

Rodino, Steliana; Butu, Alina; Ifrim, Ana Maria

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CLIMATE SMART AGRICULTURE - CONCEPT AND PERSPECTIVES

STELIANA RODINO^{1,2}, ALINA BUTU², ANA MARIA IFRIM³

INSTITUTE OF RESEARCH FOR AGRICULTURE ECONOMY AND RURAL
DEVELOPMENT, BD MARASTI, NR 61 BUCHAREST, ROMANIA¹

NATIONAL INSTITUTE OF RESEARCH AND DEVELOPMENT FOR BIOLOGICAL²
SCIENCES, BUCHAREST, ROMANIA

CERTIND SA, STRADA GEORGE ENESCU 27, BUCHAREST, ROMANIA³

Corresponding author e-mail:alina_butu@yahoo.com

Abstract: *The negative effects of climate change are felt in the form of rising temperatures, weather variability, shifting boundaries of agro-ecosystems, the spread of invasive species and pests, and more frequent extreme weather events. Climate change reduces crop yields, the nutritional quality of most cereals, and lowers productivity in the livestock sector. In this regard, substantial investment in adaptation will be required to maintain current yields and to achieve increases in food production and quality to meet food needs under the expected exponential growth of the world's population.*

Key words: *climate change, agriculture, resilience, adaptation, CAP*

JEL classification: Q20, Q57

INTRODUCTION

Climate smart agriculture- Concept and History

As an emerging field of climate change economics, agricultural carbon emission reduction has attracted much attention. The United Nations Food and Agriculture Organization and other institutions and academia have proposed the concept of "Climate-Smart Agriculture (CSA for short)", which is a new agricultural development (Chandra et al. 2018). The model emphasizes the use of climate-adaptive (smart) agricultural technologies to address the triple challenges of food security, climate change, and greenhouse gas emissions, to achieve higher crop yields, stronger climate change adaptability, and lower agricultural carbon emissions, covering economic and environmental goals. multiple comprehensive goals (Lipper et al.2018). It is the integration, innovation and transcendence of development concepts such as "ecological agriculture", "low-carbon agriculture", "circular agriculture" and "green agriculture" (Bhattacharyya et al 2020).

Climate Smart Agriculture is a term used to refer to the application of technological and data-driven solutions to improve agricultural production and reduce the environmental impact of farming. It includes the use of sensors, drones, artificial intelligence, and other technologies to monitor conditions, optimize irrigation and crop management, and improve the use of water, energy, and other natural resources (Rosenstock et al., 2016). Smart climate agriculture can also involve the use of precision agriculture, which focuses on using data to improve efficiency and reduce environmental impact (Mizik, 2021). The goal of smart climate agriculture is to increase agricultural productivity while decreasing its environmental impact.

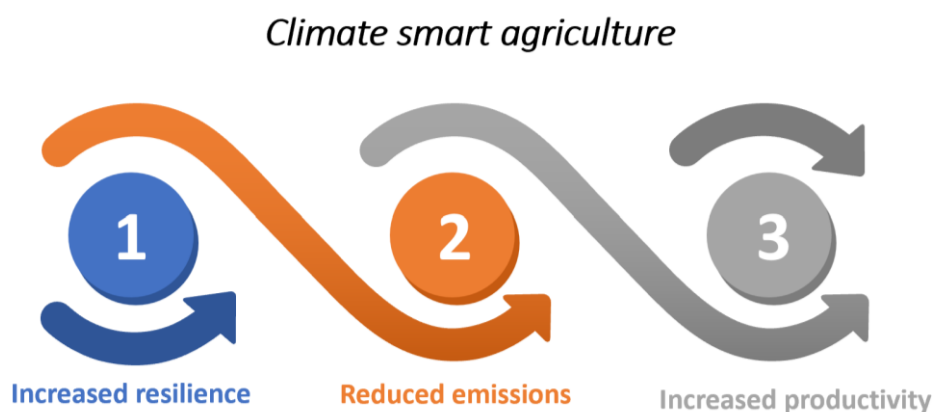


Figure 1. Climate smart agriculture objectives

The concept of climate smart agriculture (CSA) emerged in 2010 in response to concerns about the imminent threat posed by the effects of climate change. The Food and Agriculture Organization (FAO) at that time defined climate-smart agriculture as that agricultural system that aims to increase productivity in a sustainable way, adapt to the dynamics of climate phenomena and reduce greenhouse gas emissions, aiming , at the same time, ensuring food security" (FAO, 2010).

