporate sustainability into agriculture, which can be categorized as eco-agriculture, organic agriculture, biodynamic, organic and intelligent(Pretty 1995, Conway 1997, NRC 2000, McNeely and Scherr 2003, Clements and Shrestha 2004, Cox et al. 2004).

The concept of sustainable agriculture is based on the insight that natural resources are finite and, consequently, there is a need for changing the pattern of production, distribution and consumption, to promote the conservation and rational management of resources (De Camino and Mueller 1993, Schaller 1993, Altieri 1995). For the purposes of this research, sustainable agriculture is defined as that which promotes goods efficiently and adapts to the needs of society, and which seeks to mitigate the degradation of the environment, and at the same time seeks a balance between economic, social and environmental objectives (Pretty 2008).

## 3. The Mexican Agribusiness

Agriculture in Mexico is not only considered as a productive sector, but also as a sector linked to the generation of rural employment and a supplier of food. According to Instituto Nacional de Estadística y Geografía (INEGI [National Institute of Statistics and Geography])(2015), its contribution to the Mexican GDP is 4%(INEGI 2015), estimated at 1,759,706 MXN and agriculture also performs other functions in the economic, social and environmental development of Mexico, which provides strong arguments to be a key industrial sector, as follows:

- The majority of food production originates in this sector and the internal and external supply of food is critical for national security, cost of living and the population income.
- Agricultural products are the base of a large number of commercial and industrial activities (FAO 2010).
- The rural population increasingly develops activities different from agriculture, such as local commerce, handicraft, removal of materials, ecotourism, environmental services or paid work in various occupations, among others. However, agriculture remains the predominant activity in the Mexican countryside, especially among the poorest population, and this activity represents 42% of family income (SAGARPA 2005).
- Agricultural development requires greater direct-jobs and services. It allows greater investment capacity of rural families in other activities and generates a greater dynamism of local markets (International 2015).
- The eradication of poverty represents a national priority and agricultural development plays an important role in it.
- Rural development also means the incorporation of a significant economic potential for the progress of Mexico (FAO 2010).
- One of the long-term national development priorities is environmental sustainability and conservation of natural resources. The preservation of aquifers, soils, biodiversity, forests, the density of marine life and inland waters and other elements of sustainability are a national priority (International 2015).

In light of these arguments, the prospects for a steady growth in the demand for food and agricultural products with added value are an incentive for the development of agro-industries in a context of economic growth, food security and strategies to eradicate poverty. The literature indicates that agro-industries, understood as a component of the manufacturing sector in which the addition of value to agricultural raw materials is derived from processing and handling, are efficient engines of growth and development. Further, it is recognized that the ties betweenprogressive and regressive, agro-based industries have multiplier effects in terms of employment and value added creation (Davis and Goldberg 1957, Cook and Chaddad 2000, Barrett et al. 2001).

In terms of industry, Mexico has a number of strengths and opportunities to address its weaknesses and threats. The Mexican Government through its agricultural policies has included several initiatives that encourage the production and productivity of agricultural economic-units through incentives for the integration of productive chains, development of an agro-food clusters, investment in physical, human and technological capital, productive reconversion, agro-inputs, operation post-harvest and energy-efficient and sustainable use of natural resources (BMI, 2015).

Thus, Mexican agribusiness has the potential to explosively develop its natural resources. The climate and existing workforce encourage this practice. However, doing so requires technological innovations that allow for care of the environment and obtaining economic and social benefits.

## 4. Technology change for sustainability

Products and services can successfully be commercialized by price, quality, design and fierce advertising campaigns. However, to stay and compete in the markets, it is required to establish and standardize continuous innovation processes. Escorsa and Valls (2003), define innovation as 'an idea transformed into something that can be sold or used'. For Sherman Gee (1991), 'innovation is the process in which from an idea, invention or recognition of a need for a product, service or useful technique is developed until it is commercially accepted'. Pavón and Goodman (1981) point out that innovation is 'the set of activities, registered in a given period of time and place that lead to the successful introduction on the market for the first time, an idea in the form of new or improved products, services or management techniques and organization'. The above definitions are derived from the proposal of Schumpeter, who, in 1934, was the first to stress the importance of technological phenomena in economic growth.

