ARTIFICIAL INTELLIGENT TOOL WORTH SCALING FOR SUSTAINABLE IRRIGATION IN MALAWI – A CASE OF CHAMELEON SENSOR ARRAY

African Technology Policy Studies Network (ATPS)
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About the Project

Africa's rapidly growing population, projected to reach 2.6 billion by 2050, posed significant challenges for agricultural and food systems. To meet the increased demand for food, production needed to rise by up to 70%. However, resource scarcity, climate change, the impact of the COVID−19 pandemic, and socioeconomic hardships made this a daunting task. Recognizing these challenges, the initiative focused on leveraging emerging technologies, particularly artificial intelligence (AI), to transform Africa's agricultural and food systems.

The project successfully advanced the responsible development, deployment, and scaling of AI research and innovations tailored to address Africa's agricultural challenges. A key achievement of the initiative was the establishment and management of the AI for Agriculture and Food Systems (AI4AFS) research network, which comprised ten innovation research projects. These projects focused on creating and implementing homegrown AI solutions that were tested, deployed, and scaled to meet Africa's specific agricultural needs.

The initiative deepened the understanding of how AI can be responsibly developed and scaled for sustainable agriculture in Africa. By building the capacity of African researchers and innovators, the project equipped them to create and apply AI solutions that had a tangible impact on agriculture and food systems. Moreover, the project contributed to shaping both African and international AI policy and practice by sharing valuable insights gained through research and innovation.

Throughout the project, several key activities were carried out, including issuing calls for Expressions of Interest (EOI), conducting training workshops for preselected consortia, and engaging with selected grantees. The project was overseen by the Hub Management Committee (HMC), which worked closely with a Hub Advisory Team (HAT) of experts to ensure strategic guidance and support. A robust Monitoring, Evaluation, and Learning (MEL) framework was implemented to track progress and ensure that the project remained on course. The initiative also fostered networking and collaboration through platforms for knowledge exchange, with quality assurance mechanisms in place to ensure transparency and credibility at every stage.

As a result of the project, African researchers and innovators were empowered with enhanced research infrastructure and a conducive environment to lead in AI for

Agriculture and Food Systems (AI4AFS). The research network was strengthened, generating new AI research and innovations that tackled pressing agricultural challenges in Africa. Additionally, the project contributed to the development of more inclusive policies and strategies that supported transformative change in AI for agriculture and food systems, based on the needs of African societies.

This initiative was part of the larger Artificial Intelligence for Development Africa (AI4D Africa) program, which was co−funded by Canada's International Development Research Centre (IDRC) and the Swedish International Development Agency (Sida). AI4D Africa aimed to create a future where Africans across all regions use AI to lead healthier, happier, and greener lives. Through this completed project, the mission to promote responsible AI innovation, improve quality of life, and drive sustainable development in Africa was successfully realized.

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Key Messages:

- Most smallholder farmers in Malawi irrigate by trial and error leading to over or under irrigation thus wasting water and nutrients.

- The consequence of poor water management is environmental degradation, low productivity and low profitability leading to low return on investment.

- Introduction of simple artificial intelligent soil moisture and nutrient monitoring tools proved to assist farmers in irrigation decision making as it gives them a frame of reference.

- Farmers and all stakeholders using such AI tools are realizing great benefits – water saving, high yield, capacity in water and nutrient management, conflict reduction and environmental sustainability.

- These simple farmer – friendly artificial intelligent tool are called Chameleon Sensor Array System and are worth scaling through Public Private Partnership to achieve sustainable irrigation water management and adapt to the impact of climate change on water scarcity in Malawi.

1. Introduction

Irrigation is central solution to food and nutrition insecurity in the face of rapid population growth and recurring droughts, as agriculture remains the main livelihood for most Malawians. The Government of Malawi is investing and promoting irrigation farming in its attempt to mitigate the negative effects of climate change on agriculture and food security. The investment urge has been noticed with heavy irrigation investments made on Shire Valley Transformation Program and Program for Rural Irrigation Development that is developing over 50,000 ha irrigation infrastructure. Nevertheless, the Malawian irrigation system is still one of the most inefficient and low on investment return irrigation system in the Sub-Saharan Africa. Most Malawian farmers still irrigate by trial and error thereby making irrigation more expensive than in other developing regions thereby lowering probability of generating a return on investment. This setback reduces investment in irrigation water. But studies by the Department of Research Services at Kasinthula have proved that use of simple soil moisture and monitoring tool can help farmer solve this problem. This policy brief presents evidence of why Chameleon Sensor Array should be scaled through PPP in order to achieve sustainable irrigation water management and adapt farmers to impact of climate change in Malawi.

