NANGARHAR UNIVERSITY
INTERNATIONAL JOURNAL OF BIOSCIENCES
REVIEW ARTICLE
e-ISSN: 2957-9988
NUIJB Special Issue, 2024

Received: 21 Dec 2023 Accepted After Revision: 22 Jan 2024 Published Online: 10 Feb 2024

# Climate-Smart Agriculture: Climate Change-Friendly and Resilient Agriculture

**Kazimi Zaigham[1*] and Hussaini Sayed Muhammad Baqer[2]**
[1]Department of Agriculutral Economics and Extension, Faculty of Agriculture, Bamyan University, Bamyan, Afghanistan
[2]Department of Agronomy, Faculty of Agriculture, Bamyan University, Bamyan, Afghanistan
*Corresponding author: s.z.kazimi@gmail.com

## ABSTRACT
The world is now facing a dilemma because; on the one hand, agriculture intensification to feed the skyrocketing population entails more fossil fuels consumption and more synthetic fertilizers application inducing more Greenhouse Gases (GHGs) emissions that exacerbate climate change. Climate change, on the other hand, has led to adverse effects on the agriculture sector on a global scale despite some minor advantages in higher latitudes. Climate-smart agriculture (CSA), hence, is the only solution to ensure sustainable agriculture productivity and maintain its resilience to climate change consequences. It is a modern approach to responding the climate change by reducing the trade-offs and improving the synergies of agricultural practices. It stands on three main pillars namely, sustainable productivity, resilience-building, and GHGs emissions mitigation using indigenous knowledge and site-specific solutions. Among several practices applied, the Internet of Things (IoT) in agriculture is one of the modern initiatives that can achieve the principal goals of CSA significantly. Therefore, the overall goal of this review paper is to examine the reciprocal effects of climate change and agriculture, discuss the concept of CSA, and ascertain its applicability in Afghanistan.

**Keywords:** Agriculture, Climate Change, Climate-Smart Agriculture, Population

## INTRODUCTION
The world population is increasing fast–projected to reach nearly 10 billion by 2050. Thus, feeding such a huge population requires agricultural production to increase by 60% (Bhattacharyya, Pathak, & Pal, 2020). Achieving this goal, however, is not facile since natural resources are depleting and climate change is worsening agriculture productivity in terms of both quality and quantity. Increased temperature, precipitation abnormality, unpredictable weather conditions, and severe weather events e.g. floods, cyclones, hurricanes, frequent droughts, wildfires, etc. are some of the consequences of climate change that have affected the agriculture sector and deteriorated food security across the globe (EPA, n.d.). Most plants and animals live in areas with specific climatic conditions that enable them to thrive; hence, any climatic changes in their habitat affect them and the whole makeup of the ecosystem. Climate change has detrimental impacts on agriculture viability worldwide, but these impacts are more severe in developing countries associated with their fragile economy and a lack of adaptive capacities (Ludwig, *et al.*, 2007). "Afghanistan ranks eighth on the Notre Dame Global Adaptation Index of countries most vulnerable and least prepared to adapt to climate change. Today, 25 out of 34 provinces experience either severe or catastrophic drought conditions, affecting more than 50 percent of the population", (Gomo, 2023). Severe droughts, rising temperatures, weather swings, and destructive floods are some of the major climate change consequences in the country, he further argues. Climate change, on the other hand, aggravates as countries attempt to produce more food through agricultural intensification – more anthropogenic GHGs emissions. Therefore, scientists unanimously suggest that the world should be committed and practice CSA to tackle this perplexity. CSA is both climate change-friendly and resilient meaning that it can maintain agricultural productivity while mitigating GHGs emissions from agricultural practices.

## RESULTS

### *What is CSA?*

The term Climate-Smart Agriculture (CSA) was first coined by FAO in 2009 (Bhattacharyya & Pal, 2020). It stands on three pillars namely, (i) sustainable increase of agricultural productivity, (ii) adaptation and resilience-building to climate change, and (iii) mitigating GHGs emissions from agricultural activities. It provides guidelines for all agricultural stakeholders to identify suitable agricultural strategies and approaches to achieve its principal goals by reducing the trade-offs and promoting the synergies of agricultural practices (WEF, 2020).

