Agricultura sostenible y cambio climático

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Abstract: Agriculture is one of the sectors most affected by the increasingly extreme effects of climate change, but this activity also contributes a high percentage of greenhouse gas (GHG) emissions. This research evidences and analyzes the importance of the contributions that sustainable and resilient agriculture makes to the problems generated by climate change. Information was compiled and analyzed from scientific databases and organizations specializing in the subject, with a focus on Latin America and the Caribbean, since these regions are the most affected because agriculture is a fundamental pillar of their economies. Environmentally responsible agriculture significantly reduces the sector's GHG emissions and provides benefits such as the restoration and protection of river basins, biodiversity conservation, improved profitability and quality of life, among others. There is a clear need for a transformation towards resilient production systems, efficient use of resources, environmental protection, the creation of policies that promote clean energy and greater interest in rural sectors, which are the most vulnerable because agriculture is their main economic activity.

Keywords: Agriculture, Sustainability, Resilience, Climate change.

Resumen: La agricultura es uno de los sectores más afectados por los efectos del cambio climático que cada vez son más extremos, pero esta actividad al mismo tiempo contribuye con un alto porcentaje de emisiones de gases de efecto invernadero (GEI). Esta investigación evidencia y analiza la importancia de las contribuciones que la agricultura sostenible y resiliente aporta a las problemáticas generadas por el cambio climático. Se recopiló y analizó información de bases de datos científicas y de organismos especializados en el tema, con un enfoque en América Latina y el Caribe ya que estas regiones son las más afectadas al ser la agricultura pilar fundamental en su economía. Una agricultura responsable con el medio ambiente reduce significativamente las emisiones de GEI del sector, brinda beneficios como la restauración y protección de cuencas de río, conservación de la biodiversidad, mejorar la rentabilidad y calidad de vida, entre otros. Es clara entonces la necesidad de una transformación hacia sistemas de producción resilientes, un uso eficiente de recursos, la protección del medio ambiente, la creación de políticas que promuevan energías limpias y un mayor interés por sectores rurales que son los más vulnerables al ser la agricultura su principal actividad económica.

Palabras clave: Agricultura, Sostenibilidad, Resiliencia, Cambio climático.

Introduction

The negative effects of climate change are becoming more evident every year in several strategic sectors, one of which is agriculture, from its producers to the global chains that supply products on a daily basis in several countries, are suffering the consequences of more intense meteorological phenomena, a greater appearance of pests, and even the involuntary displacement of people.

Other factors that should be taken into account are the high level of people in the world suffering from chronic hunger, the constant and increasing human activity on the capacity of the land and the continuous growth of the population generating a higher demand for food which is estimated to increase globally by 60% by 2050, there is also the inefficient management of food produced since about a third of these are wasted throughout the process of the supply chain generating economic losses and impacts to the environment (FAO, 2014a).

Although the growth of agriculture is related to the eradication of hunger and poverty, it should be kept in mind that this strategic sector contributes significantly to greenhouse gas (GHG) emissions, several of these sources are the release of carbon dioxide from tillage, nitrous oxide from the use of fertilizers and methane from livestock and irrigated rice production, as well as the conversion of forests into land for cultivation or grazing.

On the other hand, there are also negative consequences in the socio-health area since several studies have shown that sudden temperature variations generate a greater number of patients admitted to hospitals and even an increase in morbidity and mortality, for example in countries like the United States it is estimated that about 650 people a year die from heat waves, the concern arises because these scenarios can generate situations of hyperthermia or heat stroke and are more common every year (Lorenzo & Liaño, 2017).

Likewise, environmental pollution generates a great variety of chemical and biological components that are present in the air we breathe and most of them have negative effects on our health. Studies show that environmental pollution is directly related to the increase of respiratory diseases in infants. In Spain after an investigation it was observed that the levels of NO2 recorded in stations measuring atmospheric pollutants exceeded 40 μg/m3 that the World Health Organization (WHO) establishes as the maximum annual permissible limit, evidencing a risk to people's health (Martín Martín & Sánchez Bayle, 2018).

In addition, according to a WHO report, the change in climatic conditions can affect the health of mankind in three ways: more or less direct repercussions due to extreme weather phenomena such as hypersensitivity of the skin, more frequent occurrence of acne or skin infections; health consequences due to various processes of environmental change and ecological disturbances such as the increase in infections due to the proliferation of vectors of various diseases such as malaria, dengue, malaria, among others, due to the gradual increase in temperature, and health consequences produced by populations displaced by climate change, which may be traumatic, infectious, nutritional, psychological and other types (López Figueroa, 2011).

