Scoping Study

Africa-Britain-China (ABC) Agricultural Technology Research Collaborations for International Development

29 February 2016

EXECUTIVE SUMMARY

The prospective Africa-Britain-China (ABC) trilateral agricultural technology (agri-tech) research programme has the potential to contribute to Africa's agricultural transformation. Research, development, adaptation, and adoption of sustainable agri-tech solutions will help Africa meet the future demands and challenges of the agricultural sector. A strong and growing agricultural sector will in turn help feed Africa's growing population and contribute to an expected $1 trillion agri-food industry by 2030.

The notion of this programme is being conceptualised in the context of significant international support to increase food security and improve nutrition through sustainable agricultural intensification, as well as to promote multilateral collaborations (North-South and South-South) for international development. However, significant gaps still exist in agricultural research and development (R&D), which this programme could address by mobilising public, private, and academic research expertise to develop and scale up new agricultural technologies that support critical value chains in Africa. Furthermore, a programme that could catalyse technology, innovation, and knowledge exchange is aligned with the United Nation's Global Goals for Sustainable Development as well as with Britain's, Africa's, and China's development strategies and national / continental interests.

In this Scoping Study, Elsevier B.V. (Elsevier), Development Finance International, Inc. (DFI), and CAB International (CABI) (hereafter "Consortium") present their findings and recommended approach for the design of a future programme in this report of the Scoping Study. To carry out this Scoping Study, the Consortium employed a programmatic and iterative approach, skilled experts with global networks, and a deep knowledge of current and past global agricultural programmes. The Consortium conducted a comprehensive assessment including: i) a bibliometric analysis of peer-reviewed and non-peer reviewed scientific publications, ii) a desk-based review of key strategy, policy, investment, and programme documents, iii) consultations with 157 stakeholders across Africa, Britain, and China, and iv) four consultative workshops. The findings from these four work streams are synthesised in this report, feeding into the four programme design options presented in Section VI and into the key decision points to be made in Section VII.

Key Findings

Through consultations and four workshops conducted in London, Beijing, Accra, and Nairobi, stakeholders confirmed receptivity for a trilateral ABC agri-tech research programme, understanding that the potential programme was still in the early stages of design. Broadly speaking, stakeholders agreed that there is a clear need to increase agricultural R&D for Africa and that a trilateral approach with Africa, Britain, and China could bring value by tapping into complementary expertise. Designing and launching an ambitious programme of this nature will come with some challenges and possible delays, but stakeholders agree that the potential for impact would justify the effort. The key findings in this Scoping Study will serve as a foundation for the Steering Committee and future institutional partners to take the trilateral agri-tech research programme forward.

African Agricultural Challenges: Macro-drivers such as climate change, population growth, and increased international trade, among others will shape the challenges in African agriculture over the next 20 years. The Consortium identified 12 broad technical challenges, as well as three other key challenges that indirectly impact African agriculture including the need to: i) increase and scale adoption of scientific research outputs, ii) build local African research capacity by attracting more youth and women, and iii) strengthen the policy and regulatory environment to promote and facilitate agri-tech research and development. With well below average investments in Africa's

agricultural R&D, a trilateral agri-tech research programme may attract further investments in agricultural R&D, which could have a multiplier effect and drive innovation and technology deployment to address Africa's agricultural challenges.

ABC Areas of Expertise: Africa, Britain, and China are well-positioned to address many of Africa's agricultural challenges over the next 20 years, whereby Africa brings a deep understanding of the needs on the continent and local context, Britain brings basic science research excellence in both agricultural technology and implementation science, and China brings strong experience in applied science, adapting, and scaling agricultural technologies and innovations. Specific technical areas in which ABC expertise align with African agricultural challenges include priority value chains in Africa such as aquaculture / fisheries and livestock / poultry, as well as key value chain segments such as inputs (e.g., seed and soil science) and post-harvest production (e.g., agro-processing and food safety).

ABC Collaborations: Research collaborations between ABC account for 12.2% of Africa's total agricultural research publications. However, this is largely driven by bilateral collaborations between Africa and Britain, and Africa and China, whereas ABC trilateral collaborations are less common, accounting for only 0.28% of Africa's total agricultural research publications. Africa-Britain research collaborations have focused on research on pests and diseases (637 co-authored publications from 2005 to 2014, or more than one in ten co-authored publications between Africa-Britain in AgBio research) and agricultural output (550 co-publications). Africa-China research collaborations have also focused on pest and diseases (128 co-authored publications) but also topics relating to value chain efficiency (127 co-authored publications). Many of these research collaborations are based on long-standing partnerships between ABC institutions. It will be important for a future trilateral agri-tech research programme to build on existing research collaborations and networks as well as existing ABC development programmes and initiatives.

Feasibility: There are key developmental, political, and practical trade-offs to be considered when the programme is taken forward. Some of these trade-offs may be in direct conflict with one another (e.g., what may be politically expedient may not be considered best practices for international development). As noted above, there is broad receptivity, yet the challenge will be to flesh out the details of programme design in such a way that ensures a workable arrangement across funders, investors, and other institutional partners. It will be critical to work closely with the partners during each step of the design process to ensure the programme's alignment with all partner priorities, particularly as many initial decisions will impact downstream programme decisions

Though many trade-offs will need to be considered going forward, consulted stakeholders broadly agreed on the following upon reflecting on the six areas for consideration: Technical, Political, Governance, Financial, Private Sector Engagement, and Administrative:

- Emphasise integration of implementation science
- Increase agricultural R&D investments and capacity in Africa
- Take a value chain approach
- Promote African ownership and align with Africa's priorities
- Engage at higher political levels to seek co-funding
- Partner with the private sector
- Allow sufficient time

This Scoping Study presents four programme design options, integrating these points of agreement while highlighting differentiating aspects. Each design option has a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis, which draws out some of the key trade-offs. Two of the

programme design options follow a more traditional R&D fund model, the third option presents a "centres of excellence" model, and the fourth option proposes scaling up an existing programme. These four programme designs offer a menu of options from which the trilateral agri-tech research programme could be designed.

Decision Points and Next Steps

Based on the findings of this Scoping Study, key decisions will need to be made in the early stages of the design process in order to mitigate potential challenges. The following, among others, will be critical to flesh out a preferred programme design option:

- Determine co-funding requirements from China
- Define programme's geographic scope
- Select programme structure
- Decide programme management
- Define role of the private sector

The Consortium notes that the decision making process may be challenging. Nonetheless, it is important to remember the strong receptivity for the agri-tech research programme and high potential to achieve impact through this trilateral approach. Should the programme move forward in the future, it has the potential to strengthen ABC's capacity to develop and adapt agri-tech research, innovation, and knowledge exchange that could contribute significantly to Africa's agricultural transformation and improve the livelihoods for many African food producers.

Structure of Report

The Scoping Study is organised as follows:

Section I: Objective, Rationale & Methodology of Scoping Study: Presents the objective for the Scoping Study, alignment with ABC strategies, and the programmatic approach implemented by the Consortium

Section II: Africa's Agricultural Challenges / Needs: Presents key findings around the future challenges facing African agriculture over the next 20 years

Section III: Africa, Britain, and China Agri-Tech R&D Expertise: Outlines the key technical areas of expertise in ABC to respond to Africa's challenges

Section IV: Past / Ongoing ABC Collaborations: Presents the technical and geographic scopes covered by recent ABC research collaborations

Section V: Feasibility of ABC Trilateral Programme: Synthesises stakeholder feedback around the Technical, Political, Financial, Governance, Private Sector Engagement, and Administrative aspects of the programme design

Section VI: Programme Design Options: Outlines a theory of change and four potential programme designs, each with a SWOT analysis

Section VII: Decision Points and Next Steps: Highlights key areas on which the Consortium requests guidance from the Steering Committee in order to flesh out the preferred option

Section VIII: Annexes

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ACRONYMS

3ie	International Initiative for Impact Evaluation
AATF	African Agricultural Technology Foundation
ABC	Africa, Britain, and China
AERC	Applied Economics Research Centre
AGRA	Alliance for a Green Revolution in Africa
ANAFE	African Network for Agriculture, Agroforestry, and Natural Resources Education
ARC	Agricultural Research Council
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASTI	Agricultural Science and Technology Indicators
ATA	Agricultural Transformation Agency
ATDC	Agricultural Technology Demonstration Centre
AVRDC	Asian Vegetable Research & Development Centre
AgBio	Agricultural and Biological Sciences
AgriTT	Agricultural Technology Transfer Programme
BBSRC	Biotechnology and Biology Sciences Research Council
BRIC	Brazil, Russia, India, and China
CAADP	Comprehensive Africa Agricultural Development Programme
CAAS	Chinese Academy of Agricultural Sciences
CABE	Centre for African Bio-Entrepreneurship
CABI	CAB International
CCARDESA	Centre for Coordination of Agriculture Research and Development for South Africa
CGIAR	Consortium of International Agricultural Research Centres
CIAD	Centre for Integrated Agricultural Development
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CIRAD	French Agricultural Research Centre for International Development
CORAF / WECARD	West and Central African Council for Agricultural Research and Development
COSTECH	Council for Science and Technology
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development
Defra	UK's Department for Environment, Food, and Rural Affairs
EAC	East Africa Community
EAFF	East African Farmers Federation
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
Embrapa	Brazilian Agricultural Research Corporation
ESRC	Economic and Social Research Council
FAAP	Framework for African Agricultural Productivity
FAO	Food and Agriculture Organisation
FARA	Forum for Agricultural Research in Africa
FOCAC	Forum on China-Africa Cooperation
GDP	Gross Domestic Production
GMO	Genetically Modified Organism
IARC	International Agricultural Research Centres
ICIPE	International Centre of Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics

ICT	Information and Communication Technologies
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INBAR	International Network for Bamboo and Rattan
IP	Intellectual Property
KAAA	Kenya Agribusiness and Agro-Industry Alliance
KALRO	Kenya Agricultural and Livestock Research Organisation
KEMRI	Kenya Medical Research Institute
LSMS-ISA	Living Standards Measurement Study – Integrated Surveys on Agriculture
MNC	Multinational Corporation
MOFCOM	China's Ministry of Commerce
MoA	Ministry of Agriculture
MoST	Ministry of Science & Technology
NARES	National Agricultural Research and Extension System
NARO	National Agricultural Research Organisation
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
PAEPARD	Platform for African European Partnership on Agricultural Research for Development
PAFFO	Pan African Farmers Forum
PAFO	Pan-African Farmers' Organisation
PanAAC	Pan African Agribusiness and Agro Industry Consortium
PMU	Project Management Unit
R&D	Research and Development
R&D&I	Research, Development, and Innovation
RCUK	Research Councils UK
RECs	Regional Economic Communities
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
S3A	Science Agenda for Agriculture in Africa
SADC	Southern African Development Community
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SAI	Sustainable Agricultural Intensification
SAIN	China-UK Sustainable Agriculture Innovation Network
SAIS	School of Advanced International Studies
SCPRID	Sustainable Crop Production Research for International Development
SMEs	Small and Medium Enterprises
SROs	Sub-Regional Organisations
SSA	Sub-Saharan Africa
SWOT	Strengths, Weakness, Opportunities, Threats
ToC	Theory of Change
UK	United Kingdom
UN	United Nations
UniBRAIN	Universities, Business, and Research in Agricultural Innovation
USAID	US Agency for International Development
WEF	The World Economic Forum
ZARI	Zambia Agricultural Research Institute
ZELS	Zoonoses and Emerging Livestock Systems

I. OBJECTIVE, RATIONALE & METHODOLOGY OF SCOPING STUDY

Objective

Elsevier B.V. (Elsevier), Development Finance International, Inc. (DFI), and CAB International (CABI) (hereafter "Consortium"), have partnered for this engagement and are pleased to present findings in this Scoping Study. Building on the strong foundation of British and Chinese international development cooperation and ongoing initiatives in agriculture research, this Scoping Study explores the feasibility of and designs for a future Africa-Britain-China (ABC)[1] trilateral agricultural technology (agri-tech) research programme. More specifically, the objectives of this Scoping Study are to:

Synthesise Experience: Catalogue and synthesise lessons from existing ABC initiatives and relationships, and those completed in the past three years in agricultural technology, innovation, and knowledge exchange, including the underpinning science.

Identify Challenges: Anticipate and analyse the future challenges facing African agriculture over the next 20 years and explore the capacity of ABC academic research and private sector expertise to respond to these challenges.

Assess Appetite: Assess the level of interest, willingness, and political feasibility in ABC to support and finance a potential new programme for agricultural research and technology development, innovation, and knowledge exchange to meet the future demands and challenges of African agriculture.

Design Options: Build upon emerging lessons from other programmes to develop options for the design of the new programme, including governance, administrative, funding arrangements, technical priorities, and themes.

The overarching objective of a future ABC agri-tech research programme would be to mobilise joint expertise from the public, private, and academic sectors across Africa, Britain, and China to: i) create new agricultural technologies and innovations, ii) analyse the behaviour of technology adoption of value chain actors, and iii) scale up the adoption rate of agri-tech research outputs. A successful programme of this nature would lead to improved agricultural productivity and improve livelihoods for actors across the agricultural value chain.

Rationale

Alignment with Stakeholder Strategies

Britain: The rationale for a future ABC trilateral agri-tech research programme is rooted in funders' strategies to innovatively and sustainably address Africa's agriculture challenges. A trilateral agri-tech research programme would be squarely aligned with the strategic objectives of DFID's recent strategy.[2] Such a programme would help promote economic development and prosperity, and should also support mitigation of and adaption to the impacts of climate change in Africa's agriculture sector. Moreover, the United Kingdom's (UK) aid strategy encourages leveraging its expertise in world-leading science, research, and development to tackle global problems, which also dovetails with the UK Strategy for Agricultural Technologies.[3] This Agri-Tech Strategy, driven by the

[1] For the purposes of this Scoping Study, North Africa is not included. The Consortium has used "Africa," "Sub-Saharan Africa," and "SSA" interchangeably.
[2] *UK aid: tackling global challenges in the national interest*. DFID. November 2015.
[3] *A UK Strategy for Agricultural Technologies*. July 2013.

private sector, emphasises the need to strengthen the connection between basic science and applied research to create modern and sustainable agriculture and food production systems, contributing to international development and global food security.

Moreover, and in alignment with DFID's Conceptual Framework on Agriculture (November 2015), a programme that promotes the uptake of agricultural technologies and innovations in Africa could be a driving mechanism to transform the agriculture sector from predominantly subsistence farming to a sector driven by small, medium, and large scale commercial farming. Such a programme would benefit from a value chain approach, transforming not only farming inputs and production, but also serving as a catalyst for agro-processing in Africa. This agriculture sector transformation would offer a pathway out of poverty for many African food producers.

China: Since the Forum of China African Cooperation (FOCAC) was launched in 2000, China has prioritised its agricultural cooperation with Africa, primarily through technical cooperation and capacity building.[4] For example, China has established 15 Agricultural Technology Demonstration Centres (ATDCs) across Africa, with another seven planned. More recently, Chinese President Xi Jinping proposed to focus on technology transfer to Africa in areas such as large scale farming, animal husbandry, grain storage, and agro-processing. This will be carried out across agricultural development projects, on-the-ground technical cooperation, and supporting cooperation between Chinese and African agricultural research institutes.[5]

Moreover, a trilateral programme with Britain would be strongly aligned with the Memorandum of Understanding (MoU) on development cooperation that China and the United Kingdom signed in October 2015, in which the Chinese Ministry of Commerce (MOFCOM) and DFID committed to broadening and deepening their cooperation in implementing the Global Goals.[6]

Africa: This programme would also be in line with the Forum for Agricultural Research in Africa (FARA) 2014-2018 Strategic Plan and the Science Agenda for Agriculture in Africa (S3A).[7] Through increased public and private investments in science and agriculture technology, this programme could increase African researchers' capacity across cross-cutting themes such as sustainable agricultural intensification and modern genetics and genomics. Moreover, a collaborative approach that attracts younger African researchers, including women, could also build longer term capacity on the continent by developing new agricultural research experts. The programme, which would also aim to strengthen partnerships between public, private, and academic sectors, could further promote the commercialisation of agricultural innovations.

Alignment with Development Objectives

In addition to being aligned with Africa, Britain, and China's development and sectoral strategies, a trilateral agri-tech research programme would catalyse ABC collaborations that would in-turn

[4] *China's Foreign Aid 2014*. Information Office of the State Council, P.R. China. http://news.xinhuanet.com/english/china/2014-07/10/c_133474011.htm, accessed on 9 December 2015.
[5] *Open a New Era of China-Africa Win-Win Cooperation and Common Development*. Address by H.E. Xi Jinping, President of the People's Republic of China at the Opening Ceremony of the Johannesburg Summit of the Forum on China-Africa Cooperation (FOCAC). 4 December 2015. http://www.fmprc.gov.cn/mfa_eng/zxxx_662805/t1321614.shtml, accessed on 9 December 2015.
[6] *China and UK Sign Memorandum of Understanding on Local Trade and Investment Cooperation and Development Cooperation*. MOFCOM press release. 24 October 2015. http://english.mofcom.gov.cn/article/newsrelease/significantnews/201511/20151101155948.shtml, accessed on 4 December 2015.
[7] FARA, 2014. *FARA's 2014-2018 Strategic Plan: Enhancing African Innovation Capacity for Agricultural Transformation*. Forum for Agricultural Research in Africa (FARA). Accra, Ghana. FARA, 2014. *Science Agenda for Agriculture in Africa: "Connecting Science" to transform agriculture in Africa*. Forum for Agricultural Research in Africa (FARA). Accra, Ghana.

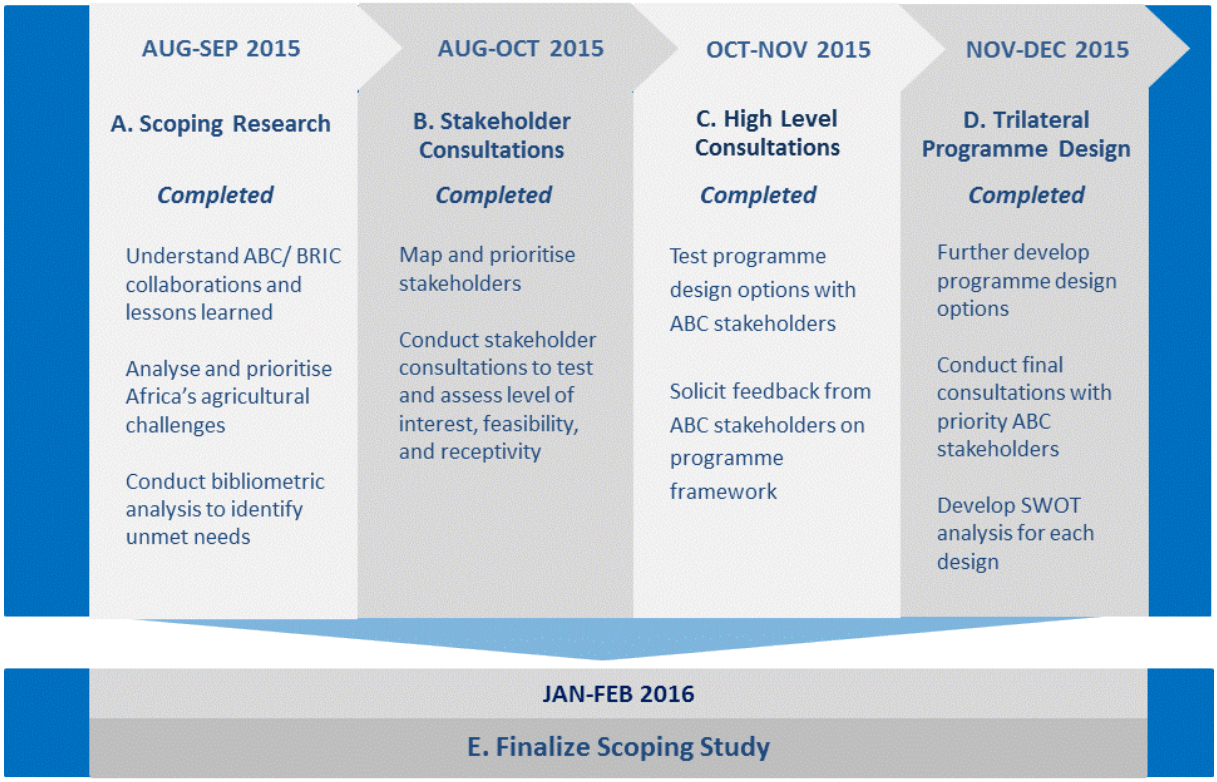
promote solutions in line with the Global Goals. For example, Global Goal 2 is to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by 2030. This potential future programme could address key Global Goal 2 targets with a focus on plant and animal genetics, sustainable agricultural productivity, and agricultural resiliency to climate change. In addition to addressing the critical needs in Africa's agriculture sector, a trilateral agri-tech research programme would directly support Global Goal 17 to "strengthen the means of implementation and revitalise the global partnership for sustainable development." Specifically, this programme has been conceived in alignment with two key targets for Global Goal 17:

- Enhance North-South, South-South and triangular regional and international cooperation on access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism.
- Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including concessional and preferential terms, as mutually agreed.

Methodology

To carry out this Scoping Study, the Consortium employed a programmatic and iterative approach (see Figure 1), skilled experts with global networks, and a deep knowledge of current and past global agricultural programmes.

Figure 1: Methodological Framework



(A) The Consortium began with a comprehensive desk-based assessment, evaluating three key aspects:
   i. Existing / recently concluded ABC and BRIC collaborative initiatives on agricultural research, technology, innovation, and knowledge exchange;
   ii. Africa agricultural challenges over the next 20 years; and
   iii. British and Chinese academic and private sector agricultural research expertise.

   This assessment consisted of two complementary and integrated approaches:[8]
   - **Bibliometric analysis** of peer-reviewed scientific publications and non-peer-reviewed literature to quantitatively examine existing research collaborations, commonly cited agricultural challenges in Africa, and the frequency with which publications coming from Britain and China's research sector cite an expertise that could address Africa's challenges.[9]
   - **Research and review** of key strategy and policy documents, private sector investments and partnerships, and programme and project documents to identify Africa's under-addressed agricultural research needs, which Britain and China may be well-suited to address.

(B) Building on the desk-based assessment, the Consortium conducted consultations with 157 stakeholders across the public, private, and academic sectors in Africa, Britain, and China. The objective of the stakeholder consultations was threefold: i) qualify and validate the findings of the desk-based assessment, ii) identify key lessons learned from existing ABC initiatives and collaborations, and iii) gauge receptivity and evaluate level of interest and willingness to support and finance a trilateral ABC agri-tech research programme.

(C) Following the stakeholder consultations, the Consortium organised four one-day consultative workshops in London, Beijing, Accra, and Nairobi. These workshops aimed to bring stakeholders together to: i) further evaluate stakeholder interest and political willingness to support a potential ABC agri-tech research programme, and ii) test, solicit feedback on, and refine initial trilateral research programme ideas, designs, and structures.

(D) The Consortium has synthesised the outputs from steps (A), (B), and (C) in this Scoping Study. Taking into consideration the results of the desk-based assessment and the feedback from the stakeholder consultations and workshops, the Consortium has also developed four programme design options (see Section VI) which highlight, at a high level, the different directions the trilateral agri-tech research programme could take. Each programme design addresses six key aspects of the programme including technical (thematic & geographic scope), political, financial, governance, private sector engagement, and administrative.

[8] The findings of the comprehensive desk-based assessment are based solely on the sample size of publications, initiatives, investment plans, and programme documents reviewed.

[9] This report draws on two major, complementary data sources to conduct the bibliometric analysis – Scopus and CAB Abstracts. Scopus is the world's largest abstracts and citations database for peer-reviewed scientific research, and its global coverage is particularly well-suited for analysing ABC research output and collaboration. Moreover, the deep citation linkages between publication records in Scopus enable advanced analyses of research impact and excellence. CAB Abstracts is the most comprehensive database for agricultural research and other applied life sciences; it covers both peer-reviewed research and some grey literature, comprising over 10,000 serials, books, and conference proceedings. Each record is rigorously curated by subject specialists and assigned keywords, classification codes, and location codes. This enables a deeper semantic analysis of what agricultural topics and challenges in Africa are attracting the most interest from researchers in Britain and China.

II. AFRICA'S AGRICULTURAL CHALLENGES / NEEDS

An Africa-Britain-China (ABC) trilateral agricultural technology (agri-tech) research programme has the opportunity to provide solutions to address future demands and challenges facing African agriculture over the next 20 years. With global population expected to grow to nine billion by 2050, Africa can help the world meet the corresponding rising demands for nutritious food. However, Africa has yet to reach its potential for agricultural productivity due to a number of challenges. The potential trilateral agri-tech research programme will need to clearly address some of these challenges in a well-defined scope. This section lays out the key challenges the African agricultural sector will be facing over the next 20 years.

Macro-Drivers Shaping Africa's Agricultural Challenges

To understand the future challenges that will shape African agriculture over the next 20 years, it is important to review the macro-drivers of these challenges:

- **Climate Change:** Changes in temperature and rainfall patterns; frequency and severity of droughts; more arid regions; rising sea levels; loss of soil fertility, biodiversity, and ecosystems
- **Energy Demand:** Shifts from food crops to biofuel crops; increased energy needs for powering machinery, irrigation, and agro-processing equipment, etc.
- **Rising Income and Demand for Meat:** Changes in land use from cultivation of food crops to animal feed and / or livestock rearing to meet the rising demands for protein and dairy
- **Population Growth:** Increased crop and livestock production to meet rising demand for food; more stress on availability of and access to land / water resources
- **Urbanisation:** Increased demand from emergence of megacities; loss of agricultural land to urban sprawl and development; loss of human capital in rural areas to manage farms; increasing need for development of urban agriculture
- **Trade:** Introduction of new invasive pests and diseases through trade; continued undercutting of local food prices and smallholders' incomes
- **Access to Land:** Changes in soil fertility and health due to erosion, degradation, slash-and-burn techniques, etc.; abandonment of degraded plots for new arable land
- **Access to Water:** Increased water demand for irrigating plots; increased stress on water sources experiencing more frequent / severe droughts
- **Education, Migration, and Diaspora:** Ageing African agricultural scientists; fewer young scientists attracted to the field; loss of human capital in the rural areas to manage farms

These macro-drivers will create new challenges and exacerbate existing ones affecting African agriculture. It will be critical for Africa, along with international partners, to invest in continued research so as to develop appropriate solutions to these challenges. Through research, development, and innovation (R&D&I), particularly at the local African level, these macro-drivers' transformational impacts on food security and nutrition will be appropriately addressed.

Research Funding in Africa: An Unmet Need

Agricultural R&D investments in Africa are currently inadequate. While one objective of this Scoping Study is to define the thematic scope of the proposed trilateral agri-tech research programme, based on identified unmet needs, it must be noted that agricultural R&D is under-funded across the continent. Even R&D for priority crops, such as maize and rice, which receive relatively greater focus by African and international research bodies (e.g., the CGIAR Centres) are still in need of additional investment for continued R&D efforts. Ultimately, every priority value chain and value chain segment is considered insufficiently funded or researched in Africa.

African governments have recognised the importance of investing in agriculture, yet actual investment remains low. In 2003, the "Maputo Declaration on Agriculture & Food Security" declared that countries should increase agricultural investments to at least 10% of national budgets.[10] As of 2013, only 13 countries met or surpassed the 10% target in at least one year since 2003.[11]

In terms of investments specifically for agricultural R&D, the African Union (AU) and United Nations (UN) recommend that countries allocate 1% of agricultural gross domestic production (GDP) to public agricultural R&D.[12] In 2013, the UN Sustainable Development Solutions Network, set a more ambitious target of 5% per year in agricultural R&D spending. Yet in 2011, Sub-Saharan Africa invested an average of 0.51% of agricultural output in research – a decline from 0.59% in 2006.[13] From 2000 to 2011, three countries – Kenya, Nigeria, and South Africa – accounted for nearly half of all of Africa's public agricultural R&D investments and in 2011, only four of DFID's 18 African priority countries reached the 1% investment mark: Kenya, Malawi, South Africa, and Uganda.[14]

Therefore, there is strong justification for introducing a new trilateral agri-tech research programme. There is a long road ahead to reaching adequate R&D investment levels, yet given the current low level of R&D investment, the proposed programme has the potential to have measureable impacts on agriculture in Africa.

Box 1: Brief Overview of the Agricultural R&D Context in Africa

Comprehensive Africa Agricultural Development Programme (CAADP)

The AU declared the CAADP as an integral part of Africa's socio-economic development in Maputo, Mozambique, in 2003. CAADP is the strategic policy framework for agricultural transformation, wealth creation, food security and nutrition, and economic growth and prosperity for all. The framework is focused around four pillars:

1. Extending the area under sustainable land management and reliable water control systems
2. Improving rural infrastructure and trade-related capacities for market access
3. Increasing food supply and reducing hunger
4. Agricultural research, technology dissemination and adoption

Initially conceived as a response to the "widely recognised crisis situation in African agriculture," the operationalisation of CAADP foresaw a "CAADP process," with emphasis on integrating its implementation with existing national, sub-regional, and regional plans. The CAADP process provides legitimacy and political support for agricultural development. To date, over 40 African countries have signed CAADP compacts and over 30 have developed agricultural investment plans.

