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SUSTAINABLE AGRICULTURE SYSTEMS TO MITIGATE CLIMATE CHANGE EFFECTS: A BRIEF OVERVIEW

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Abstract

Food security, poverty and the overall sustainability of food and agricultural systems are influenced by a series of global trends. Nowadays, economic growth, population dynamics, and climate change disproportionately affect different regions. Conventional agriculture also contributes to accentuating these changes. As a result, we are faced with several challenges in the fields of food and agriculture. So, innovative systems are needed to protect and enhance the natural resource base as productivity increases. Consequently, today, but also in the future, the farming systems that counteract the negative impact of climate change must be in the attention of practitioners. Moreover, regulations in the field are necessary, and the implementation of such systems must be carried out in relation to the specificity of the geographical area. In view of the above, in the present paper, a brief overview was made on some agricultural systems aimed at counteracting the negative effects of global climate change.

Key words**:** *climate change, agroecology, agroforestry, climate-smart agriculture, conservation agriculture*

INTRODUCTION

The demand for energy and food will overtake the supply, and in the future, it is necessary to produce more food and to use more sustainable forms of energy. Emission of large amounts of carbon dioxide from the combustion of fossil fuels is one of the most important sources of greenhouse gas emissions, which results in global warming, and implicitly climate change, a global phenomenon whose impact on agricultural activities in developed countries has increased dramatically [33], [14]. Negative effects are felt on biodiversity, agriculture and, of course, on food supply [20] and besides these, there may be problems of national and international security [26]. Although climate change is a complex issue and there are many factors involved in this context, [36] highlighted that education is the key to sustainable environmental development.

Agriculture is also a determinant of global climate changes [5] and from this point of view, conventional agriculture is the one that makes a major contribution to climate change [42]. Besides this, climate change is truly one of the major challenges in terms of sustainable resource management in agriculture [41], [46].

Food security, poverty and the overall sustainability of food and agricultural systems are influenced by a series of global trends. Economic growth, population dynamics, and climate change disproportionately affect different regions. As a result, we are faced with several challenges in the fields of food and agriculture.

Innovative systems are needed to protect and enhance the natural resource base as productivity increases. There is a need for a process of transformation geared towards "holistic" approaches such as agroecology, agroforestry, climate smart agriculture (CSA) and conservation agriculture (CA), based on both new and traditional knowledge [17].

In view of the above, a brief overview is made on some agricultural systems aimed at counteracting the negative effects of global climate change.

MATERIALS AND METHODS

This work represents a brief original synthesis, with a general character, based on the recent publications, representative in the

field concerned, with a goal to critically analyze the existing relevant data and to identify future issues that need to be supposed to attention.

RESULTS AND DISCUSSIONS

According to recently published results, in the middle of 2017, the world population was about 7.6 billion, and the tendency is one of continuous growth (Table 1).

Table 1. Population of the world and regions, according to the medium variant projections [45]

Region	Population (millions)			
	2017	2030	2050	2100
World	7,550	8,551	9,772	11,184
Africa	1,256	1,704	2,528	4,468
Asia	4,504	4,947	5,257	4,780
Europe	742	739	716	653
Latin America and the Caribbean	646	718	780	712
Northern America	361	395	435	499

Source: United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision. New York: United Nations.

Agriculture and applied agricultural systems are the main means of helping to successfully solve the requirements of the situation and to overcome the disturbances caused by the various foreseeable and unpredictable factors to which we are witnesses today and to which we will be exposed in the future.

Agroecology

According to [22], agroecology consists in applying environmental concepts and principles with a view to the design and management of sustainable agroecosystems. It involves mobilizing practitioners and academics to find innovative ways to increase productivity and sustainability in agriculture, while maintaining an environment that ensures quality of life [18], [37]. Agroecology is also a part of a social movement, that is at the forefront of transforming food systems into sustainability [23]. From a social, political point of view, but also as an agricultural practice, it brings together, synthesizes and applies the knowledge of agronomy, ecology, sociology, ethno-botany and other related sciences, with a holistic, systemic and strong ethical component, capable of generating knowledge, validate and apply appropriate strategies for the design, management and evaluation of sustainable agroecosystems [12]. Agroecology is currently focusing on food production and food systems, a vital engine for conceptualizing and implementing responsible agricultural change [19]. Agroecology should address all actors in food systems, as well as the total flow of energy and materials from their sources to production and other stages to the consumer, including the potential for return of nutrients in the field [18].

[24] announced the publication of two transformative reports prepared by the International Panel of Experts on Sustainable Food Systems (IPES-Food), called "Unravelling the Food-Health Nexus: Addressing Practices, Political Economy, and Power Relations to Build Healthier Food Systems and "Too Big to Feed: Exploring the Impacts of Mega-Fusion, Consolidation, and Concentration of Power in the Agri-Food Sector." Given that agroecology is the ecology of the entire food system, the two reports continue the activity of "IPES-Food", as a leader in the global change for the food system.

