Public Private Partnerships For Research Uptake and Commercialization in Africa: Strategies, Challenges and Policy Directions

Synthesis Report
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Executive Summary

This synthesis report is based on an analysis of the public-private partnership (PPP) initiatives under the Research and Innovation Management (RIM) project implemented by a consortium comprising of the African Centre for Technology Studies (ACTS), the Association of African Universities (AAU) and University of Cheikh Anta Diop (UCAD) in Dakar. The project aims to contribute towards building the capacities of councils in Sub-Saharan Africa to fund and manage research and innovation projects in their countries. It is funded under the Science Granting Councils Initiative (SGCI). In this context, this synthesis aims to understand the dynamics and intricacies around PPP initiatives arising from the implementation of these projects. Essentially, it interrogates the PPP arrangements, models, strategies and barriers embedded in the research initiatives funded under the RIM projects, particularly those geared towards commercialization/ scaling. Specifically, the synthesis aims to:

- Categorize the status of the PPPs funded under the RIM project and alignment to SDGs and Agenda 2063.
- Identify the structure/models of PPP arrangements embedded in research initiatives funded under RIM project – roles and responsibilities.
- Point out strategies for commercialization under the PPP arrangements – IP management, market analysis, and technology transfer.
- Discuss the challenges and barriers likely to be encountered in implementing PPPs for research commercialization in Africa.
- Discuss the policy implications of the PPP model for promoting innovation, entrepreneurship, and private sector engagement in Africa.
- Provide recommendations for key stakeholders to further enhance the effectiveness of PPPs in driving sustainable development and economic transformation.

The study mainly focused on desk review of research proposals specifically for projects focussing on up-scaling or commercialisation of outputs emanating from research initiates under the RIM project. Essentially, research initiatives under the RIM projects fall into 3 main categories: ideation/ product development, testing and adoption/uptake. Based on the above categorization, 9 RIM research PPP projects are at the ideation stage while 8 projects are at the testing stage. The remaining 6 projects fall under the stage of adoption and uptake.

The PPP projects have different arrangements and models regarding the roles of the different players – both private and public, intellectual Property (IP) and technology transfer mechanisms. However, in some projects, there seems to be lack of clarity regarding ownership of IP, which require careful negotiation and consideration of the interests and objectives of all parties involved, as well as compliance with relevant legal and regulatory frameworks. Beyond the heavy reliance on external support – which raises concerns about long-term sustainability – other challenges impeding effective implementation of PPPs include volatile market dynamics, weak monitoring systems, inadequate infrastructure, and limited policy support.

The study recommends a thorough technology assessment and market analyses to evaluate the commercial viability and potential risks in product adoption; substantial investment in training programs, technology transfer, and knowledge sharing platforms; crafting robust and equitable contractual agreements between the parties; providing adequate IP protection through patents; and establishing clear communication channels and fostering mutual understanding of each party's objectives.

Acknowledgments

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Through SGCI, the IDRC consortium has advanced the pursuit of a more equal and inclusive research and innovation ecosystem in Sub-Saharan Africa under the RIM project – an endeavor of significant importance.

Finally, we express our gratitude to the ACTS team – particularly those directly involved in the RIM project – for their dedication and support in its implementation.

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Abbreviations

AAU	Association of African Universities
UCAD	University of Cheikh Anta Diop
ACTIV	Therapeutic Interventions and Vaccines
DOP	District Production Office
IAIP	Integrated Agro Industrial Parks
IDRC	International Development Research Centre
IP	Intellectual Property
MOU	Memorandum of Understanding
NGOs	Non-Governmental Organizations
NIRDA	National Industrial Research and Development Agency
MINAGRI	Ministry of Agriculture and Animal Resources
PPP	Public Private Partnership
OICR	Ontario Institute for Cancer Research
PSP	Private Sector Participation
REMCO	Rwanda Engineering and Manufacturing Corporation
RIM	Research Innovation Management
SDG	Sustainable Development Goals
STEM	Science, Technology, Engineering, and Mathematics
SMEs	Small and medium-Sized Enterprises
SUA	Sokoine University of Agriculture
STI	Science, Technology and Innovation
SGCI	Science Granting Councils Initiative
UNBS	Uganda National Bureau of Standards
UNIDO	United Nations Industrial Development Organization

1. Background and Context

One of the key objectives of the Research and Innovation (RIM) project – funded under the Science Granting Councils Initiative (SGCI) – is synthesis of research results, generating research outputs and disseminating the same through various media. The synthesis aims to analyse and interrogate various aspects and commonalities deriving from implementation of the projects. The findings will enhance a deeper understanding of the projects that could help inform the conception and implementation of research projects under the Science Granting Councils Initiative (SGCI). Essentially, the synthesis aims to tease out what works and what doesn't – barriers and success factors.

In this respect, the project has identified specific thematic areas that form the basis of this synthesis, one of which is the Public-Private Partnerships (PPPs). Simply, a PPP is a formal arrangement between a public and a private entity for the purposes of delivering a project or a service traditionally provided by the public sector. A simple and practical definition of a PPP is '*any formal relationship or arrangement over fixed-term/indefinite period of time between public and private actors, where each partner interacts in the decision-making process and co-invest scarce resources such as money, personnel, and information in order to achieve specific goals in the area of STI*'. This arrangement can take many forms: from a partnership between a single company and a single university on a single research project with specific short term goals to the creation of research centres with a specific mission. The advantage of a PPP is that private-sector management skills and financial expertise can deliver better value for taxpayers when supported by effective public–private cooperation.[1]

For governments, public–private partnerships (PPPs) in science, technology, and innovation (STI) can make research and innovation policy more responsive to evolving innovation dynamics and global challenges. For businesses, partnering with public research institutions offers opportunities to solve problems, open new markets, and create value through collaboration and co-production. For governments, PPPs provide an attractive tool to address both market and coordination failures in research and innovation activities and leveraging private investment in STI activities. PPPs are also key instruments in addressing societal challenges of the coming decades -such as climate change, green growth or energy efficiency.[2]

1.1 Public-Private Partnership in STI

In the STI space, PPPs can accrue several advantages for both parties – government and private entities – by leveraging broader economic and social benefits from joint investments to accelerate innovation and technological solutions. PPPs can also help build new innovation capabilities, improve connectivity between national innovation systems and provide compatible incentives to all stakeholders. (OECD, 2015). This can be achieved by optimizing expertise among government, academic, and industry researchers. One special peculiarity with PPPs in STI is that many of the public assets are intellectuals – such as IP, databases, human capital or software with particular characteristics. The process is also complex as it involves standard setting, management of IPRs, and consumer acceptance. Specifically, PPPs can add value to research projects through:

1 https://www.icao.int/sustainability/Pages/im-ppp.aspx

2 https://read.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-industry-outlook-2014/strategic-public-private-partnerships_sti_outlook-2014-8-en#page1

a. Leveraging public support to business R&D by sharing costs and risks.

b. Fostering commercialization of research results from public research.

c. Internalize knowledge spillovers and overcome informational and behavioural barriers typically limiting the interactions between public research and the business sector, and

d. Securing higher-quality contributions from the private sector to government mission-oriented R&D and increasing opportunities for commercialization of public research.

Public private partnerships are conceived as legal relationships or agreements over fixed-term/ indefinite period of time, linking public and private actors e.g. industry, universities, public research/technology institutions, entrepreneurs – where both sides interact in the decision-making process, and co-invest scarce resources such as money, personnel, facility, and information in order to achieve specific joint objectives in research and innovation. Essentially, PPPs provide a legal structure to pool resources and gather critical mass, which enables a scale of effort that individual firms would not be able to achieve in spite of strong funding. The partners share risk, reward, and responsibility for shared investments[3].

In a nutshell, PPPs are arrangements between government entities and private sector companies for the purpose of financing, designing, implementing, and operating projects or services that were traditionally within the realm of the public sector. These partnerships leverage the respective strengths of both sectors to deliver public infrastructure or services efficiently and effectively.

1.2 Typology of Public-Private Partnerships under the RIM project

The term "public–private partnership" describes a range of possible relationships among public and private entities in the context of infrastructure and other services. Other terms used for this type of activity include private sector participation (PSP) and privatization. While the three terms have often been used interchangeably, there are differences: The government also provides social responsibility, environmental awareness, local knowledge, and an ability to mobilize political support. The private sector's role in the partnership is to make use of its expertise in commerce, management, operations, and innovation to run the business efficiently. The private partner may also contribute investment capital depending on the form of contract.[4] Although PSP is a term often used interchangeably with PPPs, PSP contracts transfer obligations to the private sector rather than emphasizing the opportunity for partnership. Meanwhile, privatization involves the sale of shares or ownership in a company or the sale of operating assets or services owned by the public sector. Privatization is most common and more widely accepted in sectors that are not traditionally considered public services, such as manufacturing, construction, etc. When privatization occurs in the infrastructure or utilities sectors, it is usually accompanied by sector-specific regulatory arrangements to take account of social and policy concerns related to the sale, and continuing operation of assets used for public services[5].