CAADP Pillar IV

CAADP Pillar IV is led by the Forum for Agricultural Research in Africa (FARA), the continental organisation responsible for coordinating and advocating for agricultural research-for-development. Pillar IV aims to deliver: i) enhanced adoption of available technologies; ii) technology delivery systems that bring innovations to farmers and agribusinesses, especially through use of information and communication technologies (ICT); iii) renewed capacity of agricultural research systems; and iv) mechanisms to reduce the costs and risks of adopting new

[10] *African Union 2003 Maputo Declaration on Agriculture and Food Security.* African Union. July 2003.
[11] *CAADP 10 Years Out: How Have Countries Fared in Agricultural Development*. IFPRI. November 2013.
[12] *Taking Stock of National Agricultural R&D Capacity in Africa South of the Sahara: ASTI Synthesis Report.* IFPRI. November 2014.
[13] *The Africa Agriculture Status Report 2013: Focus on Staple Crops.* AGRA. 2013.
[14] *Taking Stock of National Agricultural R&D Capacity in Africa South of the Sahara: ASTI Synthesis Report.* IFPRI. November 2014.

technologies. The approach to be used is laid out in the Framework for African Agricultural Productivity (FAAP), which envisaged a shift from producing technological packages to integrated agricultural research in which researchers (national and international) work together with smallholders, pastoralists, extension agencies, the private sector and NGOs, to achieve impact on the ground.

Malabo Recommitment to CAADP

In 2014, the AU's African Year of Agriculture and Food Security, African heads of state signed the Malabo declaration. The declaration included a recommitment to the principles and values of the CAADP process, and six other specific commitments and targets including enhanced investment in agriculture. Following Malabo, the CAADP Results Framework 2015-2025 was finalised. It foresees results at three levels:

1. Contribution of agriculture to economic growth and inclusive development
2. Agricultural change and sustained inclusive agricultural growth
3. Strengthening systemic capacity for effective execution and delivery of results

Future Outlook of Agricultural R&D

Also in 2014, FARA developed the Science Agenda for Agriculture in Africa (S3A), an African-owned and African-led process that articulates the science, technology, extension, innovations, policy, and social learning that Africa needs in order to meet its agricultural and development goals. Among S3A's ambitions are the implementation of CAADP, the creation of the enabling environment for sustainable application of science for agriculture, and ultimately the building of systemic science capacity at the national and regional levels. Improving science capacity in Africa will contribute to building a strong base of researchers capable of addressing evolving needs for farmers, producers, entrepreneurs, and consumers, especially the macro-drivers such as climate change and urbanisation.

African Agricultural Challenges – Desk-Based Research and Consultations

To identify Africa's primary agricultural challenges, the Consortium reviewed 85 documents, including i) national and regional strategies (e.g., Nigeria's Agricultural Transformation Agenda, CAADP compacts and investment plans), ii) funder agricultural strategies (e.g., African Development Bank, International Fund for Agricultural Development), iii) agricultural research institute strategies (e.g., FARA, International Centre of Insect Physiology and Ecology), and iv) private sector company growth strategies, (e.g., DuPont-Pioneer: Investing in Africa - Agricultural Development). Based on the findings from this grey literature review, the Consortium extracted keywords related to Africa's agricultural challenges. With supplemental feedback from the 157 stakeholder consultations, the Consortium identified the following 12 top-line challenges:[15]

- **Agricultural Output**: Agricultural yields as a whole remain low in Africa. Though production has increased over the years, it is primarily due to cultivating more land and mobilising a larger labour force rather than direct improvements on yields, varieties, and production techniques. Improved access to inputs and farming methods could result in improved outputs. Agricultural

[15] The challenges, diverse in nature, were aggregated into 12 high-level categories in order to capture the different priorities and perspectives of ABC stakeholders across public, private, and academic sector. For this reason, some of the challenges are more generic (e.g., agricultural output and value chain efficiencies), while others focus on specific value chains (e.g., aquaculture and livestock), and others focus on specific aspects of the value chain (e.g., seeds, access to water). It should also be noted that the 12 agricultural challenges are not mutually exclusive (e.g., the need for new pest-resistant seed varieties affects "Seeds," "Pests & Diseases," and "Agricultural Output").

transformation at the farmer level will also be possible, as increased yields will move farmers from "hanging-in" to "stepping-up."[16]

- **Pests & Diseases:** Weeds and biotic pressures, such as Striga and stem borers, affect food security and production. New pest-resistant varieties have shown strong returns in the field, however, often do not make their way to the farmers. Food contamination, particularly in the post-harvest stage, for example with aflatoxin, remains a challenge for smallholders.

- **Aquaculture & Fisheries:** The aquaculture and fisheries sector has grown in Africa and is recognised as a much needed alternative source of protein. This increase in protein demand is driven by changing tastes and preferences due to the rising incomes of a growing middle class. Challenges surround the scaling up and commercialising of the sector as well as the development of human capacity and access to proper infrastructure.

- **Access to Water:** Climate change, inefficient use of technologies, pollution, and increased demand for food increase pressure on water resources. Poor water management practices, low uptake of efficient irrigation systems, and water degradation need to be addressed.

- **Extension Services:** Linking of farmers to extension service remains low in much of Africa. The Food and Agriculture Organisation (FAO) indicated that investment in agricultural extension services needs to reach at least 3.5% of agricultural GDP in order to achieve proper coverage; as of 2011, no African government was spending even a tenth of that recommendation.[17] With less-than-favourable regional coverage and lack of agribusiness centres, agricultural technology uptake and entrepreneurship remains low.

- **Urban Agriculture:** As urbanisation drives demands for food in cities, urban agriculture must be further promoted. The main challenge around urban agriculture is the low uptake by the urban population. Given that the poorer population typically live at the extremities of urban areas, it is important to note that urban agriculture, in this context, applies to both urban and peri-urban populations. In addition, there are human health risks associated with urban agriculture, including use of untreated sewage-water and heavy metal contamination in urban soils, which needs to be addressed.

- **Land & Soil:** Challenges around land and soil pertained primarily to land degradation and soil erosion. Impacts of land and soil degradation include loss of soil fertility, nutrient degradation, and increased salinity.

- **Value Chain Efficiency:** A variety of challenges that result in low production or food loss are grouped into this category, including low-uptake and access to appropriate-sized mechanisation, inefficient post-harvest storage facilities and technologies, low capacity for agro-processing, and lagging regulations and standards for food safety and traceability. During the four workshops, value chain efficiency, and in particular post-harvest value addition, strongly resonated with participants as a key challenge area that needs increased focus.

- **Biodiversity:** Biodiversity loss due to climate change, deforestation, and invasive species, among others, will create challenges within the agricultural sector. Desertification, degraded watersheds, and loss of species may also hinder food production and sustainable development.

[16] *DFID's Conceptual Framework on Agriculture*. November 2015.
[17] *ICTs could fill agricultural extension gap, says meeting.* November 2011.
http://www.scidev.net/global/farming/news/icts-could-fill-agricultural-extension-gap-says-meeting.html

- **Seeds:** With climate change and introduction of new pests and diseases to regions through trade, new research must continue to develop appropriate seed varieties for the changing agricultural conditions. While research has led to new seed technologies, such as drought- or pest-resistant varieties, there is still a lack of access to these improved varieties at the farmer level. Constraints such as a lagging regulatory environment around new seed varieties and low extension service capacity hinder the effective implementation and use of new seeds. During the four workshops, seeds – and agricultural inputs more broadly – strongly resonated with participants as a key challenge area that needs increased focus.

- **Nutrition:** In Africa, where one in four people are considered undernourished, an emphasis on nutrition-sensitive agriculture is critical. Research around nutrient-dense bio-fortified crops will contribute to achieving food security and improved nutrition, corresponding with Global Goal 2.

- **Livestock:** Animal husbandry and feed systems were also indicated as challenges, particularly given the rising demand for protein and dairy. To meet this demand, it was noted that livestock pests and diseases, such as avian flu, swine fever, and ticks, pose a significant threat to the sector. Livestock pests and diseases were deemed an under-researched field.

Three additional challenges, though not directly related to agricultural technology, were frequently raised by stakeholders. These three challenges directly impact the research environment, and therefore have implications on the ability and capacity to conduct agricultural R&D.

- **Implementation Science:**[18] It was frequently noted that, though research around technical areas is still important, more emphasis is needed on research regarding the socioeconomics of scaling agri-tech research outputs. In fact, many stakeholders remarked that research outputs are still "sitting on the shelves" rather than being put into practice in the field. As noted in "A UK Strategy for Agricultural Technologies," even with the increase of R&D spending over the last decade, new technology development and adoption has remained variable, particularly in Africa, where research is slower to be used than much of the world.[19]

  Therefore, a focus on implementation science, also called the "Science of Delivery", could support the adaptation and adoption of technologies which would in turn effectively be put to use in the African agricultural sector. For more information, see Box 2 on Implementation Science.

- **Attracting Researchers:** African agricultural researchers and academics are ageing and there is not a field of up-and-coming younger researchers to replace them. Lack of incentives (e.g., low salary levels and poor infrastructure conditions) and the inadequate recruiting of the next generation of young Africans scientists to fill this gap will hinder the sector. Better promotion of agricultural science to youth will help to overcome this challenge, which in turn will help to build the African research capacity needed to address the local agricultural challenges.

[18] For the purposes of this Scoping Study, "implementation science" refers to the study of ***how*** to scale adoption / deployment of agri-tech research outputs. Typically used in the health sector (see for example, http://www.fic.nih.gov/researchtopics/pages/implementationscience.aspx, accessed 20 November 2015), the Consortium uses the term "implementation science" to highlight the need to focus on integrating agri-tech research findings into the marketplace. Implementation science is a new multi-disciplinary approach that aims to understand how and why food producers, and other actors in an agricultural value chain, adopt new technologies and innovations. It can also be used to identify possible bottlenecks (social, political, economic, etc.) that limit technology adoption. Implementation science is a critical link between agri-tech research itself and the deployment of the research outputs.

[19] *A UK Strategy for Agricultural Technologies.* Department for Business, Innovation & Skills; Department for Environment, Food & Rural Affairs; UK Trade & Investment; and Department for International Development. July 2013.

Beyond attracting young scientists broadly, an effort to increase the representation of female researchers is necessary. As the majority of African farmers are women, a reflection within the academic and research system would be beneficial to the research conducted, as well as helping to fill the void of low researcher capacity. For example, in the latest available figures from the UNESCO Institute of Statistics, female researchers comprised only 7.6% of all researchers in Agricultural Sciences in Ethiopia (2013) and 19.7% of all researchers in Uganda (2010). These percentages are not only far from gender-parity, but are also lower than the overall percentage of female researchers across all subject areas in those countries (13.3% female researchers in Ethiopia; 24.3% female researchers in Uganda).[20]

- **Policy / Regulatory Environment:** Lagging policy and regulations across Africa affect the volume, quality, and impact of agricultural R&D and researchers and therefore the sector as a whole. Policies and regulations around issues such as intellectual property (IP) protection, genetically modified organisms (GMOs) and seed certification, among others restrict or inhibit change and impact the agri-tech research outputs may have on the agricultural sector.

Box 2: Implementation Science

The Problem Frame

Dissemination, adoption, and diffusion of agri-tech research outputs in Sub-Saharan Africa is often constrained by the heterogeneity of agro-ecologies and farming systems, lack of access to efficient output markets, underdeveloped input markets (particularly for fertilizer), and associated lack of credit and insurance. At the same time, investors in the agricultural sector, whether private or public, seek a relevant scale to generate sufficient returns on their investments. Over the last decade, in part driven by the large project investments made by the Bill and Melinda Gates Foundation, scaling of agricultural technologies has become an implementation issue, with a significant lag in the social science research that would underpin efficient scaling of agricultural technologies in a Sub-Saharan African context. Increasing the productivity of smallholder farms depends on a complement of technologies adapted to particular contexts. Moreover, delivery infrastructure is only just being developed through innovations in agro-dealer networks, pluralistic extension systems, farmer organisations, information delivery through mobile phones, and innovation platforms. Implementation science in the agricultural sector requires methodologies that can better target the array of agricultural technologies, building on learning in the design of scaling strategies, and evaluating the effectiveness and efficiency in the deployment of those strategies.

The Emerging Field of Implementation Science

Implementation science is a new multi-disciplinary approach that aims to understand how and why food producers and other actors in an agricultural value chain adopt new methods and technologies (innovate), and on the basis of that understanding, how to most efficiently deploy those technologies to achieve a relevant scale. In other words, what are the social, cultural, and economic barriers to technology adoption and how can programmes help incentivise behaviour change to scale uptake? This field draws on innovation systems thinking, originally developed in the context of industrialised enterprise, but within the last decade applied to agricultural development. Within implementation science there is a sequenced set of research areas which are relatively independent in time and each having its own research agenda which feeds into the next stage. Such stages would include the following:

- Understanding farmers' needs and potential for adoption – priorities, decision making, preferences, constraints, particularly farmer use of information

[20] http://data.uis.unesco.org/

- Understanding the context – socio-cultural and institutional environment, input and output markets, agroecology, and aspects such as gender, laws and policies
- Assessing the needs and capacity of institutions that will be involved in the innovation process (public extension, private sector, civil society, farmer organisations)
- Identifying likely diffusion / uptake pathways at scale; bottlenecks and constraints
- Measuring uptake / adoption / impact; who benefits, and how?
- Learning from successes and failures in implementing development projects at scale, as the basis for improving the effectiveness and efficiency of future interventions

Given the early development of this field – which essentially replies on social science disciplines – in agriculture, research methodologies are only just evolving in particular areas. To date, there has been little attempt to integrate across these different stages, in part because the work is primarily based on project based funding and this is time bound.

There are very few examples of agricultural technologies being deployed and adopted at scale in Sub-Saharan Africa. One of the best known examples is the control of cassava mealy bug through the release of a parasitoid, however, in this case deployment did not depend on farmer adoption. Most agricultural technologies such as improved varieties, fertilizer blends, rhizobia inoculants, disease management, and others employ a range of variations to exploit the heterogeneity of agro-ecologies and farming systems on the continent. Scaling thus requires a framework for effective targeting in the deployment of technologies.

Big data, especially in the form of spatial data sets, are being increasingly used in such targeting. Where there is a poverty focus to scaling strategies, targeting will need to be done at the community level, where technology is deployed based on farmer typologies.[21] Effective targeting must also be embedded in effective and efficient extension systems. There has been little research on assessing the costs and effectiveness of alternative extension approaches – the work on farmer field schools is probably the exception. Evaluation of alternative extension or deployment options is increasingly using experimental techniques such as randomised control trials which are integrated into the roll out of extension projects. For example, 3ie is leading such work for AGRA and IFAD in assessing alternative deployment strategies. Implementation science thus becomes integral to the increased focus on performance metrics in investments in agricultural research.

Most of this work is based in Africa but has relied on expertise from the North or international research organizations. Building social science capacity in Africa to support this evolving agenda on implementation science will be essential in institutionalising these types of approaches in African R&D organisations. Examples of such capacity building initiatives are RUFORUM's collaborative PhD on rural innovation, AERC's collaborative MSc program in agricultural economics – where implementation science could be built into the second year options – and joint research potential of such projects as 3ie's work with AGRA grantees.

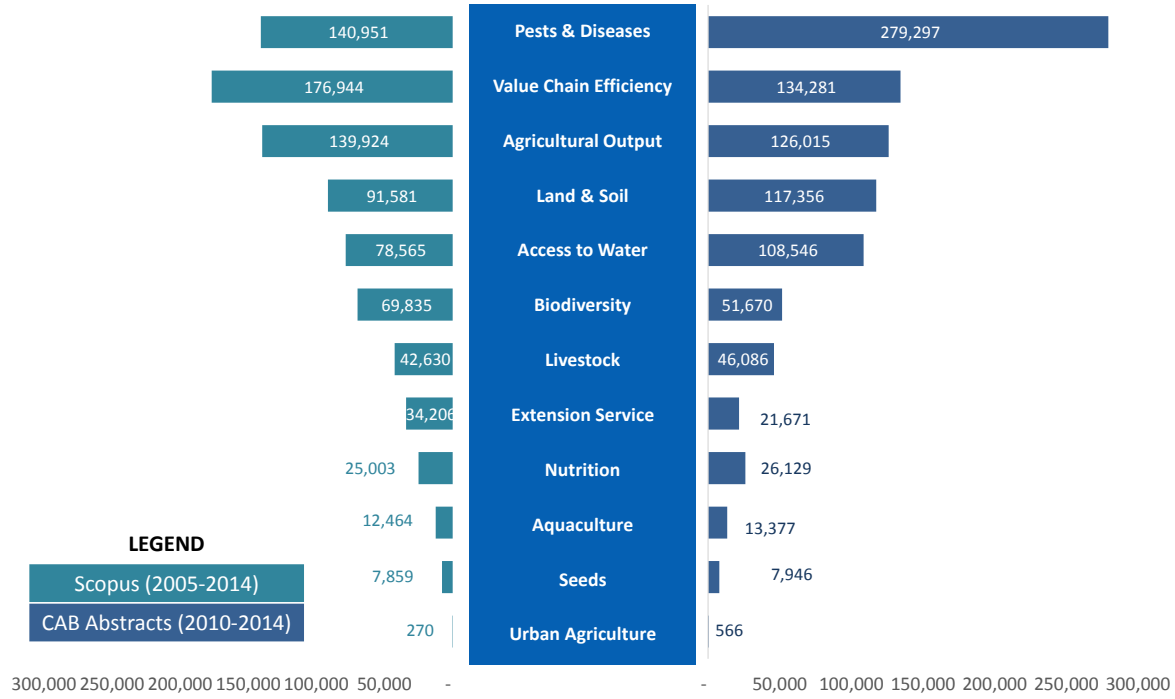
African Agricultural Challenges – Bibliometric Analysis

The keywords derived from the desk-based research were then fed into the bibliometric analysis to conduct additional analysis. The bibliometrics assessed at what level the world is producing research on the identified African agricultural challenges. Figure 2 below shows the world's number of publications by African agricultural challenge. It is important to note that the data shows absolute

[21] For example see Franke, A.C., G.J. van den Branda, K.E. Giller (2014). Which farmers benefit most from sustainable intensification? An ex-ante impact assessment of expanding grain legume production in Malawi. European J. Agronomy 58: 28–38.

number of publications. Feedback from stakeholders emphasised that publication output alone is not a good proxy for measuring whether or not a challenge is adequately researched, but rather that it would be important to also account for the severity of the challenge and government priorities.

Figure 2: Global volume of AgBio publications, by agricultural challenge, 2005-2014. Source: Scopus® and CAB Abstracts



The bibliometric research further examined how much research is being produced by Africa, Britain, and China on these challenges and what the relative citation impact of that research is.

Box 3: Relative Research Output and Impact in Africa, Britain, and China

Relative volume indicates how much more research a country or region produces in a given subject area relative to the world average. As an example, if the world produces 100 units of research and 10 units of research specifically in water science, then the world produces about 10% of its research in water science. If Africa produces 20 units of research overall and 4 units specifically in water science, then water science as a share of Africa's total research is 20%. Thus, Africa produces twice as much research in water science given the size of research output versus the world average.

Relative citation impact indicates how impactful in terms of citations a country's or region's research is in a given subject area relative to the world average. For example, a relative citation impact of 1.16 indicates that the average paper from that country is cited 16% above the world average for a paper of the same type, age, and subject area, whereas a relative citation impact of 0.91 indicates that the average paper from that country is cited 9% below the world average of that type, age, and subject area. Both relative volume and relative citation impact can be calculated for a given year and averaged (weighted) across an entire decade.[22]

[22] It should be noted that relative volume and relative citation impact do not necessarily reflect research impact on agricultural yields, but rather serve as proxies.

Table 1 and 2 below shows the relative volume and relative citation impact of publication output by Africa, Britain, and China for the identified agricultural challenge sub-areas.

China produces a relative volume of 1.37 for "Land & Soil" research, which indicates that China publishes 37% more on this agricultural challenge than expected given the world average. Other agricultural challenges in which China produces a high relative volume of research include "Access to Water" (1.31), Value Chain Efficiency (1.20), and "Agricultural Output" (1.14).

Britain produces a higher relative volume on "Biodiversity" (1.46) and "Livestock" (1.31) challenges. Research on these challenges comprises 6.72% and 3.69% of Britain's AgBio output compared to the world average of 4.59% and 2.80%, respectively. Moreover, as seen in Table 2, Britain's relative citation impact of "Biodiversity" research is 60% higher than the world average.

Africa's relative volume of publication output for the agricultural challenges is well above the world average for all subject areas except for aquaculture. As the most salient African challenges were assessed, it is not necessarily surprising that Africa's relative volume of research compared to the world average is high. If anything, the high relative volume of research output on the challenges suggests that Africa is focusing its more limited research capacity on the topics most pertinent to its agricultural sector rather than all AgBio sub-areas, broadly. Of particular note, Africa has an exceptionally high relative volume of research on "urban agriculture," the agricultural challenge with the smallest research footprint.

Table 1: Relative volume of publication output on agricultural challenge sub-areas, 2005-2014. Source: Scopus®

	Agricultural Output	Access to Water	Land & Soil	Seeds	Pests & Diseases	Extension Service	Value Chain Efficiency	Nutrition	Aquaculture	Urban Agriculture	Biodiversity	Livestock
China	1.14	1.31	1.37	1.14	0.84	0.76	1.20	0.43	0.97	0.54	0.70	0.54
Britain	0.68	0.75	0.93	0.54	0.96	1.13	0.89	0.96	1.03	0.80	1.46	1.31
Africa	1.58	1.49	1.32	2.33	1.33	2.23	1.02	2.17	0.88	8.44	1.49	1.46

Table 2: Relative citation impact of publication output on agricultural, 2005-2014. Source: Scopus®

	Agricultural Output	Access to Water	Land & Soil	Seeds	Pests & Diseases	Extension Service	Value Chain Efficiency	Nutrition	Aquaculture	Urban Agriculture	Biodiversity	Livestock
China	0.95	0.83	0.85	1.08	1.01	0.77	0.77	0.93	0.95	0.66	0.63	0.88
Britain	1.77	1.55	1.55	2.30	1.42	1.71	1.63	1.56	1.64	0.95	1.60	1.31
Africa	0.77	0.85	0.87	1.13	0.83	0.89	0.80	0.52	0.68	0.78	0.99	0.78

Conclusion

In conclusion, the African agricultural sector will face a variety of challenges driven by climatic, demographic, and economic factors. Many of these future challenges could ultimately be addressed if an adequately-funded agricultural R&D sector were in place. Increasing agricultural R&D investments by at least 1% will be critical in reducing the under-researched and under-funded challenges. Until this is achieved, many agricultural technical areas will remain insufficiently addressed. The trilateral agri-tech research programme's scope should align the identified challenges, all of which are under-addressed, with national, regional, and continental priorities.

III. AFRICA, BRITAIN, AND CHINA AGRI-TECH R&D EXPERTISE

Africa, Britain, and China (ABC) researchers are well-positioned in their respective areas of agri-tech R&D expertise to address many of the identified agricultural challenges that Africa will face over the next 20 years. The comprehensive desk-based assessment and consultations with 157 stakeholders confirmed the added value both Britain and China could bring to a trilateral collaboration. Britain has long been known for its strong research reputation in basic sciences as well as its understanding of R&D management, policy and regulatory frameworks, and project monitoring and evaluation. China, meanwhile, having undergone significant transformation and growth in the agricultural sector over the past 30 years, brings its wealth of knowledge around applied science, adopting, adapting, and scaling technology outputs. Africa's extensive knowledge of its own agricultural sector and challenges align well for the blending with Britain and China's distinct areas of expertise for impactful trilateral research collaboration.

ABC Areas of Expertise – Bibliometric Analysis

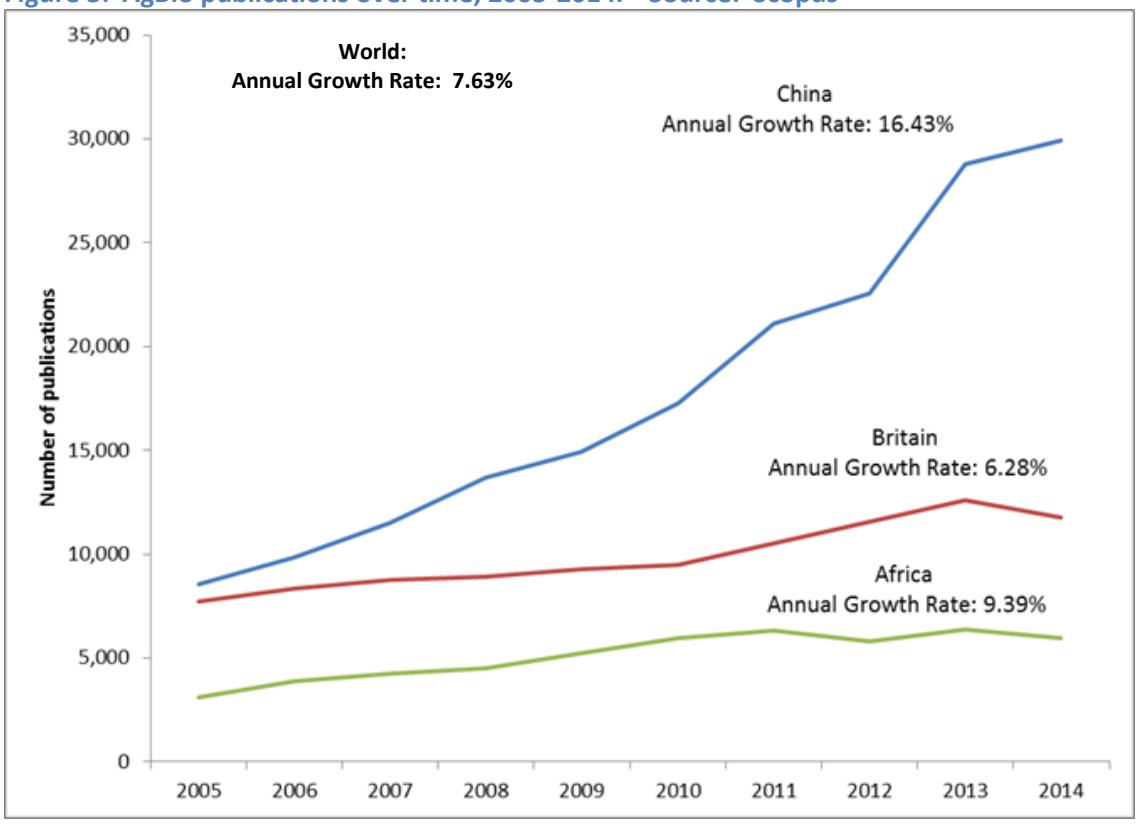
To identify agricultural areas of expertise, the bibliometric analysis focused on ABC's peer-reviewed scientific publication output in the Agricultural and Biological Sciences (AgBio). The analysis covered the time period 2005-2014 for the following agricultural sub-areas:[23] Agronomy and Crop Science; Animal Science and Zoology; Aquatic Science; Ecology, Evolution, Behaviour, and Systematics; Food Science; Forestry; Horticulture; Insect Science; Plant Science; and Soil Science. The two key metrics assessed were the relative volume of ABC's AgBio publications and the relative citation impact of these research publications.

ABC General AgBio Production Growth

In looking at the AgBio sector broadly, ABC's publication output has grown steadily over the last ten years. From 2005 to 2014, Africa produced over 51,000 publications in AgBio. By comparison, Britain and China have produced over 98,000 and 178,000 AgBio publications respectively over the same period. As Figure 3 shows, Africa's annual level of output in AgBio has grown by 9.39% per year[24] and its annual output of AgBio research in 2013 was more than double its output in 2005. Africa's annual growth rate in AgBio research is higher than that of Britain's, 6.28%, and the world's, 7.63%. Impressively, China has increased its output in AgBio from 8,500 publications in 2005 to more than 29,000 in 2014, a 16.43% growth rate per year.

[23] Please see Appendix I within Annex 1: Elsevier Bibliometrics Report for more description on the specific topics covered under each Scopus agricultural sub-area.
[24] Annual growth in output refers to Compound Annual Growth Rate (CAGR).

Figure 3: AgBio publications over time, 2005-2014.[25] Source: Scopus®



As AgBio publications, globally, have increased over the same time period, it is important to compare the relative growth of ABC's world publication share. Is ABC keeping pace overall (and in specific sub-areas) with the global growth of AgBio research? Although Africa's absolute number of annual publications in AgBio has almost doubled, its world publication share has not increased significantly over the past decade. Similarly, Britain's world publication share has slightly declined from 7.21% to 6.43%. In contrast, China's world publication share has more than doubled from 7.95% in 2005 to 16.34% in 2014. That is, nearly one out of every six articles in AgBio research today is co-authored by a Chinese researcher. This reinforces the strategic importance of including China in any research programme on agriculture.

ABC AgBio Sub-Areas of Expertise

As ABC's focus on the AgBio subject area has increased over the past decade, a closer look into the research output by sub-areas of the individual country / region, and some of the most prolific institutions in AgBio research,[26] helps demonstrate specific areas of expertise. This agricultural sub-area expertise can be measured using two different bibliometric indicators: the relative volume and the relative citation impact of research output.

