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LEVERAGING DIGITAL AND INNOVATIVE TECHNOLOGIES FOR AGRICULTURAL WATER MANAGEMENT

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Introduction

Digital technologies in irrigation systems play a crucial role in helping agriculture adapt to the challenges posed by a changing climate by promoting water conservation, resource efficiency, and improved crop resilience and productivity. By leveraging real-time data, remote control capabilities, and technology integration, IoT irrigation systems can improve system efficiency and reduce farmer's labor inputs for more climate-resilient agriculture.

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Digital Technologies Potential

Digital technologies hold vast potential for enhancing efficiency across agriculture and food production systems. By providing operators with immediate access to data, these technologies allow precise planning for irrigation, harvesting, and fertilization. This precision has the potential not only to optimize water and energy usage, but also to enhance crop yields, product quality, and environmental sustainability.

As depicted in Figure 1, digital technologies in agri-food systems production can be divided into solutions around mobile devices and social media, precision agriculture and IoT Technology, big data and analytics, integration and coordination, and smart systems.

Artificial intelligence (AI) is a key digital innovation that can revolutionize management by managing vast datasets and enabling informed decision-making. AI's capacity to analyze complex interdependencies among water, energy, and food systems makes it an invaluable tool for fostering sustainability. Through predictive analytics and scenario modeling, AI could help stakeholders anticipate challenges and implement adaptive strategies.

Incorporating digital technologies into agricultural systems has the potential to address the cascading effects of resource scarcity, particularly in climate-vulnerable regions. By integrating AI-driven insights, resource management becomes more adaptive and resilient to environmental stresses.
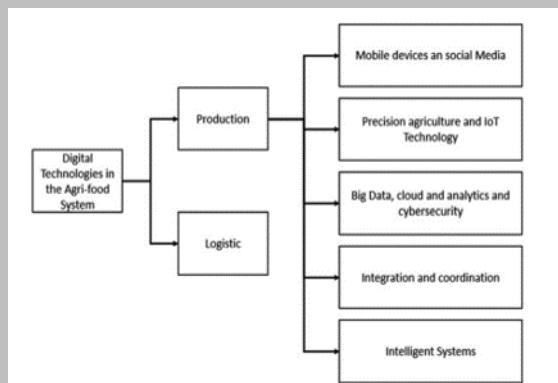
Figure 1: Digital Technologies in the agrifood system (Sanchez Santillano et al, 2022)

Case Study: IoT-Enabled Precision Agriculture in Niger

IoT-enabled and precision agriculture has the potential to increase resource efficiency and improve livelihoods for farmers. Solutions around these technologies must be tested to ensure applicability to particular contexts. In line with this, the project "Renewable energies to improve living conditions in Niger (RETO-DOSSO) has installed a Living Lab in Niamey, Niger to test the efficiency of different irrigation systems and the applicability of the technology.

Precision Agriculture and Conserving Water Use
Automated IoT- irrigation systems enable more customized water applications. Using sensors to monitor soil moisture and temperature, the system can tailor irrigation to specific crop types needs based on real-time data thereby only using the amount of water required by the crops when they need it [1]. IoT irrigation also enables farming systems to be divided based on factors such as plant type, soil type, soil exposure, or slope. Because each area can have customized irrigation, the schedules and amounts match the specific needs of the plant conserving water and increasing crop yields.

Weather Forecast Integration with Artificial Intelligence and Machine Learning
By connecting IoT irrigation system data with forecasted weather services, farmers are able to plan irrigation timing to consider upcoming weather conditions such as rainfall, temperature, and humidity and adjust accordingly to avoid unnecessary watering if rain is expected. Artificial Intelligence integration into weather forecasting opens up new possibilities. By integrating historical data, AI algorithms learn patterns to support weather predictions. AI's machine learning capabilities enable adaptation to changing weather conditions, enhancing forecast precision. Important in a changing climate, irrigation scheduling gives farmers greater adaptability to weather variability.

Remote Monitoring and Control
In addition to offering farmers more efficient water and heat stress management, IoT-enabled irrigation systems allow for remote monitoring and control over watering schedules saving on labor inputs. Traditional irrigation methods require significant labor, particularly in hot climates where evaporation rates are higher. IoT systems automate irrigation or allow for remote control saving farmers from arduous labor and freeing up their time and resources for other farm activities or economic enterprises.

Integration with Smart Farming Systems
In addition to the benefits offered by IoT-irrigation systems, integrating the systems with crop management platforms, renewable energy sources, or agrivoltaic systems contributes to the broader goals of sustainable agriculture. By integrating automated processes and using data-driven insights, energy consumption associated with irrigation is able to be reduced by aligning irrigation activities with peak solar generation periods. Agrivoltaic systems additionally offer synergistic benefits by allowing for rainwater harvesting and providing shading for the crops. Projects, APV-MaGa and RETO-DOSSO outline how integrating agrivoltaics and IoT irrigation systems can optimize the use of water, contribute to renewable energy generation, and enhance land-use efficiency.
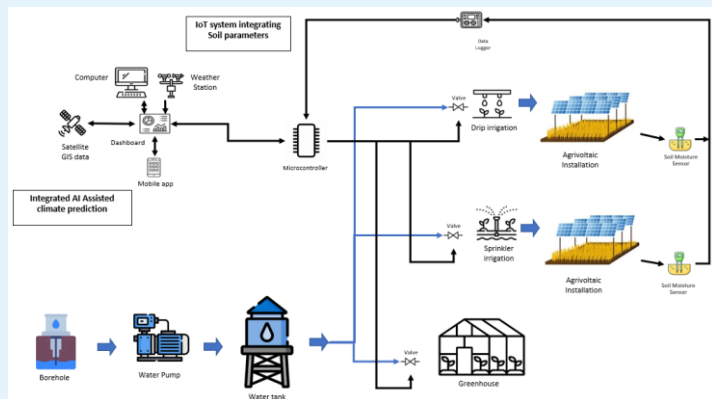
Smart Solar Irrigation System
Picture credit: Own elaboration, Icons: Flaticon.com

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Entrepreneurial Opportunity

Digital innovations in agriculture offer a wide array of entrepreneurial opportunities that can transform the sector by improving efficiency, sustainability, and productivity. Integrating business solutions or the fostering of business solutions is key to creating long-term lasting impact. Within the frame of RETO-DOSSO, youth entrepreneurial pursuits were fostered to ensure the long-term viability of the system to the community by creating economic opportunities around it.

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Conclusion

In addition to improving crop resilience to climate stressors such as heatwaves, droughts, or other extreme weather events, digital technologies in agriculture have the potential to increase entrepreneurial opportunities for smallholder farmers and technology start-ups. Innovations around agricultural water management has transformative potential for dryland areas and the Sahel. For more information and to connect with the RETO-DOSSO project staff visit the RETO-DOSSO project webpage.

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