In this sense, CSA represents an integrated approach to resource management – agricultural land, livestock, forest and fisheries – that addresses the interconnected challenges of accelerating climate change and risks associated with food security (Figure 1).

As a new agricultural development model, "climate-smart agriculture" puts more emphasis on emission reduction, adaptability and high efficiency (Figure 2).

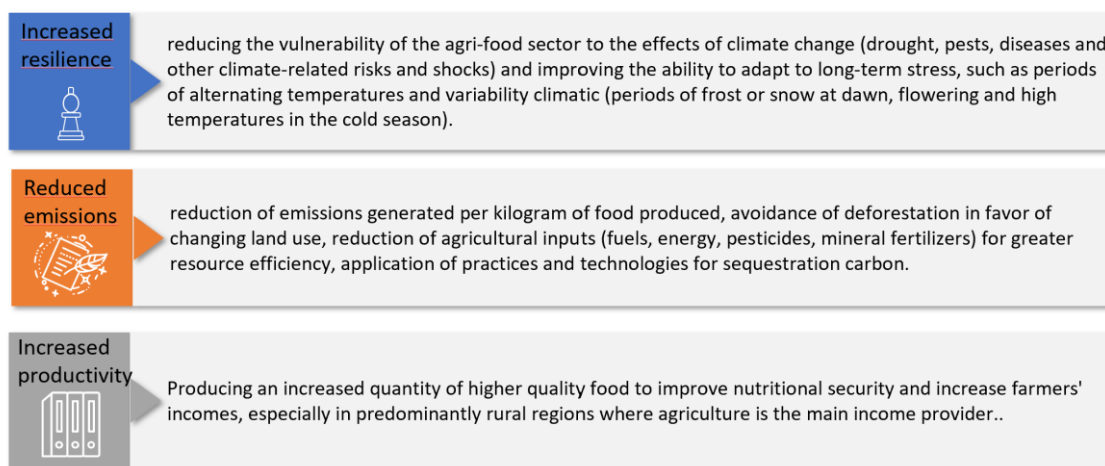


Figure 2. Climate smart agriculture explained

Having in mind the evolution of CSA concept, we have run a bibliometric analysis on Scopus Platform related to scientific publications that included this concept in. The search string was defined as “climate smart agriculture” included in authors’ keyword, title or abstract.

The search has returned 2188 documents. Several document types (erratum, notes, letter, note, editorial) were excluded, as considered irrelevant, resulting a final count of 2147 documents.

