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

African Technology Policy Studies Network (ATPS)
TECHNOPOLICY BRIEF NO. 87

Isaac Fandika
Geoffrey Mwepa
Grivin Chipula
Alinafe Kaliwo
Chimango Mlowoka
Herbert Kumwenda
Nicholas Ozor
Joel Nwakaire
Alfred Nyambane

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

Isaac Fandika[1]

Geoffrey Mwepa[1]

Grivin Chipula[1]

Alinafe Kaliwo[1]

Chimango Mlowoka[1]

Herbert Kumwenda[1]

Nicholas Ozor[2]
Joel Nwakaire[2]

Alfred Nyambane[2]

[1]Department of Agricultural Research Services, Lilongwe, Malawi
[2]African Technology Policy Studies Network (ATPS)

The African Technology Policy Studies Network (ATPS) is a transdisciplinarynetwork of researchers, policymakers, private sector actors and the civil society promoting the generation, dissemination, use and mastery of Science, Technology and Innovations (STI) for African development, environmental sustainability and global inclusion. In collaboration with like–minded institutions, ATPS provides platforms for regional and international research and knowledge sharing in order to build Africa's capabilities in STI policy research, policymaking and implementation for sustainable development.

Table of Contents

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.

About Africa Technology Policy Studies Network (ATPS)

The African Technology Policy Studies Network (ATPS) is a transdisciplinary network of researchers, policymakers, private sector actors and civil society promoting the generation, dissemination, use and mastery of Science, Technology and Innovations (STI) for African development, environmental sustainability and global inclusion. The ATPS has over 5,000 members and 3000 stakeholders in over 51 countries in 5 continents with institutional partnerships worldwide. We implement our programs through members in national chapters established in 30 countries (27 in Africa and 3 Diaspora chapters in Australia, the United States of America, and the United Kingdom). In collaboration with like–minded institutions, the ATPS provides platforms for regional and international research and knowledge sharing in order to build Africa's capabilities in STI policy research, policymaking and implementation for sustainable development.

Artificial Intellgent Tool Worth Scaling for Sustainable Irrigation in Malawi - A Case of Chameleon Sensor Array

Acknowledgement

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.

Artificial Intellgent Tool Worth Scaling for Sustainable Irrigation in Malawi - A Case of Chameleon Sensor Array

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 ofAgricultural Research Services (DARS), Mechro Ltd, World Vision Internation Malawi together with LilongweUniversity 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 improvingwater 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).
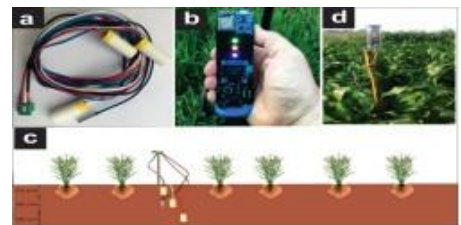
A cross-section of installed chameleon Wi-fi system with huge impact on transforming irrigation at both smallholder and commercial irrigation

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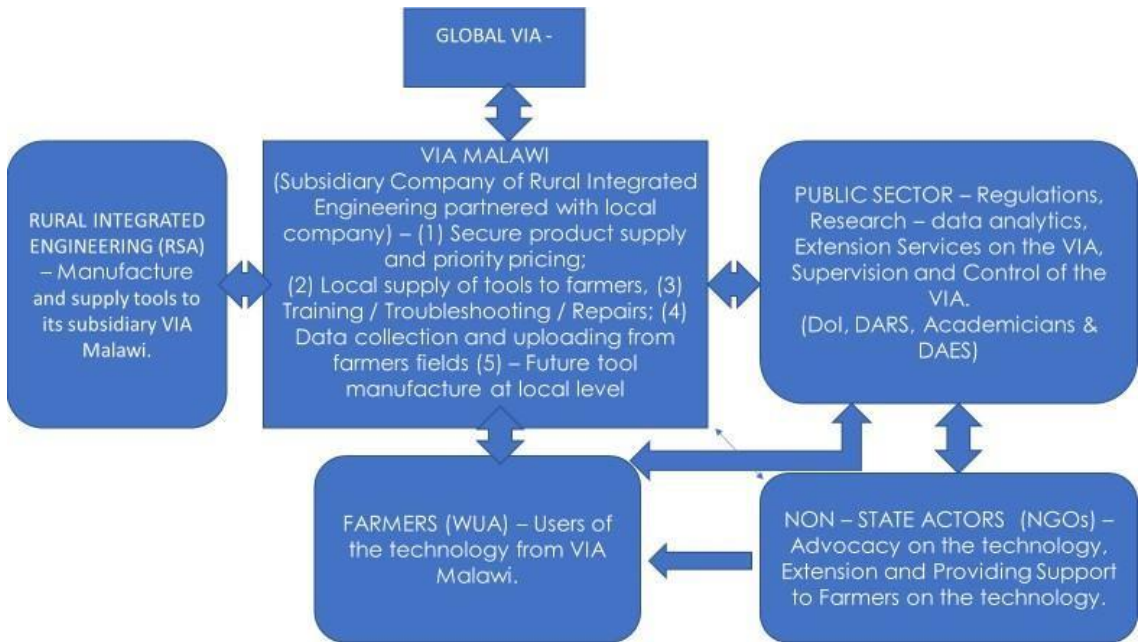
Figure 1: A Public Private Partnership Institutional structure for upscaling AIAFS – Chameleon Sensory Array in Malawi