It is important to note that PPPs in research and innovation encompass a diverse set of modalities. For this reason, there are many forms of PPPs, depending on the type and number of partners, and the purpose, scope and time-length of the project. Public/private partnerships in research and innovation can also be classified according to the functional objectives and goals of

3 https://www.oecd-ilibrary.org/docserver/sti_in_outlook-2016-10-en.pdf?expires=1712237535&id=id&accname=guest&checksum=16BF1459D3B609AD7A7C0BA7CD774A4D

4 Public-Private Partnership Handbook, Asian development bank, https://www.adb.org/sites/default/files/institutional-document/31484/public-private-partnership.pdf

5 Ibid

governments, such as support for strategic research and technology development or commercialization; by type of financing mechanisms and timeframe, or per thematic[6].

1.3 Objectives of the Synthesis

This synthesis, therefore, aims to interrogate the PPP arrangements, models, strategies and barriers embedded in the research initiatives funded under the RIM projects, particularly those geared towards commercialization/scaling. Specifically, the synthesis aimed to:

- Categorise the status of the PPPs funded under the RIM project and alignment to SDGs and Agenda 2063.
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- Point out strategies for commercialization under the PPP arrangements - IP management, market analysis, and technology transfer.
- Discuss the challenges and barriers likely to be encountered in implementing PPPs for research commercialization in Africa.
- Discuss the policy implications of the PPP model for promoting innovation, entrepreneurship, and private sector engagement in Africa.
- Provide recommendations for key stakeholders to further enhance the effectiveness of PPPs in driving sustainable development and economic transformation.

1.4 Methodology

The study mainly focused on desk review of research projects that aim to scale or commercialise outputs derived from research initiates under the RIM project through PPP arrangements. In addition, the study also examined secondary data on successful PPP best practices which can then be used to evaluate the potential of the research projects under review.

6 https://www.oecd-ilibrary.org/docserver/sti_in_outlook-2016-10-en.pdf?expires=1712237535&id=id&accname=guest&checksum=16BF1459D3B609AD7A7C0BA7CD774A4D

1.5 Analytical Framework

This study examined the RIM projects focussing on PPPs with a view to understanding the arrangements inherent in these projects and how they are structured; strategies of commercialization barriers/challenges to implementation of PPPs; and policy implications of PPP research projects. This is encapsulated in the framework below:

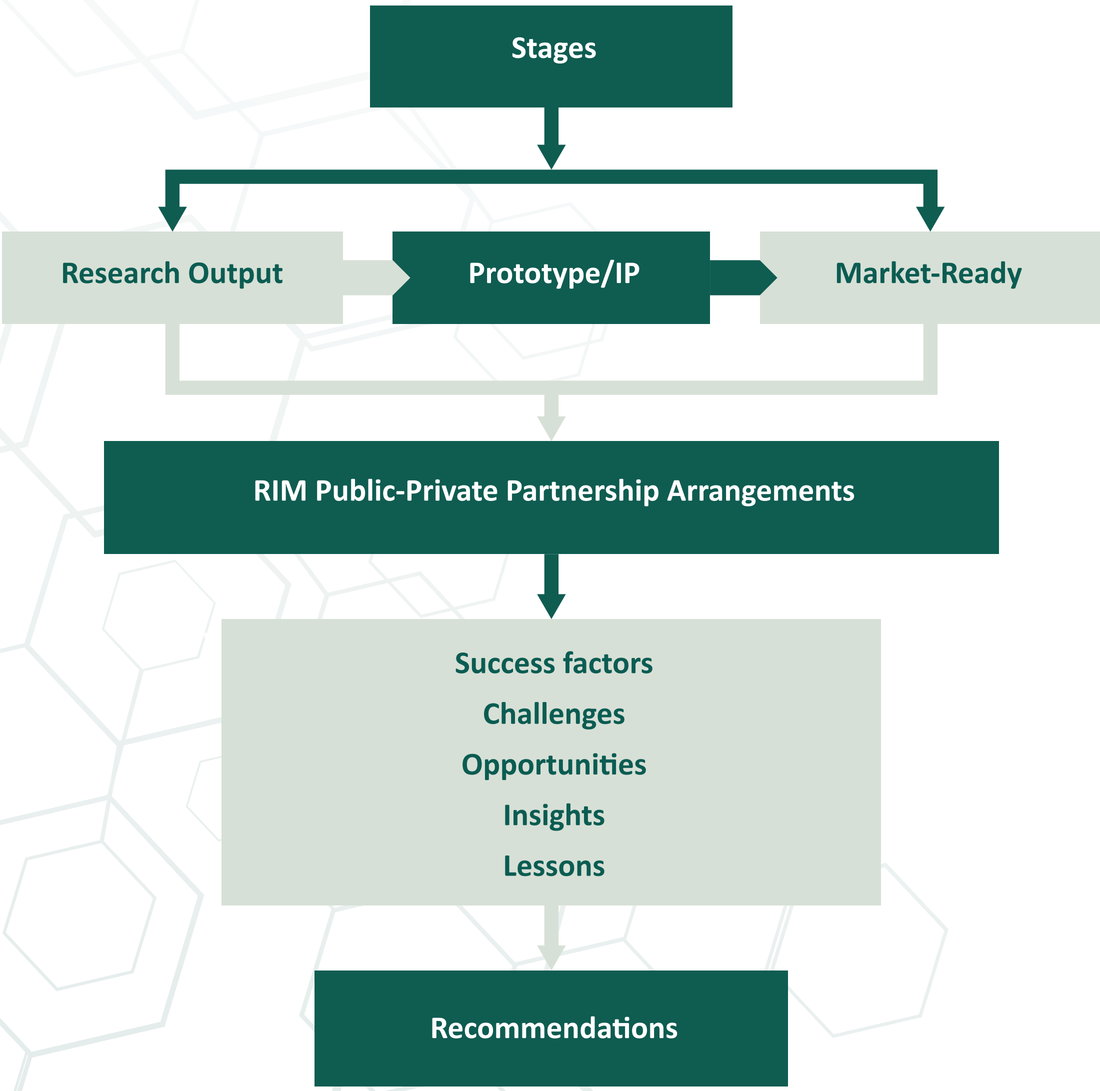

Fig. 1: Study analytical framework

2. Categorization of RIM Research Projects

This section highlights the different categories of PPP projects based on different dimensions including production sectors, stages/levels of maturity and alignment to development frameworks, mainly SDGs and Agenda 2063. It is worth noting that 27% of the 82 research projects under the RIM project – 22 in total – are PPPs, implemented across 10 of the 17 host countries.

2.1 Previously Funded SGCI and Projects

Although this synthesis focuses on the current RIM projects, It is important to note to that some projects – Kenya, Uganda, Zimbabwe and Ethiopia – were funded either during the previous phase of SGCI or by the respective councils; and are now being taken to the next stage of testing or adoption/market uptake. They could either have concretised the research products into prototypes or products which are now being taken to the next level. Some of the project funded previously under SGCI include 3 research initiatives in Uganda and one project in Zimbabwe. They are listed below:

1. Up-scaling the uptake of cocoa innovative technologies for enhanced value addition.
2. Maize germ and bran as raw materials for high fibre value added bakery and confectionery products.
3. Establishing a small scale food waste up-cycling facility for cricket feed production and marketing in Kampala.

The Research Council of Zimbabwe (RCZ) also previously funded one of the projects under SGCI 1 – *Commercialization of the development of novel Nano-engineered reagents for mineral froth flotation* – which has been taken to the next level under RIM.

2.2 Previous Projects Funded by Councils

A number of Science Granting Councils (SGCs) funded research initiatives that were later selected to be up-scaled under the RIM project, including two each in Kenya, Rwanda, and Ethiopia. They are listed below:

Kenya

- Bio-prospecting for bio-active metabolites and biological control agents from soil and aquatic habitats in Kenya.
- Commercialization of cassava for improved food and nutritional security in Western Kenya.

Rwanda

- Rwanda Cricket farming.
- Enhancement of production technologies, quality and competitiveness of Rwandan banana beverage products.

Ethiopia

- Scaling up post-harvest loss reduction technologies for horticultural crops using biomass waste packaging materials.
- Scaling up of agricultural by-Product utilization efficiency through the application of bio and physical feed processing technologies.