As [9], quoted by [6] mentioned, that agricultural policies on adaptation to climate change should be effective, should integrate at the same time:(i) equitable access to means of production; (ii) dissemination of technical levers to increase yields per hectare, for as many users as possible; (iii) sufficiently stable agricultural prices; (iv) an endogenous growth strategy, with the initial fostering of food sovereignty, driven by family farming.

[6] proposed an adaptable model in different agrarian contexts, based on micro agriculture and macro agriculture, two paradigms in a close interrelation. As can be seen in Figure 1, it is worth noting the connection between the two types of agriculture, with the possibility of achieving a centripetal, transparent and holistic flow of knowledge between the two food production models. Basically, based on agroecology, one can speak of a unified paradigm of sustainable food production.

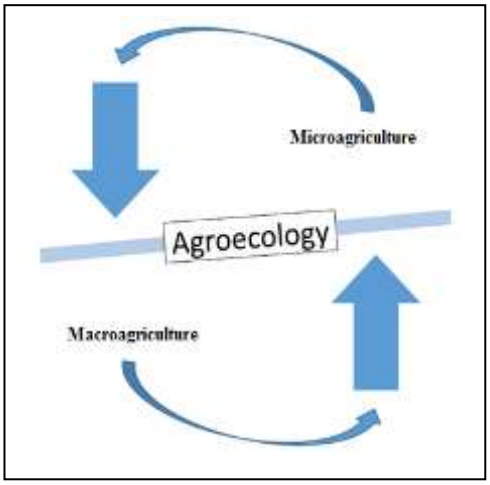

Fig.1. Interconnection between large-scale and small-scale agriculture [6].

Agroforestry

Agroforestry deals with environmentally-friendly and economically attractive strategies for adapting and mitigating climate change, being an intensive, integrated, targeted and interactive activity, that creates favorable conditions for changing microclimate, preserving biodiversity, improving soil health and so on. As [39] emphasized, agroforestry may represent a viable trade-off between economic and environmental aspects. Most of these benefits have direct advantages, such as the dynamic agricultural adaptation option to a changing local climate [3], while contributing to global efforts to control atmospheric greenhouse gas concentrations [7], [40], [8].

Integrated land use management through agroforestry has proven to be one of the most successful ways to mitigate and adapt to climate change [32], [48]. An integrated response strategy to climate change has been implemented in North America, based on six categories of agroforestry technologies tailored to rural / urban landscape needs such as stormwater treatment and bio feed stock production (Fig. 2) [40]. The authors highlighted the potential of agroforestry to contribute to counteracting the effects of climate change, as well as adapting plants to such conditions, thanks to proper sequestration of carbon, reducing greenhouse gas emissions, increasing resistance and lowering threats, with ease of migration to more favorable conditions in highly fragmented agricultural landscapes.

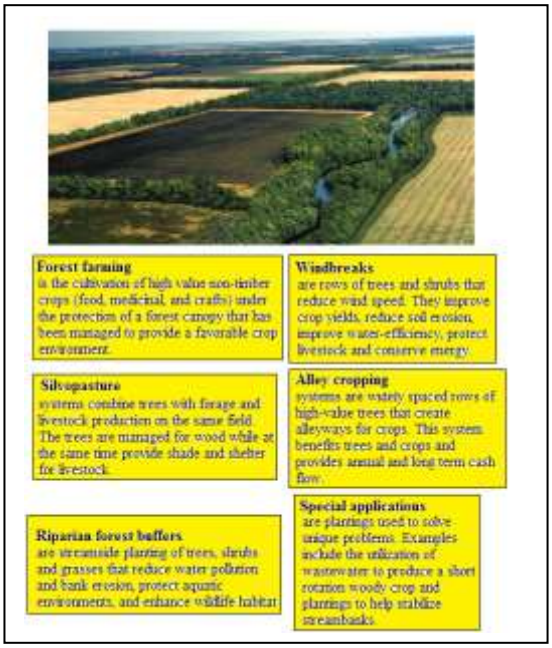

Fig.2. Six advantageous agroforestry practices in North America due to the interactive benefits from combining trees and shrubs with crops and/or livestock, to create integrated and sustainable land use systems [40].

[35] noted that agroforestry was a global solution for increasing land use efficiency, while simultaneously reducing environmental impact and economic hardship for farmers.

A recent study shows that agroforestry can be an economically efficient diversification strategy, allows for beneficial interactions between trees and crops, and a higher income diversification compared to a farm mosaic system. Moreover, as [44] mentioned, within the European Union (EU), residues from agroforestry can be a resource for the chemical industry based on bio-resources.