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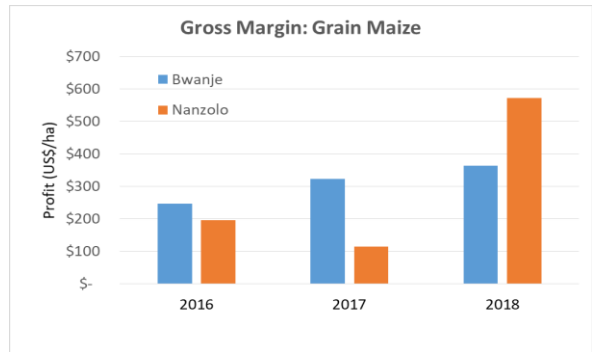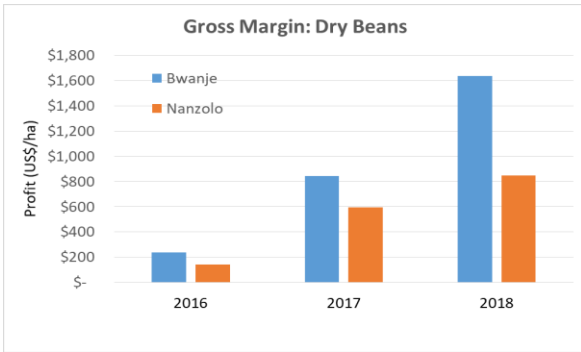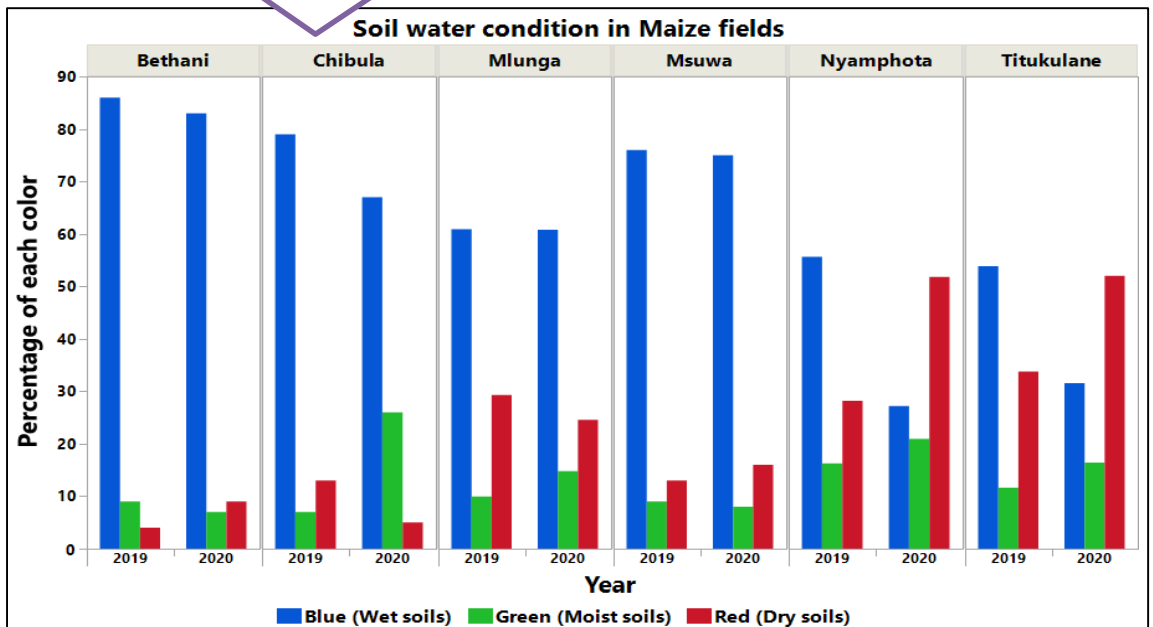
Figure 2: Gross margin of beans and maize at Bwanje and Nanzolo schemes increased with time using chameleon Sensor Array System in monitoring irrigation in Malawi.