The adverse effects of climate change have been studied in specific sectors in several countries around the world, showing that it can affect everything from crops to forests, and even environmental flows. In Mexico, a projection study determined that 5 temperate forest tree species would be affected by the rate at which the current changes are occurring, with this, the species will have to face these changes and adapt to them in very short times compared to those that have been taking place in previous decades, that is, each species will depend on its ability to adapt and migrate quickly to places with optimal climatic conditions for its development and thus avoid radical reductions in their areas of distribution (Guitérrez & Trejo, 2014).

In Baja California Sur an analysis of drought and deforestation was conducted, knowing that water is a limiting resource in these areas, it is established that sacrificing the water balance in search of increased agricultural production and agriculture has brought consequences such as water degradation, decreased availability and quality of water extracted from the aquifer, therefore it is necessary to understand and integrate the processes in projects, management plans and public policies oriented towards sustainable resource management (Diéguez et al., 2014).

In southern Spain, a study showed that there will be an increase in water scarcity problems, causing the population's demand to be inadequately met, with the reduction in contributions to the basin due to climate change and agriculture being the main causes of this problem, the latter representing a consumption of 90% of the water resource, making it necessary to implement actions that allow the balance of resources and sustainable management over time to achieve an increase in the response capacity of the basin to the coming effects of climate change (Chavez & Gonzalez, 2015). Another similar study focused on the impact of climate change on the sediment cycle of the Esera river basin in Spain showed that the total liquid portage will decrease due to less precipitation, less soil moisture and high temperatures that lead to higher potential evapotranspiration (Francésa & Bussib, 2014).

In Latin America, studies have been conducted in important areas for the economy such as the coffee-growing area in Colombia, out of 28 stations analyzed in 27 there is evidence of an increase in the minimum temperature being the most worrying trend of 0.4° C more every ten years, phenomena such as El Niño and La Niña directly influence the change of maximum and minimum temperatures in this area that directly affect crops, such phenomena are influenced by climate variability affecting its intensity, duration and even the arrival times to the Latin American coasts (Pérez Rendón et al., 2016).

Phenomena such as these generate a threat to coastal systems and low-lying areas, with the rise in mean sea level and extreme rainfall being the main causes of permanent flooding, affecting crops which are completely lost, generating economic losses. A study in Asturias showed that the lack of adaptation measures in the face of this problem will cause the loss of land in low-lying areas, overflowing of rivers, requiring protection for the population and assets, generating an impact on the economy of the countries (Toimil et al., 2016).

It is evident then that food and agricultural systems are challenged by climate change since it represents a direct threat to global food security, sustainable development, poverty eradication and health. Hence, there is a need for

adaptation and resilience of agricultural production systems with an emphasis on the rural sector, since this sector will be the most affected as it has a lower capacity to achieve this task. Therefore, the objective of this research is to demonstrate and analyze the importance and contributions that agriculture, with a sustainable and resilient approach, can make to the different problems generated by climate change.

Agriculture is an important factor in world economic development and an axis of social integration. In 2020, agricultural production grew to over 3.6 trillion dollars, which represented 5.5% of the global Gross Domestic Product (GDP) (World, 2021), although developed Western countries have lower percentages, in powers such as China or emerging countries such as Brazil, the percentages are much higher. In several Latin American and Caribbean countries, agricultural production represents between 30% and 40% of their wealth, and statistics show a growing trend since the middle of the last century.

Although agriculture has a high importance in the world, it also has negative impacts such as emissions of more than 20% of GHGs and the use of 70% of total water globally, in addition there is an inadequate management of all that is produced since approximately one third is wasted while there is a large number of people suffering from hunger, these values may continue to grow as the population increases since agricultural production must also do so to meet the demand.

Climate has been from the beginning the main factor to take into account for agriculture due to its variability, with the passing of time this activity has had to adapt to the climate through techniques such as irrigation, fertilization, pest control, among others. This has been effective since the changes have been occurring with manageable margins, periodically and even in some cases have been predictable to a certain extent, however, climate change has increased the frequency and intensity of natural phenomena reaching ranges that are difficult to manage. According to studies, the most affected areas are the tropical and subtropical regions, where most countries are dependent on agriculture and primary activities. These areas have populations with a higher rate of poverty, food insecurity and high vulnerability to meteorological phenomena such as floods, droughts, heat waves, frosts, among others (ECLAC, 2011).

Food security is understood as the condition in which the inhabitants of a country have physical and economic access at all times to sufficient food, guaranteeing its safety, as well as their nutrition in order to satisfy their food needs and preferences for an active and healthy life. Climate change certainly represents a threat to global food security in its four dimensions: availability, access, stability of supplies and the ability of consumers to make adequate use of food.

Availability refers to the physical existence of food; however, it can be considered a precondition for access to food, since it will depend on the financial resources of the population and market prices. The adequate use of food deals with nutritional well-being and is a function of factors such as the food practices of a region, which are influenced by culture, uses, customs and eating habits, as well as the procurement, preparation and way of consuming food. Stability seeks to guarantee the three previous dimensions permanently, minimizing

eventualities due to natural or biological disasters, including climate change, economic and social factors (Martínez Salvador, 2016).

