Article

Intensive agriculture and soil quality: challenges for sustainable development in Sinaloa

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Abstract

In a regional dimension, two key factors of agricultural activity in Guasave, Sinaloa, Mexico that directly influence sustainable rural development are analyzed: intensive agriculture and soil quality. This research was designed as a qualitative descriptive study of this productive branch, for this purpose, 164 interviews with producers were conducted and various documents with information on the sector were analyzed, such as technical reports and bulletins. It was found that intensive agriculture predominates in the study area, with traditional production practices and patterns, such as gravity irrigation systems and excessive use of agrochemicals, which presupposes agricultural management that goes against the sustainable context. Action-research is required for the implementation of resilience strategies with a sustainable approach, aligned with the adequate environmental governance of the activity and the needs of the sector, since problems such as the loss of soil fertility, an increase in salinity and erosion in some agricultural farms continue to be observed.

Keywords: agricultural practice, production patterns, sustainable rural development.

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Introduction

Agriculture has historically been recognized for its contributions to food and the development of peoples, today, its contribution to the economy, food supply and relationship with sustainable balance invites debate and discussion on the effects that production systems can generate towards society, environment and economic environment. The contribution to food security and the impact on sustainable development that this activity entails is, and will continue to be, a determining factor in maintaining an environmental and social balance (Viana *et al*., 2022). Laurett *et al*. (2021) argue that both the lack of information and knowledge, as well as the lack of planning and economic support, hinder the purposes of implementing sustainable agriculture.

The transition to sustainable agricultural models in agriculture and food systems is a complex challenge that requires political, legal and cultural actions with the coercive participation of interested parties, scientific community and technological innovation (López *et al*., 2021). On the other hand, but linked to the above, peasant communities form one of the basic pillars that sustain the economic activity of various regions of the world, not only for supplying food, but for being a significant socioeconomic group that provides necessity goods to rural and urban areas.

Therefore, the importance of rural population groups and their well-being will depend to a large extent on how well or poorly rural activities can be carried out. As an example of the above, the decade of the 80s was characterized by the action of peasant communities, which had to adjust to the economic situation, defining new ways of organizing socially, according to the new panorama of the country and its economic policy (González-Jácome, 2004). In such a way that groups of rural communities will have to adapt to the environment that the sector itself has fostered, implementing measures and action programs in conjunction with the government and other actors in the sector (policies, economic, commercial aspects, among others), being resilient and holistic at the same time.

Agriculture in Mexico is a sector with low participation in terms of gross domestic product (GDP), and in decline in total economic terms, for example, in 2009, it represented about 4% of GDP. However, agriculture provides employment to approximately 13% of the labor force, representing about 3.3 million farmers, 4.6 million salaried workers and unpaid family members. It has more to do with territorial development, approximately 24% of the total population lives in rural areas (Fox and Haight, 2010).

There are several studies on the environmental problems that prevail in the agriculture of the state of Sinaloa, among these stand out those related to the use of water in agriculture, excessive use of agrochemicals in the sector, environmental impact as a result of various agricultural practices, pollution in the sector, among others (Norzagaray-Campos *et al*., 2010; Peinado-Guevara *et al*., 2015; Valenzuela-Martínez *et al*., 2019; Cruz-Delgado and Leos-Rodríguez, 2019).

As for the soil and its capacity to produce and the services it provides to the ecosystem, it is evaluated by measuring a minimum group of data that correspond to various physical, chemical and biological properties (Baveye *et al*., 2016; Vallejo-Quintero, 2013). This natural resource has been very important for the population of various regions of the world, mainly because of its relevance associated with food production; however, throughout history, there have been different problems according to the Report about the Environment in Mexico published by the National Forestry Commission and the Autonomous University of Chihuahua (CONAFOR and UACH, 2013).

The problems of soil degradation are physical, chemical, wind, water, among others, where agriculture has been part of these. In this regard, studies, such as that by Valenzuela-Martínez *et al*. (2019), show that agricultural activity in the state of Sinaloa generates various environmental problems, among which the contamination of soils stands out, attributed mainly to the use of agrochemicals. Moreover, despite being the mainstay of many of the world's economies, agriculture is under increasing pressure of deterioration derived from both population growth and unsustainable patterns of global production and consumption. Díaz *et al*. (2017) point out that agriculture has been decisive in the problems that are currently exist in soils and are related to the use of chemical inputs intensively.