Agroforest systems are more beneficial alternatives to oceanic and other land-based options to mitigate climate change, due to the benefits of secondary environments, such as: helping to make food and land safe in developing countries, increasing farm incomes, restoring and maintaining biodiversity at the ground and above ground levels of corridors between protected forests such as CH_4 users, soil conservation and river basin retention [47].

If we are talking about the European Union, the studies conducted by Den Herder et al. [11] led to the obtaining of important data on the quantitative existence and distribution of agroforestry in the European Union, and at the

same time useful for the development of the support policies. According to the estimates using LUCAS (Land Use and Land Cover Data) [13], the total area under agroforestry in the EU 27 is about 15.4 million ha, equivalent to about 3.6% of the area and 8.8% of the utilized agricultural area.

„Climate-smart agriculture" (CSA)

The CSA concept was launched by FAO [15] to draw attention to the links between food security and climate change, through the development of agriculture and the opportunities for expanding synergies in this regard. The CSA approach involves integrating the need for adaptation and mitigation potential into the planning and implementation of agricultural policies, planning and investment [29], [30].

At the same time, [21] pointed out the necessity of promoting CSA.

The Food and Climate Change Conference - held in The Hague in 2010, supported by Food and Agriculture Organizations (FAO), explained the participation of the CSA in achieving sustainable progress by combining three ways of sustainable (based on community and ecology) and the mutual approach to food safety and climate issues. The major directions were: (1) sustainable growth of agricultural productivity and a income; (2) adapting and building resistance to climate change; (3) reducing and / or eliminating greenhouse gas emissions, wherever possible.

CSA looks for potential collateral benefits, too. CSA also connects other innovations such as conservation agriculture, agroecology, agroforestry and the development of plant varieties, that are more tolerant to pests, diseases, drought, floods and salinity [16].

In the recently published book, [30] extended and formalized the concepts of CSA and presented a set of case studies that highlight the CSA's economic base for reducing vulnerability, increasing adaptability and risk management capacity.

Currently, a transition to the CSA is a mandatory task to ensure food supply for nine billion people anticipated to be by 2050. By highlighting four strong tensions in the CSA, [43] supports the need to considerably broaden the scope of the CSA debate. To this end, an alternative "climate-wise" framework is proposed to highlight the inherent political dimensions of food and agriculture, in a time of climate change. Strategies of interest regarding the application of the CSA concept were explicitly reproduced in the synthesis paper by [2] (Table 2).

„Conservation agriculture" (CA)

Conservation agriculture (CA), in line with FAO requirements, aims to conserve, improve and better utilize natural resources, through integrated management of available soil, water and biological resources, combined with external inputs. Based on the three principles: direct seeding or planting, permanent soil cover, crop rotation/diversity [31], conservation agriculture contributes to the preservation of the environment, as well as to obtain improved and sustainable agricultural production [38].

At the same time, due to the change in soil properties and processes at this level, as against to conventional agriculture, CA can affect the delivery of ecosystem services and finally, biodiversity is affected, which in turn supports many ecosystem services [34].

In Europe, in 1999, the European Conservation Agriculture Federation (ECAF) was founded, with the aim of adopting CA in the Member States, but, given the specificity of the area, this system is not equally suitable for all European agroecosystems [28].

In synthesis prepared by [4] it is mentioned that, in the Treaty of Amsterdam in 1999, sustainable agriculture was proclaimed as an objective of the EU, even though the Conservation Agriculture has not been given special attention. However, through the Common Agricultural Policies (CAP), the EU is mindful of the principles of agriculture and rural development, according to Communication (COM-2010- 672 final) named "The CAP towards 2020. Meeting the food, natural resources and territorial challenges of the future".

Table 2. Strategies for „Climate-smart agriculture"

1.	**Efficient resource management** across the food chain (from agriculture, transport, conservation, processing, cooking and consumption) is a means to make efficient use of energy.
2.	**Integrated renewable energy technologies for agricultural systems** From energetic point of view, for smart food systems these can be very important for several new technologies (Figure 2).
3.	**Availability of farmers' technical knowledge** Improving people's conventional environmental knowledge and their development over time could lead to different ideas and feasible options for adaptation procedures.
4.	**The role of institutions to improve CSA,** by ensuring the transfer of useful information to people and their guidance for the understanding and application of new technologies.
5.	**Resource conserving technologies,** through techniques that increase efficiency in resource management or application of inputs and consequently lead to improved yields.
6.	**The cultivation of genetically modified plants,** that are tolerant to high temperatures, drought and salinity, which reduces the risk of climate conditions.
7.	**Land- use management,** by adjusting the crop sequence in relation to sowing time, harvesting, to benefit from changing the growth period and changing the temperature and humidity levels.
8.	**Changing crop systems,** as mitigation strategies to reduce the negative effects of marked climate variations.
9.	**The relocation of crops** in different regions, given their predisposition and / or variability in relation to climate change.
10.	**Effective pest management, by**: Developing varieties resistant to diseases and pests; Integrated Pest Management (IPM), with emphasis on biological control and change of cultural practices; Adoption of alternative plant production and techniques, as well as locations that provide better resistance to pests and other stressors.
11.	**Efficient forecasting** through successful use of Information and Communication Technology (ICT).
12.	**Crops modeling (**based on simulation models), as a tool for managing risks in agriculture.
13.	**Integration of modeling and forecasting.** CERES (Crop Environment Resource Synthesis) -Wheat is often mentioned in literature and has been successfully tested in some studies.
14.	**GIS (Geographic Information System)** is used in analysis and mapping, so, it can be realized the estimation and computation of the storm course and flooding associated with hot cyclones.