2.3 Preferred Sectors for Public Private Partnerships (PPPs)

It is emerging that the PPP research initiatives under the RIM project are concentrated on 7 production sectors – mainly based on agriculture, which accounts for more than half of the projects (13). Specifically, the PPP projects are spread across 7 sub-sectors: food and nutrition (8), agricultural technologies (5), emerging technologies (5) and water (2). The other sectors, which account for single research projects are energy, climate change and education. This is illustrated in the table below:

Table 1: PPP projects categorised by sectors

Sector	Type of Innovation	Country
Agricultural Technologies	A machine for chopping different types of crop residues	Ethiopia
	Packaging material from biomass waste	
	Adjustable multi-grain seeding machine / engine power tiller	Rwanda
	Smart technologies for minimization of post-harvest losses	Zambia
	Biological Control agents	Kenya
Food and Nutrition	Commercial Cricket flour	
	Starter culture for banana beer	Rwanda
	Cocoa products - chocolates	Uganda
	Cricket food production	Rwanda
	Maize bran and germ	Uganda
	Cassava Products	Kenya
	Jolly fryer production and commercialization	Nigeria
	Pigeon pea-based noodles and instant porridge toward improving nutrition security among households in Tanzania	Tanzania
Water	Hydrogel technology capable of harvesting atmospheric water	Nigeria
	Biosensor Device for Water Purification Using Solar Energy	Nigeria
Energy	Energy efficient briquettes	Ethiopia
Climate Change	Exhaust emissions gas analyzer and axle road systems	Rwanda
Emerging technologies	Road Safety Monitor	Nigeria
	Developing smart technologies for minimization of post-harvest losses	**Zambia**
	An AI based cattle identification mechanism for smallholder farmers in Sub-Saharan African countries	Zimbabwe
	MedScaleApp: Scaling up Mass Drug Administration for Schistosomiasis post COVID-19 pandemic	Ghana
	Commercialization of the development of novel nano-engineered: reagents for mineral froth flotation project	Zimbabwe
Education	Learning application	Sierra Leone

2.4 Stages of Innovation of the PPP Projects

Originally developed by NASA in the 1970s for space exploration technologies, TRLs assess the maturity level of a technology throughout its research, development and deployment phase progression. TRLs are based on a scale from 1 to 9, with 9 being the most mature technology. Many organizations have implemented TRLs for their own purposes, with certain organizations, such as the European Union (EU), further normalising the NASA readiness-level definitions, allowing for easier translation to multiple industry sectors – not just space exploration. This is described in Table 2.[7]

Table 2: Technology Readiness Levels

TRL	Description	Examples
1	Basic principles observed	Scientific observations made and reported. Examples could include paper-based studies of a technology's basic properties.
2	Technology concept formulated	Envisioned applications are speculative at this stage. Examples are often limited to analytical studies.
3	Experimental proof of concept	Effective research and development initiated. Examples include studies and laboratory measurements to validate analytical predictions.
4	Technology validated in lab	Technology validated through designed investigation. Examples might include analysis of the technology parameter operating range. The results provide evidence that envisioned application performance requirements might be attainable.
5	Technology validated in relevant environment	Reliability of technology significantly increases. Examples could involve validation of a semi-integrated system/model of technological and supporting elements in a simulated environment.
6	Technology demonstrated in relevant environment	Prototype system verified. Examples might include a prototype system/model being produced and demonstrated in a simulated environment.
7	System model or prototype demonstration in operational environment	A major step increase in technological maturity. Examples could include a prototype model/system being verified in an operational environment.
8	System complete and qualified	System/model produced and qualified. An example might include the knowledge generated from TRL 7 being used to manufacture an actual system/ model, which is subsequently qualified in an operational environment. In most cases, this TRL represents the end of development.
9	Actual system proven in operational environment	System/model proven and ready for full commercial deployment. An example includes the actual system/model being successfully deployed for multiple missions by end users.

7 https://www.twi-global.com/technical-knowledge/faqs/technology-readiness-levels

Essentially, research initiatives under the RIM projects can mainly be classified into 3 main categories: ideation, development/ testing and adoption/uptake. These stages are outlined below:

- **Ideation** - This is the process of generating, developing, and refining ideas for new products or features. Generating ideas through research.

- **Testing/development** - Conduct thorough testing to ensure the product meets quality standards and user requirements, including functional testing, usability testing, and performance testing.
- **Adoption/Uptake** - putting the product in the market - including pricing, distribution channels, marketing, and sales. This involves finalizing production processes, setting up distribution channels, developing marketing and sales strategies, and launching the product to the market.

Based on the above categorization, 9 RIM research PPP projects are at the **ideation** stage; 8 projects at the **testing** stage and 6 projects fall under the stage of **adoption and uptake**.

2.5 PPP Projects at the Ideation Stage

An analysis of the RIM projects show that 9 projects are at the Ideation stage. They are summarised in the table below:

Table 3: PPP projects at the ideation stage

#	Innovation	Country	Expected Output
1	A real time operating system that monitors the violations of road traffic regulations.		"iDetect23" App/device
2	Production and commercialization Jolly fryer	Nigeria	Automated garri frying technology
3	Developing a multipurpose, reusable hydrogel technology capable of harvesting atmospheric water through a sorption-desorption process.	Nigeria	Hydrogel beads and atmospheric water harvesting device
4	Creation of Biosensor Device for Water Purification Using Solar Energy.	Nigeria	Biosensor Device for water purification
5	Developing AI device for personalized learning.	Sierra Leone	AbuSensebod, an all-in-one educational platform.
6	An AI based cattle identification mechanism for smallholder farmers in Sub-Saharan African countries.	Zimbabwe	A secure biometric cattle identification device
7	Scaling up mass drug administration for schistosomiasis post COVID-19 pandemic.	Ghana	Medscale App
8	Developing smart technologies for minimization of post-harvest losses.	Zambia	Post-harvest technology
9	Production of energy-efficient bricks.	Ethiopia	Briquettes

2.6 Examples of PPP Projects at the Ideation Stage

An intelligent device that detects and records road traffic violations in Nigeria

Researchers in Nigeria are developing an intelligent device with the ability to detect and record road traffic violations in Nigeria. Dubbed *"iDetect23*", the device is a real time operating system that monitors violations of road traffic regulations and transmits the data to relevant authorities via a secure IOT platform. The innovation is informed by the need to control the high number of fatalities due to road accidents in Nigeria, which has been largely attributed to inefficient ways of tracking, reporting and recording traffic violations. This necessitates the need to have an embedded system that enables relevant agencies to effectively monitor and sanction these violators with a view to minimizing deaths resulting from road accidents. The proposed device is an embedded system that integrates a series of hardware like a GPS module, Google maps, speed sensor, collision sensor, gas sensor, buzzers, compass, LCD, Wi-Fi module, batteries, and software such as dedicated cloud server, mobile apps that detects and report drivers who violate road traffic regulations to the relevant authorities with high-level of precision. Once operational, *iDetect23*, would offer real time tracking of vehicles using Wi-Fi connectivity, real time transfer of speed data to relevant authorities. This technology possesses the potential of floating a spin-off company to manufacture and assemble as well as fit the device into the vehicles.

AI platform for personalized learning in Sierra Leone

Researchers in Sierra Leone are developing an all-in-one educational platform that facilitates personalized learning in local languages through its English-to-local language converter. The App, *AbuSensebod*, integrates human and AI-driven mentors that provide guidance to students through online communities for students to learn from each other, foster research, and provide support in their studies. It's also equipped to provide early intervention by recognizing students at risk of underachievement. Significantly, ***AbuSensebod's*** reach extends beyond the 29% of Sierra Leoneans with internet access. The App hopes to leverage the capabilities of AI in addressing Sierra Leone's unique educational challenges, enhancing the quality, accessibility, and inclusivity of education, and fostering a comprehensive and adaptive learning experience for students in Sierra Leone. It is designed to ensure students of all backgrounds, especially from remote areas or with limited English, access quality education; enhance personalized learning, early interventions, and mentorship foster superior results. It also provides insights into student behavior for corrective action and cater for students without Internet. The private sector has actively contributed to ***AbuSensebod's*** design and will stay engaged through consultations, feedback loops, and testing.