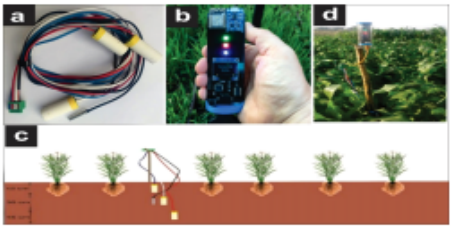
2. Rationale for the development and adoption of AI in Agriculture

For the sustainability and profitability of Malawi irrigation system, it was very important that DARS with partners developed and institutionalised adoption of the soil moisture and nutrient monitoring artificial intelligence (AI) technology called chameleon sensor array system and its institutional scaling framework. All planned irrigation development in Malawi is required to take on board issue of increased water use efficiency – more crop per drop concept in agriculture and food system. A major water efficient irrigation water management system using AI tools that involve stakeholder in a Public Private Partners framework to scale is required – This system is of great requirement so that the Malawi government sustains its irrigation investment that it has priotised and continue enjoying its associated fruits such as yield increase and climate change adaptation as well as its return on investment for a while. One main prerequisite to attain these benefits is to build a more water and nutrient efficient agricultural water management and irrigation water management system at irrigation schemes by reducing water and nutrient wastage.

The Public Private Partnership set-up is very necessary in scaling artificial intelligence in agriculture and food system. Increasing access to simple AI tools for monitoring soil moisture and nutrient under irrigated agriculture through PPP would improve crop productivity and profitability and will help Malawi meet Agenda 2063 and achieve the Sustainable Development Goal - 2 on zero hunger. Irrigation is the obvious answer for adaptation to impacts of climate challenge in order to achieve zero hunger. Yet, experience shows that achievement of this is challenging in most smallholder irrigation schemes in Malawi.

3. Methodology

A collaborative research project between Department of Agricultural Research Services (DARS), Mechro Ltd, World Vision Internation Malawi together with Lilongwe University of Natural Resources (LUANAR) and Department of Irrigation Services (DoI) was implemented in Malawi from September, 2022 to February, 2024, with support from African Policy Studies Network (ATPS). The project centred on applying AI in improving water and nutrient productivity as central solutions for sustainable agriculture development. It built on 8 years work by DARS and Commonwealth Scientific and Industrial Research Organisation (CSIRO), that developed and refined digitised soil moisture and nutrient monitoring tools (Fandika et. al, 2019; Stirzaker, 2014; Stirzaker 2017).



A cross-section of installed chameleon Wi-fi system with huge impact on transforming irrigation at both smallholder and commercial irrigation

Capitalising on this, the overarching goal was institutionalising the deployment and scaling of innovative AI solutions for improved agriculture and food availability. In order to scale sensor technology for soil water and nutrient prediction in irrigated agriculture, the project set up institution framework for scaling the responsible AI. The project followed a public-private partnership (PPP) approach which was used to institutionalise the production and deployment of responsible AI in agriculture and food systems in Malawi (figure 1). Mechro Ltd, in partnership with VIA Ltd in Australia, produced and supplied AI tools to irrigation farming communities whilst World Vision advocated its use.

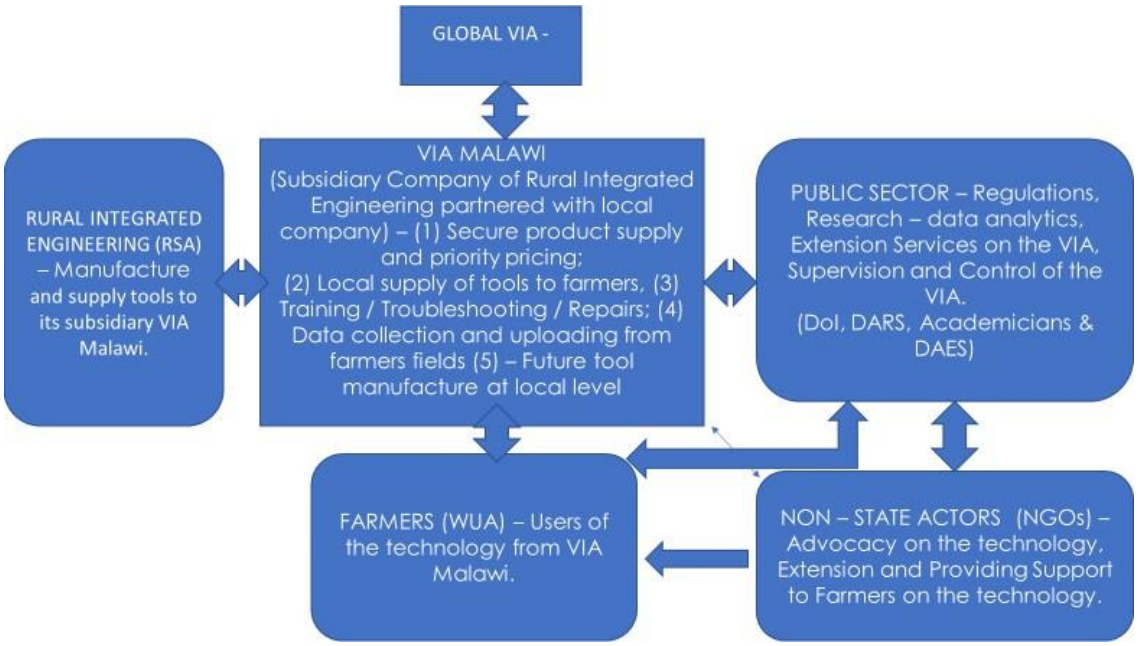
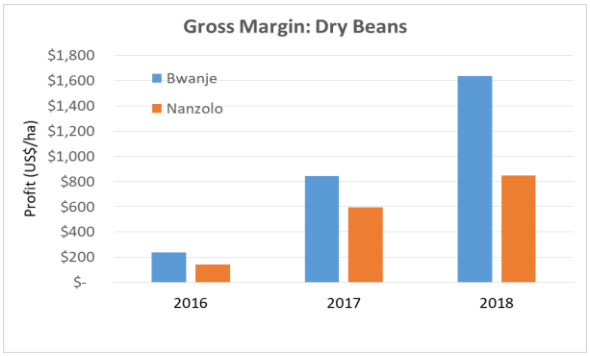