According to CONAFOR and UACH (2013), in a final report on land degradation and desertification, approximately 35% of the national territory shows problems of wind erosion. Sinaloa and Sonora are among the states where there are various complications related to land use, such as: salinity, alkalinity, sodicity, physical degradation, among other problems.

Sinaloa's agriculture has established itself as the most important in the country due to its high capacity to produce foods, but also as a generator of jobs and foreign exchange. Guasave, considered as the agricultural heart of Mexico, is one of the highly producing districts, is located in the Northwest of the State (Gobierno de Sinaloa, 2019), and supports its development mainly in primary activities, especially in agriculture, an activity that is supported by the use of high technology in production processes (Gobierno municipal de Guasave, 2019), standing out in the production of grains and vegetables (CODESIN, 2019; SIAP, 2020).

Therefore, the objective is to 'analyze the influence exerted by intensive agriculture on sustainability and soil quality in the agricultural valley of the municipality of Guasave, and that directly impacts sustainable rural development'. Which motivates being in the constant search for improvements in the sector, generating avant-garde and innovative knowledge that allows solving the needs of the sector, society and the environment, through ecosystem, integral and sustainable processes.

Intensive agriculture and agricultural practices

Agricultural activity has a direct impact on the quality and ways of life of peasants, production systems are influenced by the modernization policies of the agricultural sector, the development projects of governments, industrialization, the excessive growth of urban areas and other processes of societies in progress (González *et al*., 2007). Agricultural knowledge and practices that have originated and adapted throughout history have been the cause of development; knowledge that has been passed from generation to generation, from parents to children, forming an accumulation of riches that allow to adapt and organize, in the best possible way, the work of the agricultural field.

Among these are knowledge about the environment and agriculture, about the use of water, soil, rain, among others (Pérez-Sánchez *et al*., 2014). Researchers such as Tamayo-Manrique *et al*. (2016) emphasize that traditional knowledge of agriculture is already from the past for today's producers, pointing out that this type of activity has been gradually forgotten, because it was replaced by the application and use of new technologies. The incorporation of technology coupled with conventional agricultural practices and the use of agrochemicals have led to soil desertification, air and environmental pollution, among others (Chalán, 2019).

According to Castillo-Valdez *et al*. (2021), 'soil management practices alter its properties, especially when energy inputs to the soil-plant system are less than outputs, or its resilience is unable to return it to the pre-intervention state'. The Food and Agriculture Organization of the United Nations (FAO) defines the manual of good agricultural practices as a group of activities and/or actions that will give rise to acting under principles, standards and technical recommendations that can be adjusted to the systems of production, processing and transport of foods in order to preserve, in the best possible way, human health, take care of the environment and society (FAO, 2012a).

Given the climatic variability experienced today, good agricultural practices are an indispensable tool for risk management. Its application, however, involves promoting innovation, increasing knowledge and providing a holistic view to the interested parties, particularly small producers, so that they can improve their production systems, increase their resilience and ensure their sustainability (Díaz *et al*., 2017).

At present, agricultural practices continue to give something to talk about and are a factor of analysis for researchers who identify themselves within the lines related to the care of the environment and the well-being of society. It is very common for groups of farmers and peasants to implement a series of agricultural activities with which they seek to adapt to the properties of each unit of soil, such properties generally show negative changes such as a deterioration of this important resource, a situation that is caused by the inappropriate, prolonged or and/or intensive use of agrochemicals. (Zinck *et al*., 2005). For their part, Castillo *et al*. (2020) point out that intensive agricultural activity coupled with common agricultural practices, such as monocultures and the application of agrochemicals, has generated problems in soil quality.

The quality of the soils are the attributes or characteristics that make it be in one way or another; that is, suitable or not for certain activities. Here, soil quality is understood as the characteristics, attributes or properties, for example, the physicochemical and microbiological ones that allow the soil to be fertile and produce healthy products (Andrade *et al*., 2021). Therefore, the quality of soils is a determining factor in the production of healthy foods, so its deterioration affects the environment, the economy and social well-being. These problems have been generated by the lack of social awareness that has been observed in recent decades, coupled with the lack of solid laws and regulations that regulate and monitor the proper use of this resource in the activities where it is most exploited, leading to the wear and impoverishment of soils in countries such as Mexico (Cámara de Diputados and CEDRSSA, 2019).