2.7 PPP Projects at the Testing Stage

There PPP research projects at the testing stage are summarised in the table below:

Table 4: PPP projects at the testing stage

#	Innovation	Country	Expected Output
1	Translating innovative research-based findings on edible crickets into nutritious commercial cricket flour that reduces malnutrition in infants and pregnant women in Rwanda.	Rwanda	Edible crickets
2	Prototype of indigenous yeast based starter culture for Banana based alcoholic beverage.	Rwanda	Starter culture
3	Developing exhaust emissions gas analyzer and axle road systems.	Rwanda	Exhaust emissions gas analyzer
4	Adjustable multi-grain seeding machine / engine power tiller	Rwanda	Multi-grade seeding machine
5	Establishing a small scale food waste up-cycling facility for cricket feed production and marketing in Kampala.	Uganda	Cricket feed
6	Development of maize bran and germ to replace wheat flour and wheat bran.	Uganda	Maize germ and bran
7	Bio-prospecting for bioactive metabolites and biological control agents from soil and aquatic habitats in Kenya.	Kenya	Biological control agent

2.8 Examples of Projects at the Testing Stage

A cheaper and better starter culture for banana beer production in Rwanda

For a long time, Rwandan banana beer companies have been using indigenous yeasts as a key ingredient for manufacturing beer. However, this product has not been suitable for this purpose due to its high cost and the resulting poor taste of beer. Now, the National Industrial Research and Development Agency (NIRDA), in collaboration with University of Rwanda and Institut Catholic de Kabgayi through the support of the National Council for Science and Technology (NCST), has developed a prototype of indigenous yeast based starter culture. The performance of this starter culture has been scientifically demonstrated and the quality of resulting banana beer validated during the sensory evaluation session organized at NIRDA. Researchers involved in this project have partnered with Panovita Ltd to initiate a pilot production and commercialization of the starter culture as a starting point in preparation for mass production. NIRDA is planning, in partnership with PANOVITA LTD, to fine-tune the developed culture into an attractive form fit for commercialization. . After that product market trial and launch will be conducted to position the product in the market. This will be followed by technology transfer for commercialization between NIRDA and PANOVITA Ltd, which will include full transfer IP rights for mass production and commercialization. Samples of the culture will be produced and distributed to selected companies for piloting production of banana beer; which will be given to consumers for perception testing. After this exercise, a willing-to-pay survey will be conducted among these banana processors and banana beverages consumers with a view to getting feedback.   PANOVITA Ltd will initiate the pilot production and commercialization of the culture for usage by the wider Rwandan community.

Converting maize bran and germ to replace imported wheat flour

In Uganda, a group of researchers are working on ways to use maize bran and germ as a substitute for wheat flour. This project is supporting the use maize bran and germ as a raw material/ ingredient in the production of bakery and confectionery value added products. This initiative aims to use maize bran and germ, produced abundantly in Uganda, to replace the imported wheat flour and wheat bran, thus localizing the baking sector. Using the already developed formulation, increased production of the maize bran and germ value added products, will be undertaken at a large scale by millers and processors. Products such as roasted bran and germ can also be used by other bakery and confectionery processors and households as a food ingredient.

This technology can be profitable if scaled up, commercialized and promoted amongst the private sector. In this phase, certification, packaging designing, branding, testing and Consumer/market surveys/ research will be undertaken. The market research provided insights on the marketing strategy tailor-made to a specific market segment and obtained feedback on its quality for the purposes of improvements and market strategies. The use of maize bran and germ instead of imported wheat flour as substitutes will make the bakery value chain more resilient and profitable. These products have also been proved to lower food caloric value. The project is implemented by Makerere University and Maganjo Grain Millers Limited, Jovay School of Cookery/ Breadmart, a small scale bakery and one other selected entrepreneur for commercialization. The project will also seek to identify other flours - millet, sorghum and pumpkin - that can be incorporated in these value added products to enhance their nutritional value and cut on the use of wheat flour tremendously.

2.9 PPP Project at the Up-scaling/Adoption Stage

The PPP projects at the up-scaling/adoption stage are summarised in the table below:

Table 5: PPP projects at Up-scaling/Adoption Stage

#	Innovation	Country	Expected Output
1	Scaling up of up of a novel feed processing machine for chopping and grinding of crop residues	Ethiopia	Feed processing machine
2	Development of post-harvesting technologies	Ethiopia	Packaging materials
3	Up-scaling the uptake of cocoa innovative technologies for enhanced value addition during primary processing.	Uganda	Cocoa products
4	Commercialization of the development of novel Nano-engineered reagents for mineral froth flotation project.	Zimbabwe	Nan-engineered reagents
5	Scaling up and commercialization of a pigeon pea-based noodles and instant porridge toward improving nutrition security among households in Tanzania.	Tanzania	Pigeon pea noodles and instant porridge
6	Commercialization of cassava products	Kenya	Assorted cassava food products

2.10 Examples of Projects at the Up-scaling/Adoption Stage

Commercialization of cassava products in Kenya

In a bid to address the high cost of energy food and feed, occasioned by over reliance on maize whose production is affected by climate change, a research project in Kenya is building on outputs from previous research to enhance commercialization of cassava by increasing production and developing nutrient rich cassava products for food and feed; producing highly nutritious blended and fortified cassava products and enhancing women and youth empowerment through engagement of private partners in the cassava value chain.

The cassava commercialization project arose from the research results of a previously funded project by the National Research Fund (NRF) where farmer-preferred selected cassava varieties were recommended for commercialization. The project expects to cultivate over 200 acres of cassava from which 1600 tons of the product will be harvested to produce 320 tons of cassava flour. The flour will be processed into three nutritious cassava products including baking flour - from a blend of cassava and wheat flour and porridge/ugali flour from a blend of cassava and sorghum/ millet flour. Other products include cassava blended silage, dried cassava root chips, pellets for poultry. Feeds for pigs, poultry and fish are also processed from a blend of cassava, premix and a protein source. A milling plant with the capacity of processing 5 tons of fresh cassava per day will be installed. This will include a hammer mill and all the accompanying machinery and equipment.

Commercialization of peas-based noodles and instant porridge in Tanzania

Researchers in Tanzania have developed pigeon peas-based noodles and instant porridge to increase recipe diversification of the plant. Now, the researchers want to upscale the pigeon pea-based noodles and instant porridge for public consumption (commercialization). This will help improve dietary quality of consumers as one of the strategies towards improving food and nutrition security in the country. Based on a cross-sectional survey of product attributes, a business model was developed to guide project implementation and support product refinement. Conjoint experiment was also conducted to determine willingness to pay for pigeon peas-based noodles and instant porridge. Production trial of pigeon peas-based noodles and instant porridge was done and tested for market potential.

The project team is composed of researchers from Sokoine University of Agriculture (SUA) and professionals from Tanya Company Limited. The company is responsible for production and marketing of the products. Experience of TANYA Food Company in marketing of food products is expected to have multiplier effect in the market niche. At the end of this project, the Intellectual Property certification will be obtained and pigeon peas-based noodles and instant porridge will be in the market for public consumption.

3. The Anatomy of PPPs under the RIM Project

Analysis of the PPP arrangements under RIM show that public organisations – research institutions and universities – mainly generate ideas through research and provide the technical foundations and know-how for the projects, in addition to the initial funds for product development and testing. Some projects have multiple private entities – companies, science/Industrial parks or hubs. Private entities mainly come in during the testing and adoption stage, when the product is now being introduced to the market. However, there are some private entities engaged in prototype development.

3.1 Partnerships with Established Private Companies for Market Adoption

A number of PPPs, especially those geared towards up-scaling and commercialization, have opted to partner with established private companies to accelerate market adoption. For example, In **Uganda,** a project on translating research findings of edible crickets into nutritious commercial cricket flour has incorporated Nutrifarm, a private company which has committed to providing in-kind contribution. However, the main role of the private sector seems to be in accelerating adoption of the products into the market. **In Rwanda,** the National Industrial Research and Development Agency has partnered with PANOVITA Ltd to set up a pilot production of developed banana beer starter culture as a platform to advance the technology in preparation for mass production and commercialization. The pilot production and commercialization exercise will inform how to improve the product and strategies for commercialization.

In **Uganda**, Makerere University and the National Coffee Research Institute have engaged two renowned chocolate companies – Lwanga Enterprises and Equator Chocolates – to push their new product in the market. These two private companies have been involved in both up-and down-stream project activities related to farmer producer organization formation, product market testing, technology up-scaling and providing market to the farmers' cocoa products. To enhance technology uptake and also develop a strong bargaining power amongst farmers, and ensuring continuity of the technology uptake, **established private cocoa producer organizations** have been identified through the District Production Office (DPO).

In **Tanzania,** a project on commercialization of pigeon pea, has engaged a private company, Tanya limited, which is working in collaboration closely with experts from Sokoine University of Agriculture (SUA) to commercialize the products. Leveraging on the experience of the company in food business of rice, honey and soap, the newly developed product is benefiting from the market knowledge of company to penetrate the market. The selected company is responsible for producing pigeon peas-based noodles and instant porridge to be distributed in the market as the main implementer of the innovation developed by SUA researchers.

In **Kenya**, a project on commercialization of cassava products, has partnered with a private company – Agro Service Provider Ltd which will assume the responsibility of managing the business of high nutrient human flour and livestock feed derived from cassava.

3.2 Partnerships Involving SMEs, Producer Organizations and Industrial Parks

A number of PPPs have also engaged SMES, producer organisations and industrial parks in different capacities. A good example is a project in **Ethiopia,** which is developing packaging materials from biomass wastes. It has engaged SMEs willing to launch their business at Integrated Agro Industrial Parks (IAIPs) in the country.

