AGRICULTURA CLIMATICAMENTE INTELIGENTE. UTOPIA OU REALIDADE?

CLIMATE-SMART AGRICULTURE. UTOPIA OR REALITY?

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Resumo

As estimativas atuais preveem um crescimento da população mundial para 9,6 bilhões no ano 2050, muitos dos quais viverão em países que já enfrentam insegurança alimentar. Para alimentar tal população, a produção agrícola terá de aumentar aproximadamente em 50%, situação difícil devido aos efeitos das alterações climáticas. Para atingir as metas de produção alimentar sem colocar o meio ambiente em risco, a FAO, desde o ano 2009, tem apoiado os países membros em suas iniciativas para implementar a Agricultura Climaticamente Inteligente (CSA), que leva em consideração as especificidades e prioridades nacionais e locais, a fim de aumentar a produtividade e resiliência de forma sustentável, fortalecendo a segurança alimentar e mitigando os danos em consequência dos gases de efeito estufa. Esta revisão bibliográfica procura contribuir com as discussões sobre o reconhecimento do conceito de CSA, sua aplicabilidade em sistemas agrícolas e revisar vantagens ou desvantagens para enfrentar as mudanças climáticas globais. No Brasil existe uma crescente preocupação, devido à alta vulnerabilidade do país e a baixa capacidade de desenvolvimento para enfrentar os impactos ambientais. No entanto, apesar da atratividade do conceito, ainda não foram definidos critérios específicos para orientar as abordagens e tecnologias a serem utilizadas.

Palavras-chave: Aquecimento global. Mudança climática. Produtividade agrícola. Segurança alimentar.

Abstract

Current estimates predict a world population growth of 9.6 billion by the year 2050, many of whom will live in countries already facing food insecurity. To feed this population, agricultural production will have to increase by approximately 50%, a difficult situation due to the effects of climate change. In order to achieve food production goals without putting the environment at risk, FAO, since 2009, has supported member countries in their initiatives to implement Climate-Smart

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Agriculture (CSA) that takes into account local and national specificities and priorities, to sustainably increase productivity and resilience, strengthen food security and mitigate damage from greenhouse gases (GHG). This literature review seeks to contribute to discussions on the recognition of the CSA concept, its applicability in agricultural systems and review advantages or disadvantages to face global climate change. In Brazil, there is growing concern, due to the country's high vulnerability and low development capacity to face environmental impacts. However, despite the attractiveness of the concept, specific criteria to guide the approaches and technologies to be used have not yet been defined.
Keywords: Global warming. Climate change. Agriculture productivity. Food insecurity.

INTRODUCTION

The uncertainty generated by climate change is currently a growing threat to agricultural production, food security and the livelihood of the human population around the world (IPCC, 2014; MAKATE, 2020; BRANCA et al., 2021). Rising temperatures, erratic rainfall and flooding patterns or extreme drought events have significantly limited agricultural production in different regions of the world (IPCC, 2014; FAO, 2018; BRANCA et al., 2021).

One of the biggest challenges for the agricultural sector is responding to the growing demand for food (FAO, 2010a, 2010b). However, food production and sustainability must involve balancing ecosystems. Unfortunately, the fragmentation of ecosystems and monoculture pose great threats. There is a serious danger if forest areas continue to be invaded and transformed into agricultural land, in order to compensate for the reduction in productivity by increasing the production area, increasing greenhouse gas emissions and contributing to climate change (FAO, 2010b; FAO, 2013).

Climate-Smart Agriculture seems to be a concept that seeks to identify and develop strategies that improve production systems in a sustainable way without deteriorating natural resources, despite the adverse effects of climate change (FAO, 2010b; FAO, 2013; FAO, 2018; MAKATE, 2020).

The concept emerges as a transformative approach to agricultural systems to support food security by providing flexible, socially acceptable and specific solutions depending on local needs (LIPPER et al., 2014; AZADI et al., 2021).

Several agricultural production technologies and practices are included in the concept, including stress-adapted crops, improved water management technologies, agroforestry and conservation agriculture, crop diversification and integrated soil fertility management practices (FAO, 2013). However, there are several detractors of the concept for not presenting clear lines of action and ambiguity in application (ROTTACH et al., 2017). These reasons led to the questioning and attempt to understand the scope of the concept of "Climate-Smart Agriculture". Therefore, a bibliographic review was carried out that intends to contribute to the current debates on the recognition of the concept, its potential applicability to agricultural systems, in addition to reviewing the advantages and disadvantages that the concept presents to face the global climate change.