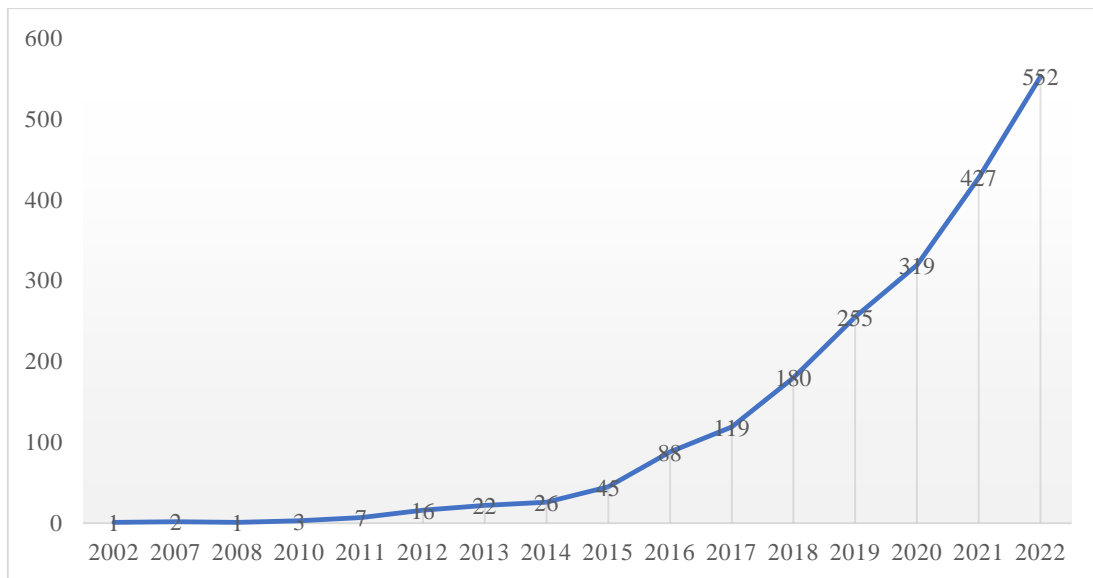


Figure 3. Number of documents related to CSA, by year

According to author's affiliation country, India United States and United Kingdom lead the scientific production of papers related to CSA (Figure 4)

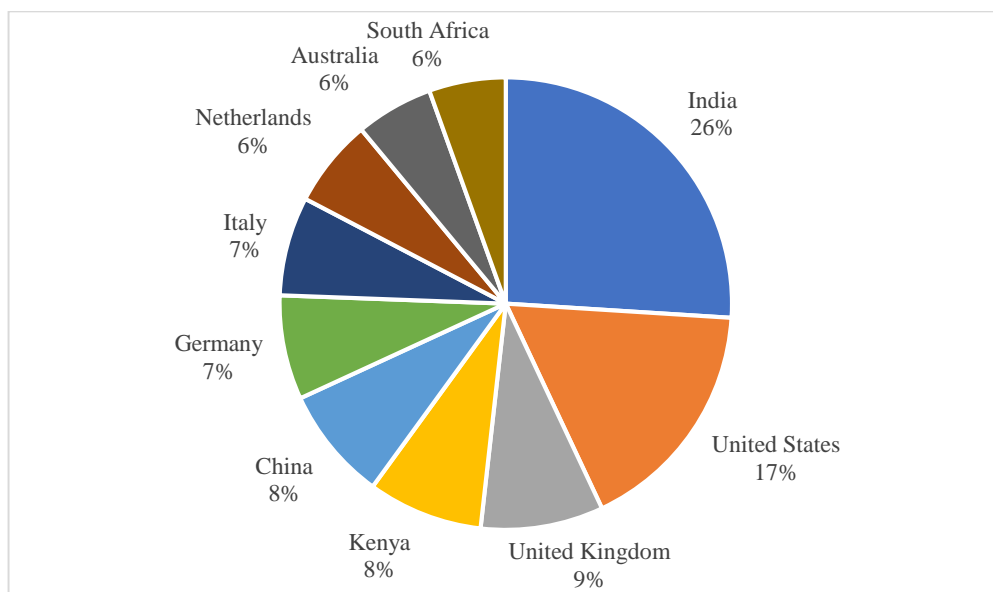


Figure 4. Top ten countries that published CSA related papers.

For content analysis, only the documents written in English were extracted to a xls. File, and co-occurrence analysis was run in VOSviewer.

A total of 5224 keywords were retrieved and minimum threshold of occurrences was set to 10, in order to generate a co-occurrence map, resulting in a total number of 76 keywords, grouped by clusters (Figure 5).