In **Uganda**, 40 local bakery factories/industries have been engaged to incorporate maize bran and germ as ingredient in their confectionery and baked products. The 40 entrepreneurs are selected basing on the first phase project interactions and their production capacities, more especially the ones involved in production of cookies, cakes and bread. Selection and inclusion criteria will also take in consideration of urban and rural locations. Also, thirty maize millers (15 female and 15 male proprietors), trained certified by Uganda National Bureau of Standards (UNBS), and mentored on the hygienic handling and production of maize bran and maize germ as ingredient/raw material for confectionery and baked products. The training focuses on the quality of the bran and germ produced by the millers and process improvement. Meanwhile, entrepreneurs involved in the project are required to participate in seminar presentations. During stakeholder workshops, practical utilization of germ and bran for bakery and confectionery are demonstrated. The selected entrepreneurs are supported with simple equipment for roasting bran and germ. They are expected to obtain roasted bran and germ to incorporate into their different product formulations. The maize millers will put into place systems to handle maize bran and germ hygienically. Also in **Uganda**, the project up-scaling the uptake of cocoa innovative technologies for enhanced value addition during primary processing is working with cocoa producer organizations and has set up demonstration centres for producer organization and other cocoa farmers.

3.3 Partnerships with Co-contribution from the Private Sector

Analysis of the PPP projects under RIM also reveal the existence partnerships through which the private sector is willing to co-contribute, either in cash or kind. For example, in Rwanda, a project developing adjustable multi-grain seeding machine is working with Tech Adopter Ltd – which has already got funding for piloting the project. The private partner has already completed 10% of the project through its own funding. Currently, the company is in the process of soliciting for funds to continue the research to achieve its implementation milestones. The project through, the Ministry of Agriculture and Animal Resources (MINAGRI) and Rwanda Agriculture Board (RAB), has also partnered with Rwanda Engineering and Manufacturing Corporation (REMCO) to manufacture the machines.

In one of the projects in **Uganda**, which aims to establish a small scale food waste up-cycling facility for cricket feed production and marketing in Kampala, has engaged a private company to guide the establishment and equipping of a facility for converting food waste to feed. The private company is expected to provide land space and complementary infrastructure while the project is providing the technological equipment and food waste processing expertise for the first 12 months of its operation. These include waste cleaning and sorting equipment and materials, food waste threshers, food waste steamers, a hybrid solar dryer, drying trays, a milling machine, a sealing machine, packaging, and a feed storage facility. This is the first private facility in Uganda dedicated to conversion of food waste to feed; it serves as a center for in-depth analysis of the social, technological, environmental and economic aspects of recycling food waste to feed on a commercial basis. The data collected from the facility will inform adaptation to an improved/ modified model that can be up-scaled by municipal centres and/or tendered waste collection companies.

3.4 Start-up/Spin-off Companies arising from PPPs

Other strategies for engaging the private sector involved registering a private company to take up wide adoption of the research products. A good example is in **Nigeria** where a project developing an application 'IDetect23,' a real-time operating system that monitors the violations of road traffic regulations, plans to register a private liability start-up company jointly owned by the TETFund and the inventors. This company is expected to produce and sell the device within the country. Startup funding will be provided by the core investor after a tripartite agreement between the Team, FRSC, stakeholders and the core investor.

Also in **Nigeria**, a project developing a multi-purpose, reusable hydrogel technology capable of harvesting atmospheric water through a sorption-desorption process, plans to establish a start-up company with basic equipment for production of hydrogel beads and atmospheric water harvesting device. This will lay the foundations towards maturing into an SME start-up fundable by specific banks to enable commercial production within a 3-5 years' timeline. In **Kenya,** the University of Embu, which is developing bio-prospecting for bioactive metabolites and biological control agents from soil and aquatic habitats, is working with DudutTech IPM Ltd to register a spin-off company that can be licensed to commercialize the innovation. Meanwhile, in a broader sense, the University of Embu has signed a start-up policy that will allow researchers at the university to form start-ups to commercialize innovations developed within or even outside the university. The university has a longstanding MOU with DuduTech that guides their collaboration. During the field testing, the project partnered with two start-ups (PlusFarm and Thorium organics) who are already working with farmers in promotion of organic farming.

In **Malawi**, a project developing a biometric cattle identification Application, is planning to register a digital start-up at the host University in Malawi. The start-up will participate in the project through testing of the digital method with cattle farmers. This project also partnered with a local AgriTech start-up in Malawi in its implementation.

3.5 Partnership on Prototype Development

In **Sierra Leone,** a private company has been involved in the design of AbuSensebod, an all-in-one educational platform. The company was available for consultations, feedback loops, and testing. In addition, the private sector and stakeholders were engaged in prototype testing, feedback, and pivotal roles in refinement. This enabled easy adoption of the technology. The project is also working closely with EasySTEM founded by passionate innovators from Sierra Leone, dedicated to providing equitable access to high-quality STEM education. Another example is a project in **Rwanda,** which has developed prototypes of exhaust emissions gas analyser and axle road system, is combining ICT-based high tech from Beno Holdings Technology Ltd, Mechanical Engineering skills from Ecomotive Ltd. and air pollution research skills from the University of Rwanda, to provide evidence-based and policy recommendations to reduce traffic emissions.

4. RIM Project Innovations and Alignment to SDGs/Agenda 2063

All the projects under review broadly fall under SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. However, they contribute to other goals, mainly Goal 2 - ending hunger, achieving food security and improving nutrition and promoting sustainable agriculture. The projects also make contributions to SDG 13 - Climate Action; SDG 12 - responsible consumption and production; SDG 6 - clean water and sanitation; SDG 4 - quality education. The table below shows the sectors and corresponding SDGs/Agenda 2063. However, some of the projects cross-cut different goals.

Sector	Type of Innovation	Country	SDG Goal	Agenda 2063
Agricultural Technologies	A machine for chopping different types of crop residues	Ethiopia	Goal 12: Ensure sustainable consumption and production patterns	Goal 5: Modern Agriculture for increased productivity and production
	Packaging material from biomass waste			
	Adjustable multi-grain seeding machine / engine power tiller	Rwanda		
	Smart technologies for minimization of post-harvest losses	Zambia		
	Biological Control agents	Kenya		
Food and Nutrition	Commercial Cricket flour		SDG Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Goal 3: Healthy and well-nourished citizens
	Starter culture for banana beer	Rwanda		
	Cocoa products - chocolates	Uganda		
	Cricket food production	Rwanda		
	Maize bran and germ	Uganda		
	Cassava Products	Kenya		
	Jolly fryer production and commercialization	Nigeria		
	Pigeon pea-based noodles and instant porridge toward improving nutrition security among households in Tanzania	Tanzania		
Water	Hydrogel technology capable of harvesting atmospheric water	Nigeria	SDG 6: Clean water and sanitation	
	Biosensor Device for Water Purification Using Solar Energy	Nigeria		

Energy	Energy efficient briquettes	Ethiopia	**Goal 7:** Affordable, reliable, sustainable and modern energy for all	**Goal 7:** Environmentally sustainable and climate resilient economies and communities
Climate Change	Exhaust emissions gas analyzer and axle road systems	Rwanda	**Goal 13:** Take urgent action to combat climate change and its impacts	
Emerging technologies	Road Safety Monitor	Nigeria	**Goal 9: Build resilient** infrastructure**, promote inclusive and sustainable industrialization and foster** innovation**.**	**Goal 4:** **Transformed Economies**
	Developing smart technologies for minimization of post-harvest losses			
	AI based cattle identification mechanism for smallholder farmers in Sub-Saharan African countries	Zimbabwe		
	MedScaleApp: Scaling up Mass Drug Administration for Schistosomiasis post COVID-19 pandemic	Ghana		
	Commercialization of the development of novel nano-engineered: reagents for mineral froth flotation project	Zimbabwe		
Education	Learning application	Sierra Leone	**SDG 4:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	**Goal 2:** Well Educated Citizens and Skills revolution underpinned by Science, Technology and Innovation

5. Intellectual Property Arrangements

Intellectual property (IP) arrangements for the projects under review are different depending on the nature of the collaboration. Nevertheless, there are a few strands that cut across, which include joint ownership – where the IP is jointly owned by the participating entities; and license agreement – where one party may retain ownership of the IP, while the other party is granted a license to use it. For example, a public institution may retain ownership of the IP and grant the private company a license to commercialize it in exchange for royalties or other compensation; and allocation of specific rights and responsibilities of each party regarding the IP are typically outlined in a legal agreement or contract at the outset of the collaboration. There are also commercialization strategies which include provisions for sharing revenues generated from commercialization; allocating costs associated with IP protection; and determining the roles and responsibilities of each party in bringing the IP to market. Other entities, mainly universities, form spin-off companies, where the university retains the IP.