[25] Annual growth rate from 2005-2013

[26] It should be noted that the Scoping Study's methodology over-represents universities and other institutions that span broad areas of science and have large counts of research personnel. Likewise, it under-represents institutions conducting strong AgBio research in more niche or focused areas, such as the CGIAR Centres in Africa or independent research centres in the UK, such as Rothamsted Research, the John Innes Centre, the Sainsbury Laboratory in Norwich, the Wellcome Trust Sanger Institute, and the Plymouth Marine Laboratory.

Box 4: Measuring Research Expertise and Growth Areas

Figures 4 through 8 and Tables 3 through 5 map the sub-areas along two dimensions of research strength: relative volume (x-axis) and relative citation impact (y-axis), which have been defined above in Section II Box 3.

The bibliometrics may be used to identify key areas of AgBio research expertise for Africa, Britain, and China based on the following indicators:

Areas of strength are defined to be those sub-areas in which the country or region produces both a high relative volume and a high relative citation impact of research over the past decade. Areas of strength are considered the sub-areas that fall in the top right quadrant.

Areas of growth are defined to be those sub-areas in which the country or region has improved or increased the relative volume and relative citation impact of its research over the past decade. Areas of growth are considered the sub-areas that are trending towards the top right quadrant.

AFRICA

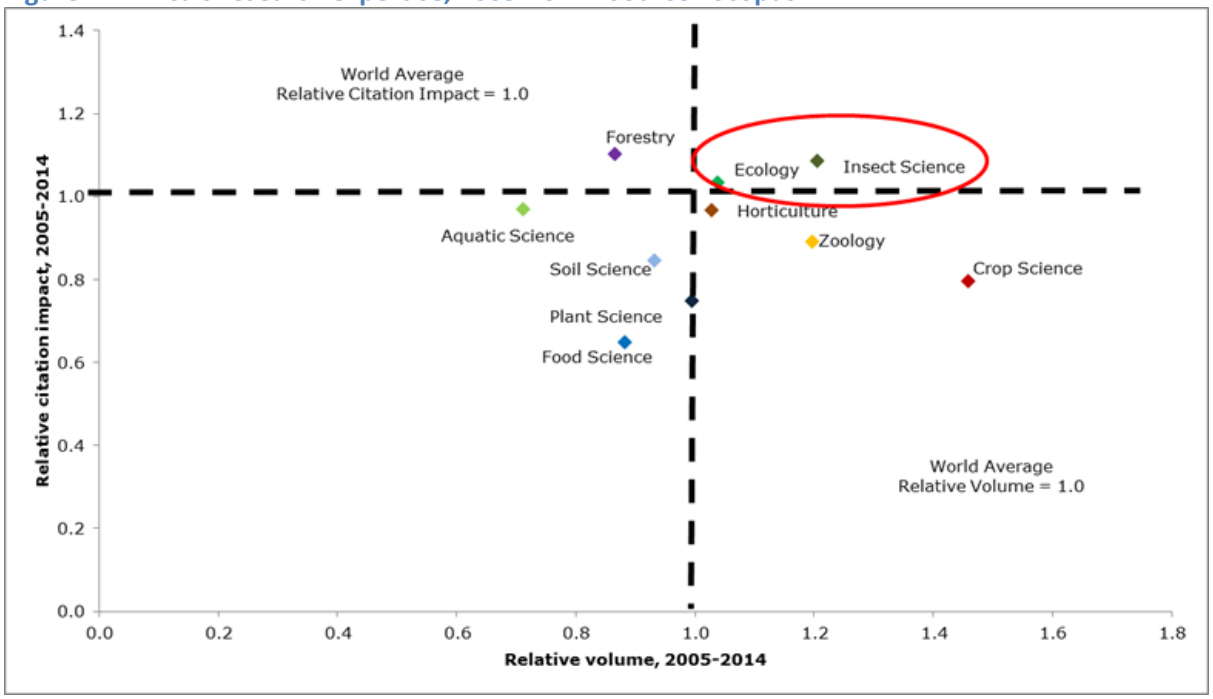
Areas of Strength:

In Figure 4 below, circled in red are Africa's relative research strengths: i) Ecology, Evolution, Behaviour & Systematics, and ii) Insect Science.

Ecology, Evolution, Behaviour & Systematics: Relative to the world, Africa produces 5% more research in this sub-area than expected, and its average relative citation impact is 3% higher than the world average. The most prolific African institutions in this sub-area are from South Africa (University of Cape Town produced over 1,100 publications from 2005-2014, and the University of Pretoria and the University of Stellenbosch each produced over 870 publications).

Insect Science: In terms of output, from 2005-2014, Africa produced 21% more publications in this sub-area than the world average. Africa achieves a high relative citation impact in Insect Science at 1.09, which is significant as it is not only above Africa's general AgBio research impact, 0.88, but it is also above the world average from 2005-2014. The most prolific African institution in this sub-area is the International Centre of Insect Physiology and Ecology (ICIPE), which produced nearly 350 publications from 2005-2014 that achieved a relative citation impact of 1.21 (or 21% above the world average). Other prominent non-South African universities in this sub-area include the International Institute of Tropical Agriculture (IITA) and Kenyatta University, Kenya.

Figure 4: Africa's research expertise, 2005-2014. Source: Scopus



Areas of Growth:

Table 3 below highlights Africa's relative research growth areas: i) Horticulture; ii) Food Science; and iii) Animal Science & Zoology.

Horticulture: Horticulture is a sub-area in which Africa's relative volume has increased dramatically, from 0.94 in 2005 (6% below the world average) to 1.12 in 2014 (12% above the world average). This suggests that Africa is substantially increasing its relative focus in Horticulture. The relative citation impact of Africa's research has also increased from 0.79 in 2005 (21% below the world average) to 1.08 in 2014 (8% above the world average). This indicates that the quality of horticulture research produced by Africa is strengthening. Africa's growth in this sub-area has been driven by institutions such as the University of Stellenbosch (over 300 publications from 2005-2014 achieving a relative citation impact of 1.46) and IITA (92 publications achieving a relative citation impact of 1.50).

Animal Science & Zoology: Africa has increased its relative volume of research in this sub-area over the past decade from 1.22 in 2005 (or 22% above the world average) to 1.37 in 2014 (or 37% above the world average). In absolute terms, the region has nearly doubled its annual output (from 588 publications in 2005 to 1,088 publications in 2014). The most prolific African institutions in this area include the University of Pretoria, University of KwaZulu-Natal, the University of Stellenbosch, and the University of Cape Town, South Africa. The International Livestock Research Institute (ILRI) and the University of the Witwatersrand stand out for the high relative citation impact of their research in this sub-area.

Food Science: Although Africa produced a low relative volume of research in Food Science that achieved a similarly low relative citation impact (both below the world average), it has improved its performance over the past decade. The two most prolific African institutions in Food Science are the University of Stellenbosch (444 publications from 2005-2014) and the University of Ibadan (411 publications). Six of the top ten most prolific African institutions in this sub-area are based in Nigeria, including IITA.

Table 3: Changes in Africa's research growth areas, 2005 versus 2014. Source: Scopus

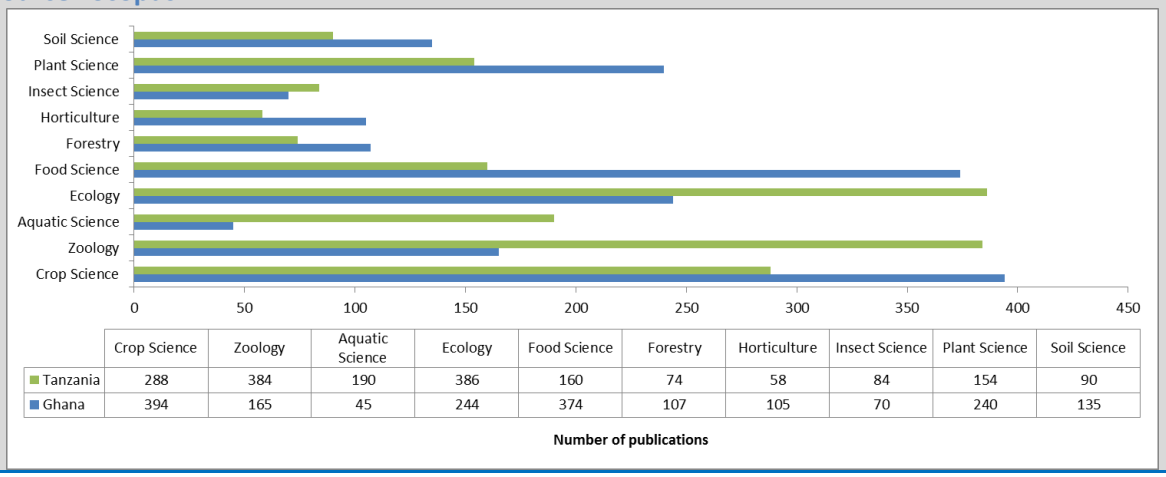
Sub-area	Percentage point change in relative volume	Percentage point change in relative citation impact
Horticulture	0.18	0.29
Zoology	0.15	0.01
Food Science	0.03	0.10
Ecology	0.18	-0.04
Aquatic Science	0.16	-0.02
Soil Science	0.14	-0.14
Forestry	-0.05	0.37
Plant Science	-0.25	0.21
Crop Science	-0.27	0.14
Insect Science	-0.15	-0.20

Given this Scoping Study's broader focus, this report aggregated the bibliometric analyses across all African countries, providing a holistic appraisal of the subcontinent's research strengths and connections with Britain and China. The callout box below provides a more in-depth analysis of the research output of two specific African countries: Ghana and Tanzania. This is a sample of the bibliometric analysis that could be performed for all SSA countries.

Box 5: Country-Specific Example of Bibliometric Analyses

From 2005-2014, Ghana produced 1,690 publications in AgBio.[27] Crop Science (394 publications) and Food Science (374 publications) were the sub-areas with the largest volumes of publications, each comprising nearly a quarter of the country's total output, as Figure 5 shows. Over the same time period, Tanzania produced 1,874 publications in AgBio,[28] with Ecology (386 publications) and Zoology (384 publications) with the greatest volume of publications, each comprising nearly a fifth of the country's total output.

Figure 5: Number of publications in AgBio, for Ghana and Tanzania, per sub-area, 2005-2014. Source: Scopus®



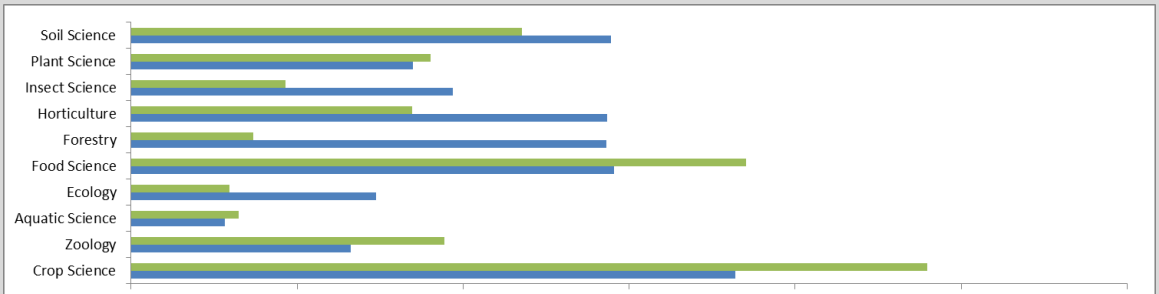
	Crop Science	Zoology	Aquatic Science	Ecology	Food Science	Forestry	Horticulture	Insect Science	Plant Science	Soil Science
Tanzania	288	384	190	386	160	74	58	84	154	90
Ghana	394	165	45	244	374	107	105	70	240	135

[27] Note that the Ghana's 1,690 publications does not equal the sum of Ghana's publications (1,879) in Figure 5 as the 1,690 avoids double counting of publications that may be counted under two or more sub-areas (e.g., a publication may be counted under "Aquatic Science" and "Animal Science & Zoology").

[28] Note that Tanzania's 1,874 publications does not equal the sum of Tanzania's publications (1,868) in Figure 5 as the 1,874 includes publications from Scopus' general agricultural sub-areas, "General Agricultural and Biological Sciences" and "Agricultural and Biological Sciences (miscellaneous)".

In terms of relative volume, Ghana and Tanzania produced significantly more research in Crop Science than expected given the world average (1.82 and 2.40, respectively). The countries also generated high relative volumes of activity in Food Science (45% higher than expected given the world average for Ghana, 85% for Tanzania).

Figure 6: Relative volume of publications in AgBio, for Ghana and Tanzania, per sub-area, 2005-2014. Source: Scopus®



	Crop Science	Zoology	Aquatic Science	Ecology	Food Science	Forestry	Horticulture	Insect Science	Plant Science	Soil Science
Tanzania	2.40	0.94	0.32	0.30	1.85	0.37	0.85	0.47	0.90	1.18
Ghana	1.82	0.66	0.28	0.74	1.45	1.43	1.43	0.97	0.85	1.44

Relative volume for Ghana and Tanzania

In terms of research impact and excellence, 7.22% (122 publications) and 11.42% (214 publications) of Ghana and Tanzania's research output from 2005-2014 are among the top-cited 10%. The most prolific institutions in each country in AgBio research are the University of Ghana and the Kwame Nkrumah University of Science and Technology for Ghana; and Sokoine University of Agriculture and the University of Dar Es Salaam for Tanzania. These four institutions are among the top fifty most prolific African institutions in AgBio research over the past decade.

BRITAIN

In Figure 7 below, circled in red are Britain's relative research strengths: [29] i) Ecology, Evolution, Behaviour & Systematics, ii) Aquatic Science, and iii) Animal Science & Zoology.

Areas of Strength:

Ecology, Evolution, Behaviour & Systematics: Britain accounts for nearly one in every eleven papers in the world in this sub-area (9.34%) with a relative volume of 1.44, or 44% above the world average. Britain's relative citation impact for this sub-area has remained above the world average over the last decade, growing from 1.44 in 2005 to 1.60 in 2014. The top three British institutions in this sub-area are the University of Oxford, the Natural History Museum in London, and the University of Cambridge. Each institution produced more than 1,900 publications in this sub-area from 2005-2014.

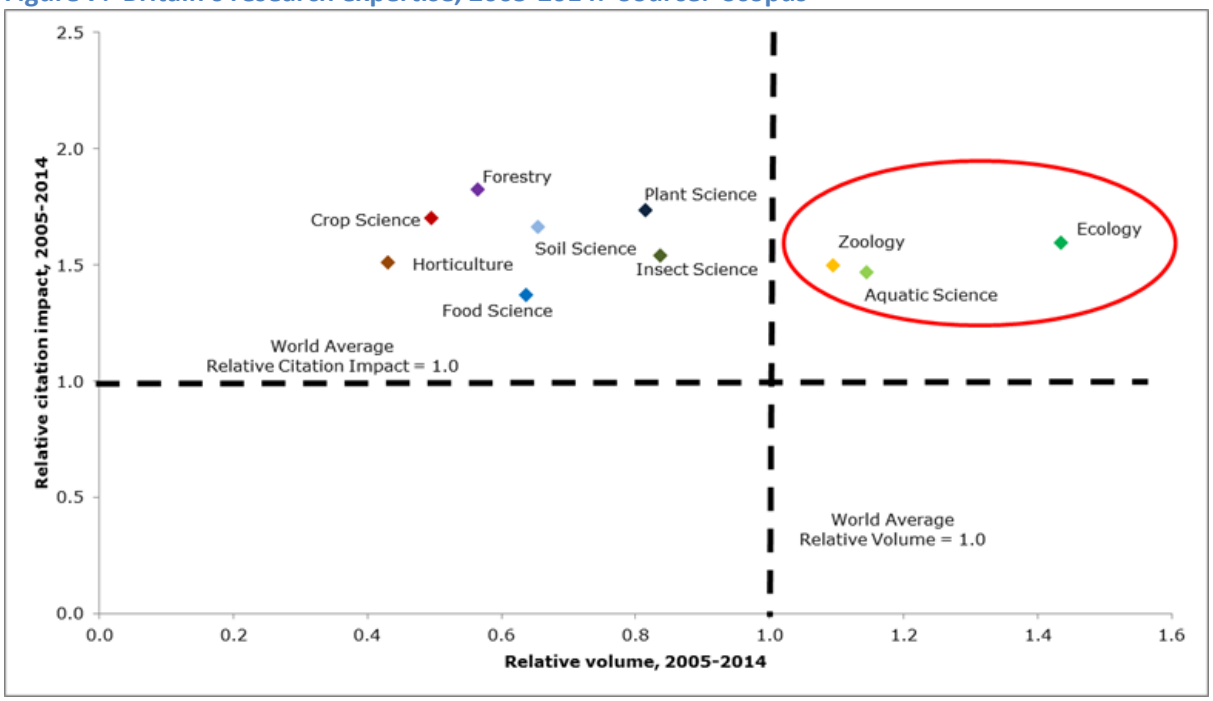
Aquatic Science: Britain's average relative volume in Aquatic Science is 1.15, or 15%, above the world average for the decade. Aquatic Science's relative citation impact has also grown over the

[29] It is important to note that the relative citation impact of Britain's research in all AgBio sub-areas is well above the world average, and the exclusion of sub-areas such as Plant Science; Crop Science; Insect Science; Soil Science; Horticulture; or Food Science from the list of Britain's "strengths" is an artifact of how the methodology defines research strengths to refer to sub-areas in which a country has *both* a high relative citation impact and a high relative volume.

last decade from 1.33 in 2005 to 1.57 in 2014. The top British institution in this sub-area is the Centre for the Environment Fisheries and Aquaculture Science, which produced over 800 publications that achieved a relative citation impact of 1.94.

Animal Science & Zoology: Britain's relative volume in this sub-area is 1.10, or 10% above the world average. The relative citation impact of Britain's research is 1.50 for the decade. The most prolific British institutions in this sub-area are the University of Edinburgh, the University of Cambridge, and the Natural History Museum of London – each produced nearly 1,000 publications over the past decade.

Figure 7: Britain's research expertise, 2005-2014. Source: Scopus



Areas of Growth:

Table 4 below highlights Britain's relative research growth areas: i) Ecology, Evolution, Behaviour & Systematics, and ii) Forestry.

Ecology, Evolution, Behaviour & Systematics: Britain's relative volume in this sub-area increased from 1.36 in 2005 to 1.51 in 2014. Likewise, the relative citation impact of British research has increased from 1.44 in 2005 to 1.60 in 2014. The most prolific British institutions in this sub-area are the University of Oxford, the Natural History Museum of London, and the University of Cambridge. The University of Oxford stands out not only for leading all British institutions in terms of output (over 2,300 publications in the past decade on this sub-area) but also ranked third among all British institutions in terms of the relative citation impact (2.28) of its research – more than twice the level of the world average.

Forestry: Although Britain's average relative volume is below the world average, at 0.57 over the decade, Britain has significantly increased the relative citation impact of its research in this area. It has grown from 1.36 in 2005 to 2.07 in 2014. The top British institutions in this sub-area are Forest Research (the research agency of the Forestry Commission), the University of Aberdeen, and the University of Edinburgh.

Table 4: Changes in Britain's research growth areas, 2005 versus 2014. Source: Scopus

Sub-area	Percentage point change in relative volume	Percentage point change in relative citation impact
Ecology	0.15	0.16
Forestry	0.07	0.70
Aquatic Science	-0.04	0.24
Insect Science	-0.08	0.08
Zoology	-0.17	0.13
Plant Science	-0.18	0.25
Crop Science	-0.29	0.56
Food Science	-0.41	0.05
Horticulture	-0.14	-0.51

CHINA

Areas of Strength:

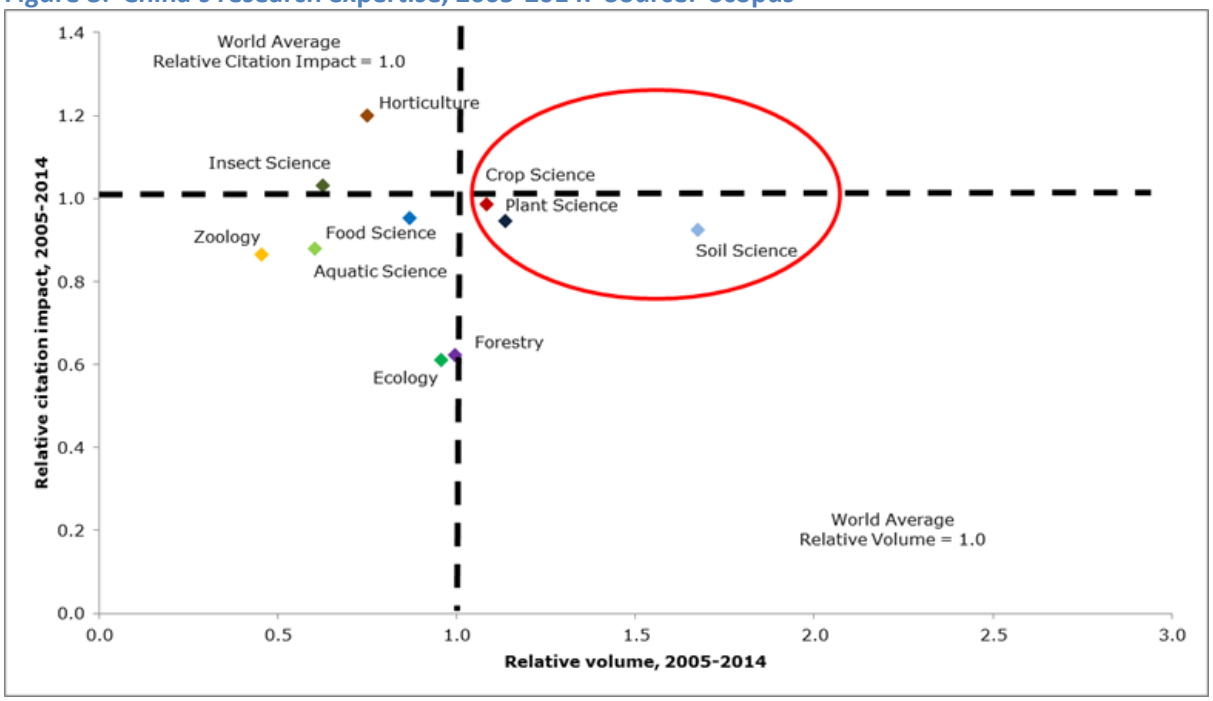
In Figure 8 below, circled in red are China's relative research strengths: i) Agronomy & Crop Science, ii) Plant Science, and iii) Soil Science.

Agronomy & Crop Science: China's relative volume for the sub-area over the decade is 1.08, or 8%, above the world's average. In addition, China has steadily increased the relative citation impact of its research in this sub-area from slightly below (0.97) the world average in 2005 to above the world average (1.08) in 2014. The most prolific Chinese institutions in this area are the Chinese Academy of Agricultural Sciences, China Agricultural University, and the Chinese Academy of Sciences. Other regional universities producing highly impactful research in this sub-area include Zhejiang University and Huazhong Agricultural University (achieving relative citation impact scores of 1.16 and 1.17, respectively).

Plant Science: China has continued to focus on the Plant Science sub-area over the decade with a relative volume of 1.14. The relative citation impact of China's research on Plant Science has grown significantly over the decade, rising from 0.80 (20% below the world average) in 2005 to 1.03 (3% above the world average) in 2014. The Chinese Academy of Sciences leads all Chinese institutions in terms of output, producing nearly 3,100 publications in this sub-area over the past decade. While less prolific, China Agricultural University and Huazhong Agricultural University produce highly impactful research in this sub-area, achieving relative citation impact scores of 1.29 and 1.35, respectively.

Soil Science: China accounts for nearly one out of five Soil Science publications in the world. Soil Science has remained a key focus for China over the decade, achieving an average relative volume of 1.68, or 68% above the world average. China's relative citation impact has remained fairly stable over the past decade, averaging a relative citation impact of 0.92. The Chinese Academy of Sciences produced nearly 3,000 publications in this sub-area, more than three times as many as the next closest Chinese institution. However, less prolific regional institutions such as the Northwest Agriculture and Forestry University and the Nanjing Agricultural University (each of which still produced over 400 publications on this sub-area over the past decade) have also achieved higher relative citation impact, attaining scores of 1.41 and 1.54, respectively.

Figure 8: China's research expertise, 2005-2014. Source: Scopus



Areas of Growth:

Table 5 below highlights China's relative research growth areas: i) Animal Science & Zoology, ii) Food Science, and iii) Insect Science.

Food Science: China has significantly increased focus on Food Science in recent years, growing from 0.65 in 2005 to 1.29, 29% above the world's average, in 2014. China's relative citation impact has increased, though at a slower pace. China's growth in this sub-area has been spearheaded by China Agricultural University, Zhejiang University, and Jiangnan University.

Animal Science & Zoology: China's focus on this sub-area is very low compared to the world average with an average relative volume of 0.46 over the decade. However, it has increased from 0.37 in 2005 to 0.47 in 2014. In addition to an increasing relative volume, the relative citation impact of China's research has been increasing, with an average relative citation impact of 0.87 over the past decade. The most prolific Chinese institution in this sub-area is China Agricultural University, which produced nearly 1,500 publications over the past decade.

Insect Science: Over the past ten years, China has taken great strides in improving both the relative volume and relative citation impact of its research on Insect Science. Its relative citation impact in the sub-area increased from 0.85 (or 15% below the world average) in 2005 to 1.02 (or slightly above the world average) in 2014.[30] The Chinese Academy of Agricultural Sciences stands out among all Chinese institutions in this sub-area for being the most prolific (472 publications from 2005-2014) and the most impactful (relative citation impact of 1.52, or 52% above the world average).

[30] Note in Table 5 that the percentage point change in relative citation impact for "Insect Science" is 0.18 due to rounding.

Table 5: Changes in China's research growth areas, 2005 versus 2014. Source: Scopus

Sub-area	Percentage point change in relative volume	Percentage point change in relative citation impact
Food Science	0.64	0.02
Zoology	0.10	0.11
Insect Science	0.09	0.18
Aquatic Science	0.19	-0.03
Horticulture	0.01	-0.02
Crop Science	-0.01	0.11
Plant Science	-0.16	0.23
Forestry	-0.22	0.40
Ecology	-0.26	0.22
Soil Science	-1.14	0.04

ABC Areas of Expertise – Stakeholder Consultations

The bibliometric analysis, which provides a unique lens in identifying areas of agricultural research expertise, was validated and complemented by additional input from consultations and workshops.

BRITAIN

Additional sub-areas of expertise for Britain are: i) Seed Science, including plant breeding, big data, and sequencing and genetics / genomics, ii) Soil Science, iii) Food Safety, iv) Sustainable Agricultural Intensification, v) Multi-disciplinary Research, and vi) Policy and Regulations.

The stakeholders emphasised the value in Britain's strong expertise in basic science research, including multi-disciplinary and socio-economic research, and this is also reflected in past bibliometric analyses of Britain's overall research base.[31] Britain is well placed to support capacity building in basic science research, particularly given Britain's strengths in producing impactful agricultural research.

CHINA

Stakeholders also suggested these additional sub-areas of expertise for China: i) Aquatic Sciences, including Aquaculture and Fisheries, ii) Value Chain Efficiency, including inputs, low-cost mechanisation, and agro-processing, iii) Water Science, iv) Crop Improvement, v) Plant and Animal Genetics / Genomics, and vi) Sustainable Agricultural Intensification. Although the bibliometric analyses do not necessarily identify China as having distinct research strengths in these areas, the bibliometrics suggest that China has improved its performance along at least one of the two dimensions of relative research volume or citation impact. For example, the relative volume of China's research in Aquatic Science has increased from 0.47 in 2005 to 0.66 in 2014; although this is still below the world average, it is a large improvement. On the other hand, the relative citation impact of China's research in Ecology (which covers Plant and Animal Genetics / Genomics) has grown from 0.52 in 2005 to 0.74 in 2014. Similarly, over the entire period of 2005-2014, the relative

[31] See page 34-35 of UK Department of Business Innovation and Skills. 2013. International Comparative Performance of the UK Research Base - 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf; and Pan, Lei, and Sophia Katrenko. 2015. A Review of the UK's Interdisciplinary Research Using a Citation-Based Approach: Report to the UK HE Funding Bodies and MRC by Elsevier. http://www.hefce.ac.uk/pubs/rereports/Year/2015/interdisc/Title,104883,en.html

volume of China's research in Value Chain Efficiency research in AgBio is 1.20, or 20% above the world average.

More generally, China, which has gone through significant agricultural transformation over several decades, has extensive knowledge on applied science, including the adaptation of agricultural technology research and the adoption and scaling of these technologies in the field.

With regards to Britain's expertise in basic science and China's in applied science, collaboration with Africa around implementation science would be particularly valuable. As stated in Section II, adoption of new technologies in Africa remains much lower than the rest of the world. ABC would be well-positioned to engage in collaboration around implementation science given the complementary areas of expertise.

Conclusion

A trilateral ABC collaboration is well suited to address some of the critical challenges that will face Africa's agricultural sector in the next 20 years. Table 6 below summarises Africa, Britain, and China's agricultural research areas of expertise. With the variety of thematic areas to be considered, an ABC programme may effectively research and address challenges impacting priority crops and value chains from pre-production to distribution. Britain's and China's complementary areas of expertise, coupled with African researchers' deep understanding of the complex needs in Africa's agricultural sector, could offer a unique and valuable trilateral arrangement that will address livelihood and food security challenges in Africa.