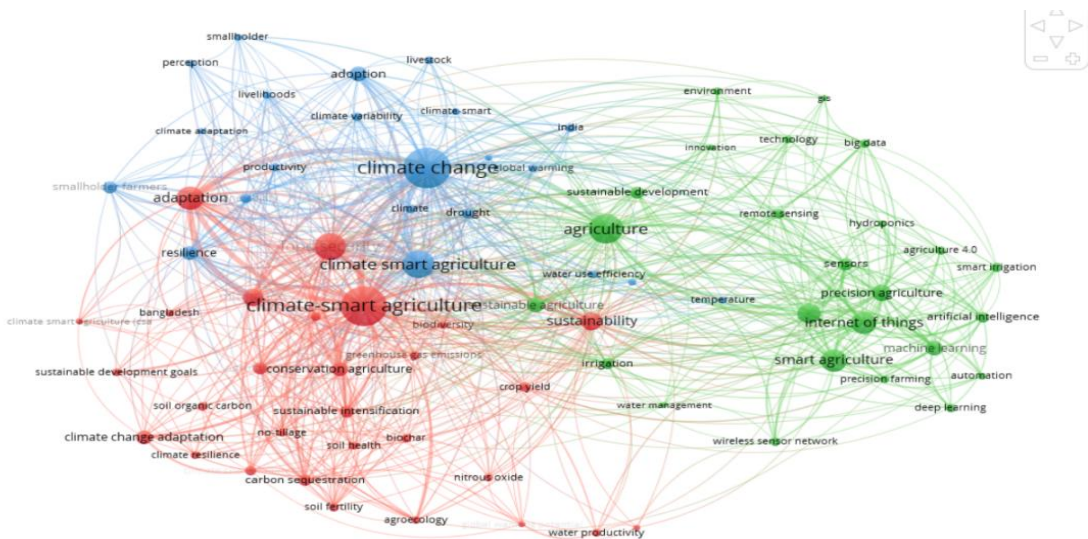


Figure 5. Co-occurrence map of keywords

Cluster 1 (red color)

Climate smart agriculture is the core keyword of this cluster (Figure 6). Other related keywords included sustainable agriculture cropping systems that embed CSA practices or technologies that are related to these systems, such as adaptation, agroecology, agroforestry, biochar, carbon sequestration, climate change adaptation, climate change mitigation, climate resilience, ecosystem services, conservation agriculture, food security, no tillage, soil organic carbon.

Cluster 2 (green color)

Digitalization of agriculture was tackled by published papers (Figure 6)., comprising keywords such as agriculture 4.0, artificial intelligence, automation, big, data, deep learning, GIS, innovation, IoT, machine learning, precision farming, precision agriculture, remote sensing, sensors, smart farming, smart agriculture, smart irrigation, technology, sustainable development, water management, wireless sensors network

Cluster 3 (blue color)

Climate change is the central theme for this cluster (Figure 6), and keywords were as follows: abiotic stress, adoption, climate adaptation, climate variability, climate-smart, drought, global warming, productivity, resilience, soil moisture, temperature, water use efficiency, vulnerability.