Materials and methods

It starts from a descriptive analysis under a qualitative approach, whose analysis variables were agriculture, soil quality and sustainability. The not very sustainable environment that is observed and predominates in daily agricultural practices, as well as in production patterns of producers in the agricultural valley of the municipality of Guasave, Sinaloa, Mexico, was taken as a reference. To determine the size of the sample, a universe of 12 446 farmers registered in the production for welfare program (formerly Program of Direct Support to the Countryside: Procampo) was considered, to which the statistical equation for population proportions was applied, where, considering a margin of error of 10% and a confidence level of 99%, it yielded a total of 164 producers, which were non-randomly selected (Reus González *et al*., 2021).

A structured interview was applied to the population under study (Arias, 2012). The following variables were evaluated: the main agricultural activities, production patterns, the use of agrochemicals, rural development, soil quality, among other determinants, for which a guide of questions aligned with the objective of the research was designed; likewise, descriptive data on the agricultural environment and direct information of the actor studied, as well as their observable activities, were taken as a reference (Taylor and Bogdan, 1984).

Results and discussion

In the interview with the selected farmers, they were questioned about the work in their agricultural farms and the time they dedicate to these activities, it was found that 48.77% dedicate from 1 to 4 h of daily activity to their agricultural farms, 27.16% from 4 to 7 h daily, 10.49% from 8 to 10 h, 12.35% say they dedicate full time to this activity, while 1.23% of the population did not know how to estimate how much time they spend on this activity. It should be noted that 61.74% of the population under study sows between 1 and 10 ha, with the sowing of corn, beans and sorghum predominating in grains and tomato, chili and pumpkin in vegetables.

As for agricultural practice related to the use of water resources for land irrigation, 90% of the population uses the gravity system through land channels, while 10% uses other systems, such as those that use irrigation technologies such as: sprinkler, micro-sprinkler and drip irrigation. In this section, it is important to note that 69.75% of the water used comes from the dams of the region, it is identified as white or raw water, while 7.41% uses treated water, the rest does not know the type of water used.

This shows that gravity irrigation is still a predominant practice for farmers, the strong dependence on water that accumulates naturally in dams indicates the origin of a serious problem, especially in drought seasons, which highlights the lack of infrastructure, support programs and efficient technologies in the use of this resource.

Table 1 shows the agricultural practices in a general way and that predominate in the region, it can be observed that the farmer continues to have preferences for activities according to their traditional knowledge, finding those that directly damage resources such as soil, without this meaning that the damage caused is due to bad intention, but rather due to a lack of knowledge in this regard, such as in the use of chemical fertilizers, chemical herbicides and insecticides; while there are low incidence levels in those practices considered sustainable, such as: use of Creole seeds, natural fertilizer, biofertilizers, organic herbicides and insecticides, soil studies, organic certifications, mainly.

Table 1. Most common agricultural practices of the farmer of the municipality of Guasave.

Num.	Agricultural practice	(%)
1	Chemical fertilizers	82.72
2	Biofertilizers	33.95
3	Natural fertilizer	50
4	Use of Creole seeds	14.81
5	Use of improved or certified seeds	69.14
6	Use of transgenic seeds	20.99
7	Chemical herbicides	64.81
8	Organic herbicides	33.95
9	Chemical insecticides	46.91
10	Organic insecticides	35.8
11	Draft animals or team	5.56
12	Tractor	80.25
13	Agricultural machinery for tractor	70.37
14	Soil salinity studies	35.8
15	Pest detection studies	44.44
16	Organic certification	0

In that sense, common practice continues to tip the balance and damage to soils, increasing the effect. The study shows data where only 35.8% of farmers carry out soil salinity studies, likewise, regarding the use of herbicides and organic insecticides, represented with 33.95% and 35.80% respectively, which are considered as sustainable practices. Regarding the use of infrastructure to support production, 51% of producers express no participation in support infrastructure, 41% were unaware or did not know about the use of this in their plot, 3% have a part of greenhouse, 2% nursery, 1% both and 2% other type of construction.

FAO, in its document on the factors that favor and limit the implementation of good agricultural practices, argues that new and innovative forms of production are required, resulting in possible increases in costs, decrease in yields due to the less intensive use of chemical substances, among others. Similarly, the reduced infrastructure and support of public institutions can be a limitation in the correct adoption of them, as well as a determining factor in developing countries (FAO, 2012b).

