Chapter 4
Climate-Smart Agriculture and Internet of Things Systems for Agricultural Production Efficiency in African Countries

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ABSTRACT

This chapter identifies climate-smart agriculture (CSA) practices and their impact on smallholder farmers in six African countries. Various CSA practices are discussed. Observations show that farmers who adopted CSA practices obtained positive results in terms of adaptability to climate change and productivity. Furthermore, internet of things (IoT)-enabled smart agricultural systems are explored. Observations indicate that IoT-based agricultural systems enable efficient utilization of farm inputs such as fertilizer, pesticides, herbicides, and water. Also, using IoT systems, it is possible to provide customized, location-specific, and easily understood climate data for smallholder farmers to facilitate decision making and planning of CSA practices. Therefore, this chapter has presented recommendations for the adoption of IoT-enabled CSA in African countries. IoT-enabled agricultural systems are recommended for a country like Senegal where climate data is considered an agricultural input and also for Tanzania where IoT devices such as UAVs are considered to be useful agricultural tools.

INTRODUCTION

It is predicted that the population of the world will reach nine billion people by the year 2050. Consequently, the global demand for food continues to increase. However, agricultural production is significantly affected by factors such as urbanization, soil erosion, climate change, and water shortages. Therefore, food security is one of the important goals in the United Nations sustainable development goals for 2030. This chapter addresses the challenge of food insecurity that is caused by climate change. Climate change refers to the increase in greenhouse gas (GHG) emissions such as nitrous oxide (N_2O), carbon dioxide

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(CO_2), and methane (CH_4) in the atmosphere resulting in irregularity, variability and unpredictability of rainfall, temperature increase, floods, and droughts (Ariom et al., 2022). Climate change causes variations in the intensity and frequency of extreme events such as droughts, which affects the agricultural production. It has been reported that Africa is among the most vulnerable zones across the globe. In Sub-Saharan Africa, climate change will result in reduced production of major cereal crops including maize, sorghum, and millet. It is predicted that by the year 2025, maize, sorghum, and millet yields will fall by 22%, 17%, and 17%, respectively. Furthermore, rain-fed crop yields will decrease by almost 50%. Many studies have indicated the vulnerability of African countries to climate change. For example, it has been projected that by 2050, East Africa will experience warmer temperatures, a 5 to 20% increase in rainfall between December and February, and 5 to 10% less rainfall from June to August (Ariom et al., 2022).

To address these challenges, the food and agriculture organization (FAO) of the United Nations proposed that agriculture practices should evolve and adapt to climate change by introducing the concept of climate-smart agriculture (CSA). CSA provides mechanisms for agricultural systems to support food production under new climatic conditions (Selbonne et al., 2023). CSA practices help to increase the adaptive capacity of farmers and ensure food security. Agricultural production is also increased when farmers use Internet of Things (IoT)-enabled smart agricultural systems. IoT-enabled smart systems help farmers to remotely monitor and report conditions of the field, climate, and crops. This enables efficient management of resources and effective control of farm inputs such as fertilizer, pesticides, and water, resulting in reduced costs and increased productivity. Furthermore, the IoT-enabled systems employ Artificial Intelligence (AI) algorithms to make predictions of the future based on present and past farm conditions so as to make agriculture less susceptible to climate change effects and sustainably produce sufficient food. The objectives of this chapter are to:

- Identify CSA practices and their impact on smallholder farmers in six African countries (Tanzania, Zambia, Nigeria, Benin, Senegal, and Algeria).
- Discuss the use of IoT-enabled smart agricultural systems for efficient utilization of fertilizer, pesticides, herbicides, and water.
- Provide recommendations for the adoption of IoT-enabled CSA in African countries.

BACKGROUND

CSA presents mechanisms for agricultural systems to produce sufficient food and ensure food security under new climatic conditions (Selbonne et al., 2023). Since the establishment of CSA in 2010, African countries have devised policies and frameworks to promote and scale CSA practices. This is because African countries have smallholder farmers who are vulnerable and worst affected by climate change. In 2014, The Malabo Declaration on Accelerated Agricultural Growth and Transformation of Africa's Agriculture for Shared Prosperity and Improved Livelihoods prioritized developing resilient agriculture as a development agenda (Kirina et al., 2022). During the summit, Vision 25 × 25 was launched with the target of at least 25 million farm households practicing CSA by 2025. Climate Change Policies in African countries provide frameworks that prioritize the adaptation and mainstreams climate change into development plans (Kirina et al., 2022). Furthermore, individual countries have devised CSA strategies to promote effective investments in CSA.