MATERIAL AND METHODS

A critical narrative review was carried out, based on an approach to the historical context that allowed the development of the concept of Climatically Intelligent Agriculture, with a look at recent times and what could happen in the future. Furthermore, the review, sought to discuss how the concept proposed by FAO, 2010b, was related to the dynamics of climate change and how Latin America had been influenced by the concept.

For the search of articles, words related to: agricultural advance, GHG, climate-smart technology, climate change, food security were used. Google Academic, Scielo, Scopus, NCBI were used, without date restriction. Explicit and systematic criteria were not used for the search and analysis of data. Scientific articles, literature reviews, theses, and government studies with deficient data were considered for the study.

HISTORY AND EVOLUTION OF THE CONCEPT OF CLIMATE-SMART AGRICULTURE

To develop the concept of Climate-Smart Agriculture and its controversies, it is necessary to understand the evolution of global climate change policies (GUPTA, 2018; LIPPER and ZILBERMAN, 2018). The beginning dates back to the first global meeting on the environment, in Stockholm, Sweden in 1972, where the objective was the need for global action to stabilize greenhouse gas emissions. Developed and developing countries would have different responsibilities for mitigating climate change (SOHN, 1973; LIPPER and ZILBERMAN, 2018; BRANCA et al., 2021; SARDAR et al., 2021). Later, in 1987, links were established between climate change and the problems of agriculture and food security, which was the environmental problem that had the greatest economic impact on sustainable development, proposed in the Bruntland Commission Report (GOMEZ, 2014).

Agenda 21 was the turning point, called by the General Assembly of the United Nations in its Resolution 44/228, held at the Rio Convention in 1992, in Brazil. This conference laid the foundations for a new world vision of sustainable development, as well as emerging issues such as biological diversity, climate change and awareness of the environmental aspects of development that were hitherto scarce or absent in the region (CEPAL, 2001).

When they adopted the Convention, governments recognized that it could be the driver of stronger action in the future. For this reason, the Kyoto Protocol was opened for signature on March 16, 1998, including developed countries that accounted for at least 55% of total carbon dioxide emissions in 1990. Meanwhile, the Parties to the Convention on Climate Change continued to observation and commitments made (BRAZIL, 1998). With the Kyoto Protocol, the reduction of greenhouse gases (GHG) in terms of CO_2 equivalence was emphasized. Mechanisms were established that allowed developed countries to use financial incentives to reduce gas emissions in developing countries through carbon sequestration in soils and forestry (MCCARL and SCHNEIDER 2001; POST et al., 2001; RINGIUS, 2002). The United States, Canada and other countries including Brazil, advocated the inclusion of soil carbon sequestration as part of the protocol and developed mechanisms to improve its accounting (PAUSTIAN et al., 2004).

The introductions of biofuel policies and alternative energy sources have had a significant impact on increasing income in the agricultural sector. However, the increase in food prices in 2008 and concerns about the indirect use of the land for agricultural production led to a reduction in biofuel policies (HUANG et al., 2012).

The potential of the Climate-Smart Agriculture approach is explicitly mentioned as part of the intrinsic actions in several countries, based on the context of poverty reduction and environmental benefits (FAO, 2016). However, what is Climate-Smart Agriculture (CSA)?

The Food and Agriculture Organization (FAO) defines the concept as that agriculture that increases productivity, resilience or adaptation in a sustainable manner, in addition to reducing, mitigating or eliminating GHG, strengthening the achievements of national development goals and food safety, production in each country where it has been implemented (FAO, 2010b). However, it

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is important to establish what is sustainable and thus be able to delimit the concept. This concept is supported by five fundamental principles: improving the efficiency in the use of resources; conservation and protection of natural resources; improving rural livelihoods and social well-being; improved resilience of communities and ecosystems; and accountable and effective governance mechanisms. The CSA concept was introduced on the basis of improving adaptation to climate change, supporting efforts to reduce carbon emissions and increasing food security (FAO, 2010b; KARLSSON et al., 2018). However, the concept comes amidst a controversy surrounding the sustainable agricultural development approach and the lack of clarity on the role of agriculture and its relationship to food security, as well as potential articulation with the political process to mitigate climate change (SCOONES, 2009; LIPPER and ZILBERMAN, 2018).