Other IP arrangements include protection of background IP where each party may retain ownership of any pre-existing IP that they bring to the collaboration. Clear provisions for the use and protection of background IP are important to avoid disputes and ensure that each party's interests are respected; confidentiality and publication – which include provisions to protect confidential information shared during the course of the collaboration, as well as guidelines for publishing research findings and disclosing inventions and government interest where public funding is involved. Government agencies may have specific requirements or interests related to the IP resulting from the collaboration. These may include provisions for ensuring access to the resulting technology for public benefit or addressing national security concerns.

A review of the IP protection within the context of PPP under the RIM project reveal a mix of the above. In **Rwanda**, for example, the project on developing commercial flour from edible crickets has engaged a private firm, Nutrifarm, which has applied for a patent right for cricket flour as the main product. The application is still under review at Rwanda Development Board (RDB). In this arrangement, the company will provide a valid patent for 1 year for the current status of innovation. Later, the Intellectual Property will apply when the product has its nutritional composition report and is finally ready for market. Nutrifarm owns 100% of this patent. However, it is envisaged that partners may seek from Nutrifarm a shared patent right or IP as rights to use the research findings for their own interests other than business. Nutrifarm is willing to share the patent certification with partners through collaborative joint ventures. This commitment is limited to the Rwanda case only.

Also in **Rwanda,** the project on developing a yeast based starter culture, the National Industrial Research and Development Agency (NIRDA) will officially license the IP to PANOVITA Ltd, which will apply for other IP applications such as trademark, and industrial design. The other project in Rwanda, which is developing exhaust emissions gas analyzer and axle road systems towards commercialization and which already two prototypes, has applied for a patent/ utility model, and the decision is still pending.

6. Technology Transfer Strategies

The PPP projects under RIM have employed different strategies for technology transfer. Some of these strategies are discussed below:

6.1 Capacity Building

A good number of projects emphasize capacity building initiatives aimed at enhancing skills, improving production processes, and promoting technology uptake. This highlights a long-term commitment to empowering local stakeholders and fostering knowledge transfer. In **Ghana**, the project developing technologies to reduce post-harvest losses is facilitating knowledge and smart technology transfer to small and medium enterprises (SMEs) specifically on processing horticultural products for different categories of value chain actors (farmers, processors, scientists). The SMEs have been engaged from the field survey on production volumes, processed products handling, fruit processing waste handling and management. One of the projects in **Ethiopia** is also providing hands on training on the supply of raw materials and production of molded pulp packaging products. The project has also conducted a consultative workshop in collaboration with UNIDO and Integrated Agro-industrial parks (IAIPs) to transfer the technology and create awareness regarding the developed postharvest reduction technologies to the stakeholders in particular local youth cooperatives and Ethio Pulp and Paper SC.

In **Uganda**, the project developing maize bran and germ has built the capacity of forty local bakery factories/industries through demonstrations on the use of maize bran and germ as ingredient for incorporating in their confectionery and baked products. The entrepreneurs have been selected based on the first phase project interactions and their production capacities, more especially the ones involved in production of cookies, cakes and bread. Selection and inclusion criteria took into consideration urban and rural locations. In addition, thirty maize millers (15 female and 15 male proprietors) have been trained and certified by Uganda National Bureau of Standards (UNBS) on the hygienic handling and production of maize bran and maize germ as ingredient/raw material for confectionery and baked products. The training focuses on the quality of the bran and germ produced by the millers and process improvement. Entrepreneurs involved in the project are also required to participate in seminar presentations. During stakeholder workshops, practical of utilization of germ and bran for bakery and confectionery are demonstrated. The selected entrepreneurs are supported with simple equipment for roasting bran and germ. They were expected to obtain roasted bran and germ and incorporate them into their different product formulations. The maize millers have also put in place systems to handle maize bran and germ hygienically.

6.2 Transfer of Technology to Private Sector/SMEs

In **Rwanda**, the project developing yeast based starter culture provided samples to selected companies for piloting and production of banana beer. Meanwhile, the project developing an adjustable multi-grain seeding machine has put in places different infrastructure to enable farmers easily access their products. The project is also using a community sharing model which will benefit a significant number of customers by applying a renting business model. In **Uganda**, the project developing innovative cocoa technologies is applying market-based approach to adoption of the innovative technologies. The transition to scaling is expected to transfer of knowledge and skills to a private sector entity, smallholder farmers and other key stakeholders in the cocoa sector to ensure sustainable adherence to cocoa quality. In **Tanzania**, the project commercializing pigeon pea purchased and installed extruders at Tanya Food Company, one of the private sectors responsible for commercialization of the product. Projects like the one in **Uganda** focusing on innovative cocoa technologies is adopting market-based approaches, emphasizing the importance of creating value chains, establishing market linkages, and ensuring the commercial viability of the innovations. There is also a strong focus on addressing market demands and creating sustainable business models, ensuring that research outcomes translate into viable products or services with tangible economic benefits

In **Ethiopia,** the project developing a novel feed processing machine have engaged different group of stakeholders to enhance technology transfer. This include regional research centers and potential livestock producers, who will be selected and endorsed to conduct the feed processing activities. The project has provided various training for targeted groups, linking the technologies potential medium and small scale enterprises. In addition, a group of farmers have been purposely selected in the study areas to implement the scaling up of the product.

6.3 Technology Dissemination Platforms and Demonstration Centres

The cocoa project in Uganda aims to set up a technology dissemination platform for continued show-casing and training of cocoa farmers and stakeholders for enhanced adoption and uptake of innovations; creation of cocoa producer societies to facilitate easy access to services and gain a high bargaining power; and ensuring market linkages and establishment of MoUs with private sector. IT platforms are meant for continuous sharing of the learning and scientific knowledge to a broad spectrum of the private sector, government and development partners. Private cocoa producer organizations have also been identified through the district production office (PO). MoUs were signed with the identified artisans who were later trained in the production of the single fermentation boxes, thus supporting local production and supply of the boxes to interested farmers. The innovations showcased include the fermentation box prototypes with the associated validated fermentation protocol for specific chocolate flavour profile. Demonstrations were established in the target districts for lead cocoa farmers. In each district, one producer organization was identified, and additional demonstrations were set up to benefit both its members and other cocoa farmers within the district. In **Nigeria**, the technology on developing a multipurpose, reusable hydrogel technology capable of harvesting atmospheric water through a sorption-desorption process created demonstration centres and raised awareness through outreach and extension services on the benefits of expected savings from replanting, less dependence on regular intense rainfall and early harvest.

6.4 Establishment of Start-up\Spin-off Companies

The establishment of start-ups and spin-off companies underscores a broader emphasis on innovation and entrepreneurship within academic and research institutions. This entrepreneurial ecosystem facilitates the commercialization of innovations, fosters economic growth, and cultivates a culture of innovation-driven development. In **Kenya,** the University of Embu, expects to register spin-off companies that can be licensed to commercialize their innovation. During the field testing, the project partnered with two start-ups (PlusFarm and Thorium organics) who are working a lot with farmers in promotion of organic farming.

6.5 Engagement of Regulatory Bodies

The involvement of governmental agencies and regulatory bodies, such as conformity assessment enterprises and agricultural boards, highlights the importance of policy frameworks and institutional support in facilitating collaboration, ensuring quality standards, and promoting regulatory compliance. One project in **Kenya** has integrated the county agricultural extension services as part of their commercialization process. The county government extension staff have taken up the responsibility of providing extension services, overseeing clean seed production and distribution and general pest and disease surveillance. In the long run, the business may expand the product range and production capacity.

7. Key Issues and Insights Emerging from the PPP Projects

One of the key issues arising from the PPP arrangement under the RIM project is balancing between public-oriented benefits deriving from the initial funding by the public sector on one hand, and the profit motive driven by the private sector, on the other. It is important to note that public entities prioritize affordable access to essential goods and services while the private sector focus on profits. This arrangement could be beneficial to the private sector as it reduces the cost of research, thus lowering the market price of the final product.

Intellectual Property

Analysis of the PPP arrangements of the RIM project does not show clear guidelines on the management of IP related issues, which are critical. Engaging legal experts in IP can help ensure compliance with relevant regulations and streamline the IP management process. Determining ownership of IP generated through the partnership can be complex. Thus, developing standardized IP agreements and templates for different types of partnerships can also facilitate compliance and reduce administrative burden. Drafting comprehensive IP agreements that clearly define ownership, licensing terms, royalty sharing, and dispute resolution mechanisms can help mitigate conflicts over IP rights. Private entities may seek exclusive rights to IP they develop, while public entities may prioritize broader access and public benefit. Clear contractual agreements should be established upfront, outlining ownership rights, usage permissions, and potential revenue sharing mechanisms. Therefore, balancing IP protection with public access can be achieved through licensing agreements that allow for reasonable access to IP while still allowing the private partner to recoup their investments. Government regulations can also ensure that essential technologies remain affordable and accessible to the public.