"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: 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 water Management (Figure 2 and 3). This will ensure that irrigation investment and development in Malawi realize investment on return whilst achieving SDG2, therefore, strong policies and financing are essential on 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: Ministry of Agriculture through the Department of Irrigation should enhance stakeholder participation in scaling the responsible AIAF tools for irrigation water and nutrient management through Public Private Partnership (PPP) to achieve sustainable irrigation water 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 Agricultural 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.

Artificial Intellgent Tool Worth Scaling for Sustainable Irrigation in Malawi - A Case of Chameleon Sensor Array

References

1. Chikankheni, J.T., Stirzaker, R., Strong, C., Fandika, I.R. & Chipula, G. (2024) Simple soil water monitoring tools increase yield and income of smallholder farmers in Malawi: A case study of four irrigation schemes. Irrigation and Drainage, 1–13. ble from: https://doi.org/10.1002/ird.301

2. Fandika, I.R.; Stirzaker, R.; Chipula, G. (2019). Promoting Social Learning in Soil Water and Nutrients Management Using Farmer—Friendly Monitoring Technology. Proceedings 2019, 36, 19. DOI:10.3390/proceedings2019036019

3. Fandika, I.R; Stirzaker, R., Mwepa, G., Chipula, G., Chikankheni, J., Kumwenda, H and Kakhiwa, H. (2020). Improving Adaptive Water and Nutrient Management in Food Value Chains for Climate Change Adaptation: A Case of Sensor Technology in Malawi. ASRIC Journal on Water, Energy and Environment 1 (2020) 17-33. https://asric.inventis.ma/engineering-sciences/asric-journal-engineering-sciences-2020-v1-i1/improving-adaptive-water-and

4. Sichali, N., (2019). Improving Water and Nutrient Use Efficiency of Maize After Flooded Rice in Bwanje Irrigation Scheme, Malawi. Master's Degree. University of Pretoria. http://hdl.handle.net/2263/68446

5. Stirzaker, R., Car, N., Christen, E., (2014). A traffic light soil water sensor for resource poor farmers: proof of concept. Aciar Gov.Au/, https://www.aciar.gov.au/sites/default/files/2021-07/FSC2013002_FR_traffic_light_soil_water_sensor.pdf

6. Stirzaker, R., Mbakwe, I. and Mziray, N., (2017). A soil water and solute learning system for small-scale irrigators in Africa. International Journal of Water Resources Development, 33(5), pp.788-803.I, https://doi.org/10.1080/07900627.2017.1320981