The first mention of the concept was presented in the 2009 FAO report, "Food security and agricultural mitigation in developing countries". However, in 2010 a document was created whose objective was to search for practices, approaches and tools aimed at increasing agricultural resilience and productivity, in addition to reducing or eliminating emissions (FAO, 2010b; LIPPER and ZILBERMAN, 2018).

The transition to CSA is promoted to ensure the food supply for 9.6 billion people expected by 2050 (KARLSSON et al., 2018; TAYLOR, 2018). Despite the wide range of successes proclaimed by the World Bank under the auspices of the CSA, agrarian social movements have criticized the foundation of the concept (TAYLOR, 2018). Several authors mention that the concept is scarce in the literature, pointing out its imprecision in the lack of firm criteria or specific direction, lack of scientific agenda and priority (NEUFELDT et al., 2013). However, other researchers point out that the lack of guidelines could provide enough space for the inclusion of experience and innovation driven by farmers (WHITFIELD, 2015; AZADI et al., 2021).

The concept has generated considerable attention and debate, being a meeting point that would unite aspects of politics and science, focusing on three areas of action such as, knowledge; the enabling environment and investments. Critics of the concept cite the concern that the livelihoods of small farmers may be compromised in the face of unequal competition with large companies that promote negative effects on biodiversity, leading to an imbalance promoted by modified or improved monocultures to the detriment of traditional or leading to accelerated land grabs by corporate interests and local elites (POWLSON et al., 2014; CARON and TREYER, 2016; WAASWA et al., 2021).

Although the concept is new and continues to evolve, many of the practices that make up CSA already exist around the world and are currently used by farmers to address various production risks. Integration requires a critical analysis of successful and ongoing practices and their relationship to current and future institutional and financial enablers (NGARA, 2017; LIPPER and ZILBERMAN, 2018). The CSA does not respond to any structure of the United Nations Organization related to food security, climate or agriculture. On the contrary, it seems to be a strategy to seek international financing aimed at combating climate change, where countries with power can meet their financial commitments in projects in which they have acquired rights (DELVAUX et al., 2014).

INFLUENCE OF CLIMATE CHANGE ON AGRICULTURE

The climate is the main determinant of agricultural productivity. Interest in addressing this topic has motivated research on climate change and agriculture in recent decades (ADAMS et al., 1998; BRANDT et al., 2017). This interest lies in the fact that climate change is becoming a major

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issue for agriculture, food security and livelihoods for millions of people around the world (IPCC, 2014; LIPPER et al., 2014; BRANDT et al., 2017; BRANCA et al., 2021).

Several researchers mentioned that the greenhouse effect could compromise agricultural production (LIPPER et al., 2014; KHATRI-CHHETRI et al., 2017). This effect can occur due to natural or anthropogenic causes. The first is not a cause for concern, as it ensures that the earth's temperature remains an average of 15°C. However, the anthropogenic cause has become a worrying factor due to the use of coal, oil and forest fires, responsible for accelerating the increase in these gases in recent years (MELO, 2014). In several countries, these ideas have been questioned, mainly by the energy, automotive and chemical sectors, in order to raise doubts about global warming and its potential anthropogenic origin (MARTINS et al., 2010).

Philosophically, agriculture has been identified as one of the main drivers of climate change. Total greenhouse gas emissions from agriculture alone accounted for ca. 10% to 12% of global anthropogenic emissions (SMITH et al., 2014). The argument is that it favored human progress, enabling development that, in turn, led to increased greenhouse gas emissions (MARTINS et al., 2010). The agricultural categories with the largest effects are fermentation, manure deposited, synthetic fertilizer, paddy rice cultivation and biomass burning (SMITH et al., 2014).

The consequences of climate change show unpredictability of weather patterns (ADAMS et al., 1998; MARTINS et al., 2010; LOBELL et al., 2012; VERMEULEN et al., 2012; BRIDA and OWIYO, 2013; FLATO et al., 2013; SINGH et al., 2013; PRASANNA, 2014), manifested by decreasing glaciers, rising sea levels and coastal erosion (IPCC, 2013; VERMEULEN et al., 2012), increased risk of droughts or floods (BRIDA and OWIYO, 2013; SINGH et al., 2013), changes in precipitation patterns (PRASANNA, 2014), and an increase in average temperature and therefore in heat waves (LOBELL et al., 2012).