Table 6: Summary of ABC Agricultural Areas of Expertise

Africa	Britain	China
• Animal Science and Zoology • Ecology, Evolution, Behaviour & Systematics • Horticulture • Food Science • Insect Science • Local Context and Challenges	• Agronomy and Crop Science • Animal Science & Zoology • Aquatic Science • Biodiversity • Ecology, Evolution, Behaviour & Systematics • Extension Service • Food Safety • Forestry • Implementation Science • Livestock • Pests & Diseases • Plant Science • Policy & Regulations • Seeds (plant breeding, high-tech science, incl. big data, sequencing & genetics) • Sustainable Agricultural Intensification	• Agronomy & Crop Science • Animal Science & Zoology • Applied Science (incl. technology adoption, adaptation, and scaling) • Aquaculture & Fisheries • Food Science • Insect Science • Seeds • Soil Science • Sustainable Agricultural Intensification • Pests & Diseases • Plant Science • Value Chain Efficiency (incl. mechanisation and agro-processing) • Water

IV. PAST / ONGOING ABC COLLABORATIONS

Africa, Britain, and China (ABC) have collaborated in agricultural programmes, focused on research, technical cooperation, capacity building, and technology adaptation, adoption, and scaling. The majority of the collaborations to date have been conducted bilaterally, Africa-Britain (AB), Africa-China (AC), or Britain-China (BC). ABC trilateral collaborations have been increasing over the years, yet remain low in comparison to the many existing multilateral collaborations addressing African agriculture.

Past / Ongoing ABC Collaborations - Bibliometric Analysis

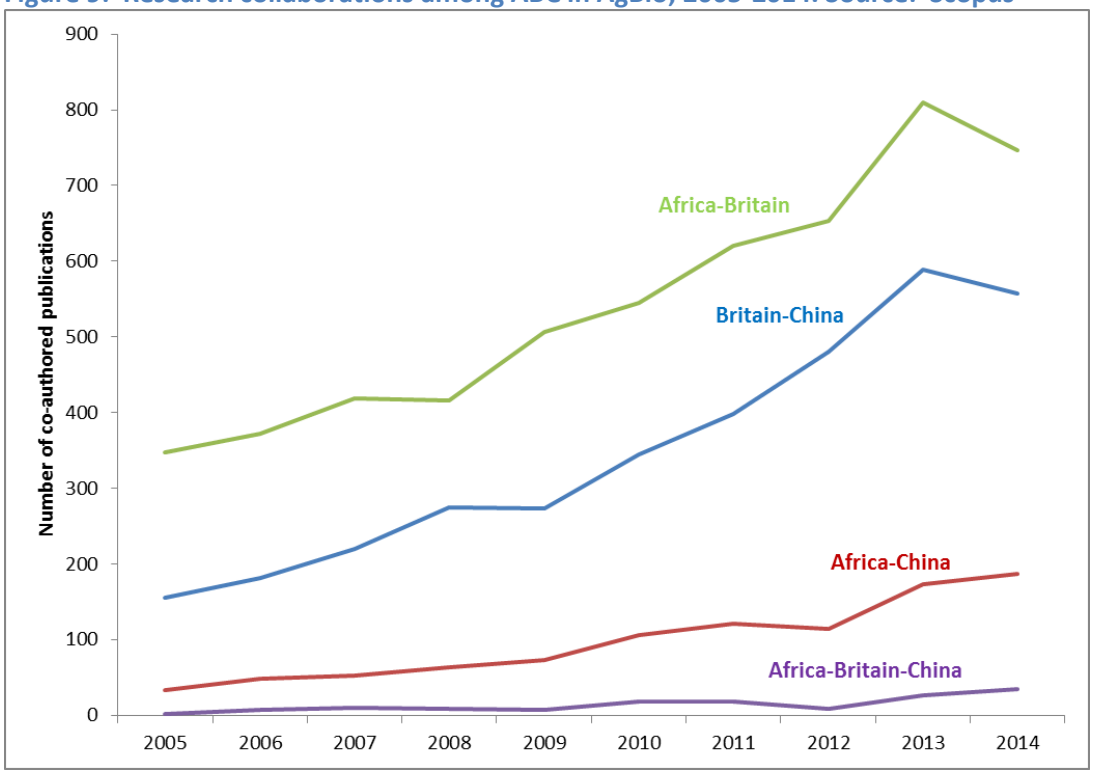
Research collaborations across countries and regions have become more and more frequent. Convenient and cheaper modes of transportation and the development of internet-based communications have made cross-border research collaboration easier and more efficient. More importantly, many of the issues the world is facing today are global in nature and require global responses. This holds for ABC research collaboration as well, noting the growing trend for ABC collaborative publications since 2005.

Co-Authored Publications

Figure 9 below, shows the number of co-authored publications[32] in AgBio for trilateral and each combination of bilateral collaborations between ABC. Africa and Britain have the largest number of co-authored publications among all combinations, followed by Britain and China co-authorships. There are a relatively small number of collaborative publications between Africa and China and an even smaller number of trilateral co-authored publications.

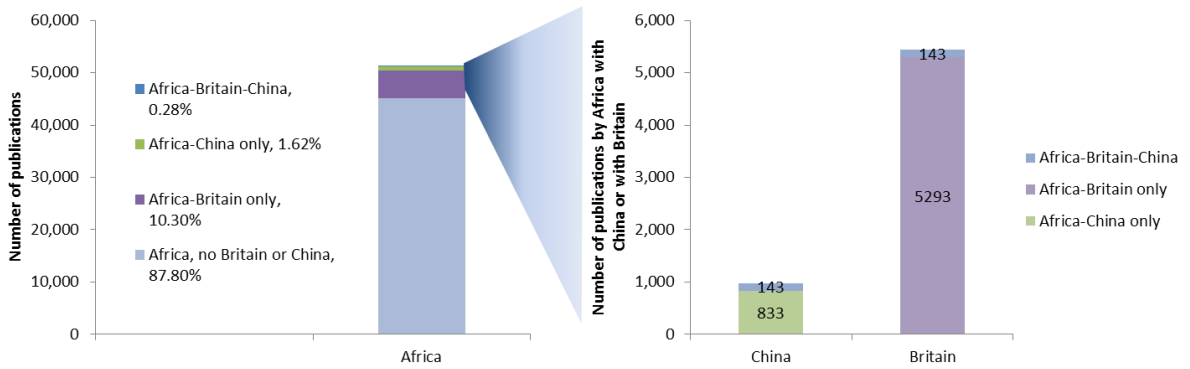
[32] A co-authored publication between two or more entities (for example, Africa and Britain) indicates that for each entity, there is at least one co-author that lists an affiliation to an institution in that entity on the publication. Authors are assigned to countries or regions based on their stated institutional affiliation, not their nationality or ethnicity. Hence, a researcher originally from Africa but now conducting research at Oxford University would be listed as a British researcher.

Figure 9: Research collaborations among ABC in AgBio; 2005-2014. Source: Scopus®[33]



For Africa, co-authored publications with Britain and China in AgBio research has been important, as 12.2% of all of Africa's peer-reviewed research output is done in collaboration with the two countries. Figure 10 shows that of the 9,400+ co-authored publications among ABC, 10.30% is Africa-Britain only, 1.62% is Africa-China only, and is 0.28% Africa-Britain-China of Africa's total agricultural research output (on left). From 2005-2014, there have been six-times more bilateral co-authored publications (in agricultural research) between Africa and Britain than those between Africa and China (on right).

Figure 10: Africa research collaborations with Britain and China as a share of Africa's AgBio Research Output; 2005-2014. Source: Scopus®



As co-authored publications with Africa contribute to a relatively small part of Britain's and China's publications in this subject area, there is opportunity for more intensive collaboration. For Britain, co-authored publications with Africa or China contribute 5.49% and 3.51% of its total AgBio

[33] The observed drop in 2014 is normal. 2014 data are about 5% incomplete at the time of data extraction, due to standard publication delays and indexation timelines.

publications in the same period, respectively, and Britain's collaboration intensity with Africa and China is growing. For China, co-authored publications with Africa or Britain contribute to only a small share of China's total AgBio publications, 0.5% and 2% respectively, and this share has not increased significantly in the past ten years.

Past research shows a strong positive correlation between international collaboration and research impact; in particular, a 2015 World Bank-Elsevier study of Sub-Saharan African research found that across all subject areas, the relative citation impact associated with international co-authored publications is more than three times higher than that associated with non-international co-authored publications.[34] The relationship between international collaboration and the relative citation impact associated with those collaborations is correlational rather than causal. Indeed, talented researchers are more likely to seek out and receive opportunities to collaborate internationally. Yet, international collaboration also expands the visibility and network of collaborating researchers, which may further increase the citation impact of those researchers' publications. The exact mechanisms are highly endogenous and difficult to disentangle. More importantly, while countries with growing research capacities greatly benefit from collaborating with those with more mature research ecosystems, international collaboration can be a win-win situation for all partners. A 2013 study by Elsevier conducted for the UK Department of Business, Innovation, and Skills on the international comparative performance of the UK research base found that the relative citation impact of Britain's international collaborations with most countries is higher than the relative citation impact of Britain's overall publications. [35] Furthermore, an analysis of the underlying data in the report shows that the relative citation impact of Britain's collaborations with key partners in Africa, such as South Africa, Kenya, and Tanzania was 19%, 14%, and 17% higher respectively than that of all of Britain's international collaborations.

Collaborating Institutions

Several institutions play central roles in fostering ABC AgBio research collaboration.[36] Based on co-authorship data, the University of Oxford and the London School of Hygiene and Tropical Medicine lead all British institutions with over 350 co-authored publications with African institutions over the past five years (2010-2014). Other specialised institutions, such as the Liverpool School of Tropical Medicine, the Royal Botanic Gardens at Kew, and the Zoological Society of London's Institute of Zoology also play key roles. Within Africa, the top five institutions that co-author the most with British institutions are unsurprisingly based in South Africa, led by the University of Cape Town (over 370 co-authored publications). Outside of South Africa, other institutions that collaborate frequently with British institutions include universities such as Makerere University in Uganda, the University of Malawi, and the University of Nairobi as well as major international research institutes such as the International Livestock Research Institute (ILRI), the Kenya Medical Research Institute (KEMRI), and ICIPE.

Since China collaborates less frequently with Africa than Britain does, the top Chinese institutions (the Chinese Academy of Sciences and the Chinese Academy of Agricultural Sciences) have co-authored far fewer publications with Africa (50-70 co-authored publications each over the past five

[34] Blom, Andreas, George J. Lan, and Mariam Adil. 2015. A Decade of Development in Sub-Saharan African Science, Technology, Engineering & Mathematics Research. Washington, D.C.: World Bank. https://openknowledge.worldbank.org/handle/10986/23142

[35] UK Department of Business Innovation and Skills. (2013). International Comparative Performance of the UK Research Base - 2013. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf

[36] Since the definition of AgBio covers sub-areas such as Insect Science that relate to not only plant diseases but also human diseases such as malaria, several of the top collaborating institutions in this area have a special focus on Medicine.

years). The most frequent African co-authors with China are the University of Pretoria and the University of Stellenbosch in South Africa.

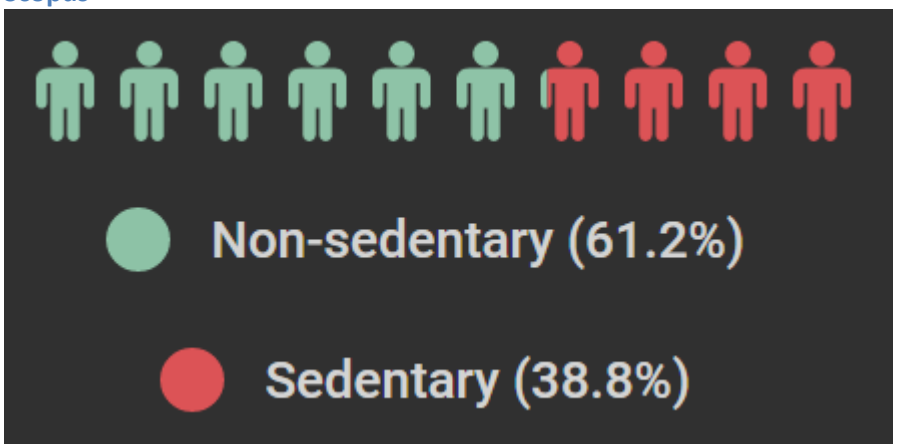
Research Mobility

New scientific ideas, methods, and expertise spread not only through collaboration networks but through the physical movement of researchers themselves. More recent studies suggest that researcher mobility results in win-win situations where all countries accrue benefits both in the short-term and the long-term.[37]

This report draws on a model of researcher mobility developed in past bibliometric studies that analyse the history of a researcher's institution affiliations. Active researchers[38] are categorised into different classes of mobility: sedentary, transitory, outflow, and inflow (the latter three of which can be grouped as non-sedentary). Sedentary researchers are researchers who have spent their entire careers publishing with affiliations to institutions in a particular country or region. Transitory researchers are visiting scholars – researchers who spend two years or less in a particular country or region. Outflow and inflow refer to researchers that permanently move from or move to a particular country or region.

The bibliometric analysis identified 8,294 active researchers in AgBio who have been affiliated at one point with an African institution. 38.8% of these active researchers have published with only affiliations to African institutions (sedentary), while 61.2% have spent some time doing research abroad in another country and have published at least one publication in affiliation with a non-African institution (non-sedentary).

Figure 11: Percentage of sedentary & non-sedentary African researchers, 1996-2015. Source: Scopus®

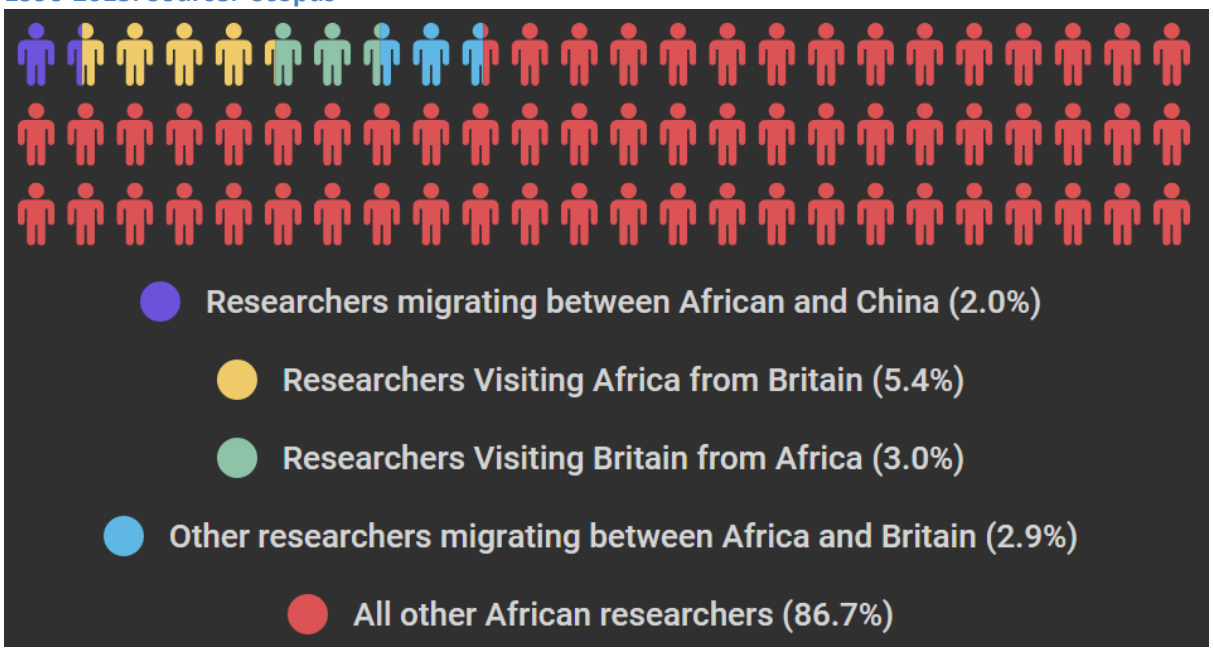


[37] Jinkers, K. & Cruz-Castro, L. 2013. Research upon return: The effect of international mobility on scientific ties, production and impact. Research Policy 42 (8) pp. 1366-1377. ; Gaillard, A.M. & Gaillard, J. 1998. The International Circulation of Scientists and Technologists: A Win-Lose or Win-Win Situation? Science Communication 20 (1) pp. 106-11; Marceau, J. et al. 2008. Innovation agents: The inter-country mobility of scientists and growth of knowledge hubs in Asia. 25th DRUID Conference on Entrepreneurship and Innovation – Organisations, Institutions, Systems, and Regions.

[38] African AgBio authors are defined as all active researchers who have co-authored at least one paper (index in Scopus) within the timeframe of 1996-2014 in which the address field indicated that that researcher is affiliated to an African institution and subject area of their publication is in AgBio. Thus, an African researcher is not necessarily a researcher who holds citizenship or considers his / her home country to be an African country. Moreover, it is not necessarily the case that researchers with African citizenship countries or familial / cultural ties are labeled as African researcher if they have not formally declared an affiliation to an institution in Africa. For more information, see Annex I: Elsevier Bilbiometrics Report's **Error! Reference source not found.** - **Error! Reference source not found.**.

Figure 12 provides a breakdown of the movement of researchers between Africa and Britain and between Africa and China. In total, more than 10% of all African researchers in AgBio have moved between Africa and Britain. The largest subgroup of those researchers moving between Africa and Britain are visiting scholars from Britain (transitory). This suggests that in addition to Africa-Britain having strong research collaboration ties through co-authorship, there is a deep network of researchers who have spent significant time conducting research in both regions. In contrast, movements of AgBio researchers between Africa and China are much lower, accounting for about 2.0% of all active African researchers.

Figure 12: Distribution of African AgBio researchers migrating between Africa, Britain, and China, 1996-2015. Source: Scopus®



Figures 13 and 14 highlight the average publications per year and relative citation impact respectively for all active AgBio researchers who have been affiliated at one point with an African institution. Consistent with overall trends for Africa, visiting researchers from Britain tend to be very productive in AgBio research, producing 3.77 publications per year (PPY) compared to 1.32 PPY for sedentary African researchers.

However, publications associated with researchers who began their careers in Africa and then moved to Britain (outflow to Britain) tend to achieve the highest relative citation impact (1.92) among all categories of African researchers. Moreover, the relative citation impact of these researchers is even higher than that of British researchers who have spent their entire careers in the UK (1.73) (not depicted in Figure 14). This is strong evidence of the research strength of the African diaspora and a reminder of the importance of engaging and connecting with that group of researchers.

Figure 13: Average PPY by AgBio Researchers Migrating between Africa and Britain, 1996-2015. Source: Scopus®

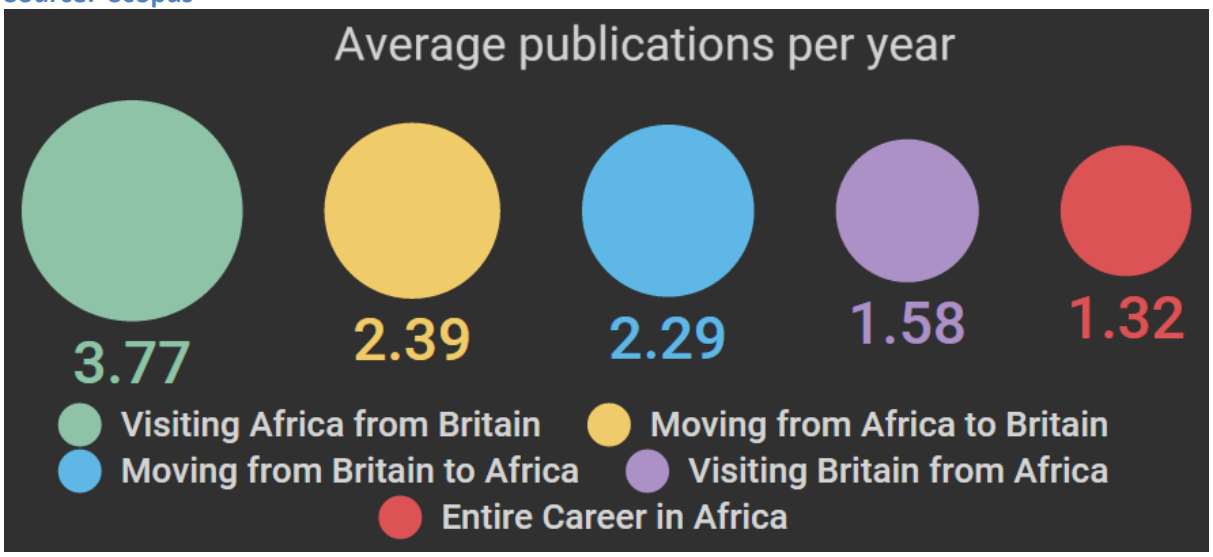
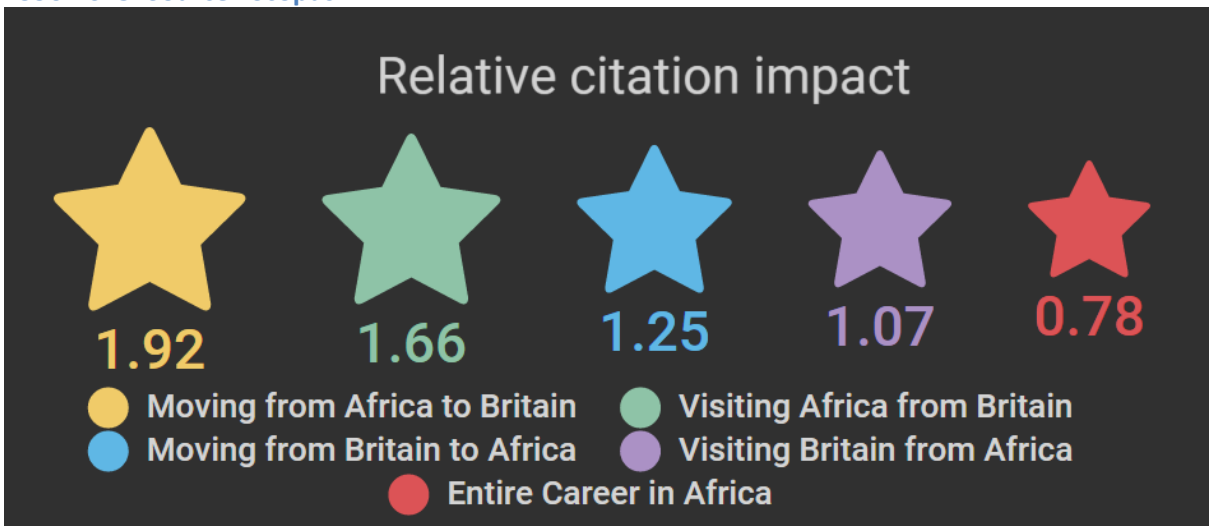


Figure 14: Relative citation impact of AgBio Researchers Migrating between Africa and Britain, 1996-2015. Source: Scopus®



ABC Collaborations Themes

Bibliometric Analysis

To assess coverage of ABC research collaborations, the bibliometrics analysed the topics in AgBio research on which African, British, and Chinese researchers tend to collaborate and co-author the most relative to the rest of the world. Figures 15 and 16 below present Wordles (visualisations of word frequency) associated with the relative frequency of key phrases occurring in co-authored publications between Africa and Britain and between Africa and China. Co-authored publications between Africa and Britain focus on the topics of weeds and root / tuber crops (such as yams and cassava). In particular, over the past several decades, there has been a strong collaboration on *Desmodium uncinatum* and Striga between Rothamsted Research in Britain and ICIPE.

Figure 15: Relative frequency of key phrases occurring in co-authored publications between Africa and Britain; 2005-2014. Source: Scopus®

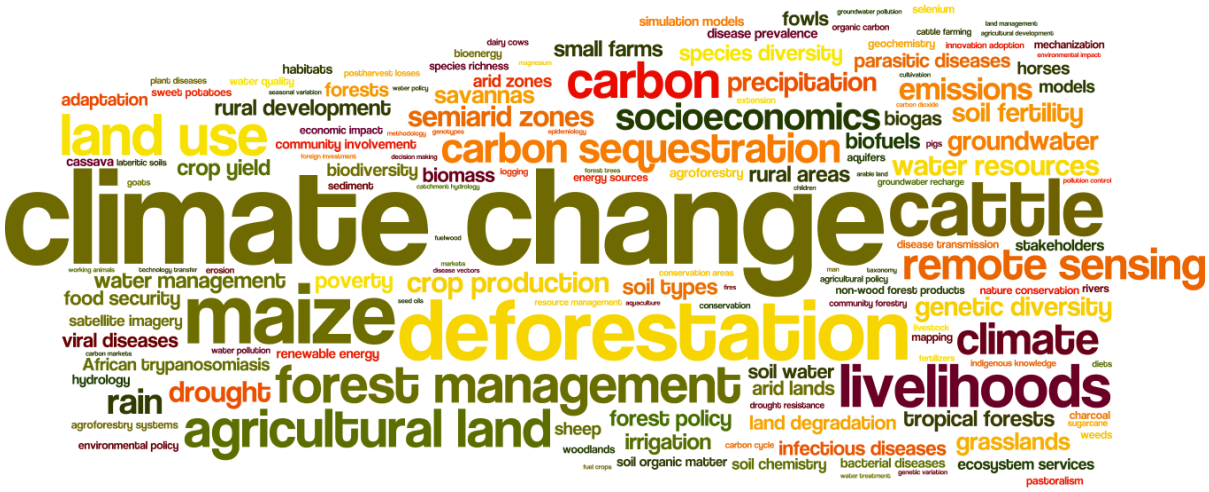
Publications co-authored between Africa and China tend to focus on insects (such as the small hive beetle) and pollination (such as various species of honey bees). The bulk of these co-authorships can be traced to a particularly strong network of apiary collaborations between Yunnan Agricultural University in China and Rhodes University in South Africa.

Figure 16: Relative frequency of key phrases occurring in co-authored publications between Africa and China; 2005-2014. Source: Scopus®

In addition to analysing the content of co-authored publications between Africa, Britain, China, the bibliometrics also analysed the content of publications by Britain and China about Africa. In particular, using region codes and key phrases generated from publications within CAB Abstracts, the bibliometrics found that the bulk of British and Chinese research about Africa focused on topics of climate change and land and water management (see Figures 17 and 19). Moreover, both British and Chinese research about Africa tended to focus on Nigeria (see Figures 18 and 20). The Consortium believes this is due to the large agricultural and agroindustry sectors as well as Nigeria's high investment into agricultural R&D relative to the rest of Africa.

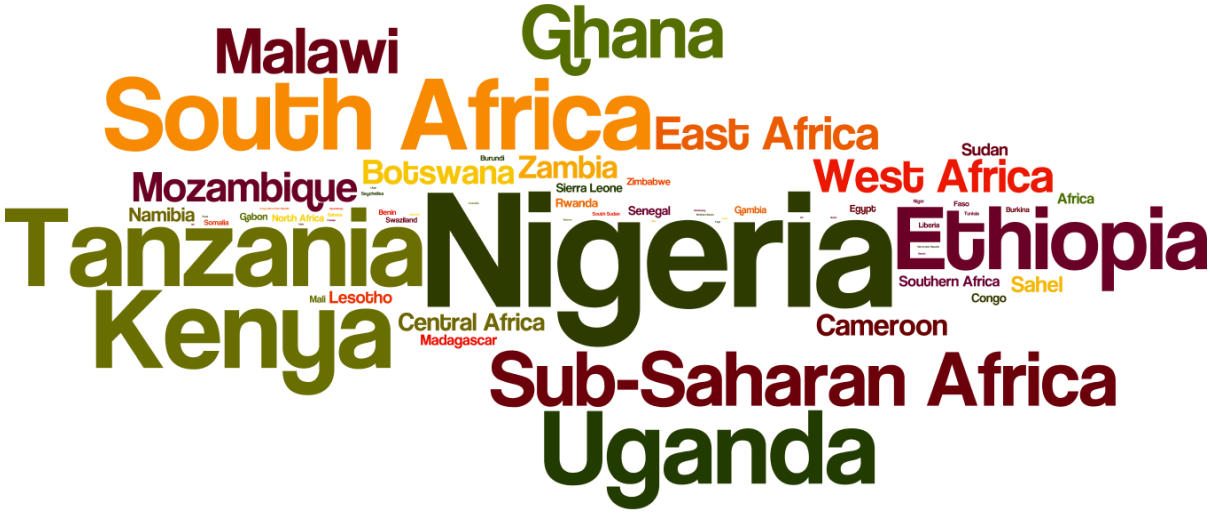
British research about Africa particularly focused on topics relating to deforestation and forest management as consequences of or responses to climate change. Topics relating to major crops such as maize, livestock such as cattle, and general agricultural productivity were also common themes.

Figure 17: Frequently occurring keywords in publications from Britain about Africa; 2010-2014. Source: CAB Abstracts.