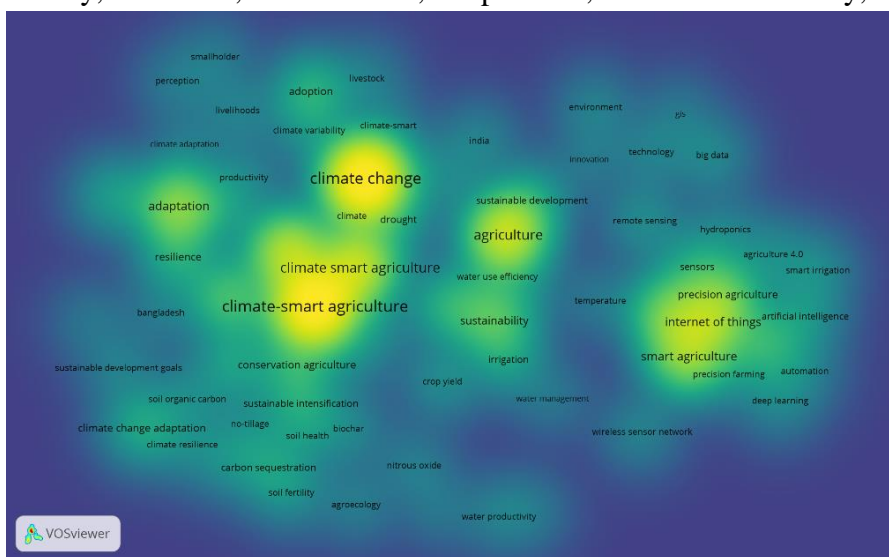


Figure 6. Core concepts of the three clusters

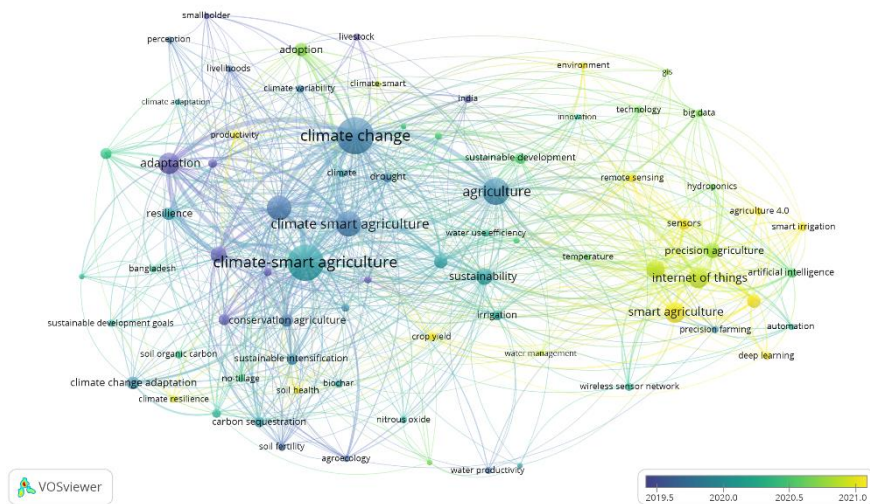


Figure 7. Co-occurrence map of keywords, by year

The interest has evolved over the years, from concepts such as conservation agriculture, agroecology, adaptation (2019) to climate change, drought, climate change adaptation (2020) and sustainability, sustainable development goals, carbon sequestration, soil organic carbon, technology (2021) reaching further to 2022 to precision agriculture, internet of things, smart agriculture, agriculture 4.0, sensors, deep learning, smart irrigation (Figure 7).

Challenges of climate change

A large amount of scientific data proves that climate change and agricultural production are an interactive whole. On the one hand, climate change changes some basic elements of the agricultural production system and increases the frequency and intensity of extreme weather events, thus bringing varying degrees of impact on agriculture. Climate change can explain fluctuations in global grain production (McCarthy et al., 2018; Azadi et al., 2021).

Agriculture is one of the most vulnerable industries to the effects of climate change, as it is highly dependent on weather and climate conditions. Climate change is causing shifts in temperature, precipitation, and extreme weather events, which can have a significant impact on agricultural production (FAO 2011). Warmer temperatures can lead to increased water stress and drought, as well as increased pest and disease pressure. More extreme weather events, such as floods and storms, can also damage crops, disrupt production, and limit access to markets. In order to adapt to climate change, farmers and agricultural systems need to become more resilient, which includes adopting sustainable farming practices and diversifying their operations. This can include implementing water-saving irrigation technologies, adopting conservation tillage practices, and planting more resilient crop varieties. Farmers can also implement climate-smart agriculture practices, such as agroforestry and soil carbon sequestration, to help store carbon dioxide and mitigate the effects of climate change (Has et al, 2021).