According to the provisions regarding the premise of sustainable development, innovation for sustainability, which Fussler and James (1996) define as new products and processes that provide customer value and business but significantly decrease environmental impacts, has emerged as a necessity. Similarly, Kemp and Pearson (2007) refer to innovation for sustainability as the production, assimilation or exploitation of a product, process, service, management or method core business of the organization that considers the life cycle of a good and/or product, reducing environmental risk, pollution and other negative impacts of resource use. From the economic perspective, Andersen (2008) suggests that innovations for sustainability should include those that are able to attract green utilities into the market. Therefore, for the purposes of this article, innovation for sustainability is defined as the creation of significant improvements into existing products, processes, methods and organizational structures that lead to environmental improvements, thereby maximizing profits.

### 4.1 Clean Technologies

Nikolai (2009) and Heng and Zou (2010) refer to clean technologies as industrial products that reduce air pollution and reduce the use of raw materials, natural resources, and energy. They suggest that such technologies properly implemented will help to ensure the satisfaction of the needs of future generations and will improve the performance of the organization (Arroyave and Garcés 2007). ONU (1992) establishes the definition of clean technologies as processes and products that protect the environment, are less polluting, use resources in a sustainable manner, recycle their waste and products and handle residual wastes in an environmentally acceptable manner.

### 4.2 Adoption of CT – successes and barriers

River (2003) points out that the decision to adopt clean technologies is complex, subject to multiple influences and difficult. Companies that participate in agribusiness need to find new technological options, whether in the form of products or processes, to control environmental damage, to reduce costs and avoid volatility of prices, without affecting productivity. As a result, they are reconfiguring their processes and organizational structures in order to adopt this type of technology as a strategy of innovation to become sustainable.

## 5. Research Methodology

A literature review has proven to be a crucial step in structuring scientific research (Easterby-Smith et al. 2002), and it aims to be the basis to create knowledge, facilitating the development of the theory and solving problems in several areas of research and discover those that require further investigation (Webster and Watson 2002). Accordingly, we carried out an in-depth analysis of the literature on sustainable agriculture and clean technology and its use by Mexican agribusiness. Similar research methodologies have been successfully used for these topics; see, for instance, Escobal et al. (2000), Levi and Ellis (2006), Business Monitor International (2015) and Harwich et al. (2004).

The processes for carrying out the research were as follows: selection, review, comprehension, analysis and synthesis of the literature, which, according to Levy and Ellis (2006), ensures a structured and effective review and provides a strong basis for theory-building. The scientific material reviewed included journal articles, special-topic-related books and specialized reports from Mexican and international agencies with a strong impact and reputation. We excluded textbooks, unpublished working papers and newspaper materials. The literature was extracted from international journals covering topics in business and management, social sciences, sustainable development, agro-industry, agriculture, environment and innovation. These materials were primarily identified in the databases of the Web of Science (WoS), Scopus and Springer. Similarly, specialized materials not contained in WoS or Scopus were obtained from editors, which included Emerald, Taylor & Francis, Elsevier, EBSCO, Wiley & Sons and Cambridge University Press, among others. Items that have been identified in the main databases according to research journals and keywords are displayed in **Table 1.**

Table 1. Breakdown of the literature found

| Research areas | Sustainable agriculture | | Innovation for sustainability | | Clean technologies in agribusiness | |
|---|---|---|---|---|---|---|
| | Number of items | % | Number of items | % | Number of items | % |
| Management and social sciences | 7 | 29.17% | 11 | 37.93% | 8 | 17.02% |
| Agriculture and agribusiness | 12 | 50.00% | 3 | 10.34% | 23 | 48.94% |
| Innovation and technology | 1 | 4.17% | 13 | 44.83% | 10 | 21.28% |
| Sustainability | 4 | 16.66% | 2 | 6.90% | 6 | 12.76% |
| Total | 24 | 100% | 29 | 100% | 47 | 100% |

In the literature review, only two articles were published before the 1990s. Considering the theoretical basis of this research, material related to innovation included frequently cited references in documents as precursors of the links between innovation and sustainability. We conducted brainstorming sessions to select the keywords, and the snowball effect was used subsequently to add keywords to the searches that were found in the literature using logical operators in the databases. A classification of the literature was conducted by research area, illustrating the area of agriculture and agribusiness with the largest number of literature examples, while linking innovation and technology together with management and the social sciences with a similar percentage, showing the importance of linking sustainable agriculture to innovation and managing of resources.