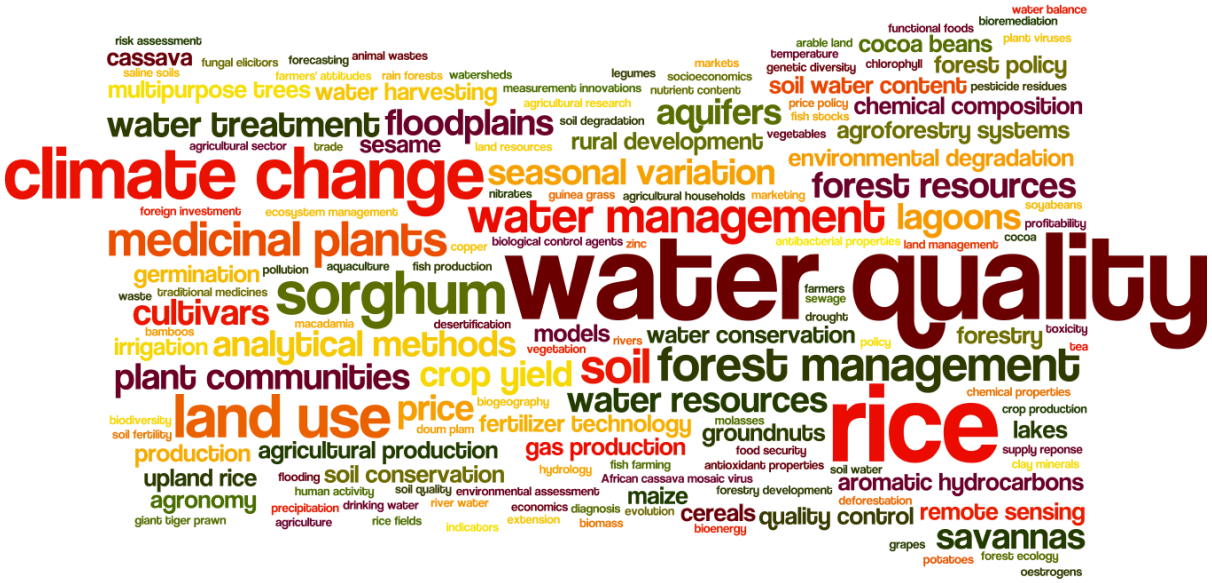
British research was more likely to be associated with former Commonwealth members (South Africa, Tanzania, Uganda, and Kenya) (See Figure 18).

Figure 18: Frequently occurring countries in publications from Britain about Africa; 2010-2014. Source: CAB Abstracts.



On the other hand, Chinese research about Africa focuses much more on water quality, sustainable use, and management. Likewise, although crop science and agricultural productivity are also important, the nature of those crops is different – there is a greater focus on rice and sorghum instead of maize.

Figure 19: Frequently occurring keywords in publications from China about Africa; 2010-2014. Source: CAB Abstracts.



Geographically, China's research about Africa also focuses more on those in East Africa, such as Sudan and Ethiopia.

Figure 20: Frequently occurring countries in publications from China about Africa; 2010-2014. Source: CAB Abstracts.

Desk-Based Research Analysis

To complement the bibliometrics, the Consortium reviewed 43 past and current agricultural initiatives and collaborations involving ABC or Brazil, Russia, India, and China (BRIC) across private, public, and academic sectors. The thematic and geographic scope of each initiative and collaboration was reviewed to gauge which themes and geographies are more or less commonly addressed.

As the review of past and current agricultural ABC and BRIC initiatives was not exhaustive, the trends noted below are based on the sample size assessed. Findings were further tested and validated during consultations and workshops to validate trends and mitigate misrepresentation of trends.

COMMON OVERARCHING OBJECTIVES

Of the 43 initiatives and collaborations reviewed, there were two frequent themes that were common overarching objectives: i) Food Security and Agricultural Production, and ii) Knowledge Dissemination, Technology Transfer, and Capacity Building.

Food Security and Agricultural Production: Of the 43 initiatives reviewed, 40% explicitly addressed the need to enhance food security and improve agricultural productivity in Africa. For the remaining 60% in which food security and agricultural productivity were not stated outright, the collaborations still contributed to the overall improvement of these two goals. For example, the AFTER[39] initiative's stated aim was to improve indigenous African food products' safety, quality, and nutritional content by adapting traditional processing techniques. While improved food security was not an explicit goal of this programme, the outcomes very clearly have benefits for Africa's food security.

Knowledge Dissemination, Technology Transfer, and Capacity Building: 37% of the initiatives explicitly aimed to support knowledge dissemination, technology, transfer, and capacity building between collaborating partners. All eight BRIC initiatives stated this as one of the main objectives, indicating the need to share experiences of adaptation and adoption of technologies for similar agricultural landscapes, histories, and opportunities for sector development and transformation.

Knowledge transfer programmes generally included components for a direct "teaching" exchange through workshops and courses conducted by experts. For example, Brazil's More Food for Africa Programme financed trainings in the field conducted, by Brazilian technicians on the operation and servicing of agricultural equipment. Alternatively, technology transfer programmes, such as the India-Africa Agriculture Innovations Bridge Programme, provided grant funding for the transfer of low-cost agricultural technology from Indian innovators to African smallholder farmers in Kenya, Liberia, and Malawi.

Over the past several years, China has reinforced capacity building collaborations with Africa in the establishment of Chinese Agricultural Technology Demonstration Centres (ATDCs) throughout the continent. For example, as part of the Forum on China-Africa Cooperation (FOCAC), China pledged in 2006 to send 100 agricultural experts to Tanzania as well as support short term trainings for up to 30,000 Africans in China.[40] The ATDCs, which primarily serve a commercial purpose to drive exports, have had mixed development results. Feedback from stakeholders indicated that most ATDCs did not use technology adapted to the local African context.[41] However, some cases, such as that in Tanzania, have some success in delivering impact from trainings.

FREQUENTLY ADDRESSED THEMATIC AREAS

Beyond the overarching objectives above, several thematic areas appeared more frequently than others. Of the 12 identified agricultural challenges in Section II, only one, aquaculture, appeared relatively frequently in initiatives.

[39] AFTER, a €2.9M EU 7th Framework Programme for Research and Technological Development funded initiative (2010-2014), included partners from Britain (Natural Resources Institute), Benin, Cameroon, Egypt, France, Ghana, Italy, Madagascar, Portugal, Senegal, and South Africa.
[40] *An Overview of Chinese Agricultural and Rural Engagement in Tanzania*. Brautigam, D., Xioayang, T. January 2012.
[41] A Future Agricultures' working paper, "Chinese and Brazilian Cooperation with African Agriculture: The Case of Mozambique", indicates the varied perspectives of the ATDCs. Government officials tend to view the engagement favourably with the view that china holds the answers to Mozambique's lack of technology. For lower officials and technicians, beyond language barrier issues, Future Agricultures indicates that even when technology or knowledge transfer is achieved, it is not always clear to recipients how to apply the information to their local context, in part due to lack of access to the inputs and tools used.

Aquaculture: British and Chinese collaborations with Africa around aquaculture varied whereby Africa-Britain collaborations focused on capacity building and sector strengthening, whereas Africa-China collaborations were more commercial in nature through the provision of infrastructure. With that, Britain and China, through the Agricultural Technology Transfer (AgriTT) Programme, have experience in joint collaboration with Africa around aquaculture, supporting Malawi's tilapia sector. With a working knowledge and established partnership, continued and expanded work in the aquaculture sector could be of interest for ABC going forward.

Sustainable Agricultural Intensification (SAI): Similar to agricultural production, emphasis was put on increasing food production in an environmentally sustainable manner. Both Britain and China, as shared in consultations and workshops, have expertise in SAI.

Water: Water was frequently addressed in several capacities including focus on irrigation development, water harvesting for rain-fed agriculture, and water management. British partners were involved in irrigation, water harvesting, and water management projects. Chinese partners were involved in irrigation infrastructure projects which tended to be more commercial in nature.

LESS FREQUENTLY ADDRESSED THEMATIC AREAS

Five African agricultural challenges were not frequently addressed themes of past and current initiatives reviewed, while the remaining African agricultural challenges appeared with some frequency in initiatives.

Pests & Diseases: Plants & Diseases, though the most-researched African agricultural sub-area in terms of peer-reviewed research, was not a common thematic area for collaborative programming. This sub-area frequently appeared during desk-based research and consultations as an under-funded and under-researched area, despite Pests & Diseases accounting for the second-highest global publication output of the 12 agricultural challenges (see Figure 2).

Value Chain Efficiency: Of the initiatives reviewed, the area remains under-served. For example, two key components grouped under value chain efficiency – post-harvest storage and agro-processing – were frequently noted as challenges during desk-based research and consultations, yet not often the focus of key initiatives reviewed.

Soil: Soil science is another challenge area that, compared to other sub-areas, has a relatively high number of peer-reviewed publications addressing the topic (see Figure 2). However, in terms of non-peer-reviewed science, ABC collaborations focusing on soil science, including soil health and fertility, are few.

Livestock: Collaboration around livestock focused more on pests and diseases than on breeding and feed systems. ABC collaborations on livestock, as well as peer-reviewed science addressing African livestock, demonstrate that it is under-served.

Inputs: Inputs, including seeds and fertilisers, did not appear often in initiatives. Seeds, as a focus area for both peer-reviewed research and initiatives, are less frequently addressed.

FREQUENTLY INVOLVED GEOGRAPHIES

Of the 43 initiatives and collaborations reviewed, the African countries most commonly involved were: South Africa, Kenya, Ethiopia, Tanzania, Uganda, Rwanda, Nigeria, Ghana, and Senegal.

South Africa was the most common African collaborative partner, quite often playing a dual role. In some initiatives, participating South African institutions were the beneficiaries, on the receiving end of technology transfer and capacity building from more developed countries. In contrast, South Africa has also played the role as one of the technical experts bringing innovation to other African countries. Given the worldwide recognition of the strength of South African universities, the country has much to offer to research collaborations.

Notably, East African countries participated in 23 of the initiatives reviewed. Based on consultations, the East African region offers significant potential given the strong research capacity within the universities and R&D centres, the dynamic agribusiness and agroindustry sector, as well as developed agricultural infrastructure. East Africa hosts a number of strong agricultural research and advisory institutions and regional offices (International Livestock Research Institute, ILRI, International Maize and Wheat Improvement Centre, CIMMYT, and International Crops Research Institute for the Semi-Arid Tropics, ICRISAT). Examples of national level participants include Kenyan organisations such as the Kenya Agriculture and Livestock Research Organisation and Egerton University, and Ethiopian organisations such as Mekelle University and the Ethiopian Agricultural Research Institute.

In terms of West African representation, Nigeria was the most common partner in initiatives. This could be because Nigeria has the highest public research spending in 2011 out of all Sub-Saharan African countries and also boasts a stable and expanding agribusiness and agroindustry sector and also hosts ECOWAS and IITA. Ghana and Senegal also host a number of strong agricultural research and advisory institutions (FARA, Association of African Universities, CORAF), offering opportunity for multilateral collaborations. Examples of national level participants include Ghanaian organisations such as University of Ghana, and Senegalese organisations such as Université de Cheikh Anta Diop, and the Ministry of Higher Education.

LESS FREQUENTLY INVOLVED GEOGRAPHIES

Of the 43 initiatives reviewed, many Sub-Saharan African countries, including several DFID priority countries, were rarely-to-never included as partners. The countries include Sudan, Sierra Leone, the Democratic Republic of the Congo, Somalia, and South Sudan, which are typically considered fragile states.[42]

Sudan and Sierra Leone, DFID priority countries, each appeared only once in collaborations with China; there are no current DFID-funded agricultural programmes in either country.[43] Given the fragility and instability of both countries, along with Sudan's low investment of Agricultural GDP to R&D, 0.14%, and Sierra Leone's, 0.21%, in 2012,[44] low rates of participation in agricultural research collaborations could be expected.

Meanwhile, three other DFID priority countries, the Democratic Republic of the Congo, Somalia, and South Sudan, did not appear in any of the initiatives reviewed. Again to note is that this finding is

[42] *Fragile States Index. Fund for Peace*. Accessed December 2015. http://fsi.fundforpeace.org/rankings-2015
[43] *Research for Development Portal*. http://r4d.dfid.gov.uk/
[44] *Agricultural Science and Technology Indicators*. IFPRI. http://www.asti.cgiar.org/

true for the sample sized reviewed; this does not definitively indicate that the three countries are not at all included in some past or current agricultural collaborations. However, given the countries' status among most fragile states as well as their lower agricultural research spending, the three countries may have not been selected as agricultural research partners.

Conclusion

Overall, collaborations among ABC focus on all 12 African agricultural challenges, with varied frequency, and most of DFID's priority countries. Table 7 below summarises ABC thematic and geographic scopes covered in ABC peer-reviewed research and initiatives. Ultimately, as all the themes and geographies are considered under-served and under-funded, an ABC agri-tech research programme has a wide range of options through which it can most positively impact livelihoods and food security challenges in Africa.

Table 7: Summary of ABC Thematic and Geographic Areas

	Thematic Area	Geographic Areas
With most frequency	• Agricultural Production • Aquaculture & Fisheries • Capacity Building • Food Security • Knowledge Dissemination • Sustainable Agricultural Intensification • Technology Transfer • Water	• Ethiopia • Ghana • Kenya • Nigeria • Rwanda • Senegal • South Africa • Tanzania • Uganda
With some frequency	• Biodiversity • Extension Services • Nutrition • Urban Agriculture	• Liberia • Malawi • Mozambique • Zambia • Zimbabwe
With little-to-no frequency	• Inputs (incl. seeds) • Livestock • Pests & Diseases • Soil • Value Chain Efficiency	• Democratic Republic of the Congo • Sierra Leone • Somalia • South Sudan • Sudan

V. FEASIBILITY OF ABC TRILATERAL PROGRAMME

First and foremost, there is exceptional receptivity for trilateral collaboration between Africa, Britain, and China in the area of agricultural technology (agri-tech) research. Through the consultations with 157 stakeholders and the four workshops, it is evident that the public, private, and academic sectors across the geographies see the value in a trilateral approach whereby Africa brings an astute understanding of the needs on the continent and local context, Britain brings deep expertise and excellence in agri-tech and implementation science research,[45] and China brings its experience in adapting and scaling technologies. Such a trilateral approach will add value to the agri-tech research field and enhance the current approach to addressing Africa's agricultural challenges. Broad buy-in is critical to the success of any programme, and it will be especially important to build on this common support for a trilateral approach.

The stakeholder consultations and workshops allowed us to further assess the level of interest and support for such a programme as well as evaluate the feasibility of various programme design elements. The Consortium asked stakeholders to reflect on the six key areas of consideration: Technical, Political, Governance, Financial, Private Sector Engagement, and Administrative. There is strong consensus across the board regarding a number of important aspects, which have been integrated in the programme design options proposed in Section VI. Stakeholders from Africa, Britain, and China, and from public, private, and academic sectors agreed on the following:

- **Emphasise focus on implementation science:** Stakeholders were clear in the need for a programme that focuses on the adoption and scale up of research outputs. Some stakeholders indicated they felt there were enough innovations and technology outputs "sitting on a shelf" that have yet to be taken up by farmers, whereas others acknowledged a need for a continuous pipeline of new agri-tech research outputs as new challenges (e.g., pests, climate conditions) are continuously introduced. Therefore, there was strong support for this programme to focus on *both* agri-tech research as well as the research on scaling the uptake of research outputs.

- **Increase agricultural R&D investments and capacity in Africa:** While there are debates around the exact thematic and geographic scope of the potential programme, there was consensus that agricultural R&D investments and capacity in Africa are low and that a trilateral programme could help leverage public and private sector funding to attract further investments, while simultaneously building capacity through partnerships.

- **Take a value chain approach:** Stakeholders supported taking a comprehensive approach, focusing on specific value chains. The rationale for this approach is that it is important to look at challenges in the context of the full value chain (inputs, production, harvest, storage, transport, processing, packaging, marketing), and therefore understand how addressing a challenge at any particular value chain segment will impact the other value chain segments.

- **Promote African ownership and align with Africa's priorities:** To ensure political buy-in from Africa, and meaningful engagement from African partners, the programme design must promote African ownership. While stakeholders understood the interest to identify the "unmet need," they encouraged the Consortium to propose programme design options in which the thematic scope aligns with the stated priorities in SSA, regional, and national level agricultural sector strategies and investment plans; otherwise, African stakeholders may be less interested in supporting the programme.

[45] As previously mentioned in Section II (see footnote 19), for the purposes of this Scoping Study, "implementation science" refers to the study of *how* to scale adoption / deployment of agri-tech research outputs.

- **Engage at higher political levels to seek co-funding:** This Scoping Study proved too early in the programme design process to have substantive discussions with key government officials regarding co-funding. That said, there was general sentiment that co-funding from Africa and / or China would more likely be through in-kind contributions, as opposed to significant financial contributions. If, however, the Steering Committee for this Scoping Study is committed to seeking financial contributions, British government officials will need to engage with Chinese and African high-level government officials (e.g., ministers and deputy ministers). Engagement will need to happen early in the design process to solicit buy-in and take into account their preferences and potential requirements, while also allowing for time to align with governments' budgetary planning cycles.

- **Partner with the private sector:** Stakeholders from Africa, Britain, and China agreed that private sector involvement is critical, as they bring expertise and capacity both in terms of agri-tech research, as well as in the commercialisation and marketing of the research outputs. Including the private sector, especially in the governance structure, will bring a valuable commercial mindset to trilateral collaborations.

- **Allow sufficient time:** Based on their experience with past or ongoing research programmes, the stakeholders were unanimous that a programme of two to three years is just too short. First, it takes time to build partnerships and align cultures, ways of working, organisational systems, etc. and the programme design must allow for sufficient time to get everything up and running, while also allowing for time to achieve outputs and communicate the results.[46] Moreover, the proposed programme needs to be at least five years, if not longer, to allow for sufficient time for the agri-tech research itself, the implementation science research, as well as communication of the research outputs.

While there is strong interest in an ABC trilateral agri-tech research programme and agreement across many top-line aspects of such a programme, the challenge will be in fleshing out the details and assuring a workable arrangement across funders, investors, and other institutional partners. The following sub-sections take a closer look at each of the six areas for consideration. Where applicable, the Consortium expounds on the key trade-offs through three lenses: i) developmental, ii) political, and iii) practical. The Steering Committee will need to evaluate each aspect based on their priorities as they move forward in the decision making process.

TECHNICAL

With regard to the technical considerations of programme design, there are three primary variables:

1. **Thematic Scope:** In defining the programme's thematic scope, the programme design could take a number of different approaches when considering the agricultural challenges in Africa and areas of African, British, and Chinese expertise identified above in Sections II and III, respectively. For example:

[46] For example, a long-standing partnership between Egerton University in Kenya and Nanjing Agricultural University (NAU) in China has yielded a range of joint initiatives. Working together for over 20 years, the two universities have developed a strong working relationship, contributing to joint technical trainings, technology demonstrations, and scientific research activities. Most recently, in September 2015, the Chinese government is investing $1 million in a crop molecular lab at Egerton University which is being launched in collaboration with NAU, and the two universities plan to establish an African Centre for Research and Graduate Training in Agriculture in the next five years. (*China-funded lab to boost Kenya's agricultural innovation*. 21 September 2015. http://www.focac.org/eng/zxxx/t1299350.htm, accessed on 25 September 2015.)

- **The theme could focus on pre-selected value chains (e.g., cocoa, maize, cowpea, dairy, poultry) or groups of value chains (e.g., cereals, horticulture, livestock).** The value chains would be selected based on the challenges identified through the desk-based research, as well as value chains identified during consultations and workshops, for which there is known expertise in Britain and China. Moreover, the value chain selection would need to be aligned with priority value chains as defined at the SSA, regional, or national level (depending on the geographic scope). Eligibility of research proposals could be kept broad to focus on agri-tech within those value chains.

- **Alternatively, the theme could focus on key value chain segments (e.g., inputs, agro-processing).** These value chain segments would be selected based on the challenges identified above. For example, stakeholders in the Kenya workshop identified "post-harvest losses" and "seeds" as the top priorities where further agricultural R&D is needed. Eligibility of research proposals could be kept broad to focus on these key challenges across any value chain, promoting cross-value chain learnings.

- **A hybrid approach could also be used, whereby the thematic scope of the programme pre-selects value chains of focus, and emphasises key value chain segments, or vice versa.** In other words, the programme could combine both dimensions, and create certain incentives (such as extra evaluation points) to encourage research collaborations to further focus on a particular value chain segment within the identified value chain (or vice versa).

- **A critical aspect that needs to be evaluated is how to integrate implementation science research in the thematic scope of the programme.** Given the strong feedback from stakeholders that the programme should focus on socioeconomic and multi-disciplinary research, as well as actual technology deployment, one option could be to have the programme focus solely on implementation science, which serves at the pivotal link between agri-tech research outputs and their uptake. Alternatively, the programme could fund *both* agri-tech research as well as implementation science. This could be done in such a way that the programme would fund both, but specific research proposals would not necessarily be mandated to cover both; or the programme could mandate that each proposal must include components of both agri-tech research and implementation science.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating the trade-offs around defining the thematic scope of the programme.

Developmental considerations:

- The value chain approach is aligned with stakeholder recommendations, and would strengthen key value chains in a more comprehensive, rather than ad hoc, manner.

- To have the greatest developmental impact, value chains could be selected based on volume and value of production, yield gaps,[47] as well as the number of farmers and other actors whose livelihoods depend on the value chain. Considering these factors when selecting the value chains could result in the programme reaching a greater number of beneficiaries, and potentially having a greater impact.

[47] See for example: Johnson, M., S. Benin, L. You, X. Diao, P. Chilonda, and A. Kennedy. January 2014. *Exploring Strategic Priorities for Regional Agricultural Research and Development Investments in Southern Africa*. IFPRI Discussion Paper 01318. Washington, DC: International Food Policy Research Institute.

- Including a focus on implementation science in the thematic scope will strengthen the link between agri-tech research and adoption of the research outputs. Implementation science is critical to being able to adapt agri-tech research outputs to the local context, and understanding the socioeconomic dynamics necessary for scaling the uptake of adoption of the agri-tech research output. This will accelerate the rate at which research output is put into use by farmers, impacting agricultural productivity.

- Research that targets three to five key themes (in which Africa, Britain, and China have expertise) allows for a deeper focus on each theme, rather than covering a wide breadth of issues. This leads to greater impact and dissemination, stronger partnerships, and the opportunity to take a more holistic, value chain, approach. Conversely, too few themes may omit important thematic areas, limiting participants, beneficiaries, and collaborations. London workshop participants noted that a "wider programme focus stimulates more competition, raising the quality of research excellence." Further, it could be the case that for certain value chains (such as those focused on by CGIAR centres), many research programmes are likely already in place, so a focus on implementation science and the adoption of research outputs of those value chains could be a clear niche.

Political considerations:
- For African support, the thematic scope will need to be aligned with CAADP Pillar IV, and will need to demonstrate how it is aligned with the specific agricultural sector priorities at the national, regional, or continental levels.

- For British and Chinese support, the thematic scope will need to be aligned with each country's respective development strategy for agriculture in Africa.

Practical considerations:
- The programme's thematic scope must be specific enough to warrant a new programme, carving out a niche among other public and private sector-funded research programmes. At the same time, the thematic scope, and selection criteria, must be kept broad and flexible enough to promote a competitive process whereby quality proposals are not crowded out by the programme's restrictions.

- With regards to including implementation science in the scope: On the one hand, mandating that each proposal include both agri-tech and implementation science research will strengthen the links between research outputs and uptake throughout the value chain. On the other hand, this requirement may be a constraint to quality proposals. The programme wants to ensure research excellence in terms of both agri-tech and implementation science research. Therefore, to avoid, for example, geneticists researching scale up methods for hybrid seed adoption, an argument could be made that it is better to keep the agri-tech and implementation science research windows separate, allowing agri-tech and socioeconomic researchers to specialise.

2. Geographic Scope: In defining the programme's geographic scope, three different approaches could be taken, while simultaneously considering implications for implementation capacity, risk, and governance structure. For example:

- **The programme could be open to all SSA countries.** Given the possible size of the fund and range of challenges Africa's agriculture sector is facing, one approach could be to make all SSA countries eligible. This would also appeal to continent-wide institutions such as the African Union and FARA, as the Science Agenda for Agriculture in Africa has explicitly noted that "in advancing the cause of science for agricultural transformation, no country should be left

behind."[48] A wider geographic scope could allow for opportunities to promote cross-regional learnings as well.

- **Another approach would be to focus the programme's geographic scope at the regional level.** There was broad support from African stakeholders to take a regional approach to the programme, as this would allow for a concentration of effort within a single economic (or ecological) zone, contributing to building capacity in that region.

- **The programme could concentrate its scope on three to five pre-selected countries.** There was also support for a more targeted approach, focusing on a select few countries. This would, again, allow for focused capacity building, as well as reduce possible bureaucratic processes whereby you have fewer stakeholders involved. Working directly with a handful of governments may also ensure full political buy-in from those countries.

- **In line with DFID's new strategy, the programme could focus on fragile and conflict states.** In November 2015, DFID announced that it plans to allocate 50% of its funding to fragile and conflict states.[49] Of DFID's 18 priority countries in Africa, 13 are considered to be a fragile or conflict state.[50] By focusing on fragile and conflict states, this trilateral programme could focus on countries and regions that traditionally receive less attention and funding, building capacity and targeting extreme poverty.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating the trade-offs around defining the geographic scope of the programme.

Development considerations:

- From a developmental impact perspective, a more narrow geographic scope may have a greater concentration of impact, learning, and unified agri-tech solutions, yet fewer overall proposals; whereas a wider geographic scope may result in more dispersed impact, yet may also raise overall quality of research projects as competition is increased, with proposals coming from more countries.

- At the same time, a programme with research collaborations from different regions / countries within Africa may benefit from cross-regional learning (if the research topics are applicable) as well as opportunities to establish new intra-African researcher and institutional collaborations.

- Regional and institutional capacity could be another consideration when defining the geographic scope. If the preference is to focus on countries / regions where there is a greater need (i.e., lower capacity), such as fragile and conflict states, this programme could emphasise capacity building as a key components, beyond just the agri-tech research outputs. The risk could be that without such a programme in fragile and conflict states, agriculture research in these countries may be a lower governmental priority.

Political considerations:

- On the one hand, a pan-SSA approach may appeal to some key African institutions, garnering political support. On the other hand, by keeping the programme open to all countries, there

[48] FARA, 2014. *Science Agenda for Agriculture in Africa (S3A): "Connecting Science" to transform agriculture in Africa*. Forum for Agricultural Research in Africa (FARA), Accra, Ghana.
[49] *UK Aid: Tackling global challenges in the national interest*. Department for International Development. November 2015.
[50] *Assessing the Impact of the Scale-up of DFID's Support to Fragile States.* Independent Commission for Aid Impact. February 2015.

clearly isn't sufficient funding to be directed to all SSA countries; therefore, a competitive proposal process may inadvertently side-line some countries with lower capacity and / or those that are not already receiving support. A possible solution is to integrate a knowledge-sharing component that would still help to build capacity in all countries, such as an annual workshop or conference which would be open to participants from any SSA country.

- Funding work across many countries may introduce difficulties in harmonising priorities, while focus on one region could lead to competition on which country / institute adopts the lead position. Meanwhile, focus on one region promotes investment and research efforts around more unified or common priorities that could lead to more impactful development of agri-tech solutions.

- It may be difficult to get political buy-in from Britain if programme funding would be going to SSA countries that are not amongst DFID's 18 priority Africa countries. Moreover, as noted above, DFID's new strategy commits to allocate 50% of DFID's budget to fragile and conflict states. This will need to be factored into the decision of geographic scope of the programme. Such political implications will need to be evaluated by the DFID.

Practical considerations:

- Geographic scope will have implications for African institutional partners in the governance structure. If the programme focuses on specific countries, the Steering Committee and those who develop the programme will need to determine if it should include national level representation for each country. Doing so may increase bureaucracy and make decision-making more complicated with more actors involved. Alternatively, working with a regional or pan-SSA institutional partner may also have implications regarding capacity.

- Administrative and bureaucratic costs would be high if multiple countries were involved, particularly if from different African regions, due to many more stakeholders being included at the table. A regional approach would likely include partners / stakeholders with similar administrative systems, institutional infrastructures, and education systems.

- Any programme that explicitly focuses on fragile and conflict states bears an inherent risk. First, there may be security risks. If the situation in a country becomes unstable or unsafe for partners to collaborate, this may result in a delay or cessation of programme efforts in that country, impacting overall programme success. Second, there is a higher likelihood that there is lower institutional and implementation capacity, as well as lower absorption capacity in these countries. Participants at the Beijing workshop felt that the primary criteria should be that target countries are safe as well as politically and socially stable, so as to ensure smooth research collaboration and implementation, while a secondary consideration should be research resources. Therefore, while there may be developmental and political considerations for focusing on fragile and conflict states, there may be practical reasons for focusing on countries with greater stability, security, and capacity.

3. **Duration:** With regards to the programme duration, there was broad agreement across the stakeholders that the funding should be longer than two to three years. However, this can be addressed in more than one way. For example:

- **Multiple calls for proposal can ensure longer programme duration, while being sensitive to realities of long-term funding commitments.** For example, to address the feedback from stakeholders, the programme can be five or more years (up to ten years), where funding would be disbursed across multiple calls, for which single proposals would receive funding for

four to five years. This would both allow research collaborations sufficient time to achieve meaningful results, while also ensuring that funding is not spread over long durations where impact is more difficult to measure.