Changes in agricultural biodiversity associated with monocultures, the prevalence of pests and diseases are, in turn, some of the main causes of the impacts of climate change on agriculture (ADAMS et al., 1998; NORTON, 2014; ZABEL et al., 2014;).

Some researchers take positions against the catastrophic idea of climate change, as they mention that potentially some ecosystems can increase their biodiversity. However, the increase in temperature directly influences the photosynthetic activity, therefore, enzymatically catalyzed reactions can be compromised, resulting in the loss of its activity (MELO, 2014; NORTON, 2014; ZABEL et al., 2014).

Agricultural systems are dynamic and depend on changes in the environment with which they interact (ADAMS et al., 1998). This is why climate change simulations have been carried out combining models from the National Center for Atmospheric Research (NCAR) and the Commonwealth Scientific and Industrial Research Organization (CSIRO). In both projections, the highest temperatures were projected in 2050, which would cause greater evaporation and increased precipitation (NELSON et al., 2009).

An increase in temperature can change the ecological patterns of agricultural environments, causing a change in the geographic distribution of crops (LIPPER et al., 2014). For example, future simulations were carried out based on the coffee zone in Brazil, generating less than encouraging projections, with severe reductions in suitable areas (ASSAD et al., 2008).

Assessments of the possible impacts that global warming could cause on major agricultural crops in the coming decades indicated that their productivity could significantly decrease, generating large economic losses (LIPPER et al., 2014; MELO, 2014), if corrective measures are not taken to improve adaptability (ROSENZWEIG et al., 2014).

Estimated impacts of historical and future climate change on crop yields indicate a 60% reduction in corn yield, 50% in sorghum, 35% in rice, 20% in wheat and 13% reduction in barley,

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depending on location, future climate scenarios and projected year (PORTER et al., 2014; KHATRI-CHHETRI et al., 2017; MAKATE, 2020). In addition, several researchers warn of sharp drops in crop yields when temperatures exceed critical physiological thresholds (LIPPER et al., 2014). In turn, it is also estimated that the yield of rainfed crops will decrease by 50% due to climate variability and change (MAKATE, 2020).

Agricultural systems are managed, so the human response is essential to understanding the effects of climate change on agricultural production (ADAMS et al., 1998). Given that these impacts on agricultural production influence the poverty levels of the population who depend on it for subsistence and/or work, it is clear that climate change could make it worse (ADAMS et al., 1998; CARDONA, 2001; MARTINS et al., 2010). In addition, the impacts generated by climate change have caused populations to migrate to cities in search of work, as they have less access to agricultural resources to adapt to variability and change (KAKOTA et al., 2011; WRIGHT; CHANDANI, 2014).

Producers and consumers continually respond to changes in commercial dynamics that depend on agricultural production. Therefore, considering these adaptations, although difficult, it is essential to accurately measure the impacts of climate change (KHATRI-CHHETRI et al., 2017).

CSA AND ITS RELATIONSHIP TO CONSERVATION AGRICULTURE

Climate-Smart Agriculture should not be confused with agroecology. Agroecology is a comprehensive approach, based on the principles of ecology, food security and nutrition, which seek to enrich agricultural systems using and recycling natural resources. In this sense, farmers improve biodiversity and diversify crops, ensuring healthy soils, water conservation and increased income for communities in the face of climate change (IPCC, 2014; JAT et al., 2021).

The pressure on agroecosystems is constantly increasing, leading to the intensification of agriculture, generating immediate consequences for the environment (WHEELER and VON BRAUN, 2013; LIPPER et al., 2014). This has led agriculture to look for trends to achieve sustainability that meet the growing food needs of the human population without generating environmental disturbances (LIPPER et al., 2014). Studies on technological innovation in agriculture reflect the profound changes that have taken place, but have not gone through the process of achieving high levels of productivity (VIEIRA and SILVEIRA, 2013).

There are several practical and technological options to reduce climate risks in agriculture in ecological and sustainable agricultural intensification systems (VIEIRA and SILVEIRA, 2013), as integrated cultures, agroforestry systems; better control of pests, water and nutrients; landscape approaches; forestry; reduced tillage; integration of trees into agricultural systems; restore degraded lands; anaerobic digesters, crop establishment methods, irrigation and waste incorporation. All options seek, together, to improve performance, with efficient use of water and nutrients, in addition to reducing gas emissions from agricultural activities. However, these systems were questioned because the boundaries of their concepts are not completely clear or share common points (LOBELL et al., 2011).