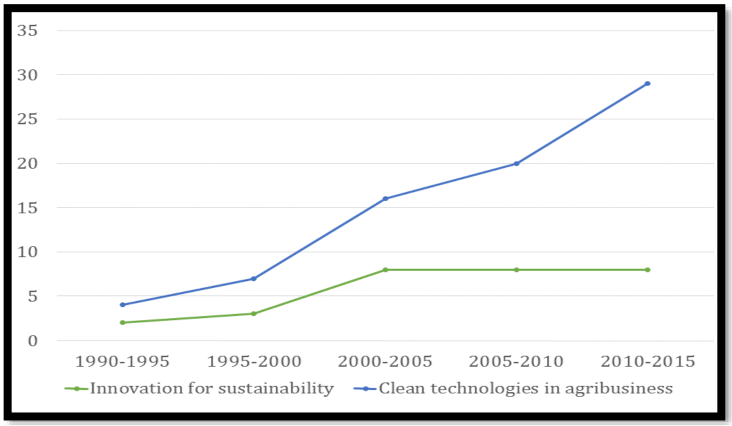


Figure 1. Relation between innovation for sustainability and clean technology

In this context, Figure 1 shows that the research related to innovation for sustainability has remained constant with an increase over the period of 1995–2000. At the same time, clean technologies in agribusiness show a significant growth during the same period, which indicates the relevance of the topic and such technologies in the sector. Each of the scientific articles found was examined from a content perspective, i.e. that it is relevant from the perspective of the research objectives. The result of this process of analysis resulted in the selection of 47 articles for evaluation in depth according to the subject of the investigation. Following the proposal from Levi and Ellis (2006), the stages of "review", "analysis", "comprehension" and "synthesis" of the literature were performed and deployed in Section 6.

## 6. Analysis and discussion of results

Agribusiness represents an important activity in the economy, however, itsnegative environmental impact has been questioned (Olarte, 2012). Thus, a sustainability focus has become essential for the development and growth of this industrial sector since it uses land, water and other resources, and its products reach consumers worldwide (Lee, Barrett, & McPeak, 2006). According to (Barrett, Barbier & Reardon, 2001), the main issues of sustainability in the agriculture and food supply chain include the use of resources, environmental impacts, labor and human rights, health and safety and community development. Other studies focus their research on the prospect of the farmer and good agricultural practices (Baptist & Sumberg, 2015; Brown & Gil, 2003; Wirén-Lehr, 2001), perceptions of the consumption in the food market (Brunett, 2004; Cook & Chaddad, 2000), the importance of considering strategies for sustainability in the food companies (Barrett, Barbier & Reardon, 2001; Chen & Luo, 2011; Chidiak & Murmis, 2003), and the components needed to make sustainable agribusiness supply chains (Dao, Langella & Carbo, 2011; Escobal, Agreda & Reardon, 2000; Veisia, 2012).

### 6.1 The need of technology for agriculture

Tait and Pitkin (1995) and Aranda et al. (2008) point out that sustainable development is based on technological change to achieve the goals, in which it is the role of governments to take measures to strengthen radical technological innovation. The actors involved in such innovation need a long-term vision and the readiness to assume short-term economic costs, while the industry readjusts. Markatou (2011) also argues that innovation applied to natural resources, energy, green buildings and sustainable agriculture, among others, is characterized by a traditional technology orientation, where a large part of technologies is related to the construction and agricultural industries. In this sense, Sonnino and Ruane (2008) established that the promotion of agriculture in developing countries is the key to achieving food security and point out the importance of innovation in agriculture.

There is a range of technological options that increases productivity and preserves natural resources, which are based on developments in the life sciences and offer opportunities for significant progress. In this sense, Aleke, Ojiako and Wainwright (2011) identified that the provision of technologies is influenced by the recognition and incorporation of social imperatives during the process, such as the identification of optimal adoption channels that will ensure their dissemination. Similarly, Chen and Luo (2011) noted that sustainable development is important for the agricultural enterprises, science and technology. In this context, Flavell (2010) has established that knowledge and technologies will continue to be part of the development, but the majority of countries have limitations and inefficiencies. In this sense, an integrated application of science and technology with social wisdom, can help mitigate the adverse effects of climate change and rejuvenate/revive agriculture (Joshi, 2003). Based on the above studies, there is a need to foster innovation in agriculture so that future generations can have resources that guarantee food-security and to improve their quality of life.