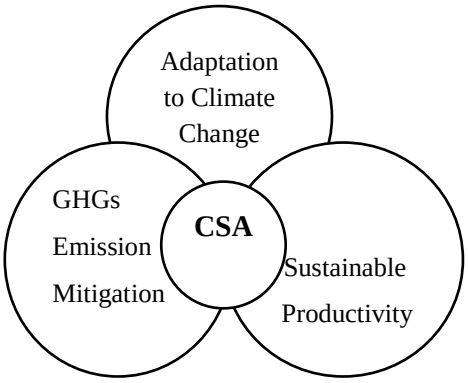


**Figure 1:** Pillars of CSA

Source: WEF, 2020

### *Dimensions of CSA*

As seen in Figure 2, CSA is an integrated approach of six dimensions namely, Water-Smart, Weather-Smart, Nitrogen-Smart, Energy-Smart, Carbon-Smart, and Knowledge-Smart that need to be addressed simultaneously (Bhattacharyya, Pathak, & Pal, 2020). The following sections provide a concise guideline of how to achieve the goals of each dimension:

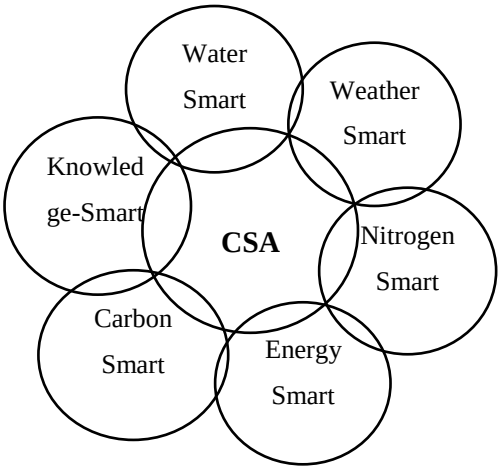


**Figure 2:** CSA Dimensions

Source: Bhattacharyya, & Pal, 2020

### *Water-Smart Dimension*

The overall objective of the water-smart dimension is to use irrigation water efficiently and conserve water resources. Since agriculture irrigation accounts for 70% of global water consumption (OECD, n.d.), this dimension of CSA is highly crucial as water resources are becoming scarce associated with consecutive droughts. Therefore, rainwater harvesting, in situ moisture conservation, integrated farming systems, mulching, cover crops, organic matter supply in soil, land leveling, sprinkler, and drip irrigation, greenhouse production, humidity and moisture sensors installation, drought-resistant and short-season varietal development are some of the major practices and technologies used to produce agricultural products with zero or minimum loss of water resources.

### *Weather-Smart Dimension*

The main purpose of the weather-smart dimension is to provide farmers with proactive information about weather conditions for better crops and livestock production and protection. It is mainly concerned with real-time monitoring and reporting of weather parameters (temperature, rainfall, humidity, storms, etc.), weather-based agro-advisory services, weather-based crop insurance, climate awareness, and climate-based housing for livestock. The establishment of "rain gauges" and the installation of automatic weather stations can help the peasant communities monitor weather parameters on a real-time basis and plan out their activities accordingly.

### *Nitrogen-Smart Dimension (NSD)*

The principal goal of the nitrogen-smart dimension is to optimize N-fertilizer application, improve N-uptake efficiency, and reduce $N_2O$ emissions. As N-based fertilizers (synthetic or organic) applied in soils are the main source of $N_2O$ emissions, any approach that can supply the required N in soil, improve its uptake efficiency, and minimize $N_2O$ emission is considered a nitrogen smart approach. Hence, green manuring, site-specific nutrient supply, leaf color chart-based N application, cereals-legumes cropping, 4R nutrient stewardship, catch crops, and farmyard manure management are some of the agricultural practices of NSD.

### *Energy & Carbon-Smart Dimension*

The core objective of energy and carbon-smart agriculture is to minimize $CO_2$ emissions, maximize energy use efficiency, and reduce the cost of production. Hence, using resource conservation technologies, conservation agriculture, integrated farming systems, agroforestry, integrated pest management, crop diversification, etc. are some of the agricultural practices through which the goals of energy and carbon smart can be achieved.

### *Knowledge-Smart Dimension*

Knowledge-smart agriculture refers to technological development and use, capacity building, ICT application, mobile-controlled nutrients, pests and disease management, remote sensing, etc.

### *Livestock Management in CSA*

In most cases, animal husbandry is an integral part of agriculture known as agropastoralism. This subsector is also highly prone to climate change consequences. Therefore, Pasture Management, Building Appropriate Shelters, applying methanogenesis-preventing vaccines, Manure Management, and Breeding heat-resistant and low methane-emitting breeds are some of the practices of livestock management in CSA.