CSA is currently trying to integrate traditional and innovative practices, technologies and services that seem relevant to the adoption of climate change and variation. However, it is worth asking the question: what does this emerging concept have from its predecessors? Unless the focus of planning and investment for agricultural growth and development shifts, some researchers mention that there is a risk of misallocating resources, generating agricultural systems unable to support food security (LIPPER et al., 2014).

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CSA is an approach that has reoriented farmers, researchers, and civil and political society in seeking climate resilience and resilience through evidence creation; increase local institutional effectiveness; in addition to promoting coherence between climate and agricultural policies; and, finally, linking climate and agricultural financing (KANGOGO et al., 2021). Apparently, CSA differs from previous approaches in emphasizing the ability to implement flexible and context-specific solutions, supported by innovative financial policies and actions. In addition to identifying associations between food security, adaptation and mitigation as a basis for informing and reorienting policies in response to climate change (LIPPER et al., 2014).

Importantly, CSA insists on agricultural systems that use ecosystem services to support productivity, adaptation and mitigation. However, these must be complemented by efforts to change consumption patterns, reduce waste and create positive incentives throughout the production chain (PARFITT et al., 2010; JELLASON et al., 2020).

Some researchers believe that a technology or practice like CSA can help increase productivity and reduce gas emissions. However, farmers must make climate risk decisions in addition to making short- and long-term investments, depending on the degree of current climate variability and expected future climate change (CALLAWAY, 2004; KHATRI-CHHETRI et al., 2017).

A simulation in crops under various climate scenarios found that those adapted to CSA plans had average yields between 7 and 15% higher, increasing the efficiency of input use and reducing gas emissions, compared to those without adaptation (CHALLINOR et al., 2014; KHATRI-CHHETRI et al., 2017). However, despite the many benefits, the rate of adoption of the concept by farmers is low (PALANISAMI et al., 2015).

Despite the importance of prioritizing technologies, existing climate change adaptation programs lack information for better adaptation planning, so it is necessary to incorporate farmers' experiences to make informed decisions in line with government policies and institutional arrangements (KHATRI-CHHETRI et al., 2017).

THE CONCEPT IN LATIN AMERICA

Agriculture in Latin America and the Caribbean is undoubtedly an essential factor for economic and social development. According to estimates by the United Nations Food and Agriculture Organization, the region's agricultural potential over the next decade may exceed that of the United States of America (FAO, 2018).

Currently, Latin America is responsible for 16% of world exports of agricultural products, the most important items being soy (55%), coffee (39%), corn (20%) and rice (20%) and wheat (10%) (CEPAL, 2021b). Since the 1990s, the added value of this sector to the Gross Domestic Product (GDP) of the region rose from 4.7% to 8.1% in 2017 (CDKN, 2017).

Efforts should be focused on ensuring food security in the face of climate change in developing countries, improving the resilience of their agricultural systems and their ability to adopt technologies that adapt to the effects of climate change and can help mitigate it when possible (PARRY et al., 1999; SARDAR et al., 2021).

Related GHG emissions during the COVID-19 pandemic apparently improved (LE QUÉRÉ et al., 2021); in a period in which everyone stopped, but, unfortunately, everything has already returned to a scenario tending to catastrophe. However, there is uncertainty around trends in agriculture, forestry and other land-use based GHG emissions, as these emissions seem to continue to increase (SHINDELL and SAUNOIS, 2021).

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The emission growth rates have accelerated over 6 per cent higher the past 15 years (WMO, 2020). Approximately 35 % come from fossil fuels and 40 % from agriculture (3/4 from fermentation and manure management and 1/4 from rice), 20 % from landfills and 5 % of biofuel and biomass burning (IPCC, 2021; SHINDELL and SAUNOIS, 2021).