- **Funding can be disbursed in phases, to ensure funder satisfaction of deliverables.** An alternative approach would be to commit funding for longer periods (e.g., four to ten years) but research collaborations would need to demonstrate key deliverables at set milestones to ensure funding for subsequent phases of work.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating the trade-offs around defining the programme duration.

Developmental considerations:
- The programme needs to allow sufficient time for research collaborations to deliver meaningful output from *both* agri-tech research and the implementation science research. This research can be done simultaneously or sequentially, depending on the case. Inadequate programme duration risks resulting in incomplete research, thereby limiting the potential impact and success of the programme.

Political considerations:
- Shorter programme durations, and funding cycles, help to ensure continued political support for the full length of the programme. If a programme extends beyond an existing political or budgetary cycle, it runs the risk that a newly elected leader will have different priorities and will not honour the budgetary commitments to complete the programme.

Practical considerations:
- There has been substantial feedback from the stakeholders that it takes time to develop trust, understand different cultures, and sort through administrative issues before partners can establish effective ways of working. Even where institutions have partnered together in the past, perhaps individual researchers are new to working with each other, and programme duration needs to take this "ramp up" time into account.

- Offering multiple opportunities for applications would avoid "win all" or "lose all" situations for proposals, giving rejected project proposals, or those who missed initial call for proposals, the opportunity to apply again with an improved proposition.

POLITICAL

With regard to the political support for a trilateral agri-tech research programme, the Steering Committee must consider the perspective from each of Africa, Britain, and China:

1. Africa:

- **The primary driver for political support from Africa will be the programme's alignment with CAADP and Africa's agricultural strategy and priority value chains.** Whether this is at the SSA, regional, or national levels, the programme design will want to highlight how it supports the agriculture sector ambitions of the relevant geography (pan-SSA, specific country, etc.). Not only will it be difficult to get contributions from key ministries (e.g., Agriculture, Science & Technology, Education, etc.) but it will also be difficult to garner support among researchers if the programme is not aligned with the relevant sector and development strategies. It should

also be noted that if financial contributions from African governments are mandated, this may also temper political support for such a programme, especially if governments are willing to commit in-kind contributions.

- **Taking a regional approach may garner greater support than a programme with pan-African or national level scope.** Some stakeholders in Africa suggested that there is greater capacity (and possibly ability to finance) within the regional economic communities (RECs) such as EAC (East African Community), ECCAS (Economic Community of Central African States), ECOWAS (Economic Community of West African States), and SADC (Southern African Development Community). This political (and financial) support would need to be further evaluated through additional consultations with senior leadership of the RECs. Alternatively, a regional approach could involve the sub-regional organisations (SROs) of FARA, such as ASARECA, CORAF / WECARD, and CCARDESA.

- **It will also be critical to appropriately manage possible negative perceptions among partners.** While these perceptions may not be held by individual government officials, there was strong feedback from both the Accra and Nairobi workshops that there are hesitations among Africans about partnering with the Chinese. These stakeholders are sceptical that Chinese partners are primary motivated by commercial opportunities. Whether the perception is true or not is irrelevant; it will be important to leverage existing governmental ties and successful Chinese-African partnerships to address this perception and strengthen cross-cultural ties. Therefore, during further discussions with African government officials regarding this potential trilateral programme, it will be important to discuss how best to mitigate such perceptions, and encourage African researchers to partner with the British and the Chinese in agri-tech research.

2. Britain:

- **To ensure political support from Britain, the programme will need to align with British government strategies (e.g., DFID's Conceptual Framework on Agriculture and UK Strategy for Agricultural Technologies).** As laid out above in Section I, the potential ABC trilateral agri-tech research programme will be in line with Britain's overall development and agricultural strategies. This will be critical to obtain buy-in from all key organisations, including but not limited to DFID, Defra, BBSRC, and RCUK.

- **Support from key funders will also be dependent on the programme meeting international ODA standards and scientific excellence.** The programme design will need to ensure it follows best practices for international development. Moreover, it will be important that the programme ensures funding is going to support high quality scientific research. If there are no checks on quality control, political support from key funders in Britain may be tempered.

3. China:

- **To ensure strong political support at the leadership level, Britain will need to engage early in dialogue with Chinese officials at a higher political level (e.g., ministerial).** Based on the feedback from the stakeholder consultations and workshops, political support (and any financial commitments) will need to come from senior decision-makers in the Ministry of Agriculture (MoA), Ministry of Science & Technology (MoST), or Ministry of Commerce (MOFCOM). For example, DFID can build on the recently signed MoU signed with MOFCOM (see Section II), in which the parties agreed to strengthen and broaden their development

cooperation to implement the Global Goals.[51] Therefore, Britain will need to decide how much political clout it is willing to commit to solicit support from China.

- **The Steering Committee will also need to consider which Chinese ministries would bring the most value to a trilateral partnership: MoA, MoST, or MOFCOM.** Each of these three ministries has different responsibilities that could be relevant to the ABC trilateral collaboration: MoA would bring strong knowledge of China's agricultural sector; MoST is responsible for R&D investments in China and would have strong linkages in this space; while MOFCOM plays a central role through its Department of Foreign Aid and Department of Outward Investment and Economic Cooperation, and would also bring a stronger private sector perspective regarding how to commercialise agri-tech research outputs. However, the Steering Committee will also need to consider that the selection of the Chinese ministry may have implications for the African perceptions of Chinese partners, as noted above.

Lastly, across all three geographies, it is important to be aware of upcoming leadership transitions during programme design and implementation. New government officials and / or executives of key institutional partners may replace current government officials and executives, and come into office with their own agendas. Therefore, in the next phase of programme design, it will be critical not only to work with current government officials and executives on their vision for the programme, but it will also be important to think through how changes in government or executive leadership of key institutional partners may impact programme implementation. The programme design should build in tools to mitigate such risks.

FINANCIAL

With regard to the financial considerations of programme design, there are three key questions to address:

1. Who will fund the programme and is co-funding a "deal breaker"?

- **Co-funding from China will depend on which ministry is the primary partner, and will require early dialogue to align with China's budget planning cycle.** As noted above under political considerations, MoA, MoST, or MOFCOM could all be potential institutional partners for the trilateral agri-tech research programme. Ability to co-fund, as opposed to in-kind contributions, may vary. That said, if co-funding from China is desired, it will be important to engage early on at high political levels to align with China's budget planning. The Chinese governmental departments submit their 2017 budget plans in mid-2016. In addition to specific ministries, the China Development Bank or its private equity group the China-Africa Development Fund, may also be willing to contribute financially to the ABC agri-tech research programme, however, these avenues have not yet been explored.

- **Co-funding from Africa is more likely to be in the form of in-kind contributions, given tight fiscal budgets and competing priorities.** While some stakeholders indicated that the RECs in Africa may have a greater ability to co-fund, this will need to be verified through direct conversations with the relevant RECs. Moreover, direct funding from national MoAs in Africa is unlikely, given many national governments' tight fiscal situation. As noted above in Section II, although more than 40 countries have signed CAADP compacts and 30 have developed

[51] *China and UK Sign Memorandum of Understanding on Local Trade and Investment Cooperation and Development Cooperation*. MOFCOM press release. 24 October 2015. http://english.mofcom.gov.cn/article/newsrelease/significantnews/201511/20151101155948.shtml, accessed on 4 December 2015.

agricultural investment plans, only 13 countries, in at least one year since 2003, have met the commitment of dedicating 10% of national budget to the agriculture sector. British government stakeholders will need to make the case to African governments why they should be co-funding this trilateral agri-tech research programme, investing more in agriculture, when there are other sectors such as health and power that have equally important investment needs.

- **As Britain will likely be the primary funder, the Steering Committee will need to decide whether co-funding from Africa and / or China is a "deal breaker."** The Steering Committee and those who take the programme forward will need to evaluate how much funding each entity (DFID, Defra, RCUK, BBSRC) will have to commit to such a fund, and whether or not – both politically and financially – co-funding from Africa and / or China will be required. While both Africa and China are likely to commit support to the programme through in-kind contributions (e.g., staff time), financial contributions are not guaranteed. If co-funding is deemed to be required, the Steering Committee should also consider the minimum level of co-funding that would be desired. The Steering Committee may also wish to explore the option that co-funding would be committed a few years into the programme, rather than up front.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating the trade-offs around co-funding.

Developmental considerations:

- Co-funding, even if only nominal or token amounts, may demonstrate that key stakeholders, whether in China and / or Africa, have additional "skin in the game." From the perspective of Chinese researchers and companies which are going to benefit from such a programme, they would wish the Chinese government to co-fund, which may not necessarily align with government departments' priorities. From the African perspective, co-funding could further promote African ownership, and assuage any stakeholder concerns that this is a traditional western funding model whereby outsiders are "telling Africa what it needs." Co-funding the programme may also give African governments a greater seat at the table in the programme design. Therefore, the Steering Committee has an incentive to encourage co-funding from both Africa and China.

Political considerations:

- As noted above, obtaining commitments from China and Africa for financial contributions will be more difficult than getting in-kind contributions. Therefore, Britain will need to decide how much political clout it wants to dedicate to efforts to solicit financial contributions.

- Britain may also wish to consider how it will work to establish balance among the institutional partners from Africa, Britain, and China, especially if there is no co-funding. While the primary funders, on the one hand, may have the largest say in terms of how the funding is used, this may also create tensions with the Chinese and Africans.

Practical considerations:

- While co-funding from China and / or Africa would be ideal for all the reasons outlined above, the process alone of obtaining co-funding and negotiating amounts will be cumbersome and could delay the launch of the programme. Therefore, the Steering Committee will need to weigh the value and importance of having co-funding with what it will take to successfully get financial commitments from China and Africa.

- Even if co-funding, in form of financial contributions, from Africa and / or China is committed, the management of funds may be complex. Some co-funders may want to support specific programme

components and therefore may wish to keep their financial contributions separate from other funds, resulting in multiple buckets of money. It would be much easier to manage a single pot of funding.

2. What funding models could be used to promote sustainability?

- **The programme could use a traditional grant funding model and require co-financing from other sources.** This would limit the risk that the partnership would end once the funding ends, especially if the programme specifies that it will fund no more than a certain percentage of the total project costs. If the proposal can demonstrate how it builds on past work and can attract multiple investors / funders, this implies that the project is "marketable" to investors and funders and could contribute to longevity of trilateral collaborations.

- **Integrating blended financing mechanisms for the commercialisation of intellectual property (IP) would promote sustainability of the research investment efforts.** Whether ultimately through licensing, creation of spin-off companies, or other, an agri-tech research programme downstream IP commercialisation that meets market demand is the ultimate definition of sustainability, in that it would demonstrate the market uptake of the programme's research outputs. Therefore, grant financing for upstream basic science research could be blended with debt and equity financing for downstream commercialisation of research outputs. This would further encourage engagement with the private sector, and would introduce business innovation into the agri-tech research field. Moreover, with a debt and equity component to the programme, funders and investors could re-invest the returns on initial investments in new research collaborations, perpetuating the operations of such a programme. For additional information on innovative financing mechanisms, please see Box 6.

- **In a programme that funds centres of excellence, the programme could mandate that the centres must integrate revenue generation activities to ensure the sustainability of the centre, further attracting young researchers.**[52] These types of activities could be around industry consulting services, student fees, and licensing IP. While these may be indirect approaches to sustainability, the idea would be that in developing a centre of excellence, the programme would further attract new talent, building the centre's expertise, and thereby generating a re-enforcing mechanism for sustainability. Especially in a field that is plagued by ageing researchers, a centre of excellence could draw a new generation of African researchers to the agri-tech field, especially youth and women. By growing PhD, MSc, and post-doctoral programmes within the centres of excellence, the centres could not only increase revenue from student fees, but it may also increase the quality of researchers and thereby increase the amount of funding and consulting services awarded to the researchers affiliated with the centre of excellence.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating the trade-offs around various funding models.

Developmental considerations:

- From a development perspective, stakeholders were unanimous in their agreement that the programme design must address sustainability. Too many times, stakeholders commented, have they seen programmes (and / or projects) that end once the funding runs out. Therefore,

[52] Alternatively, some stakeholders raised the idea of funding agri-business parks focused on key value chains. These agri-business parks would bring together private sector actors across the value chain from inputs to processing, to collaborate on agri-tech research and deployment. Such an approach would promote sustainability through market forces, ensuring there is market demand for the outputs from the research collaborations within the agri-business park.

irrespective of *how* this is done (which will depend on the specific programme design), it will be important that the funders plan for an "exit strategy" that will allow for continuity of the agri-tech research, implementation science research, and of course ultimate deployment and scale up of the research outputs.

- The Steering Committee may wish to consider innovative funding models that promote programme sustainability. Often a challenge of traditional grant funding is that the work or partnership is unable to continue once the initial funding runs out. The programme design should take this into consideration and ensure that the existing agri-tech trilateral collaborations are not entirely reliant on this programme's grant funding.

Political considerations:
- On the one hand, integrating more innovative financing mechanisms can be attractive, on the other hand, new approaches may be more risky, unproven, and therefore may be a harder "sell" to key funders.

Practical considerations:
- Mandating co-financing requirements for upstream research and / or downstream deployment could be burdensome for researchers to meet these requirements, which may result in lost opportunities for research.

Box 6: Funder-Supported Innovative Financing Mechanism for R&D&I

Blended financing mechanisms for agri-tech research and innovation could help promote long-term sustainability of research projects and programmes. Recently, increased attention has been given to innovative financing mechanisms that help catalyse collaboration between the public and private sector to deliver results in international development.[53] The focus of the discussion is around two key questions: i) How can international development funders attract greater private investment to address key challenges? ii) How can innovative financing mechanisms be used to achieve development outcomes?

Regarding the first question, investments by international development funders can have a multiplier effect, mobilising private sector capital and helping to reduce the risk of an investment. Attracting investments for basic agri-tech research may be challenging, as there may not be a clear return on investment, yet there may be some approaches where public and private financing can be combined to catalyse efforts. For example, one innovative approach could be to couple grant-funded upstream basic science research with debt or equity funded downstream commercialisation and deployment. While there could be any number of funders / investors in such a model, one option could be to have an international development funder provide grant financing for the research while a private investor would finance the commercialisation of the research outcomes. Such impact investments for the development, adaptation, and adoption of agricultural technology could generate developmental impact alongside financial returns for research institutions, SMEs, and MNCs working in the African agricultural sector, further promoting the sustainability of investing in agri-tech R&D.

[53] See for example: *Innovative Financing for Development: Scalable Business Models that Produce Economic, Social, and Environmental Outcomes.* Global Development Incubator. September 2014; *Africa Agriculture and Trade Investment Fund (AATIF) Case Study.* Convergence. November 2015.; *A How-To Guide for Blended Finance: A practical guide for Development Finance and Philanthropic Funders to integrate Blended Finance best practices into their organizations.* World Economic Forum and OECD. September 2015.; and "Impact Investment: An International Development Opportunity?" hosted by the Center for Strategic and International Studies. Attended January 2016.

The CDC Group plc (CDC), the UK development finance institution, could act as a potential partner to provide innovative financing for the agri-tech research programme and promote sustainability. CDC's mission is to support the building of businesses throughout Africa to enhance livelihoods through the provision of capital, including equity, debt, and guarantees. Agribusiness is one of their priority sectors. Another potential partner could be the European Investment Bank (EIB), which could provide equity investments and guarantee financing. The EIB, aiming to generate long-term private sector-led growth, already supports the Africa region, including SMEs, tertiary sector, and sufficient and safe food supplies.

Innovative financing mechanisms that encourage the "crowding-in" of private sector include:

- **Catalytic First Loss Capital (CFLC):** CFLC is credit enhancement provided by an investor or grant-maker who agrees to incur first losses in an investment in order to catalyse the participation of co-investors who otherwise would have not invested. Funders are well-positioned to play the role of CFLC providers. At the R&D&I stage, there is no guarantee that the research will result in a commercial technology. Therefore, the traditional model of grant funding for R&D&I with no expectation of a return to recoup this investment allows for greater financial risk to be taken. As such, when a funder supports the transfer or deployment of a technology, a grant could be a strategic injection of capital that lowers the level of risk and therefore leverages more capital that could have been mobilised otherwise. CFLC can help draw investors to commercially and financially viable technologies in the agricultural sector that they may have previously assumed too risky. In other words, the funder provides the "cash cushion" that ensures other investors will get fully paid if the investment does not succeed.

- **Prize Funding / Advanced Market Commitments (AMC):**[54] In contrast to grants, which finance researchers to develop agricultural technologies that are not always taken up by farmers and other actors in the food supply chain, funders could incentivise private sector and research organizations through prize funding or AMC. Funders would specify market failures and gaps in the agricultural sector in which new agri-tech solutions are needed. Prize funding or AMC rewards those who develop a successful solution and could be awarded to a single or multiple solution provider(s). In this way, funders lead the private sector to front the initial capital to work with universities and public research organisations to focus on under-addressed challenges in the agricultural sector, taking the risk to develop agri-tech solutions. The AgResults Programme, a multi-donor funded initiative, is a platform that uses such a model.

- **Debt / Equity Financing:** The transfer, deployment, and commercialisation of agri-tech research could benefit from complementing grant funding with debt or equity financing. The EU Horizon 2020 funding model for innovative SMEs and technology transfer[55] is set up such that:

    - Debt Financing can be accessed for R&D&I investments by larger companies, research institutes, stand-alone projects, and PPPs
    - Equity Financing can be access as early stage finance for start-up and spin-off companies and licensing purposes in order to bring R&D results to the market

[54] Advanced Market Commitment is a binding agreement that is typically offered by a government or other financial entity, used to guarantee a viable market if a specific solution is developed to respond to an indicated market failure. AMC is most well-known for implementation around vaccine or drug development in developing countries.
[55] http://www.astp-proton.eu/downloads/Events/Conferences/AC2014/Presentations/Martin%20Koch%20-%20Instruments%20and%20funding%20provided%20by%20Horizon%202020.pdf

These risk-sharing and risk financing models are being implemented through banks, funds, and other intermediaries (e.g., European Investment Bank and European Investment Fund.) Eventually, the funder could sell its stakes in the business or redeem loans. The principal and any profit gained could then be reinvested in another agri-tech R&D&I, transfer, or start-up investment.

Should the Steering Committee wish to explore the use of innovative financing mechanisms in a trilateral agri-tech research programme, DFID and the other Steering Committee members will likely need to partner with another institution. While this was outside of the scope of this study, the Steering Committee may wish to initiate preliminary discussions with CDC and EIB to explore what blended financing mechanisms may be feasible to jointly offer.

3. How should funding be awarded?

- **Research could be commissioned using a two-stage competitive application process.** Most stakeholders were supportive of this approach, which will help ensure scientific research excellence. A two-step process, whereby the first-stage would include an initial review of capabilities and a concept note and the second-stage would evaluate a full proposal, ensures that potential applicants do not invest too much time up front on a proposal if they do not meet basic criteria. This also protects the review panel from having to review sub-par proposals. Some stakeholders proposed including a preparation grant that would provide some funding to allow for partners to spend the necessary time working together to flesh out details of their partnership, research scope, roles and responsibilities, budgets, and work plans. This could also elevate the quality of the first-stage concept notes and final proposals and contribute to increased levels of success.

- **Alternatively, research could be commissioned through a more programmatic approach whereby a trilateral agri-tech research network is established.** Given the general lack of institutional linkages between African and Chinese research institutions, there is a strong need to ensure complementarity and synergy between the capacities of ABC partners. The programme would be directed by a Secretariat which should have knowledge of the institutions and research capacities in the particular theme across the three regions. Such a programme would directly strengthen capacity within African institutions by matching institutional capabilities with Britain and China, for example with a focus on how to develop clear research priorities and how to strategically manage a project portfolio. The Secretariat would provide direct input on project development with a focus on both scientific excellence and the integration of other programmatic elements such as scientific meetings and knowledge exchange, targeted training activities, and methods development in implementation science.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating the trade-offs around how research is commissioned.

Developmental considerations:

- Some stakeholders from African academic institutions or public research organisations expressed concern that a competitive funding process would favour collaborations with a lead partner from a

British institution, given differences in capacity.[56] This would negatively impact not only African ownership, but also responsibilities and budget allocated to African partners. Whereas a network approach may allow for partners to more equitably divide responsibilities, a competitive proposal development process may result in cutting corners and inequitable division of responsibilities and funding in an effort to meet certain criteria specified by the programme.

- A preparation grant will allow more time for the establishment of ABC collaborations which still remain few to date. Small grant funding for this stage could help the programme promote, build, and strengthen ABC trilateral partnerships.

Political considerations:
- While there may be a developmental trade-off between emphasising research excellence (through a competitive funding process) and emphasising building capacity in African research systems (through developing a non-competitive network), the decision is political in nature.

Practical considerations:
- The Steering Committee should also consider what mechanisms can be put in place alongside a possible competitive grants programme that would ensure more grant recipients where the African partner is the prime. For example, in advance of the call for proposals, the programme could conduct some financial management and proposal writing workshops that would help build the capacity of African partners, or include a small window for proposal preparation grants.

GOVERNANCE

With regard to governance of a trilateral agri-tech research programme, the Steering Committee must consider the following questions:

1. Should the funding be for a new programme or should it scale an existing programme?

- **A new programme could provide an opportunity to be innovative.** With *carte blanche*, the Steering Committee and future institutional partners have more flexibility to develop a programme that focuses on a niche area that other funders have not addressed before or that has not been addressed adequately. While this may carry more risk in that there are more "unknowns", a new programme could build on lessons learned from past programmes, taking new approaches to funding, governance, and research.

- **Scaling an existing programme could have a multiplier effect for ongoing research.** Rather than introduce another programme, which may increase competition among funds, scaling an existing programme will allow funders to concentrate their funds with ongoing initiatives to scale and replicate successful research structures and output. Also, this approach would build on existing institutional partnerships, reducing the period of time typically required to develop ways of working. Whether it's an existing Africa-Britain-China partnership, or existing Africa-Britain and Britain-China partnerships that are joined, scaling an existing programme could promote future phases of ongoing work.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when evaluating whether to set up a new programme or scale up an existing programme.

[56] See for example, Vera-Cruz, A. O., Dutrénit, G., Ekboir, J., Martínez, G., & Torres-Vargas, A. (2008). Virtues and limits of competitive funds to finance research and innovation: the case of Mexican agriculture. *Science and Public Policy*, *35*(7), 501–513.

Developmental considerations:
- From a development perspective, there is no major trade-off between introducing a new programme or scaling up an existing programme. As long as the programme design of the new programme, and any adjustments to the design and governance structure of an existing programme, are undertaken with sound judgment and based on strong development principles, either approach has the potential to have substantive developmental impact addressing Africa's agricultural challenges.

Political considerations:
- For government officials in Africa, Britain, and China, it will be more attractive to be able to announce the launching of a new and innovative programme that will appeal to voting constituents. Government officials will view a new programme as more marketable than scaling up an existing programme.

- However, academic stakeholders in Africa noted that there is a sense of funder fatigue, and they do not want to see government officials launching yet another new programme, which may also create competition for proposals among programmes. The perception is that government officials announce new programmes for visibility, but that scaling existing programmes could have more meaningful impact for sector and human capital development.

Practical considerations:
- Stakeholders rightly pointed out that from a practical perspective of designing a programme, while a new programme may be able to learn from challenges of past programmes, building a new programme structure from scratch is inherently more risky. That said, even if there is a chance to adjust the design of an existing programme prior to scaling, there is also the risk that imbedded challenges are perpetuated in a second or third phase.

- There was substantial discussion at all four workshops regarding how long it can take to develop strong relationships between institutional partners. While a new programme would need to account for this time, and would likely involve institutional partners who are new to working with each other, introducing a new partner to a well-functioning partnership of a programme that will be scaled, could be equally challenging. Therefore, the Steering Committee will need to evaluate if there is a preference for having all institutional partners starting on equal footing in a new programme, or if there is a preference for working through how to change the governance structure and ways of working when introducing a new stakeholder (e.g., introducing an African partner to a British-Chinese initiative).

2. How can the governance structure assure both transparency and legitimacy?

- **A Steering Committee, comprised of the institutional partners, would set the overall strategy and provide programme oversight.** The institutional partners would need to work together in the early stages to set the programme's objectives and strategy. Once the programme is launched, the Steering Committee would largely be responsible for strategic oversight. For example, this could entail a review of quarterly management reports submitted by the Project Management Unit (PMU) (see below), as well as an annual meetings for budget review. The Steering Committee would be made up of programme funders, as well as relevant public, private, and academic stakeholders.

- **A Technical Advisory Committee would work with the funding recipients to ensure research quality excellence.** Technical Advisory Committee members would be called upon to support

funding applicants and / or recipients on designing their research projects. It will be important to have experts on the Technical Advisory Committee from the specific fields selected for the thematic scope, but especially to include experts both from agri-tech research and implementation science research fields, as well as from the private sector. The Technical Advisory Committee can help run proposal writing workshops prior to the call for proposals, review and evaluate proposals submitted, and then work with the funding recipients on a regular basis to ensure the quality of research excellence and that progress is being made.

- **A PMU would be responsible for the day-to-day management of the programme.** The PMU could be housed within one of the institutional partners or it could be a third-party that would be selected competitively. The PMU would be responsible for implementing the strategy laid out by the Steering Committee, preparing the calls for proposals, conducting the outreach to market the programme, liaising with the programme applicants and the Technical Advisory Committee, monitoring and evaluation of the programme, as well as delivering quarterly management reports to the Steering Committee. The PMU would also be responsible for organising annual knowledge sharing workshops, and preparing annual budgets for Steering Committee approval.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on, when establishing the governance structure.

Developmental considerations:

- Selection of Steering Committee and Technical Advisory Committee members, as well as the PMU, will need to account for African ownership, as it is important from a development perspective to ensure that the primary beneficiaries are well represented throughout the governance structure.[57] This can be addressed in a number of ways noted below.

- The Technical Advisory Committee will work with partners that may have lower capacity and need support in terms of improving research quality. In addition, private sector representation on the Technical Advisory Committee could help ensure that the agri-tech research is applicable in a commercial setting downstream. This could help address concerns raised by some stakeholders regarding capacity and quality of research from African partners.

Political considerations:

- Selection of Steering Committee members will need to find a way to address balance across Africa, Britain, and China, even if the financial and in-kind contributions are not of equal value. While an argument could be made that the largest contributors should have the largest say in terms of the programme's direction, this will need to be politically balanced with the opinions of other key institutional partners, so as to maintain strong political buy-in from all partners.

- DFID and the other programme funders will need to decide if they prefer to house the PMU within one of the funder organisations, or whether there is a preference for hiring a third party supplier. The key trade-off here would be between potential cost savings by housing within a funder, versus housing the PMU with a third party in Africa, further encouraging African ownership.

[57] As discussed at the Policy Dialogue on Triangular Co-Operation in May 2013, a necessary element for good triangular co-operation is that the partnership is driven by the needs of the beneficiary countries, which are in the lead from design to implementation. See *Summary of Discussions, Policy Dialogue on Triangular Co-Operation*. Ministry of Foreign Affairs, Lisbon, Portugal, 16-17 May 2013. http://www.oecd.org/dac/dac-global-relations/[FINAL]%20Summary%20Policy%20Dialogue%20on%20Triangular%20Co-operation.pdf, accessed on 27 August 2015.

Practical considerations:

- Selection of the Steering Committee members will need to balance ensuring equitable representation across public, private, and academic sectors as well as across Africa, Britain, and China, while simultaneously accounting for the number of stakeholders at the table. Too many institutional partners can increase bureaucracy and make processes cumbersome, mitigating the ability to make progress.

3. How can the governance structure promote African ownership?

- **African representation on Steering Committee is a must.** Even if African institutional partners are not contributing financially, it will be critical to have African representation on the Steering Committee to ensure ownership and accountability. Moreover, given that this would be a trilateral programme, it is essential that there is representation from all three Africa, Britain, and China (in addition to private sector representation, see Private Sector Engagement section below). This is the only way to ensure it is truly trilateral collaboration.

- **The selection of the African institutional partner(s) will largely depend on the ultimate programme design.** First, it would need to be determined if the programme will be pan-SSA or focused on a particular region or country. Then, it can be determined if the institutional partner should come more from the political sphere (e.g., African Union, RECs, or Ministries of Agriculture), agriculture research sphere (e.g., FARA, SROs, or NAROs), academic sphere (e.g., RUFORUM, specific university), or some other key stakeholder (e.g., farmers organisation or private sector).

- **Housing the programme in Africa will further promote African ownership.** As noted above, the PMU could be housed with one of the funder organisations, or it could be a third party supplier. In the latter case, encouraging (or requiring) that the PMU be housed in Africa – relying on majority African staff – would ensure that the African perspective is accounted for in the day-to-day management of the programme. This would demonstrate African leadership for the programme and would likely be well received by African researchers and governments. It should be noted, however, that while Chinese workshop participants supported this notion (as they felt it would result in African researchers being more engaged in the collaborations), they also suggested having a PMU liaison office located in China, which would allow for more regular communication. For a summary of the various programme management and governance approaches, please refer to Box 7.

Following are the various developmental, political, and practical considerations the Consortium recommends reflecting on regarding how to promote African ownership.