## 6.2 Innovation in agribusiness

Not everything seems to be positive with agribusiness. According to Trevors and Saier (2010) and Rankin (2010), practices in agribusiness tend to destroy the environment. First, the argument is that the land used for agricultural purposes is modified from its natural state. Second, processes in agribusiness produce contaminated water, which is added to rivers, lakes and oceans in ways that can change entire ecosystems. Third, the fertilizers used to grow grains generate hazardous chemicals in large quantities that are diverted into rivers, lakes and oceans. Fourth, the large scale of production practiced by agro-industry generates pollution that will increase not only because of the use of fertilizers, but also by the use of hazardous pesticides. Finally, agro-industry, in contrast to agriculture, depends on a great source of cheap labor that often is provided by poor people. Despite those arguments against agribusiness, it is still a sector that is growing rapidly, and challenges will have to be overcome in the coming decades with the support of innovation at several levels.

In this way, Castellanos, Fonseca and Ramirez (2011), along with Chidiak and Science (2003), suggest that the agro-industry in emerging economies should be a strategic priority to promote competitiveness. They point out that the implementation of technologies represents a set of challenges focused on strengthening this sector. Regarding innovation in agribusiness, Fava and Thomé (2008) suggest four dimensions of innovation that can be incorporated into agribusiness projects. The first has to do with the viability of technical and financial issues; the second with the organizational structures (e.g. the ability to have officers that coordinate efficient transactions); the third is related to the competitiveness of the agro-industrial system; and finally, the fourth regards sustainability as a measure to streamline processes and minimize damage to the environment resulting from its operations.

Other authors such as Cook and Chaddad (2000) and Rosano, Guarnieri, Amorim, Marques and Kimura (2014), examine the process of agro-industrialization from the economy of agro-industrial research and development, identifying the importance of considering innovation in this process. Barrett, Barbier and Reardon (2001) support this theory, since they indicate that the process of agro-industrialization comprises three changes in the companies: 1) growing trade, agro-processing, distribution and provision of input activities; (2) institutional and organizational change in the relations between farmers and companies; and (3) changes in the composition of products, technologies and market structure.

In this line, participants in agribusiness have prospects for growth and development with opportunities to add value to their products and at the same time to minimize negative environmental impacts. Thus, some companies have incorporated various practices in their processes, enabling them to cover new markets and to achieve modest economic, social and environmental objectives. Finally, Colin and Morton (2013) indicate agro-industries are required to meet the changing needs of consumers and to recognize that the performance of the agricultural and food industries will largely depend on increased implementation and use of cost-effective existing technologies, as well as the exploitation of new and innovative technologies.

## 6.3 Agribusiness in Mexico and the use of clean technologies

We have discussed the importance of agribusinesses in emerging economies such as Mexico and its relevance for the food production industry. The following table was built based on Solleiro et al. (1993), who categorize the CT by type and provide information in the way it is being used in Mexico. CTs in agribusiness are classified as shown in **Table 2.**

Table 2. Summary of clean technologies in Mexico

| Clean technology type | Concept and/or type | Use/adoption in México |
|---|---|---|
| **Energy** | Solar energy technologies, which cover several types of solar photovoltaic and thermal technologies for pumping water, drying crops, cooling tanks and for production of greenhouses heating/cooling (Mekhilef et al. 2013). | Three strategies to adopt technologies that minimize the use of energy in agribusiness:<br>○ Energy efficiency of machinery and equipment.<br>○ Use of biomass.<br>○ Use of photovoltaic systems connected to the energy network. (Solleiro et al. 1993) |
| **Planting and harvesting** | These technologies support the reduction of intensive agriculture and promote extensive agriculture. They aim to develop production systems that preserve soil and promote crops that alternate every year, so that they maintain the fertility and reduce the levels of erosion. | These technologies are used to reduce costs and to maintain the land and natural resources. |
| **Irrigation and water use** | Involves control of the channel and time duration of the spill; drip irrigation; ecological lagooning for wastewater treatment. The benefits deriving from these technologies consist of the reduction of the process of erosion by water, the increase in humidity by plants and removal of matter from wastewater (Moschitz and Home 2014). | The development of the sector of irrigation in Mexico is related to the Mexican Revolution in 1910 and the agrarian reform process. Mexico faces major challenges in the field of water management since the watershed is undergoing water stress; the quality of rivers, lakes and aquifers is decreasing; while floods, droughts and hurricanes are more frequent (Silva and Cantou 2012). |
| **Floor maintenance** | Introduction of live barriers and cover crops, creation of inert roofs, stimulation of microflora, micro fauna and worms in the soil are clean technologies that allow soil protection from erosion and maintenance of biodiversity (Songstad et al. 2014) | In Mexico, the Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) applies strategies to consolidate a consciously guided environmental culture in the countryside to be able to assess and act with a broad sense of respect for natural resources (Pothier 2012). |
| **Fertilization** | Clean technologies include the use of compost from remnants, organic fertilizers, inoculation of microorganisms and leguminous nitrogen fixing. Many benefits come in the form of the return of nutrients removed from the ground to collect crops and organic nitrogen fixation. | The increase of awareness of the need for environmental care and evidence of environmental deterioration caused by agrochemicals has had the effect that farmers see the alternative implementation of environmentally friendly fertilizers as a viable possibility (Altieri and Nichols 2000). |
| **Organic agriculture** | This includes conservation tillage that leaves the field crop residues in place to prevent erosion and help to preserve water. It avoids the use of pesticides, inorganic fertilizers, herbicides or other chemicals with potential to harm consumers' health or the environment. | The organic sector is the most dynamic agricultural sub-sector in Mexico; several states produce organic food that includes coffee, fruits and vegetables. The consumer markets for these products are in the United States and the European Union. The internal market is still in the incipient stage (SAGARPA, 2005). |
| **Biocides** | Intercalated organic and repellent plants are used to decrease the use of biocidal products of a chemical origin. | Sustainable chemistry research aims to develop new technologies, including pesticides of plant origin; |