The experiences that the farmer has acquired throughout this millenary activity and that today are represented in agricultural practice is, without a doubt, an element that must be analyzed in depth so that this relationship presents innovative patterns and behaviors according to the needs of our natural environment, as well as those of society, something that, when consensus is achieved, will lead to sustainable development, defined as a process in which economic, social and environmental factors must be properly integrated and managed within a society, in order to create spaces conducive to human life (Rosen *et al*., 2014; Zarta-Ávila, 2018).

Rural development, sustainability and soil quality

There is a huge gap between the achievements of the urban areas of a region and what has been achieved by the rural areas of the same, we refer to the development aligned with the quality of life, to which the different social groups of these places can have access. Analyzing rural development means addressing evolutionary and unidirectional ideas of rural territory development, in the same way, rural areas are characterized with a type of institutionalized development, where the State and some social actors play a very important role (Herrera-Tapia, 2013).

Sustainable rural development is related to the correct management of a term known as agroecosystem, within which social, environmental and natural systems interact, generating an activity under a socioeconomic dynamic with phenomena related to the efficient use of resources. 'Sustainable development is a development that meets the needs of the present without reducing the ability of future generations to meet theirs' (ONU, 1987).

Contrary to what was proposed by various authors and organizations, such as Altieri and Nicholls (2000); Sotomayor *et al*. (2011); Altieri (2012); Guzman *et al*. (2016); CELAC (2017); ONU (2019), that point out that sustainability in agricultural production systems, as well as agroecology, will be fundamental to redirect the events of the rural peasant sector, helping to mitigate the problems that, in their research, point to soil degradation, water and air pollution, among others, a study carried out by Martin *et al*. (2018) states that, in 20 years of intensive agricultural exploitation, the fertility properties of the soils were maintained (increased pH, CEC, K_2O, P_2O_5, Ca and Mg of the soil).

Ramirez-Mocarro (1998) highlights the importance of adopting new approaches and patterns of rural development as a guide to reduce socioeconomic inequalities and conditions, improve territorial integration between communities to face and solve environmental problems and support sustained and sustainable economic growth. According to the Office of Agricultural Studies and Policies (ODEPA, 2016), sustainability and development aligned with this factor have been added to the international political agenda of nations, managing to position themselves in the political discourse, within which agriculture and its production patterns have stood out; however, it has been observed that this activity has caused significant soil degradation.

The Law on Sustainable Rural Development of the State of Sinaloa (2013) aims to promote the sustainable rural development of the state, in one of its sections, it refers to the design and promotion of productive practices with orientation to the conservation and improvement of the conditions of natural resources, such as soil and water, biodiversity, food safety and environmental services of the countryside. It can be seen that sustainable development is promoted from the laws, but not in the regulated activities, the sufficiency in this area does not make the difference, the facts in the various contexts speak for themselves and are, for many, devastating, where the activity of the agricultural sector is no exception.

Rural areas are among the most vulnerable to primary exploitation, not only because of the characteristics of the environment in terms of its main activity, but also because of the elements that characterize its population and the lack of support from the authorities (environmental governance), who are the ones who must encourage joint participation with rural society and the search for suitable development for these areas, sometimes, they are forgotten by society. Thus, the first role of agriculture is to maintain ecosystems; thus, changing agriculture from a source of degradation to a driver of ecosystem restoration and health (ONU, 2017). This same organization points out that resources such as soil should be managed in a more coordinated and efficient way.

In the case of the study area, the challenges are not minimal, rural spaces definitely presents delays that in these places it can be felt that there are many, if we focus on what is related to sustainable development and its relationship with the productive factors in agricultural activity (exploitation of resources such as soils and water), we will be able to realize that what has been done for decades has not been the right thing to do by any of the actors involved, public or private, at least not mostly, especially in those who destine their activity to economic benefit and not to family consumption.

In such a way that the sustainable development of Sinaloa’s agricultural sector represents one of the main challenges for the actors involved in it, because its activity is intensive and its production patterns are a mixture of traditional and modern management, which, although they have been decisive for economic activity, has also been characterized by the great environmental problems that this activity has originated. But how can sustainable development be defined or conceptualized? How important is this term today for the well-being of regions and society? Especially for settlements or groups of people who live in rural areas and who have agriculture as their main economic-productive activity.