The production systems and the policies and institutions in charge of ensuring global food security have been overtaken, making their actions less and less efficient, necessitating that the primary actors in agriculture also make changes in their activities, thus bringing agriculture to a sustainable mode seeking to ensure food security, healthy ecosystems and sustainable management of natural resources. To achieve this, an approach must be adopted that meets the needs of current and future generations, taking into account factors such as profitability, environmental health and social and economic equity.

According to the Food and Agriculture Organization of the United Nations (FAO) the key principles for the development of new approaches and transition to sustainability are: more efficient use of resources, actions to conserve and enhance natural resources, protect and improve rural livelihoods and social welfare, increase resilience of communities and ecosystems, governance that seeks sustainability of natural and human systems (FAO, 2014b).

Resilience is a concept widely used in environmental sciences, it refers to the capacity of the system to absorb disturbances and maintain its functions, while renewing and reorganizing itself. This will depend on the conditions of human resources such as soil, water, biodiversity, as well as the level of knowledge, learning and management capacity of human groups and institutions; while adaptability is the ability of the system to reduce the negative effects of a disaster and obtain advantages and opportunities in search of sustainable adaptations, realistic with the context, and with a focus on recovery (Balvanera et al., 2017).

A scenario in which the reconversion of several productive activities to more sustainable practices with links to regional markets is a priority is a clear example of adaptation, this involves the organization of producers, reducing production costs to obtain products that can compete in the market. Although initiatives such as these incur large initial investments, their prolonged profitability and the short return on investment make these sustainable plans viable; likewise, adequate land management allows more space to work in other activities, enabling producers to diversify their products (Avila-Foucat, 2017).

Several scenarios like this, with a focus on Latin America and the Caribbean, are highlighted by FAO, which have been successfully implemented in some projects focused on sustainable and resilient production, demonstrating that it is possible to achieve a transformation of agriculture in the region by improving productivity and profitability while offering opportunities for both economic and social development.

Livestock as part of the agricultural sector accounts for 18% of Ecuador's GHG emissions, partly due to the use of unsustainable management practices with obsolete technologies, thus generating more emissions and demonstrating its vulnerability to the effects of climate change. This is why this initiative was born, which sought soil conservation, adaptability and reduction of emissions in the sector through the creation of policies between various sectors, as well as the promotion of sustainable livestock farming in vulnerable provinces of the country. The results were cost reductions for producers due to better livestock feeding thanks to proper pasture management and nutritional supplements. GHG emissions were reduced by 20%, thus improving the health of ecosystems

through the responsible and efficient use of natural resources such as water and forests. These results led several farms to replicate these practices, and the provincial governments and Ministries such as the Ministry of Environment and Agriculture committed to ensure their scalability in other territories of the country (FAO, 2021).

In accordance with the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, several countries committed to reducing GHG emissions by 2030, one of them was Mexico, which took action in the agricultural sector and industry, since agriculture accounts for 12% of the country's emissions while the industrial sector accounts for 17%. The initiative consisted of promoting efficient, low-emission technologies in both agriculture and agroindustry, and measures such as the self-supply of clean energy, the use of clean fuels and incentives to achieve energy efficiency made it possible to meet the project's objectives. Among the benefits were the reduction of GHG emissions by 6 million tons of CO2 , the production of 221 megawatt hours of energy through biomass, savings of 382 million kilowatt hours and the generation of local suppliers of technology and related services at a lower cost, since these were previously imported (FAO, 2021).

The use of pesticides and the use of natural resources has boomed in the last 20 years in Uruguay, generating environmental degradation with negative effects on the rural population and on exporters; therefore, alternatives were sought, such as the development of new technologies that replace chemicals as far as possible. The project demonstrated that it is possible to implement good agricultural practices without negative effects on profitability; on the contrary, these practices reduce costs and improve soil conservation. Crop monitoring allowed a 12% reduction of all chemicals used in a planting cycle (soybean), and finally improved the image of the conglomerate in the eyes of society due to the environmental and health effects generated by unsustainable techniques (FAO, 2021).

Regulated in 2010 and structured as a Nationally Appropriate Mitigation Action under the United Nations Framework Convention on Climate Change (UNFCCC), they initially sought to promote environmental improvements by boosting the productivity and competitiveness of companies using clean energy, In 2015, their focus shifted to small and medium-sized enterprises (SMEs) and family farming. The agreements in this sector have promoted sustainability, safety, efficiency and competitiveness, while the benefits for farmers include technical assistance, subsidies for clean technology and easy access to international markets. With emphasis on the Maule Region, an increase of 15% was achieved in the economic aspect, easy access to international markets through compliance with food safety and traceability standards, reduction of GHG emissions and efficient energy use (FAO, 2021).