#### *Internet of Things (IOT) – A Modern Approach to Practice CSA*

IOT means "Internet Controlling Things" and refers to a system of interconnected devices through which farmers can monitor their farms on a real-time basis and practice smart and precision farming and livestock management. The term Internet of Things was coined in 1999 by Kevin Ashton, the executive director of MIT's Auto-ID Laboratory (Foote, 2022). Although it's been quite a while since sensors were introduced to agriculture, however, the problem with the conventional sensor application was the inability to get real-time data, but later from their attached memory sticks. With the introduction of IoT in Agriculture, advanced sensors connected to the cloud via cellular/satellite networks help farmers monitor their farms on a real-time basis, make informed decisions, optimize efficiency, enhance automation, use agricultural drones and robots, and overcome anomalies effectively and instantly. Hence, farm monitoring and control from everywhere, predictive analysis, efficient production, increased productivity, greenhouse automation, cattle monitoring and management, quick response to anomalies, etc. are some of the outcomes of IOT application in agriculture. Nonetheless, high initial costs, well-trained staff, incessant power and internet connectivity, fragmented farmlands, and hardware maintenance costs are some of the limitations and hindrances against the introduction of IOT in agriculture (Shalimov, 2023).

## DISCUSSION

CSA is the only solution through which the world can feed the growing population while keeping the planet a safe place to live. Countries should stay committed and it is the ethical responsibility of the richest countries (industrial countries) to provide financial, technological, and educational support to the poorest ones to help them improve their resilience and adaptive abilities because CSA adoption requires modern knowledge and technologies such as the case of IOT. In countries like Afghanistan with fragmented and scattered farmlands, CSA can be implemented using traditional methods mostly through reforming agricultural practices, however, the use of IOT presently seems a little inapplicable except for the greenhouses. But still, it is recommended for the farm managers to put in their maximum efforts and adopt IOT-based practices as much as possible.

## CONCLUSION

Climate change is inevitable. There are several ways human beings emit GHGs into the Earth's atmosphere leading to warmer temperatures on the planet's surface. Among other serious effects on human life, the agriculture sector is immensely affected by climate change leading to the sector's low productivity and low-quality products. These effects are more severe in developing countries associated with their fragile economy and a lack of adaptive capacities. Afghanistan, as a poor country, is also severely affected by the aftermath of climate change. One way to deal with the effects of climate change and sustain agricultural productivity is to adopt the CSA approach since it is both climate change-friendly and resilient. In other words, CSA helps farmers maximize farming efficiency and minimize GHGs emissions via farming activities. Among a range of technologies and approaches implemented, IOT is one of the modern scientific initiatives in agriculture which can be very handy to practice CSA in a real sense.

## REFERENCES


Bhattacharyya, P., Pathak, H., & Pal, S. (2020). *Climate Smart Agriculture: Concepts, Challenges and Opportunities.* Singapore: Springer.

EPA. (n.d.). *Climate Impacts on Agriculture and Food Supply*. Retrieved from United States Environmental Protection Agency: https://tinyurl.com/2p83t796

Foote, K. (2022). *A Brief History of the Internet of Things*. Retrieved from DATAVERSITY: https://www.dataversity.net/brief-history-internet-things/

Gomo, T. (2023). *Afghanistan: The alarming effects of climate change*. Retrieved from OCHA: http://tinyurl.com/23pu5s7a

Ludwig, F., Scheltinga, C., Verhagen, J., Kruijt, B., Ierland, E., Dellink, R., . . . Kabat, P. (2007). *Climate change impacts on Developing Countries -EU Accountability*. Retrieved from EU Parliament: http://tinyurl.com/2ume5n4y

OECD. (n.d.). *Water and agriculture*. Retrieved from The Organisation for Economic Co-operation and Development: http://tinyurl.com/4zv86z5w

Shalimov , A. (2023). *IOT IN AGRICULTURE: 9 TECHNOLOGY USE CASES FOR SMART FARMING (AND CHALLENGES TO CONSIDER)*. Retrieved from http://tinyurl.com/3e6w3tsd

WEF. (2020). *Why we must scale up climate-smart agriculture to feed a hungrier world*. Retrieved from World Economic Forum: http://tinyurl.com/mrx8skkd