Source: Adapted after [2].

In this context, through the EU 2020 strategy, the commission wanted the CAP to contribute to the Smart Growth (by increasing resource efficiency and improving competitiveness); Sustainable Growth (by maintaining the food, feed and renewable production base) and to Inclusive Growth (by unlocking economic potential in rural areas).

As can be seen in Figure 3, among the objectives proposed by the European Commission, the CAP 2020 also includes climate change, caused by the global warming and that are being witnessed across the globe.

Effective control and stabilization of the effects of global warming and, implicitly, climate change require a concerted effort by global committees, good public leadership initiatives, and individual actions [1].

Therefore, conservative agriculture, through its three basic principles: a) minimal soil disturbance, b) permanent soil cover, and c) crop diversity in the form of well-balanced and wide crop rotation, enables realization of agricultural sustainability and sustainable crop production intensification.

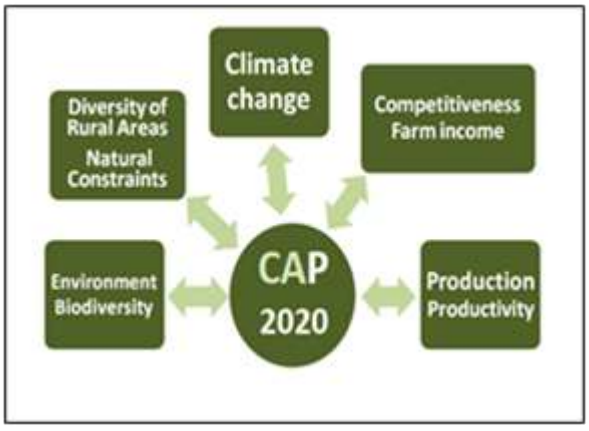

Fig.3. Main objectives to be met by the revision of the Common Agricultural Policy (CAP) [4].

Europe's lagging behind in adopting CA is caused by: 1) there is less need to consider the risks, because cost reduction is not as important as in other areas; 2) lack of

technologies for European conditions; 3) lack of adequate technology transfer; 4) lack of institutional support, conditions that have remained valid until the beginning of the 21st century [27].

As [25] noticed, a recent study carried out by European Conservation Agriculture Federation (ECAF) shows that European farmers could remove nearly 200 million tons of CO_2 (the equivalent of closing 50 coal-fired power plants) from the atmosphere, by implementing conservation agriculture techniques.

CONCLUSIONS

Considering estimates of population growth and consumption needs (agricultural output should increase by 60% by 2050), greater attention is needed to meet the food security and agricultural development objectives adapted to climate change, focusing on a change in land use, water, soil nutrients and genetic resources, possible management through intelligent farming systems to climate change [2]. Particular attention should be paid to biodiversity in agriculture, not only from the perspective of the classical paradigm, but also as an essential component of the improvement of agricultural systems [20].

Although climate change is a complex theme and there are many factors involved in this context, [36] highlight that education is the key to sustainable environmental development. Therefore, it was pointed out that for sustainability in a wider social context, the issue of education should be re-evaluated.

There is an urgent need for public funding of agroecology-based systems and research into sustainable agroecology, especially for advanced studies, in very promising areas, such as farm-based biological diversity and animal husbandry systems [10].

In the European Union, because of geographic, climatic, ecological, cultural, European traditions and policy pressures, as well as the EU programs, the future of conservation agriculture will be different, in different parts of Europe. Performance and stability performance, operating costs, environmental policies, programs, and climate change will be the main driving forces that define the direction and expansion of the conservation agriculture in Europe [27].

We underline again that, nowadays, one of the challenges we must face is climate change, which adversely affects agricultural production, but conventional agriculture also contributes to accentuating these changes. Consequently, today, but also in the future, the agricultural systems that counteract the negative impact must be in the attention of practitioners. Moreover, regulations in the field are necessary, and the implementation of such systems must be carried out in relation to the specificity of the geographical area.

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