Latin America has increased from 2.73 to 5% the emissions of GHG emitted by the energy sector, agriculture and land use change. Unfortunately, the percentage is increasing as countries continue to use fossil fuels, therefore investing in renewables and reducing deforestation could curb rising emissions (RODRÍGUEZ et al., 2015; IPCC, 2021). During the second half of the last century, these regions were considered key areas of future climate change (GIORGI, 2006). So far, these regions have experienced increases of 0.55°C in the last 30 years (MERTZ, 2009; MCCARTHY, 2014). Although the countries of the region have mostly increased mitigation targets, they are still well below what they need to limit the global temperature rise to 1.5 ° C by the end of the century (WWF, 2021). Looking to the future, Judgment STC 4360-2018 of the Supreme Court of Justice of Colombia is perhaps the most significant projection due to its scope and implications. The established arguments mentioned the worrying increase in temperature from 1.6ºC to 2.14ºC between 2041 and 2070 according to current climate change scenarios (CEPAL/ACNUDH, 2019), leading to droughts with isolated but intense precipitation events (MERCADO et al., 2017).

High temperatures are expected to cause critical water scarcity and therefore a decrease in precipitation in the near future in areas of Bolivia, Ecuador, Colombia, northeastern Brazil, Peru and southern Chile (MCCARTHY, 2014), and much of Central America (IPCC, 2007). The opposite case is expected in the Amazon rainforest region of Brazil, Argentina, Uruguay and Paraguay, where steady increases in precipitation patterns have been reported (SCHIMMELPFENNIG et al., 1996). For example, reductions in corn production have already been seen in Mexico, while in coastal areas of Peru, mango and cotton production has been affected (IPCC, 2007).

Agriculture in the Andes has shown greater sensitivity to climate change, favoring the loss of plant cover, leading to the alteration in the dynamics of crops such as potatoes, quinoa or corn. Climate change in the Andes will cause countries such as Brazil, Bolivia, Ecuador, Venezuela, Guyana and Colombia to increase their temperature and water scarcity, causing the loss of important crops such as rice. In contrast, countries like Peru, Argentina, Chile, Bolivia and Uruguay will register lower temperatures that will affect their production and yield in crops such as quinoa and potatoes (LOZANO-POVIS, 2021).

Studies for the year 2021, based in various scenarios as a consequence of the increase in temperature due to climate change, they reported a decrease in the Latin American corn yield (61%). However, specific increases are shown in Mexico, with estimates of an increase in yields from 5 to 22% considering the effects of carbonic fertilization (NORIEGA-NAVARRETE, 2021).

In turn, for wheat there were variations due to a drop in yield, estimated at 30% for Uruguay and 15 to 50% in Brazil, but an increase of 3 to 48% in Argentina due to the increase in temperature. Studies projected for the year 2055 mention that the biggest drops in yield will occur in Venezuela, Uruguay, Belize, Guyana and Brazil and, on the other hand, increases in Chile and Panama will be observed for the same items (ADAMS et al., 1998; MCCARTHY, 2014)

At the Latin American level, Mexico is the country most exposed to extreme weather events. Between 1970 and 2009, this country suffered 18% of all disasters in Central America. In turn, 15% of farmers were affected by extreme events between 1980 and 2000. The frequency and intensity of future extreme events is uncertain (TWB, 2014).

Wheat is one of the crops being studied in Latin America. In Mexico it has mentioned strategies that include growing varieties that can tolerate higher temperatures, incorporating agroforestry to reduce temperatures, and moving the harvest to other regions to mitigate the negative effects of climate change. Unfortunately, detailed long-term data is lacking for many other cultures (MCCARTHY, 2014). However, some models have shown the yield of potato, corn, barley, rice, cassava, sugarcane, soy, palm and wheat in the Andean region, as well as the production of rice, corn, cassava, sugarcane and wheat in Central America has a tendency to increase significantly (LOBELL et al., 2008; MCCARTHY, 2014).

In El Salvador, as in other parts of Central America, traditional agricultural systems include several techniques that are now recognized as CSA. The National Biodiversity Strategy highlighted that the most important practices are “milpa” agriculture, which is based on the sowing of a wide variety of crops in association; the consortium of cultures, with which the efficient use of water resources is guaranteed, in addition to contributing to the biological control of pests and protection of soils against erosion; and the integral systems of sugarcane production with the reuse of plant residues (EL SALVADOR, 2013).