This initiative seeks to reduce the climate risk faced by producers by promoting good decision making based on scientific and accurate information for each context, the first meetings were held in 2014, three years later with the support of FAO 8 tables were developed reaching 36 different crops and about 631 thousand producers, becoming one of the most outstanding and replicable initiatives in terms of climate and agriculture. Thanks to this, producers are able to act preventively before adverse climate events due to the timely information they receive, they have also improved agricultural practices through adaptability

to climate change, minimizing costs and improving profitability, finally, the rural sector is taken into account, seeking its development, dissemination of local knowledge, inclusion and cooperation in climate change resilience (FAO, 2021).

In the basins of the Porce and Chinchiná rivers, Colombia, an investigation evidences the practices that some coffee growers take as a measure against extreme climatic events, among the findings were observed the management of shadows in the coffee plantations, the association of crops, cover crops, staggered planting, use of organic fertilizers, reforestation, among others that allow reducing the vulnerability of coffee plantations in the rural sector, which is also limited by other factors besides climate, such as economic factors, This is why this sector is one of the most fragile and requires public policies on the part of the government that seek a sustainable and climate-smart agriculture, since economic subsidies are only temporary solutions (Turbay et al., 2014).

Materials and methods

The approach of this research is bibliographic, based on the search, collection, analysis, critique and interpretation of information from various secondary digital sources of scientific databases, as well as bulletins of specialized organizations on the subject. The main problems and effects, which are becoming more extreme every year, that have a negative impact on agriculture as a result of climate change were defined through a review of publications in various countries, making it clear that environmental pollution is present in every corner of the planet, with Latin America and the Caribbean being the most affected. For this reason, the study focused on these regions by analyzing several successful sustainable agricultural practices that were disseminated by the Food and Agriculture Organization of the United Nations (FAO) in order to guide the collection of information so as to obtain significant and real data that will allow the research to develop and achieve its objective.

Result

For sustainability to have a real impact, it must be approached as a process and not as a temporary or one-off solution. The support of all those involved in the production chain is essential for its growth and implementation, hence aspects such as governance, financial, technical and even political aspects at both the national and global levels are the pillars of support for farmers, since most of them are part of the most vulnerable population and have scarce resources.

A true transformation of agricultural practices goes hand in hand with technology, which is why there must be investment in research and development with an emphasis on university centers, which have personnel trained in various sciences and together with the ancestral knowledge of farmers can generate innovative, scalable and replicable ideas that, with the support of municipalities or governments, can be applied in local or national programs.

It is important to implement policies or create institutions that promote the use of sustainable practices, clean energy sources, reduction of energy use and GHG emissions through economic or commercial incentives, and at the same

time regulate and impose sanctions on companies that practice processes against the environment and natural resources. Access to knowledge and understanding of innovative technologies that can be implemented in rural and industrial areas must be guaranteed, while at the same time ensuring that the necessary resources will be available in the adaptation process.

A frequent problem in rural populations is the lack of information that facilitates the planning and management of the sectors involved. Databases, statistics, geospatial maps, pollution meters, among other relevant data must be updated or created, as this will help to verify that the measures implemented have an effect and to observe indirect benefits in some cases such as the reduction of pollution in natural resources, reduction of pests, better quality of life of the inhabitants, among others.

The influence of climate change on agriculture is evident, not only in the variability of temperatures but also in meteorological phenomena that are becoming more and more extreme, although there are countries that contribute less to climate change, they are the ones that suffer the most from its adverse effects, that is, we are facing a model in which development is promoted without control and with a high rate of pollution, the same that is rooted in world powers and the main affected are the populations with few resources. It is necessary an international ethical-political court which focuses its actions on climate justice, with the protagonism of peoples and organizations that are the most affected, thus enabling the creation of international policies in search of sustainability and resilience, as well as sanctions with the aim of taking care of the world, its biodiversity and population (Borras Pentinat, 2013).

Conclusions

Although agriculture is part of the climate change issue, with proper guidance and under the right conditions, it can provide several options that help to significantly reduce its negative impact on the environment. Several success stories have shown that it is possible to reduce GHG emissions, restore and protect river basins that serve as a water supply, conserve biodiversity, and in some cases even improve profitability. The process of farmer adaptability goes hand in hand with sustainable agricultural practices that seek to maintain production and mitigate techniques that have negative effects on crops, the environment and the health of both producers and consumers, thereby reducing the risks that supply chains run due to the climate in terms of food supply, and at the same time promoting food security in its four dimensions.

Sustainable agriculture is possible through resilient production systems, a more efficient use of resources, greater protection of the environment, policies that promote clean energy and prioritize rural areas, thus addressing the variability of conditions due to climate change and at the same time reducing the carbon footprint of this sector, which through strategies focused on growth will achieve a transition to more environmentally responsible practices.

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