Developmental considerations:

- The 2005 Paris Declaration on Aid Effectiveness and the 2008 Accra Agenda for Action espouse the importance of developing country ownership. In addition, the OECD Dialogue on triangular co-operation re-emphasises this message as ownership can build capacity in engaging in and managing South-South co-operation. Moreover, the Dialogue notes that the beneficiary of triangular co-operation should be responsible for ensuring that results are sustainable.[58]

[58] See OECD. *Triangular Co-Operation: What can we learn from a survey of actors involved?* OECD Development Co-operation Directorate. May 2013.
http://www.oecd.org/dac/dac-global-relations/OECD%20Triangluar%20Co-operation%20Survey%20Report%20-%20June%202013.pdf, accessed on 27 August 2015.
See *Summary of Discussions, Policy Dialogue on Triangular Co-Operation*. Ministry of Foreign Affairs, Lisbon, Portugal, 16-17 May 2013.

Therefore, to the extent possible, it is strongly recommended that the trilateral agri-tech research programme promotes African ownership.

Political considerations:

- In the Accra and Nairobi workshops, participants felt very strongly that the programme should be African "owned" or "managed" and noted that if the perception was that there was not African ownership, there may be less support or interest in participating in the programme. This was further substantiated by participants in the Chinese workshop who noted that because AgriTT was housed in China they felt that some of their African partners were not as engaged in the collaborative projects as the Chinese partners would have liked them to be.

- At the same time, Chinese stakeholders have commented on the importance of having face-time with the PMU and other key stakeholders. Whether the PMU is housed in China or there is a liaison office, there may be pressure from Chinese institutional partners to have some representation in China, which of course may create other logistical and financial challenges.

Practical considerations:

- Capacity will need to be considered for the selection of the African partners in the governance structure. While African ownership would be ideal, there may be capacity limitations or more affordable options that would need to be considered.

Box 7: Programme Management and Governance Overview

Two important decision areas are programme management and programme governance. Programme management is assumed to be by a dedicated Programme Management Unit (PMU), while governance involves some sort of Steering Committee that has oversight of the work of the PMU and provides strategic direction. As indicated in Section VII, the decisions regarding these two areas can either influence, or be influenced by decisions on other areas such as geographic scope.

Here, the Consortium summarises the main options and the advantages and disadvantages of each. A fuller evaluation of the various options should be undertaken in the future, prior to moving forward, and will need to include key evaluation criteria. In selecting these criteria (and their relative weights), the Consortium recommends that the Steering Committee or whoever takes this programme forward consider the following aspects which are important, and have been considered in the analysis below.

- **Costs:** The cost to the programme of a particular governance or management option. All things being equal, a lower cost is preferable; but a cheaper option might be less effective in satisfying other criteria. Set-up and ongoing costs need to be considered.
- **Co-financing:** Co-financing from all partners is desirable, but, as noted elsewhere, more likely under some scenarios than others. It is linked to programme management and governance in that co-financers are likely to expect more say in management and governance. As co-finance is an early decision point (see Section VII), assessing the effect of management and governance arrangements on co-financing is less important, although it might have an impact on the possibilities for later co-financing, including from the private sector.
- **Ownership and Sustainability:** The Consortium groups these two considerations here as in terms of the management structure and governance, they are likely to be correlated; a programme management and governance that promotes ownership is also likely to promote sustainability, both of which are desirable. While ownership by all partners in Africa, Britain and China is important, African ownership is paramount for effective implementation, impact, and sustainability of the programme.

- **Practicality and Efficiency:** Different management and governance arrangements will have different operational issues and challenges to address, so these are considered. The arrangement should be effective and efficient at ensuring the programme achieves its stated objectives and so delivers impact. Practical issues such as language and funds disbursement also need to be considered. Part of efficiency is transparency and accountability.
- **Visibility:** Partners and funders will likely expect their role in a substantial programme to be visible. This may include political motivations by DFID or other British, African, and Chinese public sector partners, who might play a role in funding, managing, or overseeing the programme. Private sector and academic partners may also wish to highlight (or "market") their participation in such a programme, demonstrating their commitment to social impact.

Programme Management

For programme management, there are two main decisions: the location of the PMU and the programme manager. The options for location are between Africa, Britain, and China, or having the PMU in Africa or Britain, but with a satellite office in China. The options for who manages the programme are either a stakeholder / partner from the location (e.g., a British stakeholder in Britain), or an independent third-party contractor. A further possibility that has been used in some programmes is for an African organisation to house and manage the programme, but with a contractor providing some degree of support and / or leadership.

Location (Manager)	Advantages	Disadvantages
Britain (partner such as BBSRC)	• PMU likely to have strong financial management capacity and ability to disburse funds • May be more attractive to British partners and funders • Could use existing infrastructure / staff • Would increase visibility of funding body(ies) • Could promote longer term accountability / funder ownership since internal contacts / resources may be enduring beyond programme	• May not promote African ownership / interest • Promotes view of Britain and funder rather than partner • Could stretch RCUK (e.g.) resources • Sustainability of the interaction with contracted company would depend strongly on follow-on funding
Africa (partner such as AfDB, FARA, AU, SRO; or contractor)	• Closer to demand and to action • Strong African ownership and political support • Good understanding of practicalities in Africa • Builds capacity in research programme management	• British partners might lack confidence in transparency and accountability • Might have limited to no prior experience managing such a programme • Would likely need to hire new staff for the purpose
China (partner such as MOFCOM, MoA, MoST)	• Likelihood of Chinese buy-in from government • Better opportunity for linking with Chinese private sector partners • May encourage South-South collaboration	• May not promote African ownership / interest • May compromise political and funder support from UK • Difficulties in money transfers between continents
Africa, Britain or China (independent third-party contractor)	• Advantages as above according to location • Specialist programme managers could be more efficient	• Disadvantages as above according to location • Possibly more expensive • Paris declaration on aid effectiveness seeks to avoid "parallel project implementation units"
Africa or Britain with satellite in China	• Better understanding of Chinese partners' interests • Improved links to Chinese partners	• Cost of an additional office • Increased time and effort for cross-office coordination, and risk of potential

	• More opportunity for resolving practical challenges related to China • Better visibility and ownership in China	lack of coordination and misalignment

Programme Governance

It is assumed that the programme would be governed by a "Steering Committee" of some sort, with support from a Technical Advisory Committee focused on the technical proposals and execution of the research. Regarding the Steering Committee, it will be critical to decide who from the public, private, and academic sectors will be represented, and how a balanced geographic representation will also be achieved across Africa, Britain, and China.

Should this programme move forward, the key stakeholders driving the process will need to assess the advantages and disadvantages for each possible representative. Below, the Consortium has demonstrated a preliminary assessment for potential Steering Committee members from Africa. At an appropriate time in the future, this would need to be replicated for prospective British and Chinese institutional partners (as well as for the Technical Committee members).

Organisation	Advantages	Disadvantages
African Union Commission	• Would foster high level political support • Some experience of managing regional programmes (e.g.; PACA)	• Less contact with research organisations • AUC sometimes viewed as over-bureaucratic
FARA	• Apex body for agricultural research in Africa (delegated by AU) • Responsible for CAADP Pillar 4 • FARA governance includes different stakeholder groups, so represents them all	• Secretariat possibly overstretched • When implementing, works through SROs (more relevant to programme management than governance) • Some recent organisational difficulties
SROs (e.g., CCARDESA, ASARECA, CORAF / WECARD)	• Would suit a regional geographic focus • Excellent links to NARES • Promoting Centres of Excellence	• Some recent organisational difficulties
National Agricultural Resaerch and Extension System NARES	• Would suit a national geographic focus • Would promote public researchers to participate in the programme	• May pursue national interests, less focused on cross-border or regional challenges
RECS (e.g., ECOWAS, COMESA)	• Would suit a regional geographic focus	• May be overstretched • Research not a primary focus
IARCs	• Likely to be undertaking related research that could be complementary • Could be involved in projects • Sit on FARA and SRO boards • Might be able to fund their own participation	• Have own research agendas
Universities: networks such as RUFORUM or ANAFE; or individual universities such as Egerton (20 year partnership with China)	• Strengthening university linkages to other R&D seen as important for capacity building and increasing impact of their research • Some are already fostering innovative research partnerships • Well recognised and respected within and beyond Africa	• RUFORUM largely Eastern and Southern Africa to date • Individual universities may not have a wider view
Agribusiness umbrella body (e.g., PanAAC) or individual African companies	• Involved in FARA, SROs governance • Provide linkage for potential uptake pathways and commercialisation of research outputs • Valuable insight if involved in a value chain being researched	• Secretariats possibly overstretched • Might have difficulty representing all members • Potentially only knowledgeable in specific areas of business • Costly if several required
Multinational corporations	• Could provide or link to commercial co-finance opportunities	• Might be more interested in high value globally traded products / value chains

	• Aware of international issues / trends • Links to research in other countries	• Not always viewed positively in Africa
Farmers' organisations (e.g., PAFFO, EAFF etc.)	• Involved in FARA, SROs governance • Would ensure programme emphasises research responding to farmer needs, thereby increasing probability of adoption of research outputs	• Secretariats possibly overstretched • Might have difficulty representing all members • Less expertise in the R&D sector
Funders (e.g., AfDB)	• Could provide access to additional co-finance • Strategic, high-level view • AfDB President is an agriculturalist • AfDB has offices in many countries	• Might not have knowledge of programme research areas
Independent organisations (e.g., AGRA, FANRPAN, AATF)	• Bring specialised knowledge in specific areas (e.g., FANRPAN – policy; AATF – PPPs) • Provide regional and international linkages, in public and private sector	• Sometimes limited personnel overstretched • Do not directly represent value chain actors

PRIVATE SECTOR ENGAGEMENT

With regard to private sector engagement, there was strong agreement that the private sector should be involved in the trilateral agri-tech research programme. There was more debate with regards to how the private sector should be involved. There are three primary aspects to consider:

1. Defining the "private sector"

- **Different types of private sector participants can add value in different ways to research collaborations.** Initially the Consortium talked to stakeholders about engagement with the private sector in broad terms. However, it quickly became apparent that it is important to distinguish the varied roles different types of private sector companies could play:

    - Global Multi-National Corporation (MNC): These companies are defined by their size, global operations, and substantial experience partnering with other organisations. While an MNC may be headquartered in Africa, Britain, or China, it may also be headquartered in the US, Switzerland, or elsewhere. Irrespective of its corporate headquarters, MNCs such as Syngenta, DuPont-Pioneer, Mars, Unilever, etc. can bring high quality research excellence, a commercial mindset, and wide capacity to work with global teams. MNCs are also likely to have in-kind resources (staff time, research infrastructure and equipment) that they could commit to research collaborations.

      While MNCs already conduct research through their own laboratories and networks, those which were consulted for the Scoping Study were receptive to participating in an agri-tech research programme. MNCs see value in partnering with public research institutions which often trigger the basic research, invention, and development of products that MNCs may eventually commercialise.[59] Expanding on this current engagement, with additional financial resources of an agri-tech research programme, MNCs could share the research cost with funders to pursue commercially viable research projects with public research institutions.

[59] Boccanfuso, Anthony M. "Why University-Industry Collaborations in Biotechnology Matter". http://www.forbes.com/sites/gmoanswers/2016/01/19/university-industry-collaboration/#13de33ce5edf Accessed 20 Jan 2016.

- British and / or Chinese small and medium enterprises (SMEs): These companies are defined by their niche expertise in a particular agri-tech area, or value chain. British and Chinese SMEs can bring strong understanding of their domestic markets, and how their technologies have been adapted to local contexts. Again, these private companies will also bring a commercial mindset, and may also have political support from their national governments to participate in a trilateral ABC collaboration.

- African SMEs: Similar to British and Chinese SMEs, African SMEs bring a strong understanding of the local agricultural context and of local markets. The Consortium has seen African SMEs less involved in agri-tech research and more on the deployment of research outputs. This could be an opportunity for researchers to partner with African SMEs and farmer associations to scale up the adoption of the research outputs.

2. Role in governance structure

- **Private sector representation in the governance structure will bring a commercial and market-oriented mindset to the agri-tech programme.** Multiple stakeholders, in speaking about lessons learned from past / ongoing programmes, noted that it was difficult to actually integrate private sector participation in the research collaborations if private sector was not represented in the governance structure. Rather than simply discussing the importance of working with the private sector, and asking the research partners to do so, it is important that the private sector is represented as an institutional partner. Private sector representation on the Steering Committee, for example, will bring a unique perspective on commercialising the deployment of agri-tech research outputs, working to ensure that the funded research will ultimately have a market for uptake.

- **The private sector can be an institutional partner in a number of ways.** Most simply, including a single company (likely a MNC) as an institutional partner would bring value. However, this may raise concerns around conflicts of interest for that company. Alternatively, the Steering Committee could hold a seat for private sector representation where there is a rotation of companies seated on the Steering Committee for fixed terms. While this would address concerns of conflict of interest (as these companies would be participating in a pre-competitive manner), this may be more bureaucratic to change institutional partners, and may impede continuity of long-term discussions. A third option would be to include an association representing a group of companies from relevant industry. An organisation such as the Kenya Agribusiness and Agro-Industry Alliance (KAAA), which serves as a coordinating entity across the private sector in Kenya's agriculture sector, could effectively bring the private sector perspective to the governance of the programme. However, an organisation such as this would need to be aligned with the geographic scope of the programme as well, which may prove more complicated.

3. Private partner criteria

- **Similar to governance structure, the private sector should be represented in the actual research collaborations.** Again, stakeholders involved in past / ongoing programmes noted that when a call for proposal encourages collaboration with the private sector, but does not make it a requirement, few proposals include genuine collaboration with the private sector. Therefore, stakeholders strongly encouraged that this programme mandate in its calls for proposals that at least one of the partners involved needs to be private (for-profit), bringing

knowledge and capacity with regards to technology deployment, and how this should be factored in the upstream research collaboration. There was some debate about whether or not the requirement should be even more specific, mandating that one of the partners in the proposal must be an African private company with a focus on deployment of the research outputs, however this approach may be too limiting.

ADMINISTRATIVE

With regard to administrative issues that are likely to arise, following were the lessons learned from past / ongoing initiatives:

- **Language:** Past collaborations have faced challenges when key partners can't communicate. Considering a trilateral approach across Africa, Britain, and China, there could be language barriers across English, Chinese, French, and Portuguese speakers. Some stakeholders have noted that basic language communication is not necessarily the hurdle, but rather ensuring all partners can communicate on technical / scientific issues has been more challenging. This will be especially true if the collaborations are multi-disciplinary in nature, as it will be important for researcher conducting agri-tech research to be able to effectively communicate with researchers conducting the implementation science research.

- **Capacity Building:** Through the stakeholder consultations it became evident that capacity may be uneven across partners. Successful projects must be planned jointly, with each partner actively participating in the proposal and implementation process, with a clear understanding of roles and responsibilities. These should be closely aligned to each partners' strengths and should be laid out in the proposal, with a clear work plan, budget, and expected outcomes. In addition, based on past collaborations, some stakeholders expressed concerns about the financial management capacity of African partners.

  Therefore, some stakeholders suggested that holding preliminary workshops that focus on "how to prepare a strong proposal" or on "financial management" may be effective in strengthening capacity across all research partners. Past programmes have taken this approach with varying levels of success. Incorporating such capacity building workshops would need to be further evaluated.

- **Ways of Working:** As noted above, many stakeholders commented on the amount of time it takes to develop trust and strong working relationships among partners. From a more practical perspective, this has direct implications for developing ways of working. This can include everything from coordinating how to work across time-zones to understanding cross-cultural working styles. For collaborations with travel, this also had an administrative impact with partners having different travel procedures and per diems. To the extent possible, aligning these ways of working in advance will be important, as will allowing for sufficient time in the early stage of the project to manage a learning curve when partners are new to working together.

- **Dissemination of Funds:** Reflecting on past / ongoing programmes, some stakeholders noted that in multilateral collaborations, disbursing funds out of China has been problematic. Therefore, this needs to be factored in when deciding where the programme should be housed, and who is responsible for the disbursement of the funds. Similarly, once funds are awarded to specific projects, a lead partner (who would receive the funding and be responsible for secondary disbursements to the other partners) based in China may have difficulty in transferring funds to its other partners in Africa and / or Britain.

- **Intellectual Property:** Workshop participants cautioned that partners should sort out in advance any issues with regard to IP rights. While private sector companies may choose to leverage IP rights as a way of recuperating their research investments, public and academic research institutions strive to make their research outputs publicly available (for free). Therefore, in a potential collaboration between a public and private institution, it will be important to come to a legal agreement in advance around how IP rights will be handled both upstream during the research and downstream once (and if) the research outputs will be commercialised. For more information regarding the challenges and consideration around IP rights in trilateral collaborations, please see Box 8.

- **Visas:** Many past / ongoing programmes include budget for travel. What is often not accounted for when developing budgets and work plans at the proposal stage is potential challenges obtaining the necessary travel visas. Therefore, in preparing and reviewing proposals, it is advised to give realistic consideration to time and cost of obtaining the necessary visas to be able to successfully implement the research projects. Similarly, it would be wise to require proposal applications to address these risks, and present ways of mitigation, so as to not derail project progress.

Box 8: Intellectual Property (IP) Considerations in Trilateral Collaborations

In a future trilateral ABC agri-tech research programme, Intellectual Property Rights (IPR) will be a critical point of negotiation among research partners. While the institutional partners of the programme will not need to address IPR issues directly among themselves, IPRs will necessitate negotiations between any partners who are recipients of programme funding. Therefore, the Steering Committee should be aware of the potential challenges that research collaborations face regarding establishing IPR. A trilateral research programme that considers ensuring proper protection of IP, fair negotiations among partners, and the accessibility of the IP by the public, has the opportunity to result in impactful commercialisation of agricultural technologies. Partners of trilateral research collaborations between Africa, Britain, and China that include representatives from the public, private, and academic sectors, should reflect on the following prior to finalising research partnerships:

1. **IPR Variation by Geography:** The extent to which IPR law, and its enforcement, exists in the three geographies varies widely, especially from country to country within Africa. A weak framework for IPR policies and regulations in a given country may deter research collaborations with organisations from that country. This may particularly impact those wishing to partner with the private sector, which may perceive the weak regulatory environment as added risk for the commercialisation of the research outputs. Some SSA countries, such as South Africa and Kenya, have stronger IP laws in place, enhancing the research ecosystem and attracting collaboration. However, a significant number of SSA countries, many of which are considered fragile and conflict states, lag behind in their implementation and enforcement of IPR legal and policy framework and therefore may cause disincentives for research collaborations.

2. **IPR Negotiations:** Collaborating parties should negotiate the IP framework ahead of commencing the research. Establishing clarity on IPR upfront helps to define all parties' rights to revenue / royalties, publications, access to the technology, and more ahead of research findings. Collaborations which instead wait to begin negotiations only once research findings

start to show a commercial component position themselves for potential disputes that could significantly delay the project. The Lambert model[60] may be used to facilitate trilateral IP negotiations between sectors.

3. **IP as a Public Good:** A primary goal of the trilateral agri-tech research programme may be to ensure public access to the outputs of the research collaborations, as these outputs should benefit the African agricultural sector. While IP offers the possibility of royalties for collaborating partners, it should not be at the cost of making the technology inaccessible (financially or otherwise) to the public. A model to consider is South Africa's IPR Act,[61] in which all resulting IP transactions from publically funded R&D must provide the country with a royalty-free license to use or have that IP; however, when the IP is introduced to a foreign market, royalties can be earned. Alternatively, though not as common, there are examples of private sector companies donating, royalty-free agricultural technologies.[62] Incentives for the private sector to license patents royalty free include: complementary assets (company benefits from others' adoption of the technology as it has complementary capabilities which may earn revenue[63]), lead-time and learning-curve advantages, reputation, reciprocity, and lower transaction costs.

[60] See https://www.gov.uk/guidance/lambert-toolkit, accessed 3 February 2016
[61] Taken from South Africa's *Intellectual Property Rights From Publicly Financed Research and Development Act 51 of 2008* current version dated 2 August 2010.
[62] Monsanto, as a participant in Water Efficient Maize for Africa (WEMA) since 2008, has donated hybrids of corns and "germplasms" to this Public Private Partnership.
[63] See Leslie, Christopher R. *Antitrust Law and Intellectual Property Rights: Cases and Materials.* 2011. Oxford Press.

VI. PROGRAMME DESIGN OPTIONS

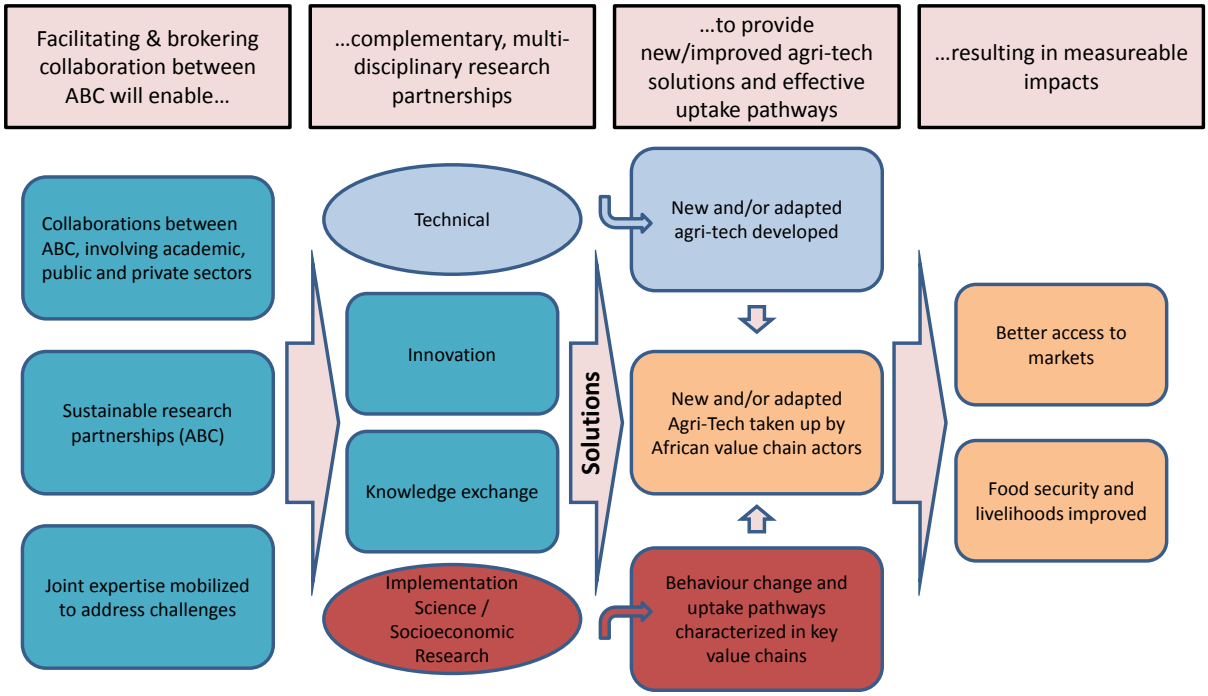
Theory of Change

One of the most common questions the Consortium heard from stakeholders was "What is the objective of this programme?" The Terms of Reference for this Scoping Study noted that at a high-level, the potential ABC agri-tech research collaboration programme "aims to mobilise joint expertise, both academic and private sector expertise, in the development of new, and adaptation of existing agricultural technology, innovation, and knowledge exchange which will provide solutions to help meet the future demands and challenges facing African agriculture over the next 20 years." The Consortium proposes a modified version of this wording, as the Programme Objective: "To mobilise expertise in agricultural technology, innovation and knowledge exchange from Africa, Britain, and China to address livelihood and food security challenges in Africa."

The Consortium presents below a theory of change that describes how a trilateral ABC agri-tech research programme will contribute to the ultimate goals of: i) improving livelihoods and ii) achieving food and nutritional security. While this can be achieved through any number of means, each programme design would still follow a similar logical framework. Successful ABC research collaborations would need to include partners from the public, private, and academic sectors. These partnerships, with appropriate funding and support, could build on past collaborations, contributing to lasting and sustainable partnerships. Figure 21 depicts the theory of change for a successful programme.

Convening complementary skill sets across technical and implementation science researchers would catalyse the identification and scaling of solutions to African agricultural challenges. The research outputs generated by these collaborations would include both innovation of new ideas and technology as well as facilitation of knowledge exchange between partners, the wider research community, policy makers, and industry. Through these research outputs, the potential trilateral ABC agri-tech research programme would result in behaviour change and ultimately the adoption and scaling of solutions by actors at each stage of the value chain. Through the scaling of adoption of new and adapted agri-technologies and innovations, the programme ultimately would enhance access to local, national, and global markets, while improving livelihoods and achieving food and nutritional security for farmers and food producers / processors / traders.

Figure 21: Theory of Change



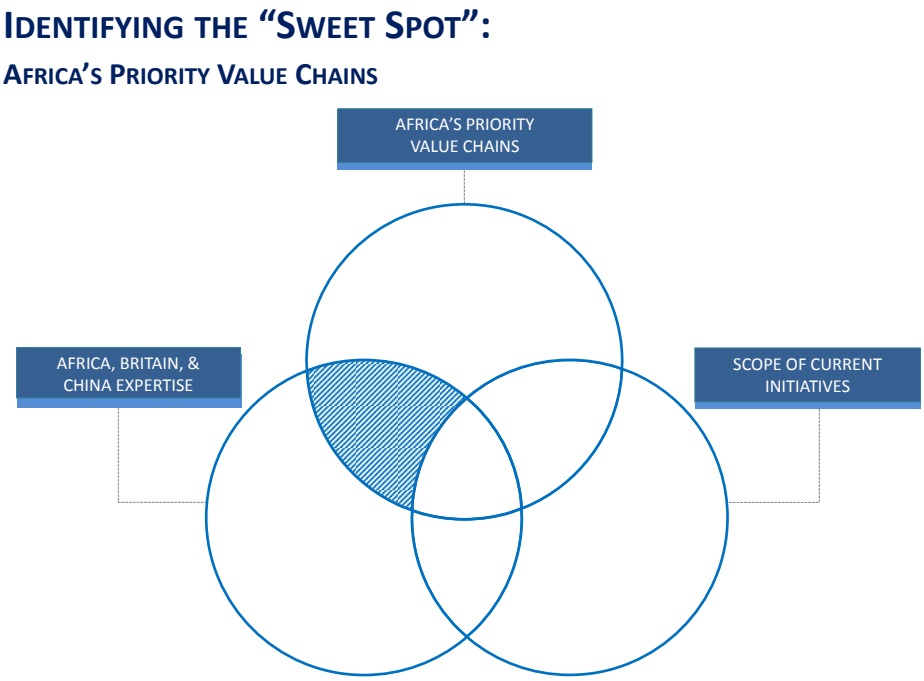
This theory of change is based on the following key assumptions:

- Partners from each geographic region are institutionally supported to develop equitable relationships.
- Multidisciplinary collaborations utilise and communicate in a common language and understanding. This is addressed through relationship building and encouraging interactions during the project development stage and through, for example, inception workshops.
- Value chain intervention points are identified at the local level. Thorough justification will be required for each project.
- Farmers delivering to existing and emerging markets can increase productivity by adopting the use of both new and existing technologies, innovations, and knowledge.
- Agricultural markets provide opportunities for adoption of research outputs.

Value Chain Selection

With regard to defining the programme's thematic scope, and based on unanimous feedback from the consultations and workshop participants, the Consortium recommends the programme takes a value chain approach. As initially laid out in the methodology (see Section I), a key objective of this Scoping Study was to identify the "sweet spot" (see Figure 22) for the proposed programme's thematic scope. When applied to the value chain approach, therefore, the idea is to identify the value chains that are priorities for the region, for which Britain and China have an expertise, and that are relatively (to the need) under-addressed or under-funded by ongoing programmes.

Figure 22: Identifying priority value chains for the ABC programme thematic scope



While the figure above presents a theoretical approach to defining the thematic scope, the Consortium determined that, in reality, the process is not so simple. In particular, different regions or countries may have different priority value chains. Therefore, the thematic scope of the programme will be largely dependent on the defined geographic scope.

Building on the outputs of the bibliometric research on the most research value chains and strengths in ABC, plus reviewing the thematic focus of existing collaborations, feedback from consultations, and reviewing policy documents (e.g., CAADP Policy investment frameworks and country strategies, and other national and regional policy and strategy documents) a preliminary landscape of key value chains emerged.[64] However this process of identifying key value chains is highly dependent on the underlying data gathering mechanisms. For example, the Consortium did not have access to robust data (policy documents, stakeholders, or otherwise) for some key Central African countries. Given the constraints, the value chains identified below form a focus to draw a deeper discussion in any future implementation of the Scoping Study.

Building on the developmental considerations for identifying key value chains (Section V), the Consortium proposes the following value chains, by geographic scope as a baseline for further iterations:

- If the programme is pan-SSA in nature, the programme could focus on key animal value chains. The Scoping Study identified livestock and aquaculture as key challenges, as well as priority value chains across Africa. This is largely driven by the increased demand for protein as derived by increasing incomes and a growing middle class. From the bibliometric analysis

[64] It should be noted, however, that this landscape may change quickly. With the recent adoption of the Global Goals in late 2015, the Consortium has observed a recent push by funders and investors to commit future budget to a number of the value chains mentioned in this Scoping Study. For example, the CG centers released research priorities for 2017-2022 and indicated expectations to dedicate $125M and $401M to livestock and fisheries research, respectively. While this funding is not ABC specific, the Steering Committee should be aware that the landscape for priority value chains will change as funders and investors establish new programmes in the coming months and years.