Studies carried out in Colombia, Ecuador and Peru actively promoted cocoa planting as a sustainable transformation strategy. It not only seeks to reduce rural poverty, it also tries to overcome challenges of low productivity due to the effect of climate change, due to longer and more intense periods of drought, irregular rainfall patterns and higher incidence of pests and diseases. Some of the related practices include diversification through well-adapted agroforestry systems, sustainable and climate-adapted genotypes or improvements in soil management, all part of the development called “Cacao: Climate-Smart Agriculture with an emphasis on agroforestry. Ariari´s Experience, Meta, Colombia” (ZAPATA, 2020).

In the case of Peru, it is one of the Latin American countries most affected by hydrometeorological phenomena associated with the El Niño phenomenon and by atmospheric disturbances generated in the equatorial Pacific Ocean (DEL CARPIO, 2009). Climate change has been evident in the migration of species such as the native potato that is produced in higher areas and in changes in the distribution of pests and diseases (MINAM, 2010). According to climatological projections, the general temperature is expected to rise from 1 to 2°C and that changes in rainfall will vary according to the region, which will affect the availability of water for the cultivation of yellow corn and potatoes in the south coast, rice yield and coffee production (COLLINS et al., 2013). These climate-smart practices include potato and corn management in traditional systems, efficient water management in canals, lakes and ponds, soil conservation on terraces and platforms and associated crop alternation, in addition to the use of chemical and organic fertilizers, genetic improvement, the use of certified seeds and agroforestry in the case of coffee, cocoa and fruit (SENASA, 2012).

In the case of Paraguay, the introduction of direct seeding and agricultural technology allowed progress towards sustainable development. The country grew in production and became, together with Argentina, Brazil and Uruguay, a supplier of 30% of the food to the world, minimizing the impact on the environment through the use of biotechnology. Before 1992, Paraguay had laws such as the agrarian statute that promoted land occupation, generating deforestation and colonization. As of 1992, the Constitution is amended and the advance in the concept of sustainable development begins, adopting Climate-Smart Agriculture, recognizing that the materialization of the options will depend on the context and capacity of the country (FAO, 2018).

The agricultural sector in Argentina contributes 7.2% to the country's GDP, high compared to the 5.2% average in the rest of the Latin American and Caribbean (OBSCHATKO et al., 2007). In general, agricultural land tends to be concentrated in large-scale agribusiness companies for the cultivation of tobacco, cotton, yerba mate, sugarcane, wheat, corn, soybeans and sunflower. Many

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farmers traditionally use climate-smart techniques in an attempt to adapt their production patterns to changing political, climatic and institutional market conditions (FRANK et al., 2014).

Uruguay actively participates in numerous regional and international forums related to environmental issues of global importance. At the same time, it stands out for having been the first country in Latin America to draw up a detailed soil aptitude map covering the entire agricultural area of the country. This categorization remains in force and is widely used for research, inspection and even commercial transactions for the purchase and sale of rural properties. This productive transformation, and the significant growth of foreign investment, led to the development of a strategy known as "Uruguay Agro-Intelligent", which, as of 2010, guides public policies in the agricultural sector, being part of the guidelines for Climate-Smart Agriculture. This vision came out together with the formal launch of the concept at a global level and recognizes the social dimension of competitiveness, intensification and productive adaptation, by incorporating into the strategy the particular needs of family producers (FAO and PNUD, 2017).

SITUATION OF CLIMATE-SMART AGRICULTURE IN BRAZIL

There is concern in Brazil and Latin America about increasing climate variation and will have significant negative impacts on the Brazilian landscape and agriculture, national economic growth and associated livelihoods (ASSAD and PINTO, 2008; MARGULIS et al., 2011).

Agriculture is an important sector of the Brazilian economy, which contributes to the GDP from 5.5%, to 36% when agribusiness and exports of its derivatives are included. As agriculture is essential for national food security and plays a strong role in increasing GDP, there is concern because the sector is increasingly vulnerable to climate change. In order to maintain national development, Brazil needs to raise the productivity of its systems for growing food products and pastures for animals, while reducing deforestation and rehabilitating millions of hectares of degraded land (MARGULIS et al., 2011; ASSAD et al., 2013).