Funding

Commercialization and up-scaling of technologies require significant initial investment. Whereas the private sector would be willing to invest in such ventures, they are wary of the risks of losses. Although the RIM project has provided the initial funding, it may be inadequate and may not sustainable over time. Apart from funds, it is important to provide incentives for technology transfer with a view to bridging the funding gaps and stimulating private sector investment. It is also critical to have a special fund specifically designed to support technology transfer activities and facilitate collaboration between public and private entities.

Cultural differences

The public and private sector differ in the way they conduct their business. Differences in organizational culture, management practices, and decision-making processes between public and private sector partners can hinder effective collaboration and technology transfer. Private companies may be reluctant to invest in technologies with uncertain commercial potential or long development timelines, while public institutions may be risk-averse when it comes to engaging with the private sector. Establishing dedicated project teams with representatives from both public and private entities can facilitate coordination and decision-making.

8. Risks and Assumptions

Implementation of the RIM projects need to take into account inherent risks and assumptions that can determine success or failure of PP projects – which if not carefully managed – can pose significant challenges to the success and sustainability of PPP initiatives. By understanding and addressing these risks proactively, stakeholders can enhance the resilience and effectiveness of their endeavors, ultimately driving progress towards the intended goals. Some of the risks and assumptions are outlined below:

1. Projects may rely heavily on external support from international organizations or donors, which could impact sustainability and long-term scalability.
2. Projects face risks related to market dynamics, competition, and changing consumer preferences, which could impact the adoption and commercial success of innovations.
3. Limited resources, both financial and human, could pose significant challenges to the successful implementation of the PPP projects. This includes constraints in funding, expertise, infrastructure, and access to technology, which may hinder the scalability and effectiveness of the interventions.
4. While the projects aim to transfer technology and knowledge to local stakeholders, there may be uncertainties regarding the long-term sustainability. Without proper mechanisms for ongoing support, training, and capacity building, the benefits may not be sustained beyond the project duration.
5. While technology transfer is a key objective, the actual adoption of innovations by end-users, such as farmers and small-scale enterprises, may face barriers related to awareness, access, and affordability. Ensuring effective dissemination and uptake of technologies is critical for realizing their potential benefits. Issues such as limited resources, inadequate infrastructure, and a lack of policy support could hinder the widespread adoption and long-term impact of innovations.
6. Adequate monitoring and evaluation mechanisms are essential for assessing the impact and effectiveness of projects. Weaknesses in monitoring systems may lead to challenges in measuring outcomes, identifying lessons learned, and making evidence-based decisions for future interventions.
7. Training programs and capacity-building initiatives, as seen in Uganda and Kenya, are essential components of many projects. These initiatives empower local stakeholders, enhance skills, and promote technology uptake, thereby contributing to long-term sustainability.

However, it is important to keep in mind that not all research products get to the market due to several hurdles along the process. This could be due to lack of market viability, funding constraints, regulator challenges and intellectual property issues. Other reasons, which are more pertinent to this synthesis include lack of industry partnerships and skills gap. Therefore, the main reason for engaging the private sector is to forestall such risks. And, as indicated above, the RIM research projects have taken into account the aforementioned handicaps and have developed mechanisms for circumventing them by creating linkages with private entities. They are also at various stages of seeking for regulatory approval and working on Intellectual Property related aspects. The RIM research projects are also working on other relevant processes including seeking regulatory approval, developing marketing strategies and scaling, some of which are being undertaken in parallel.

9. Conclusion

It is evident that PPP initiatives under the RIM project show tremendous promise and may provide valuable insights into commercialization of research products. Inclusion of the private entities, if well managed, can help infuse the much needed know-how to launch the products into the market. However, some loopholes need to be sealed. Addressing these weaknesses and challenges will be crucial for maximizing their impact and contributing to sustainable development in the region. Continued collaboration, adaptive management, and learning from both successes and failures are essential for advancing the objectives of the PPP projects under RIM. However, it is important to embed sustainability mechanisms to ensure the project do not stall. Issues related to funding and IP should be well thought out to ensure the projects are taken to the next level and sustained. Documentation of the processes and milestones can provide valuable lessons for similar endeavors within and outside the RIM project.

10 Recommendations

For the PPP projects to be successful, it would be important to tie the loose ends to ensure the project achieve the indeed objectives. The following recommendations, if adopted, can help enhance the chances of success for the PPP initiatives.

1. Conducting thorough technology assessments and market analyses to evaluate the commercial viability and potential risks of transferring specific technologies can help mitigate uncertainty and build confidence among private sector partners.
2. Building institutional capacity and transferring knowledge between public and private partners are essential for sustainable development. This involves investing in training programs, technology transfer, and knowledge sharing platforms to enhance skills and expertise in sustainable practices.
3. Crafting robust and equitable contractual agreements is essential for PPP success. Disputes over contract terms, performance criteria, payment mechanisms, and dispute resolution mechanisms can arise during negotiations and implementation, leading to delays and conflicts.
4. Ensuring sustainability over the project's lifespan is essential. Balancing short-term economic interests with long-term social, environmental, and economic sustainability is crucial for the success of the projects.
5. Providing adequate IP protection through patents, copyrights, or trade secrets can incentivize private partners to invest in innovation. Governments can also offer incentives such as tax breaks or grants to encourage private sector participation.
6. Establishing clear communication channels and fostering mutual understanding of each party's objectives can help align interests and facilitate cooperation.
7. Developing shared goals and objectives at the outset of the partnership can also promote collaboration and minimize conflicts.

Annexes

Annex 1: Case Studies of Successful PPPs in research and innovation

Research endeavors, especially those funded from public coffers, are often focused on academic publications, securing external funding and generation of IPs. However, it is becoming increasingly important for public funded research to include such metrics as job creation, formation and scaling of start-ups and commercialization. This section looks at some of the most successful PPPs in research globally.

PPP in Development of Covid-19 Vaccines

An analysis of the partnerships for developing Covid-19 vaccines, show that nearly one third of all vaccine candidates were developed by partnerships, which tended to use next-gen vaccine platforms. One of the studies conducted on the development of Covid-19 vaccines. The study identified 93 partnerships with ≥2 entities and 190 single entities developing COVID-19 vaccines registered by the World Health Organization (WHO). Of the 81 partnerships analyzed, the study found that 71 had a company partner while 46 (56.8%) were involved in "materials transfer" and 35 (43.2%) in "knowledge sharing". An example of a "materials transfer" partnership was the collaboration between the University of Oxford and the pharmaceutical company AstraZeneca. Oxford and its spin-out company Vaccitech jointly own a proprietary platform for vaccine development. After creating a vaccine candidate, they sought a commercial partner for seeking regulatory approvals and supply agreements—an example of serial innovation between partners[8].

In the United States, for example, the Foundation for the National Institutes of Health linked up with leading pharmaceutical agencies to combat the pandemic. The Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) partnership developed a collaborative framework for prioritizing vaccine and drug candidates, streamlining clinical trials, coordinating regulatory processes and/or leveraging assets among all partners to rapidly respond to the COVID-19 and future pandemics. Both government and industry partners in this arrangement provided infrastructure, subject matter expertise and/or funding (both new and in-kind) to identify, prioritize and facilitate the entry of some of the most promising candidates into clinical trials. Industry partners made available certain prioritized compounds, some of which had already cleared various phases of development, and associated data to support research related to COVID-19. Essentially, the partnership between the federally funded researchers and a broad array of drug companies aimed at prioritizing research into drugs and vaccines that are having high near-term potential. The collaboration focused on standardizing the methods and models that researchers used to test promising Covid-19 compounds. It also provide researchers access to high-level laboratory facilities and standardize endpoints to ensure different companies and researchers are judging potential medicines by the same criteria. Finally, it established one joint control arm to be shared among all clinical trials, the NIH said in a press release[9].

8 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8410639/

9 https://www.statnews.com/2020/04/17/nih-partners-with-16-drug-companies-in-hopes-of-accelerating-covid-19-treatments-and-vaccines/

Canada's PPP in Cancer Research

FACIT, Canadian organization has successfully played this critical innovation-enabler role between several industry partners and its strategic partner, the Ontario Institute for Cancer Research (OICR). Funded by the Government of Ontario, OICR harnesses the province's high impact research and strengthens collaboration among its world-class cancer research centres to generate a rich pipeline of breakthrough oncology assets. As a partner to OICR and Ontario Universities, FACIT empowers entrepreneurs with a unique source of Ontario First seed capital for cancer innovations, experienced executive management and connections to both industry and investors. FACIT has invested $40M into Ontario innovations, which has been leveraged into a remarkable $750M+ in private investment into the province. FACIT and OICR's joint mission is to build Ontario's oncology innovation economy, capturing local value from IP and benefitting patients with improved therapies and diagnostics[10]. Together, FACIT and OICR have strategically laid the foundation for a commercialization pathway that sets the stage for successful PPPs, and ultimately, achieves high-impact innovation outcomes. In early 2019, when FACIT and one of its portfolio companies, Triphase Accelerator, announced a historic $1B USD strategic partnership with U.S.-based Celgene for an OICR-discovered first-in-class drug candidate for blood cancers.