Animal Science and Zoology was a growth area of expertise in Africa and China and an area of strength in Britain. An ABC collaboration in this thematic area could be successful as it is within the expertise base of each system.

- If the programme is regional or national in nature, the value chain selections will vary. In addition to the animal value chains (which are relevant across the continent), maize was identified as a priority crop that is facing a number of challenges. The most frequently cited cereal crop research in Africa-Britain collaborations was maize (see Figure 17), while rice and sorghum were the most frequently cited cereals in Africa-China collaborations (see Figure 19). While the challenges may differ from region to region (e.g., based on different climatic and ecological conditions), maize is an important crop across Africa. In addition, based on the findings of the desk-based research and the consultative process, the Consortium has identified the following crops for each region as potential thematic areas of focus (the Consortium acknowledges that a review of additional policy document, possibly from other African countries and speaking with other stakeholders, may result in different value chain recommendations):
    - West Africa: Rice, cassava, sorghum
    - East Africa: Sorghum, millet
    - Southern Africa: Legumes and pulses (e.g., cowpea, soybean, ground nut)
    - Central Africa: Cassava, yam, sweet potato, horticulture

Furthermore, based on the identification of the challenges in agriculture across Africa (see Section II), the thematic scope of the programme can emphasise key value chain segments. While the primary focus will be value chain based, the programme can still address key challenges identified by encouraging key areas of focus within each value chain. This can be done either through an incentive whereby applicants receive "extra credit" for proposals that focus on specific areas. Based on the findings of the desk-based assessment and feedback from stakeholders' inputs, pests and diseases, and post-harvest (especially agro-processing and value addition) were identified as key areas of focus in crop value chains. In animal value chains, stakeholders identified the following key value chain segments: feed systems, production, food safety, and value addition / commercialisation.

Programme Design Options

Building on the output from the bibliometrics, desk-based research, stakeholder consultations, and workshops, the Consortium presents below four programme design options. Each option stems from the theory of change above. It should be noted that these options are intended to highlight, at a top-level, possible key differentiations. In evaluating the various programme options, it should be noted that in some cases specific aspects of one option can be combined with aspects of another programme. Therefore, as the Steering Committee and other stakeholders explore in which direction to take this programme, any specific "deal-breakers" should be considered as well as which priorities (developmental, political, and practical) should be integrated.

Following each program design option is a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis. Figures 23 through 26 demonstrate the trade-offs across the programme design options, as well as the comparative advantages and risks for each design option. The SWOTs look first to strengths and weaknesses of internal aspects of the programme (i.e., specific programme characteristics) and secondly at external opportunities and threats (i.e., market trends and conditions).

Both traditional models (Options A and B) would probably engage a similar number of researchers, but on the ground, the major difference would be the geographic focus. Assuming the programme

will have a fixed budget, the narrower geographic focus in Option B may allow for larger local impact than the pan-SSA approach in Option A. This may in-turn impact level of stakeholder engagement, particularly at the regional, national, and university level.

Another key difference between Options A and B is that where as in Option A all proposals must demonstrate how they will include both agri-tech research and implementation science research, Option B allows for applicants to submit their proposals to either window. From a practical standpoint this means that while Option A may be more successful in generating research outputs for a specific agri-tech innovation with clear data on how best to scale up adoption of that innovation, it may also limit the number of potential applicants, as it may be hard for partners to put together teams of both agriculture and social scientists. In contrast, Option B may allow for applicants to specialise and apply to one funding window, yet there is a risk that the funded proposals for the implementation science window focus on topics that are un-related to the funded proposals for the basic agri-tech research window. In other words, Option B risks funding some agri-tech research without the follow on implementation science research for that specific project.

Meanwhile, Option C would differ from Options A and B in that it could have a greater impact on strengthening institutional ties between ABC researchers, further contributing to programme sustainability. The CoE model might provide more opportunities for drawing in additional funding to the CoEs as well as the commercialisation of research outputs through consulting, IP licensing, etc. Option C would also offer a strong focus on human capital development as an outcome, attracting and breeding a future generation of African agri-tech researchers.

The outcomes on the ground of Option D would be largely dependent on which programme is selected for scale up.

Option A: New "Traditional" R&D Fund Housed in Africa

Geographic Scope: All SSA countries eligible (and for those not awarded, all are welcome to attend Annual Knowledge Sharing Conference for cross-pollination of ideas, capacity building, etc.)

Thematic Scope: Value chain focus on i) ruminants / dairy, ii) poultry, and iii) aquaculture / fisheries with emphasis ("extra points") on feed systems, production, food safety, and value addition / commercialisation

Financing: £60M over 10 years (each project funding for max. 4 years), 3 calls (in year 1, 3, 6) across 2 windows:

1. (3%, £1.8M) Project planning / preparation grants
   - £10K - £50K per proposal team
   - 50-70 project preparation grants awarded (16-23 per call)
2. (96%, £57.6M) Project must include BOTH basic agri-tech research AND implementation science research on tech scale up
   - £750K - £5M (requires project co-financing – may be in-kind from private sector / can be blended grant, debt / equity financing)
   - 18-22 projects awarded (6-8 per call)
3. (1%, £600K) Funding for Annual Knowledge Sharing Conference
   - $60K per conference – Funds may be used for conference logistics, as well as sponsoring travel for researchers from SSA countries that did not have any award recipients

Eligibility / Competition:

- 2-stage competitive process
- Applicants must have A-B-C partnerships
- Must include at least 1 private (for-profit) partner
- Must demonstrate how proposed partnership builds on existing work among proposed partners
- Extra points for co-financing or blended financing

Governance:

- Steering Committee:
  - Rotating seat for MNCs
  - A: RECs (ECOWAS, SADC, ECCAS, EAC)
  - B: Funders (DFID, Defra, RCUK)
  - C: MoA or MOST (either / or)
- Technical Advisory Committee: FARA, regional orgs (CORAF, ASARECA, CCARDESSA) & BBSRC
- Programme Management by 3rd Party (competitively bid): Must be housed in Africa (using local staff) (e.g., AGRA, or Landell Mills with local staff) & have liaison office in China

Figure 23: Option A SWOT

Strengths	Weaknesses
• Wide geographic scope increases competition / quality, aligned with S3A "no country left behind," promotes inter-regional knowledge exchange • More attractive for funders / government officials to promote and brand a new programme • Multiple calls allow for success with revised proposal in subsequent call • Project planning grants help build capacity, opens door for more newcomers • Requiring co-financing at the project level could be more easily met through private sector in-kind contributions • Mandating proposals include both agri-tech and implementation science directly links research outputs to deployment • Governance structure promotes African ownership, especially PMU with local African staff • Liaison office in China likely to attract Chinese political support	• Risks sidelining some countries with lower capacity unable to put together competitive proposals • Time horizon for proposals potentially too short for measurable impacts • Limits long-term sustainability • Requiring co-financing at project level may be burdensome for researchers • Potential challenges in communication between agri-tech and social science researchers, impacting effectiveness of collaboration • Number of Steering Committee members may increase programme bureaucracy • Potential higher management costs with 3rd party PMU • Liaison office in China adds management costs and complexities
Opportunities	**Threats**
• Preparation grants stimulate new long-term ABC collaborations • To meet the project co-financing requirement, proposals that successfully attract debt / equity are more likely to result in commercially-viable research outputs, thereby potentially having greater impact on market for technology uptake	• Potentially low impact if funding spread across multiple countries • Long-term programmes may be less politically attractive as more difficult to demonstrate results within election cycles • ABC-only partnerships may restrict volume of proposals submitted and therefore limit competition / quality

Option B: New "Traditional" R&D Fund Housed in Britain

Geographic Scope: 3-4 DFID priority countries from 1 region (of which at least 2 must be a fragile / conflict state) (e.g., for East Africa country selection could include Tanzania, South Sudan, Kenya, Ethiopia)

Thematic Scope: Focus on i) inputs, ii) pests & diseases, and iii) post-harvest (incl. agro-processing) with emphasis ("extra points") on key value chains depending on region. For example:

- West Africa: Maize, rice, cassava, sorghum
- East Africa: Maize, sorghum, millet
- Southern Africa: Maize, legumes and pulses (e.g., cowpea, soybean, ground nut)

- Central Africa: Maize, cassava, yam, sweet potato, horticulture
- Pan-SSA: Ruminants / dairy, poultry, aquaculture / fisheries

Financing: £50M over 5 years (each project funding for 3 years), 2 calls (in year 1, 3) across 2 windows:

1. (50%, £25M) Basic agri-tech research
   - £750K - £1.5M per project
   - 20-25 projects awarded (10-12 per call)
2. (50%, £25M) Implementation science research on tech scale up
   - £400K - £750K
   - 40-45 projects awarded (20-23 per call)

Eligibility / Competition:

- 2-stage competitive process
- Applicants must have A-B-C partnerships
- Must include at least 1 private (for-profit) partner
- Must demonstrate how proposed partnership builds on existing work among proposed partners

Governance:

- Steering Committee:
  - Private sector association (e.g., Kenya Agribusiness & Agroindustry Alliance)
  - A: MoA from the 3-4 eligible countries
  - B: Funders (DFID, Defra, RCUK)
  - C: MoA or MOST (either/or)
- Technical Advisory Committee: NAROs from the 3-4 eligible countries, top-ranked universities from Africa, Britain, and China with implementation science expertise
- Programme Management by Funder(UK)

Figure 24: Option B SWOT

Strengths	Weaknesses
• Promotes intra-regional knowledge exchange • Aligned with DFID's new strategy to focus on fragile / conflict states • More attractive for funders / government officials to promote and brand a new programme • If funders allowed to fund specific windows, may be more attractive to potential co-funders • Allows more flexibility for researchers to focus on agri-tech or implementation science research • PMU in UK funder couldl have lower management costs, and may result in stronger financial accountability / transparency of funds	• Narrow geographic scope may limit competition / quality of proposals • Time horizon for proposals potentially too short for measurable impacts • Limits long-term sustainability • If funders want to fund specific windows, may complicate programme financial management, including how to finance overhead costs • Keeping agri-tech and implementation science research windows separate results in possible lack of coordinated approach and risks not successfully scaling up research outputs • Number of Steering Committee members may increase programme bureaucracy • Relevant African regional private sector association may not exist, only national • PMU in UK funder may result in lower interest / support from African partners
Opportunities	**Threats**
• Potentially high impact for 3-4 countries with funding concentrated in single region	• Emphasis on fragile / conflict states risks resulting in programme complications, including possible cancellation • While post-harvest is a clear priority for African agriculture, this thematic scope may result in duplicating other research efforts • Mandating applicants demonstrate how proposals build on existing ABC partnerships may restrict volume of proposals submitted and therefore limit competition / quality

Option C: New Virtual Centres of Excellence

Geographic Scope: Centres would be virtual networks, each with an anchor / host institution

- 6-8 centres in Africa (within DFID's 18 priority countries)
- 1-2 in Britain
- 1-2 in China

Thematic Scope:

- Centres to focus on postharvest & value-addition for single value chain (aligned with regional / national priorities of host institution location)
  - West Africa: Maize, rice, cassava, sorghum
  - East Africa: Maize, sorghum, millet
  - Southern Africa: Maize, legumes and pulses (e.g., cowpea, soybean, ground nut)
  - Central Africa: Maize, cassava, yam, sweet potato, horticulture
  - Pan-SSA: Ruminants / dairy, poultry, aquaculture / fisheries
- Components of Centre of Excellence could include:
  i. R&D (60-90% of allocated funds)
     - Individual research projects should ABC partnerships
     - By end of first year, centre to manage own research fund with calls for proposals
  ii. Advanced Human Capital Development (maximum 25% of allocated funds)
     - Short-term stays for PhDs & post-docs in industry (3-12 months)
     - Short-term faculty exchanges (e.g., British or Chinese professor in Africa) (maximum 6 months)
     - Training technology transfer managers
  iii. Infrastructure and Equipment (maximum 15% of allocated funds)
  iv. Knowledge Sharing and Dissemination (up to $1M for annual workshops / conferences)

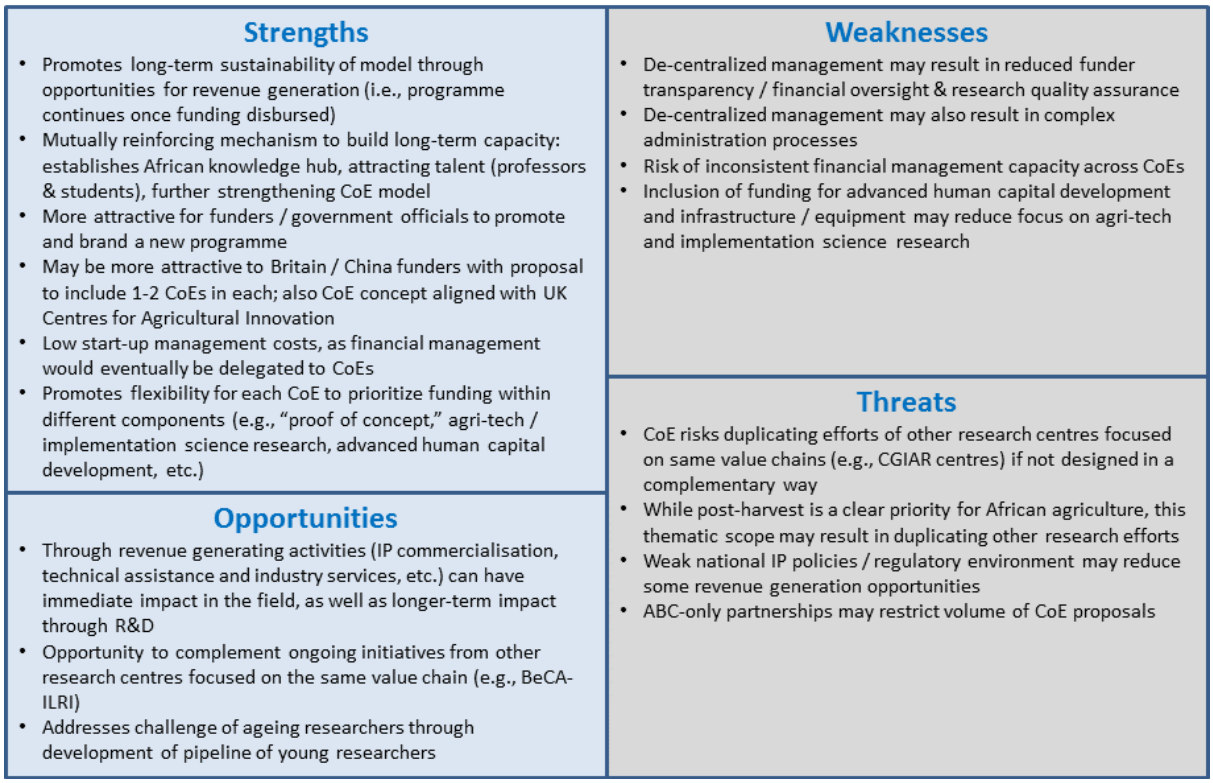
Financing: £100M over 5 years (~£10M per centre)

- Must demonstrate co-funding from other sources to show multiplier effect for grant financing
- Mandate revenue generation: Student fees, IP, industry collaboration → this will demonstrate sustainability

Governance:

- Steering Committee:
  - A: African Union Department on Human Resources, Science, & Technology (other ideas: RUFORUM, NEPAD; Pan-African Farmers' Organisation (PAFO), SROs)
  - B: DFID, Defra, RCUK
  - C: MoA (or MOFCOM or MOST)
- Funds would be managed out of UK funder (e.g., DFID, BBSRC), with funding disbursed to Centres of Excellence -- management would eventually be delegated to Centres themselves
- Centres of Excellence would be selected through 2-stage competitive tender

Figure 25: Option C SWOT



Option D: Scaling Up an Existing Programme

Geographic Scope: Pan-SSA (via expansion of existing networks / programmes)

Thematic Scope: Following are a few examples of programmes that could be scaled up:

- AgriTT: A second phase of AgriTT would likely focus on deployment of results from AgriTT Research Challenge Fund projects, with increased programme management in Africa, and an expanded programme reach with focus on inputs, pests and disease control, postharvest issues / value addition.
- SCPRID or ZELS: Follow on funding could introduce Chinese expertise in these programmes as well as increase the range of crops, or expand to efficient production / commercialisation (respectively). Functional networks are being established and nurtured for each programme, which can also be built on for deployment stages, and expanded.
- SAIN: Additional funding would allow SAIN to expand to include African researchers. The network's theme is sustainable agriculture with key foci (of most current projects) on input efficiency and climate change mitigation and adaptation. Introducing core programmatic funding, for example via a challenge fund, would enable broader scope in value chain stages addressed. An initial funding stage could enable existing network participants to link with African groups, and new trilateral groups to emerge.

Partnerships: Key partnerships could be sought through active new links with existing programmes and networks including:

- *PAEPARD* (Platform for African European Partnership on Agricultural Research for Development, coordinated by FARA)[65]

[65] PAEPARD is a consortium of research / education organisations in Europe that supports research collaboration in Africa and Europe. It connects a wide range of actors, from farmer organisations to policy networks, and supports funding applications and advocates for support for demand-driven collaborative research. The initiative is supported by the

- *UniBRAIN* (Universities, Business, and Research in Agricultural Innovation, funded by Danish government)[66]
- *Agriculture Innovation Market Place* (formerly Africa-Brazil Agricultural Innovation Marketplace)[67]
- *AGRA* (The Alliance for a Green Revolution in Africa)[68]

Governance & Administrative: While scaling up an existing programme would build on the existing governance structure, some adjustments may need to be made. Following are some key factors for consideration:

- There may be complexities in adapting a bilateral UK-Africa or UK-China programme into a trilateral program.
  - Which additional institutional partners need to be added to the governance structure, if any?
  - How would that impact current processes and ways of working?
  - Should co-financing from China and / or Africa be mandated at this scaling up stage?
- Promoting African ownership may be challenging when moving from a bilateral to trilateral collaboration that introduces Africa to an existing programme (e.g., SAIN).
  - Would the PMU / secretariat need to be moved to Africa and what are the implications?
  - Would this be more burdensome than developing a new programme with its own governance structure?
- Appetite for scaling up the programme will be dependent on the outcomes and perceived success of the existing programme.
  - Are current and future stakeholders of the programme aligned on the lessons learned from the initial phase?
- Is there broad support for scaling up the programme with existing governance structures?

European Union through its Food Security Thematic Programme. Such an established network could act as a springboard towards identifying partnerships to target or invite to collaborate or join with Chinese.

[66] UniBRAIN, an initiative between international African organisations and led by FARA, aims to boost employment and incomes through sustainable agribusiness development by linking universities, business, and agricultural research institutions for the purpose of commercialising agricultural technologies and human capacity building (training graduates in business skills through agribusiness incubator partnerships). A consortium of universities, businesses, and agricultural research institutions from Kenya, Ghana, Mali, Uganda and Zambia are involved, dealing with various value chains (coffee, banana, sorghum, non-timber forest products, cereals, fruits and vegetables).

[67] The Agriculture Innovation Market Place, launched in 2010, is the initiative of EMBRAPA and FARA, funded by B&MGF, IFAD, DFID and World Bank. The objective is to enhance agricultural innovation and development on the African continent through the establishment and strengthening of partnerships between Africa and Brazil. Along with international, high profile funding bodies, the Steering Committee also includes engagement from high level representation from Brazilian, African, and international representation (the latter including World Bank, DFID, IFAD, B&MGF, FAO).

[68] AGRA works to catalyse an African Green Revolution through formation of partnerships and advocacy for policies that span key aspects of African agricultural value chains, including getting improved seed to farmers and working with agro-dealers. AGRA, headquartered in Nairobi, has presence in 17 African countries. Funding for AGRA is primarily from the Gates and Rockefeller Foundations and DFID.

Figure 26: Option D SWOT

Strengths	Weaknesses
• Builds on established partnerships, while introducing innovative mechanisms • "Leapfrogs" necessary partnership building phase, allowing more time for research • Existing institutional partners may already have strong governance capacity already in place • May prevent "donor fatigue" in Africa	• Less attractive for funders / government officials, as not a "new" programme • Could be a politically and practically complex process to add a new institutional partner to governance structure
Opportunities	**Threats**
• May be more likely to attract co-financing from Africa or China if presented as scaling programme after successful "proof of concept" • Opportunity to scale existing work / research collaborations through to technology deployment • Potential to leverage and scale integration of existing networks and partnerships	• Limited list of existing programmes to scale to successfully • If scaling a Britain-China programme by adding African institutional partner, not aligned with development principles of including African participation from beginning of design process • Risk of road blocks to scaling programme due to complicated negotiations between institutional partners • Risk of scaling an unsuccessful or low impact programme

VII. Decision Points and Next Steps

As this Scoping Study clearly demonstrates, there is a strong need for increased agricultural R&D in Africa and an interest in future trilateral collaboration to catalyse Africa's, Britain's, and China's complementary expertise in the agri-tech research field. Should the programme be taken forward, the four programme design options presented above are deliberately designed to offer a menu of approaches from which the Steering Committee could either select a single programme design option in its entirety or it could choose to design a programme pulling different aspects from the various components of Options A, B, C, and D (or other programme design elements laid out in Section V that were not included in the four options in Section VI).

In order for the programme to move forward, at a future point in time and when appropriate, key decisions will need to be made for each component. Any path forward will present its own set of challenges, however, the merits of each component should be evaluated based on the developmental, political, and practical trade-offs as well as the Steering Committee's priorities. As each trade-off poses a risk or challenge in the programme's development, it will be critical for those developing the programme to work closely with key institutional partners (once identified) during the design process to ensure the decisions that are made are also aligned with partner priorities. Buy-in from the institutional partners at each step of the process will be necessary for a successful programme.

Therefore, the Consortium recommends that the suggested sequence below is followed in order to address these key decisions:

First, questions of co-funding and geographic scope will need to be addressed.

Chinese Co-Funding: Among the first decisions to be made is around the question of co-funding from China. Will co-funding (financial contribution) be a required element of the programme? The answer to this question will heavily influence the selection of the Chinese institutional partner(s). If co-funding from China is desired, the decision may narrow the potential institutional partners to include MoST or MOFCOM which, based on past examples, are more likely to be able to commit budget to fund programmes. MoA's or CAAS's more limited ability to co-fund programmes, beyond in-kind resources, may make them less attractive institutional partners should Chinese co-funding by required. As detailed above, the pros and cons of the potential Chinese institutional partners will need to evaluated and weighed against the trade-offs of requiring co-funding. Moreover, if it's decided that co-funding will be required from China, this will also impact programme timing, as it will be critical to engage with the institutional partners early enough so that timing can aligned with the Chinese government's budget planning cycle.

Geographic Scope: Similarly, a decision will need to be made early on regarding the geographic scope of the programme, which in turn will help narrow the field of appropriate African institutional partners.

Based on internal priorities and capacity, a decision will need to address whether the geographic scope of the programme should be pan-SSA, regional, or national in nature. Moreover, in the decision process, should the focus be on one or two regions or a handful of key countries, questions to consider include: Is this in line with DFID's strategy to focus on fragile and conflict states? Is there political support in that specific country / region? Does the Steering Committee have the management capacity to develop a programme in these countries, this region, or across the continent?

Regardless of the decision, the final geographic scope will in turn drive the selection of institutional partners and thematic scope accordingly. For example, should the West African region be selected, a potential institutional partner could be CORAF or ECOWAS (as opposed to FARA or the AU / NEPAD) which could then steer and tailor the thematic scope to address the agri-tech challenges which affect West Africa, specifically. Similarly, if the programme focuses solely on three countries in different regions, perhaps the respective ministries of agriculture or national research councils would be more appropriate institutional partners.

Nevertheless, when it comes to selecting the African institutional partner, this decision could also be done in reverse. In other words, if the Steering Committee has a strong history of engagement with a particular African institution at the pan-SSA, regional, or national level, and is keen to work with this pre-identified organization, then a partnership could be established. From there, the partners could work together to define the appropriate geographic scope. In this way, the Steering Committee may ensure collaboration with an institution with which they have already developed ways of working and / or agreed on mutually beneficial priorities. Alternatively, the Steering Committee may select an institution with which they have not yet engaged, but from which there is positive receptivity to partner on the agri-tech research programme.

In this case, the selection of the institutional partner may inherently drive the geographic and thematic scope of the programme. For example, a pan-SSA institutional partner, such as the AU, FARA, or RUFORUM, would lend itself to a pan-SSA geographic scope as well as thematic scope addressing agricultural challenges that SSA faces. Whereas an institutional partner from a specific country's Ministry of Agriculture would inherently drive the decision for a programme to address the national challenge.

As previously mentioned, it will be crucial for all institutional partners to be a part of the programme design process in order for the decisions points to address each institutional partner's priorities. If key programme design decisions were to be made prior to engaging with institutional partners, there is possible risk of alienating important stakeholders from collaborating on the programme due to misalignment of objectives. Therefore, the two decision points outlined above – Chinese co-funding and geographic scope in Africa – will have a critical impact on downstream programme decisions.

Once the programme's institutional partners are selected, the Steering Committee can work with its partners on key downstream decisions such as: programme structure, programme management, and role of the private sector. It should be noted that this set of programme design decisions are often interlinked and do not necessarily follow a linear process.

Programme Structure: Section V and VI demonstrate the trade-offs between establishing a traditional research fund, centres of excellence, and scaling up an existing research programme. The selection of appropriate programme structure will depend on the Steering Committee and institutional partners' joint objectives as well as interest, bandwidth, and capacity to oversee the programme. The selected structure will likely drive the potential on-the-ground impact and results of the programme as well as some of the funding components to define.

While the programme generally aims to mobilise joint expertise, both academic and private sector expertise, in the development of new, and adaptation of existing agricultural technology, innovation and knowledge exchange which will provide solutions to help meet the future demands and challenges facing African agriculture over the next 20 years, the

selected structure will alter the programme results and impact. As noted throughout Section V, distinctions in programme structure may impact geographic focus, reach and engagement of stakeholders, and adaptation and adoption of agricultural technologies.

The selected programme structure will also lead the Steering Committee to consider other key questions around funding components. In terms of the funding model, should blended and innovative financing mechanisms be considered as a way to promote sustainability? If so, which mechanism and how? As additional programme co-funders are considered, is the Steering Committee open to co-funders allocating contributions to support specific programme components of their choosing? Lastly, in defining programme timeline and funding windows, what length of time is the Steering Committee comfortable with to allow the research programme and funded research projects to run and demonstrate impact? How many funding windows, and at what size, would be appropriate, particularly given the programme's duration?

Programme Management: There are two decisions for consideration regarding day-to-day management of the programme. First, should the PMU be housed within an institutional partner or a third-party? Second, where should the PMU main office be physically located? The trade-offs to consider around managing and housing the programme include cost, capacity, sustainability, and African ownership, all of which must align with the Steering Committee and institutional partners' priorities and administrative practicalities.

Role of the Private Sector: The programme's aim, as stated in the Terms of Reference to this Scoping Study, includes mobilising private sector expertise in addition to the academic sector. The Steering Committee and institutional partners must weigh the advantages of emphasizing private sector engagement with the challenges that this may bring, as laid out in this Scoping Study. An assessment of these trade-offs will inform the extent to which private sector participation should be mandatory, both within the programme's governance structure, as well as downstream within the research projects or centres of excellence. If it were to be mandatory, further decisions must be made to define which private sector representative (e.g., MNC or SMEs) is most suitable for the governance structure as well as the role the private sector must have within the research. If, rather, private sector participation is strongly encouraged, but not deemed mandatory, considerations should then be given to incentivise Africa-Britain-China private sector participation.

The decision points above will drive the overarching programme design; however, there are plenty more detailed decisions to be fleshed out that will result from the above points. Additional points to consider include: the integration of implementation science, any pre-requisites and criteria around the development of ABC trilateral research partners (e.g, an already existing partnership, brokered bilateral partnerships, or completely new), and any specific mandates around the lead / prime partner. Following such decisions, there will be a host of details to further define from the six areas for consideration: technical, political, governance, financial, private sector engagement, and administrative.

The Consortium notes that the programme design process may face obstacles and delays, regardless of which direction is pursued. However, it is important to remember that despite these challenges, there is strong receptivity to promoting ABC agri-tech research, and there is a strong rationale for using this trilateral approach to achieve impact. Therefore, it will be critical for the Steering Committee and institutional partners to work together in unison to clearly define and align their key priorities and preferences to help facilitate a smooth process in designing and launching the programme.

This trilateral approach has the potential to strengthen ABC's capacity to develop and adapt agri-tech research, innovation, and knowledge exchange that could contribute significantly to Africa's agricultural transformation. By developing and scaling adoption of agricultural technologies and innovations from inputs to processing, this ABC trilateral agri-tech research programme offers the opportunity to improve the livelihoods for many African food producers.

VIII. ANNEXES

The report is accompanied by the following attached annexes:

Annex 1: Elsevier Bibliometrics Report
Annex 2: List of Reviewed ABC and BRIC Programmes
Annex 3: List of Stakeholders Consulted
Annex 4: Proceedings and List of Participants from Focus Group Consultations
Annex 5: List of References