The Food and Agriculture Organization of the United Nations estimates that at least one-fifth of total greenhouse gas emissions come from the agricultural sector, mainly from fertilized soil, ruminant fermentation, straw burning, rice production, organic and chemical fertilizer releases emissions of methane and nitrous oxide, forestry and land use change, such as rice fields, are one of the most important sources of methane emissions in the world, and ultimately cause continuous

changes in the global climate (FAO 2013). Therefore, agriculture has become one of the important fields for countries to cope with, mitigate and adapt to climate change.

CSA and Common Agricultural Policy 2023-2027

The new Common Agricultural Policy (CAP) contains a series of reforms to support the transition to sustainable agricultural systems in the European Union in the context of meeting the objectives set out in the European Green Deal. The environmental ambitions of the new CAP are increased, and climate action is recommended to be stepped up compared to the previous programming period. Furthermore, member states are required to align their strategies if the EU updates climate and environmental legislation.



Figure 8. CSA and CAP 202-2027

The CAP also proposes a major contribution to the objectives of the Green Deal, and the CAP recommendations set out how this contribution is expected (Figure 8).

Organic agriculture, Agro-ecology, Regenerative agriculture

CSA has become a benchmark of a "triple win", based on a synergistic development mechanism of three pillars, namely: adapting and mitigating the effects of climate change and ensuring food security. On the other hand, CSA has given rise to heated debates both in the scientific community and in civil society, although it addresses the urgent need for an effective strategy to manage the natural resources necessary for agri-food systems.

When it comes to a comparison between climate-smart agriculture and organic agriculture, the former is defined by the desired outcomes - agricultural systems that are resilient, productive and have low emissions, while organic agriculture is defined by the production method (without the use of synthetic pesticides or fertilizers). However, many of the practices used in organic farming are climate smart. Ecological farming practices lead to the improvement of the uptake of nutrients from the soil and the restoration of organic matter in the soil, which can support resistance to climate change and contribute to the sequestration of carbon in soils.

Agroecology has been variously defined, from the simple "application of ecological principles" in agriculture (Saj et al., 2017) to the integrative study of the ecology of the entire food system", encompassing ecological, economic and social dimensions (FAO, 2016).

Regarding regenerative agriculture (carbon farming), it has been shown that agriculture has enormous potential to sequester organic carbon in soil, plants and trees, reducing CO₂ emissions that contribute to global warming (Zilberman 2014). Healthy soils help mitigate the effects of climate change and lead to better yields, maintaining biodiversity and improving ecosystem services (Gosnell *et al*, 2019). In the long run, agricultural practices such as agro-ecology, conservation agriculture, using rotations of crops and greening technologies including cover crops and permanent pastures are able to support capture carbon in the soil (Newton *et al.*, 2020).

CONCLUSIONS

Agriculture, perhaps the most climate-dependent human activity, was initially seen as a victim of climate change. Increasing temperature trends, greater frequency of extreme weather events and greater seasonal variability have been described as posing new threats to global agriculture. Agriculture was then considered to be one of the culprits responsible for climate change, due to direct emissions of greenhouse gases from ruminants, the manufacture and application of fertilizers, as well as energy use on farm or indirect emissions related to land-use change. Agriculture is now also beginning to be seen as a solution to climate change due to the role it can play in mitigating greenhouse gas emissions. Climate-smart agriculture can help design land-use systems that make adaptation-mitigation connectivity a reality at all levels, and thereby help farmers become key players in climate change solutions

Sustainable, climate-smart agricultural practices are essential for mitigating the effects of climate change on agricultural production. Governments and international organizations should continue to provide support to farmers and rural communities in order to help them adapt to the changing climate. This could include providing access to financing, investing in research and development of new technologies. CSA is also a key component of the European Union's CAP. The CAP encourages farmers to adopt CSA practices, such as the use of climate-smart crop varieties and soil-management practices, as well as to improve the resilience of agricultural production to climate change. Furthermore, CAP provides financial support to farmers to help them adopt CSA practices and invest in technologies and infrastructures that are adapted to climate change.

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