ATPS TechnoPolicy Briefs Series

- Leveraging Artificial Intelligence for Sustainable Production and Market Access to Nsukka Yellow Pepper in Nigeria. (ATPS TechnoPolicy Brief No. 86)
- Decentralised Community – Powered Weather Networks for Hyper-localised Weather and Climate Information Services in Kenya. (ATPS TechnoPolicy Brief No. 85)
- Participation Des Parties Prenantes À La Mise En Œuvre Des Contributions Déterminées Au Niveau National (CDN) En (ATPS TechnoPolicy Brief No. 84)
- Enhancing Climate Action In Zimbabwe: Implementing Nationally Determined Contributions (Ndcs) (ATPS TechnoPolicy Brief No. 83)
- Unlocking Zambia's Climate Potential: Enhancing Stakeholder Roles in the Implementation of Nationally Determined Contributions (NDCs) (ATPS TechnoPolicy Brief No. 82)
- Empowering Local Communities and Enhancing Public Awareness for Sustainable NDCs Implementation in Namibia (ATPS TechnoPolicy Brief No. 81)
- Empowering Stakeholders for Inclusive and Sustainable Nationally Determined Contributions (NDCs) Implementation in Botswana (ATPS TechnoPolicy Brief No. 80)
- Uniting for a Sustainable Future: Boosting Stakeholder Engagement in Sierra Leone's Climate Goals (ATPS TechnoPolicy Brief No. 79)
- Stakeholder Participation in the Implementation of Nigeria's Nationally Determined Contributions (NDCs): Best practices, challenges and opportunities (ATPS TechnoPolicy Brief No. 78)
- Stakeholder Participation in Ghana's Nationally Determined Contributions (NDCs) Implementation: Challenging issues and opportunities (ATPS TechnoPolicy Brief No. 77)
- Stakeholder Participation in the Implementation of Nationally Determined Contributions (NDCs) in Côte d'Ivoire (ATPS TechnoPolicy Brief No. 76)
- Collaborative Climate Action for Sustainable Development: The case of NDCs Implementation in Uganda (ATPS TechnoPolicy Brief No. 75)
- Advancing Tanzania's Nationally Determined Contribution (NDCs) Goals Through Inclusive Stakeholder Engagement (ATPS TechnoPolicy Brief No. 74)
- Enhancing Stakeholder Participation in the Implementation of the Nationally Determined Contributions (NDCs) in Ethiopia (ATPS TechnoPolicy Brief No. 73)
- Paving the Way for Climate Action: Kenya's Journey towards Implementing the Nationally Determined Contributions (NDCs) (ATPS TechnoPolicy Brief No. 72)
- Quelle Est La Place De La Science, De La Technologie Et De L'innovation Dans L'emploi Des Jeunes Au Sénégal ? (ATPS TechnoPolicy Brief No. 71)
- Using Science, Technology, and Innovation to Enhance Skills Development, Job Creation, and Entrepreneurship in Zimbabwe (ATPS TechnoPolicy Brief No. 70)
- Fostering the future and livelihood of young people in Uganda through Science, Technology, and Innovation (ATPS TechnoPolicy Brief No. 69)
  - What is the place of Science, Technology, and Innovation in Youth Employment

- Improving the Relevance of University Training to Labour Market Demands in Africa (ATPS TechnoPolicy Brief No. 47)
- Developing Policies for Biodiversity Informatics in sub–Saharan Africa (ATPS TechnoPolicy Brief No. 46)
- ICTs role in Agricultural Development: Prospects of Land Potential Knowledge System (LandPKS) (ATPS TechnoPolicy Brief No. 45)
- Mainstreaming Gender in the National Science, Technology and Innovation (STI) Policy of Kenya (ATPS TechnoPolicy Brief No. 44)
- Social Innovation: An Untapped Resource for Inclusive Green Growth (ATPS TechnoPolicy Brief No. 43)
- Policy Axes that Can Uphold Agricultural Innovations for Climate Change Adaptation and Food Security in Central Africa: Case of Cameroon, Equatorial Guinea and Central African Republic (ATPS TechnoPolicy Brief No. 42)
- Frameworks for Intellectual Property Protection of Traditional Knowledge in Tanzania (ATPS TechnoPolicy Brief No. 41)
- Assessment of Possible Intellectual Property Protection Options of Traditional Knowledge System in Ethiopia (ATPS TechnoPolicy Brief No. 40)
- Towards influencing National Legislation, Policies, Strategies and Programmes for appropriate Protection and Benefit–Sharing of Traditional Knowledge (TK) with and by Traditional Herbalists in Uganda. (ATPS TechnoPolicy Brief No. 39)
- Traditional Healers and their Provision of Mental Health Services in Cosmopolitan Informal Settlements in Nairobi, Kenya. (ATPS TechnoPolicy Brief No. 38)
- Policy Implications for Intellectual Property Systems for Traditional Healers in Lesotho. (ATPS TechnoPolicy Brief No. 37)
- Incidence of Indigenous and Innovative Climate Change Adaptation Practices for Smallholder Framers' Livelihood Security in Chikhwawa District, Southern Malawi.(ATPS TechnoPolicy Brief No. 36)
- Machobane Farming System and its Relevance to Climate Change Policy in Lesotho. (ATPS TechnoPolicy Brief No.3

The African Technology Policy Studies Network (ATPS) is a transdisciplinary network of researchers, policymakers, private sector actors and the civil society promoting the generation, dissemination, use and mastery of Science, Technology and Innovations (STI) for African development, environmental sustainability and global inclusion. In collaboration with like–minded institutions, ATPS provides platforms for regional and international research and knowledge sharing in order to build Africa's capabilities in STI policy research, policymaking and implementation for sustainable development.

African Technology Policy Studies Network (ATPS)
Contact Executive Director:
executivedirector@atpsnet.org
8th Floor Chancery Building, Valley Road
P.O. Box 10081-00100 Nairobi
Tel: +254 (020) 2714092
www.atpsnet.org

Science, Technology and Innovation for African Development