Figure 1: A Public Private Partnership Institutional structure for upscaling AIAFS – Chameleon Sensory Array in Malawi

Recent innovations in soil moisture and nutrient monitoring using simple tools – chameleon Wi-Fi system can dramatically transform irrigation by improving resource use, PPP scaling and gender and social inclusion leading to sustainable irrigation development and management as well as capacity enhancement in the sector.

4. Major Findings

- The simple and smart soil moisture monitoring tool gave farmers new frames of reference which has helped them in irrigation knowledge and decision making – now farmers can easily decide when and how much to irrigate their crops (Fandika et..al., 2019, 2020).
- Through learning by doing, AI tools – Chameleon Sensor arrays was easily learnt and applied well by farmers that helped the farmers to reduce number of irrigation events by half in a season without comprising yield (Stirzaker et…al., 2017; Fandika et..al., 2019, 2020).
- With the reduction in irrigation intervals and irrigation amounts, the AI tools improved farmers on time, labour and water saving. The saved time and labour were used in other productive work whilst the saved water improved the environment from water depletion or used in by other farmers (Fandika et..al., 2019; Sichali et…al., 2019).
- The AI tools also reduced conflict for water in irrigation schemes between upper and downstream users. This increased social cohesion among the farmers in irrigation schemes (Fandika at…al. 2019; 2020).
- The findings shows that the tools are socially inclusive where all gender categories and all literate levels can use them without much difficulties.
- Institutional Framework on Public Private Partnership can easily scale AI solution for irrigated agriculture in Malawi.
- The implemented pilot is showing over 90% adoption rate by the farmers. That is, the tool is now ready for out scaling in other geographic areas to benefit more smallholder farmers.



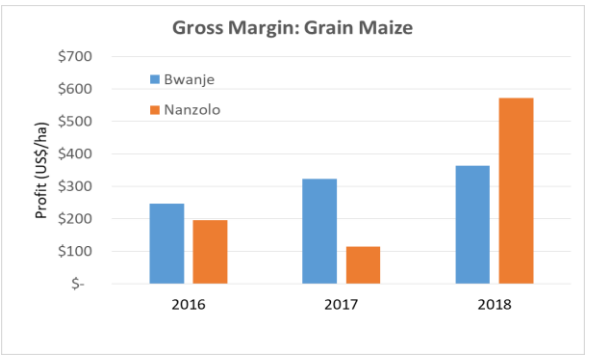
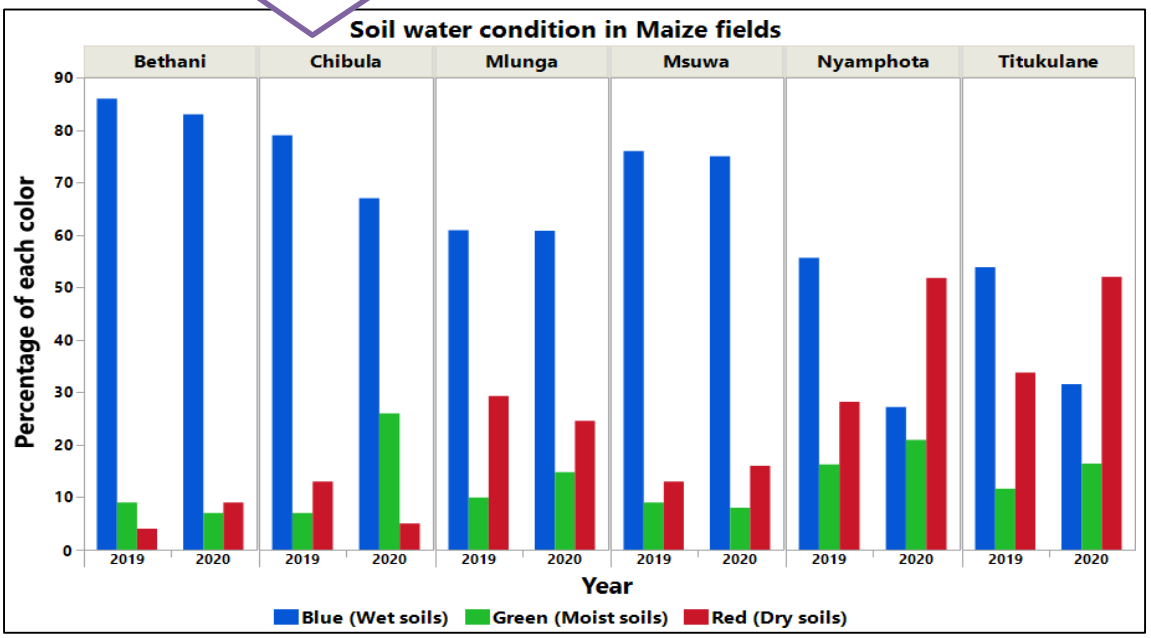