Moreover, why are many of the regions of the world in the constant search, at least in the political discourse, to achieve such development? What effects does overexploitation and inappropriate use of soil generate on natural resources such as this one? Perhaps the answers to this series of questions can be found in studies and research of different academics, in sources of information of studies of government institutions, in reports of international organizations, etc.; however, the ideal responses are in rural communities, in their daily local events, in the needs that are not met by the agricultural producer, who, with their traditional knowledge, puts into practice an activity as noble as agriculture, lacking technological infrastructure and financing for a better activity, but doing part of their work as an economic and social agent, that in turn, often deeply ignores the effects that may be generated from the inappropriate practice of the activity, due to the lack of knowledge or, simply leaves it aside, because they have no other option to subsist and cover their needs and those of their family.

In this way, farmers in the region studied have used, for decades, technological methods that, in their own opinion, are seen more as strengths, but it is important to note that such methods and ways of practicing agricultural activity also translate into regional ecological imbalances, which are supported by the green revolution and bioengineering (Aguilar-Soto and Aguilar-Aguilar, 2008). A clear example of the impact of inappropriate agricultural practices and the negative externalities of the activity to its own environment is the irreversible damage caused to soils. The national territory has 21 of the 25 types of soils that exist in the world; 10 of them cover 90% of the national territory, and among the most important the following stand out (Table 2).

Table 2. Types and main characteristics of soil in Mexico.

	Soil type		
	Regosol	Lithosol	Xerosol
Characteristics	22% of the national territory	17% of the national territory	12% of the national territory
Suitable for	Fruit tree plantations and grazing	Subsistence agriculture, grazing and forest plantations	Intensive agriculture if water is available

Elaboration with data from the weekly bulletin number 4 on the soil of the Agrifood and Fisheries Information Service (SIAP, for its acronym in Spanish) of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food. (SAGARPA, 2013).

With data extracted from the interview, the predominant soil types in the plots of farmers in Guasave, Sinaloa, are as follows (Table 3).

Table 3. Types of soil in the plots in the study area.

No.	Soil type	(%)
1	Sandy	30.86
2	Clay	23.46
3	Alluvium	14.2
4	Loam	8.64
5	Clayey	8.02
6	Silty	5.56

The rest of the soils were represented with smaller percentages.

Figure 1 describes the main problems that farmers mentioned having at the time of agricultural practice, for the analysis of the result, only the positive responses were taken into account for each component studied, where it is found that 25.93% has problems of loss of fertility in the soil, 59.26% considers that input costs are a predominant problem (purchase of fertilizers, agrochemicals, among others), 10.49% answered that their plot has salinity, 74.7% do not know the type of soil of their land and 43.21% has carried out some type of study to the soil, with the purpose of knowing the quality of these for crops.

As can be seen, the loss of fertility in the soils is a fact and is accompanied by the salinity in them, if to this are added variables such as not knowing the predominant soil in the plot and that most farmers do not carry out soil studies to know the problem they face directly, even though 43.21% of the interviewees consider that it is very important to carry out studies of the land to know its degree of quality, this makes the problem even greater and the action of the peasant is still based on their experience and not on applying technological strategies and science to their activity within the sector and their agricultural farm.

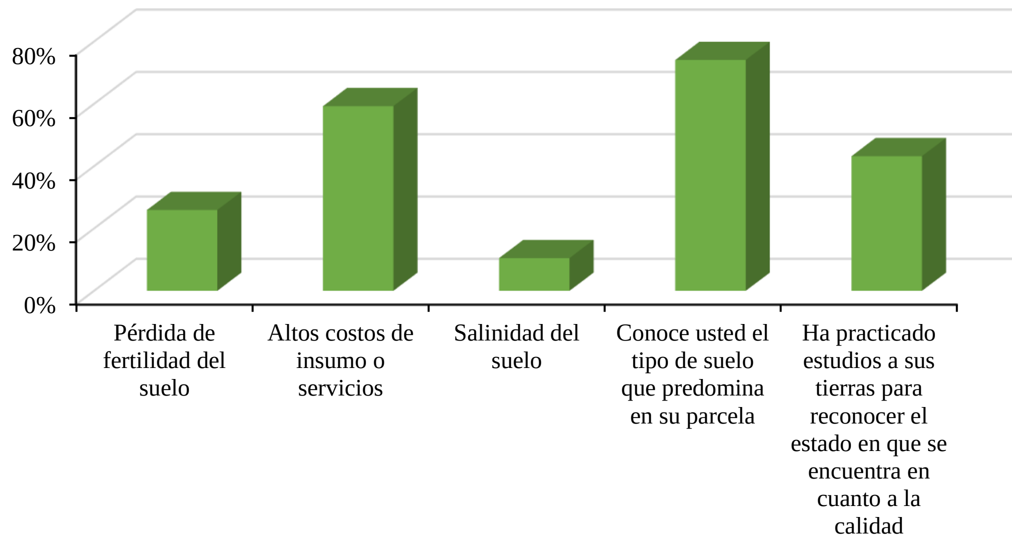

Figure 1. Main problems that the farmer had for the development of agricultural activity.