Studies showed an evaluation of 35 agricultural products with climatic risks, but only cotton, rice, coffee, sugar cane, beans, sunflower, cassava, corn and soybeans, as well as pastures and beef cattle, representing 86% of the area planted in Brazil, received special attention (ASSAD and PINTO, 2008). While climate impacts are projected to be very negative by 2030, generating a world with uncertain conditions (CEPAL, 2021a). It is estimated that during the period 2016-2025 there will be a relative stability in the production of the markets in the main countries cotton and soy producers (OECD/FAO, 2016). However, for beans and corn it can be much more serious than the problem. This is why it is important to take advantage of the country's soil, water and climate datasets so that climate change modeling methods are more analytical and differentiated. In the absence of climate change, the Brazilian crop could reach an expansion of 17 million hectares in 2030 (ASSAD et al., 2013).

The vulnerability or low capacity of developing Brazil to defend itself from the impacts of climate change becomes more aggravating when it comes to its impacts on agriculture. In order to adapt to these impacts, an important first step is to seek to know them, defining future agricultural scenarios based on future climate change scenarios. Therefore, the database and models must be created that allow for a first approximation towards the definition of these future agricultural scenarios at the national level (QUEIROZ et al.,2007; JELLASON et al., 2020).

Countries like Brazil that have an emerging economy, there is a greater concern with the development of solutions that enable the inclusion and valorization of environmental assets. For this reason, a great effort was made in the country aiming at the elaboration of the National Policy on Climate Change (PNMC). If there is significant intervention, deforestation rates are expected to

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stabilize for the year 2023. Otherwise, deforestation rates could rise steeply (COSTA et al., 2021). A model estimated that with an investment of R $ 1.45 billion of Brazilian reals (BRL) in 20 years, the sectors associated with the use of the Amazon Biome, would allow to neutralize the negative impacts of the zero-clearance policy (BRAZIL, 2021). The Climate-Smart Agriculture has played the coordinate strategy with the objective to involve the private sector and demonstrate the economic viability of investments in projects to reduce greenhouse gas emissions (MOZZER, 2016; APTA, 2020).

In 2008, the NGO Vitae Civilis identified public institutions, universities and research centers, civil society and the private sector working on the issue of climate change. However, the theme was only within the scope of the discourse, but not the actions focused on mitigation. Results of this study elected water as the main adaptation resource, and in two variables that proved to be highly effective for agricultural adaptation in Brazilian regions particularly vulnerable to climate change (MAY and VINHA, 2012).

The CSA concept, while attractive to FAO and widely publicized by the World Bank (TWB, 2014), finds rejection in Brazil, through organizations such as the “Grupo Carta de Belém” created in 2009, formed by social and environmental movements and organizations, family farming, traditional communities, women's organizations, unions and students who share the fight against deforestation and environmental justice in the country. In addition to presenting a firm rejection of the mechanisms of commodification of nature, based on the negotiation process of the climate agreement that came into force in 2020. This rejection is due to the fact that it strengthens the current agricultural model, which is highly fossil energy, pesticides and large machinery, which has historically been responsible for greenhouse gas emissions from the agricultural sector, which causes the replacement of land use for food production by agro-fuels and other green commodities.

On the other hand, groups involved in plant breeding and biotechnology see this opportunity as a great challenge to develop stress resilient crops through conventional and molecular breeding. The use of Omics associated with CRISPR-Cas technologies can deliver crops that are better designed to respond to climate change and, therefore, mitigate its effects (LI and YAN, 2020). Of course, these technologies alone will not solve all issues, needing to find partners in environment friendly actions.

FINAL DISPOSITIONS

Climate change is one of the topics with endless global debates. Excessive rainfall or periods of extreme drought negatively impact food production, both in extensive and family farming. The question then arises: how to face climate change with good agricultural yields? Perhaps it is a matter of making better use of available resources by applying improvements in agricultural technification.

Climate-Smart Agriculture in recent years has become the agricultural approach that seeks to improve the capacity of agricultural systems to support food security and incorporate the need for adaptation and mitigation possibilities into sustainable agricultural development strategies. The model followed today by most Countries, where commodities are produced as feed to generate animal protein and later human food can be challenged. The conversion of humankind into vegetarians is proposed by some authors (SUSSEL et al., 2014; PÄIVÄRINTA et al., 2020; LANE et al., 2021). However, this can be a radical departure from the current models, and perhaps some gradual consciousness could be evoked through educational programs in primary schooling.

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Innovations to improve the efficiency of input use, smart and precision agriculture independ from the dietary regimen that humankind chooses to follow and are some examples of priority areas of current research, which are fundamental to enable the modernization, increased productivity, competitiveness and sustainability of the agriculture of the future.

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