| | | |
|---|---|---|
| | | synthetic pheromones and volatile organic compounds of plants, in order to manipulate the behavior of insects; the resistance of plants and plant varieties (Sonnino and Ruane, 2008). |
| **Bioinformatics** | Computer software and databases are used to analyze biological data. | Bioinformatics will prove invaluable for the food industry, including analysis of DNA and proteins for the development of products, traceability and authenticity of food through the use of genetic markers in breeding Programs (Da Silva et al. 2013). |
| **Nanotechnology** | The possibility of a greater use of evolutionary nanotechnology in food products has generated debate. Since changing the size of the materials can lead to radical change in properties, concern lies in how any change in size will affect other properties and, in particular, the possible toxicity of the materials (Solleiro et al. 1993). | Nanotechnology in Mexico is a science of recent introduction because it requires a high investment of capital. However, this will have direct and indirect impacts on the food industry. |
| **Biotechnology** | Plants are resistant in varying degrees to pests, climate and herbicides, for which purposes some are created or modified genetically so as to benefit the crop. The main benefit of this technology is increased productivity and reduced tillage (Borch 2007, Wilkinson and Rocha 2009, Rains et al. 2011, Veisia 2012). | In Mexico, there are several successful cases related to biotechnological applications. However, virtually all have been developed in urban communities and then applied in the field, limiting the benefits in terms of employment and income (FAO, 2002; Spencer & Cranfield, 2013; Rosano et al., 2014). |

In this way, environmentally friendly products have been emerging since the adoption and use of clean technologies. Challenges remain in the creation and design of appropriate clean technologies for specific processes, as well as the implementation of adequate strategies that address local social, economic and environmental issues.

## 7. Conclusions

Agricultural processes have become a security issue not only for local regions but for all states in the world. The objective is clear: meet the food demands of present and future generations, at the same time without having negative impacts on the environment and ecosystems. The problem is complex, and in this regard, clean technologies and their progress, along with other strategies, may contribute to ameliorating the problem. There is a call to innovate products and production processes and to adopt methods and organizational structures that lead to environmental improvements, without affecting profits.

Clean technologies were found to be a key factor to foster agribusinesses in Mexico, accounting for the rapid development and growth of this sector. These technologies were found to have an impact on energy consumption, planting and harvesting, irrigation and water use, soil maintenance, fertilization, organic agriculture, biocides, use of bioinformatics and applications of nanotechnology and biotechnology, which play a major role in the growth and orientation of food production. Opportunities were identified in the design and development of appropriate technologies and processes that allow for better food production efficiency. Since resources of all types are becoming scarce, all types of innovations in the forms of products and process levels will contribute to solutions of the problem.

Finally, this research points out that there is a need for more research concerning the use of CT in agro-industries in Mexico to promote their quick adoption, and thus, to contribute to sustainable development. In this way, governments, especially in emerging economies such as the Mexican one, must continue to promote and foster the adoption of CT, running financial programs for sustainable agriculture and promoting sustainability standards for the agribusiness sector.

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