For the Secretariat of Environment and Natural Resources (SEMARNAT, for its acronym in Spanish) and the College of Postgraduates (CP), in Mexico, the most important process that causes soil degradation is water erosion, the states most affected by salinization caused by chemical degradation that is represented within traditional agricultural practices, and in these areas are Sinaloa with 3.5%, Guanajuato with 3.3% and Tamaulipas with 2% of the area (SEMARNAT-CP, 2003).

Table 4 shows data from the agricultural census of the National Institute of Statistics and Geography (INEGI, 2007). It can be seen that agricultural practice is mainly based on fertilization, use of chemical herbicides and insecticides, leaving natural fertilizers with less importance in application.

Table 4. Production units with agricultural area and type of technology or practice used in the state of Sinaloa.

Number	Production units	40 187
1	Chemical fertilizers	32 201
2	Improved seed	27 054
3	Natural fertilizers	2 428
4	Herbicides (total)	19 962
5	Chemical herbicides	19 249
6	Organic herbicides	1 739
7	Insecticides (total)	20 750
8	Chemical insecticides	20 596
9	Organic insecticides	552
10	Controlled burning	2 298
11	Other technologies	67

Elaboration with data from INEGI (2007).

In this sense, farmers were asked under what criteria they used or implemented activities such as those described in the previous table, 56.79% of the interviewees comment that they request the help of an agronomist, 51.85% do so based on empirical knowledge (experience), while 16.67% seek the help of another farmer and 12.35% receive help from sellers; if the empirical knowledge and the help between farmers are added, this gives 68.52%, which indicates that the experience remains the basis of the farmer's behavior in their agricultural practice.

As can be seen, if the problems derived from inappropriate agricultural practices that affect the sustainability of soils were few, to this is added what is caused by climate change, effects that for many can be devastating, starting with the low production and impact on the food security of the millions of people who inhabit this planet Earth, but that is the subject of another research paper, it is only mentioned as part of a domino effect.

Conclusions

The current situation of the agricultural environment is an effect of the world context, the globalization of markets and economies, this has restructured the work of economic agents and the preponderant economic activities of each of the regions of a country and the world, resulting in a series of factors that harm the well-being of society and that as a whole, these have preyed on the natural environment in which they develop and coexist, thus leading to the lack of development within the framework of sustainability.

Agricultural activity represents, for the municipality of Guasave and the northwest region of the state of Sinaloa, one of the main economic-productive bases, since it is one of the strongest, economically speaking, in that sense, the lack of sustainability of the rural sector has been one of the most severe effects that originate from the action of these economic agents, as well as the quality of the increasingly poor soils, mainly due to the inadequate agricultural practice, which has as its origin the traditional behavior of the peasant or the lack of technical-productive knowledge about their main activity within their plot.

The pressure generated by productive activity on the environment is related to the need to produce the goods with the highest yield, since the low prices of the products generate the need to seek greater productive intensity, both to obtain the indispensable goods and to increase the benefits of selling. This last objective has achieved strong influence in recent decades, with the freedom of companies and less State control, characteristic of the capitalist model in force in most of the world. In such conditions, it is necessary to balance these extremes, where there is greater control by the institutions over the companies and the improvement of the income and services of the population, so that it can demand the quality requirements of foods, regulating companies in environmentally friendly technologies, to relax the pressure of overexploitation of resources and emission of pollutants.

If one wants to see positive changes in favor of natural resources such as the case of soil, a change in the technical-productive structure of the agricultural sector is urgent, in addition to a modification to the behavior patterns of the productive agents of the sector, in the same way, it is necessary to improve the legal aspects that regulate the use of agricultural inputs that increasingly deteriorate the available natural resources and the well-being of society (environmental governance) or the damage in the short or medium term will be irreversible and catastrophic in sustainable, environmental, economic and social terms.

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