The PPP is the largest oncology licensing transaction for a preclinical asset in Canadian history, and the largest biotech asset transaction worldwide for academia and non-profit research institutes. Moreover, this partnership solidified a "discovered and developed in Ontario" pathway for commercialization of oncology innovations. The pathway reflects the collective efforts of multiple local stakeholders and receptors to accelerate innovation and capitalize on Ontario's investments in research, training and healthcare. The PPP could not have happened without the industry-experienced drug discovery team at OICR, whose top-tier, high quality science attracted multiple potential partners. FACIT, who led the global business development strategy, strategically invested $3M to further de-risk the asset locally, creating more value and ultimately negotiating the transaction to have maximum Ontario impact. Without access to this Ontario First capital, the IP would have been undersold to an international suitor, taking R&D jobs and real economic impact along with it. Through Triphase, R&D jobs, clinical trials and industrial development are anchored in Ontario, benefiting both the economy and patients.

10 https://sciencepolicy.ca/posts/public-private-partnerships-as-drivers-of-research-translation-and-innovation-outcomes-in-healthcare-commercialization/

Annex 2: Summary of PPP Research Initiatives under the RIM Project

#	Country	Research Topic	PI	Lead Public Agency	Private Agent	Specific Focus	Expected Result
1.	Rwanda	Cricket Farming	Musabirema Alex	Rwanda Agriculture and Animal Resources Development Board	Nutrifarm Insecti-Pro, Kenya	Cricket farming	A commercial product well packaged, branded, promoted, certified, and ready for to test the market
2.	Rwanda	Enhancement of Production Technology, Quality and Competitiveness of Rwanda Banana Beverage Products.	Emmanuel Munezero & Prof. Antoine Nsabimana	University of Rwanda	PANOVITA Limited (pilot production and commercialization of starter culture) Institut Catholique de Kabgayi	Banana Beverage Products	Production and commercialization of banana beer
3.	Rwanda	Vehicle pollution monitoring & SIZANA-Environmental Friendly Transport System	Dr. Kalisa Egide	Benoholdings Ltd. University of Rwanda,	Ecomotive Ltd.	Exhaust gas analyzers and axle load control system	Commercialization of Exhaust gas analyzers and axle load control system
4.	Rwanda	Development of Multi-Grain Seeding Machine	Israel Niyonshuti	The Integrated Polytechnic Regional College (IPRC)	Rwanda Engineering and Manufacturing Corporation TechAdopter	Multi-grade seeding machine	Adjustable multi grain seeding machine / engine power tiller
5.	Ethiopia	Scaling up post-harvest loss reduction technologies for horticultural crops using biomass waste packaging materials	Dr. Hailemariam Gebru Teka	Ministry of Innovation and technology	Ethio Pulp and Paper SC Integrated Agro-industrial parks (IAIPs)	Sustainable packaging materials	sustainable packaging materials made from biomass waste for post-harvest loss reduction in horticultural crops

6.	Ethiopia	Scaling up of Agricultural By-Product Utilization Efficiency through the Application of Bio and Physical Feed Processing Technologies	Dr. Girma Debele Delelesse	Bio and Engineering Technology Institute (BETin)	Ethio-feed processing PLC, SME's in selected areas	Bio and Physical Feed Processing Technologies	Agricultural By-Product Utilization
7.	Ethiopia	Sustainable Solutions for Industrial Waste Management in Ethiopia: Transforming Industrial Sludge into Energy-Efficient Bricks, Biomass Briquettes, & Nano-Fertilizers	Dr. Yedilfana Setarge	Addis Ababa University	Bio and Emerging Technology Institute	Industrial Waste Management in Ethiopia	Sustainable Solutions for Industrial Waste Management
8.	Kenya	Bio-based Agro-inputs for Sustainability and One Health (BASOH). Research on food and nutrition security and sustainable agriculture (FNSSA) upscaling.	Prof. Romano Mwirichia Kachiuru	University of Embu	DudutTech IPM Ltd, a subsidiary of Bioline Agrosciences	Biopesticide formulations	Commercialization of biopesticides.
9.	Kenya	Commercialization of Cassava for Improved Food and Nutritional Security in Western Kenya (CCIFNS)	Dr. Vitalis Ogema	KALRO, MMUST, Kibabi University, University of Eldoret	Agro-service providers Ltd	Commercialization of Cassava	Baking flour from a blend of cassava and wheat flour Porridge/ugali flour from a blend of cassava and sorghum and millet flour Installation of cassava processing machinery and equipment-
10	Kenya	Capacity Building for the Job Creation and Growth of the Leather Goods and Leather Footwear Manufacturing Enterprises in Kenya	Dr. Paul Tanui	DeKUT	Yallo Leather Limited	Leather Manufacturing	Leather Products
11.	Uganda	Up-scaling the uptake of cocoa innovative technologies for enhanced value addition during primary processing	Prof. Archileo N. Kaaya	Makerere University	• Private cocoa Producer Organizations • Equator chocolates. • Lwanga Enterprises • Nile chocolates	Cocoa Innovation technologies	Singer Fragmentation box

12.	Uganda	Establishing a small-scale food waste up-cycling facility for cricket feed production and marketing in Kampala	Dr. Geoffrey Ssepuuya	Makerere University, Bureau of Standards	PKM reliable Enterprises Christian University, Uganda	Cricket feed	Commercial Cricket feed Small scale food waste processing facility
13.	Uganda	Maize germ and Bran as raw materials for high fibre value added bakery and confectionery products/ Up-scaling and commercialization of maize bran and germ value added products in Uganda.	Prof. Charles Muyanja	Makerere University	JOVAY School of cookery Maganjo Grain Millers	Maize baked products	Commercialized maize baked products: Muffins, Bread, cookies, maize bran and germ
14.	Nigeria	IDETECT23: An Intelligent Device that Detects and Records Road Traffic Violations	Prof. Gregory O. AVWIRI	University of port Harcourt	A Private Liability Company jointly owned by the TETFund and The Inventors.	IoT	Idetect23 Device that detects road traffic violations
15.	Nigeria	Development of Automated Garri Frying Technology (Jollyfryer)	Prof. Mohammed Nasirudeen Suleiman		Innov8 Hub	Domestic Cooking Appliance	Commercial Jolly fryer
16	Nigeria	Development of Hygrogel Technology to Mitigate the Effect of Drought in Desert Areas of Northern Nigeria	Sani Mohammed Yahaya	Aliko Dangote University of Science and Technology	Innov8 Hub	hydrogel technology	A multipurpose, reusable hydrogel technology
17	Nigeria	Creation of Biosensor Device for Water Purification Using Solar Energy	Prof. V.O. Nwaugo	Abia State University,	Innov8 Hub	Water Purification	Creation of Biosensor Device for Water Purification Using Solar Energy
18	Zimbabwe	Commercialization of the development of novel nano-engineered: reagents for mineral froth flotation project	Mr. Tatenda Crispen Madzokere	Midlands State University (MSU), Ministry of Mines and Mining Development	• Bindura Nickel Corporation/ Trojan • Mine, Bindura • Muriel Mine, • Mutorashanga • Mimosa Mine, Zvishavane	Mining	Nano-engineered reagents

19	Zimbabwe	Advancing Agricultural Sustainability: Leveraging Artificial Intelligence for Optimal Livestock Security and Productivity.	Eng. Bright Chisadza	Lupane State University	To be identified	Artificial Intelligence in agriculture	Improved livestock security and productivity.
20	Tanzania	Scaling up and commercialization of a pigeon pea-based noodles and instant porridge toward improving nutrition security among households in Tanzania	Dr. Zahra Saidi Majili	Sokoine Uni of Agriculture (SUA)	Tanya Trading Company Ms. Wende Mengele Roderick	Nutrition Security	Production of Noodles and instant porridge
21	Siera Leone	Artificial intelligence in education - abu sense bod	Mr. Abdul Rahim Jalloh	Ministry of Communication, Technology and Innovation	Rabit Education, Sierra Technologies, STEM Africa SL	Emerging Technologies	AbuSensebod, an all-in-one educational platform.
22	Ghana	MedScaleApp: Scaling up Mass Drug Administration for Schistosomiasis post COVID-19 pandemic	Dr. Gideon Kye-Duodu	University of Health and Allied Sciences	Franko-Trading Enterprise, Penuel Research Consult (PRC),	Emerging Technologies	App for mass drug administration for Schistosomiasis
23	Zambia	Developing smart technologies for minimization of post-harvest losses and value addition in the pineapple, mango and tomato value chains in Ghana and Zambia (SMARTFRUIT)	Dr. Emelin Mwenda	Zambia Agriculture Research Institute (ZARI)	To be identified	Agricultural Technologies	Smart technologies for minimization of post-harvest losses

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