Figure 2: Gross margin of beans and maize at Bwanje and Nanzolo schemes increased with time using chameleon Sensor Array System in monitoring irrigation in Malawi.

"Chameleon Sensor Array System: A simple farmer – friendly artificial intelligent tool for monitoring and governing irrigation schemes for increased crop



5. Conclusion and Implications

Sustainable irrigation water management has been a challenge to achieve more crop per drop concept and realizing investment on return in most irrigated agriculture in Malawi and the whole of sub-Saharan Africa. The available artificial intelligence solution for the problem could not be easily accessed by farmers because of limited public private partners and stakeholder collaboration. This policy brief recommends policy strategies that can enhance capacity of Malawi irrigation system to achieve its three policy areas of priority – sustainable irrigation development, sustainable irrigation management and irrigation capacity building at farmer, extension and research level as well as stakeholders.

The available and emerging evidence from pilot studies, provide proof that with AI tool - chameleon soil moisture monitoring system, farmers are able to improve the value of irrigation water by more than threefold across irrigation season (before and after farmers used the tools). Farmers and all stakeholders can realize great benefits from use the AI – water saving, high yield, capacity in water and nutrient management, conflict reduction and environmental sustainability. Improved access to AI tools can be easily achieved by engaging stakeholders in a public private partnership. Therefore, Malawi's desires to continue upscaling the utilization of these responsible AI tools and make it sustainable can be achieved by the PPP business model.

It can be concluded that chameleon sensor array system is one of the best responsible AI tools that need to be scaled and that the PPP business model is the best approach for scaling artificial intelligence for agriculture and Food system in Malawi.

6. Policy Recommendations

Recommendation 1: The Department of Irrigation and its partners should integrate AI4AFS tools, like the Chameleon Sensor Array System, into irrigation schemes and lobby for import tax removal to ensure affordability, sustainability, and achievement of SDG2. Department of Irrigation and its development partners in irrigation development should be including AI4AFS tools - Chameleon Sensory Array System installation at the time of establishing irrigation schemes for sustainable irrigation investment and development in Malawi realize investment on return whilst achieving SDG2, therefore, strong policies and financing are essential in monitoring the irrigation system. Decision-makers must consider scaling AI4AFS tools. It would be imperative if the Ministry of Agriculture could initiate lobbying to Malawi Government of import tax removal for AI4AFS smart irrigation technologies such as Chameleon Sensor Array System so that they are affordable.

Recommendation 2: The Government of Malawi should promote stakeholder-driven Public-Private Partnerships (PPP) to scale AI4AFS tools for sustainable irrigation management, supported by regulatory frameworks and standards from relevant public institutions. Ministry of Agriculture through the Department of Irrigation should enhance stakeholder participation in scaling the responsible AI4AFS tools for irrigation, water, and nutrient management (Figure 1). The proposed institutional arrangements should include public sector, private sector, civil society or NGOs, academia and Water User Associations and this framework will be used to specifically; (1) provide irrigation management services using AI4AFS tools in an efficient and cost effective manner; (2) allocate the risks of the irrigation venture fairly between the private and public entities and (3) empower local private firms in providing AI4AFS tools and back up services to smallholder and private irrigators in Malawi. Public sector, Department of Agriculture Research Services and Malawi Bureau of Standards should be able to develop and provide regulatory framework and standards that will be used to regulate Agriculture and food systems.

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