BBSRC-led workshop on the sustainable intensification of agricultural systems in sub-Saharan Africa

13-15 March 2017

in partnership with

Biosciences eastern and central Africa-International Livestock Research Institute (BecA-ILRI) Hub, Nairobi, Kenya
A BBSRC-led workshop, funded through the Global Challenges Research Fund (GCRF), was held at the Biosciences Eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub, Nairobi, Kenya from 13 to 15 March 2017. The purpose of the workshop was to help inform potential future funding opportunities from the GCRF for collaborative research between UK and African scientists, with the objectives of:

- identifying research challenges, and associated scientific and partnering opportunities, relevant to the sustainable intensification of agricultural systems in sub-Saharan Africa
- contributing to relevant partnership-building between research organisations in the UK and countries in sub-Saharan Africa

The workshop comprised a one-day field trip (with visits to six sites around Nairobi), and two days of interactive discussions at the BecA-ILRI Hub.

During the workshop, eight broad challenges were identified as priority research areas:

1. Integrated landscape management to deliver ecosystem services
2. Improving soil health, nutrient management and nutrient use-efficiency
3. Improving water management and water use-efficiency at multiple scales
4. Managing pests and diseases in the context of climate change
5. Plant breeding for multiple traits, focussed on the needs of end users
6. Livestock breeding for multiple traits, focussed on the needs of end users
7. Exploitation of indigenous and ‘orphan’ crops and farmed animals
8. Using mobile phones on farm for agricultural development

The following topics were identified as cutting across multiple challenge areas. Time constraints prevented their exploration in depth during the workshop, but they need to be borne in mind when considering the challenges described this report.

- More systems research/systems thinking
- Adapting to, and mitigating the effects of climate change
- The requirement for nutritional diversity
- Improving capacity and capability
- Effective research translation
- Recognising issues of gender
- Recognising issues of land rights
- Influence of policy and regulation
- Developing partnering opportunities between the UK and sub-Saharan Africa

Key areas to consider in relation to research design, translation and impact included:

- Identifying and communicating with beneficiaries and end-users of the research
- Involving stakeholders throughout the research process (co-design and delivery)
- Collaborating and building partnerships with public, private and NGO partners
- Aligning with existing Government strategies and policies, and with development agency programmes to bring added benefits
- Consideration of potential gender, age and cultural differences in access to, and uptake of, research
- Technological limitations hampering the uptake of research
- Tailoring communication of research outcomes to the most appropriate audiences
- Recognising the key role of extension services
- Building capacity and capability (human, infrastructure and financial)
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BACKGROUND TO THE WORKSHOP

This BBSRC-led workshop was funded through the UK’s Global Challenges Research Fund. It was organised with the very active cooperation of the Biosciences Eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub, and additional assistance from the UK Sustainable Intensification Research Network (SIRN), the John Innes Centre (JIC) and Bioversity International.

The purpose of the workshop was to help inform potential future funding opportunities from the GCRF for collaborative research between UK and African scientists, with the objectives of:

• identifying research challenges, and associated scientific and partnering opportunities, relevant to the sustainable intensification of agricultural systems in sub-Saharan Africa
• contributing to relevant partnership-building between research organisations in the UK and countries in sub-Saharan Africa

The workshop was attended by over 50 people, comprising invited researchers and others from nine African countries and the UK, together with representatives of BBSRC and participants from BecA-ILRI, SIRN, JIC and Bioversity International. Participants were selected for their ability to bring a strategic perspective to the discussions, as representatives of their broader constituencies.

The workshop briefing booklet (including attendees’ biographies) is at Annex 1. The workshop programme is at Annex 2 and details of the field trip at Annex 3.

The workshop was held concurrently with a University of Edinburgh-led workshop to establish a community of practice on the topic of ‘Earth Observation in Support of Climate Smart Agriculture’. The opportunity was taken for cross-over between the two workshops, including a common introductory session for all participants.

GLOBAL CHALLENGES RESEARCH FUND

The Global Challenges Research Fund is a five-year £1.5Bn resource funding stream, announced as part of the British Government’s 2015 spending review, to support the role of UK research in helping to address the problems faced by developing countries. Working with developing country partners, it would deploy the UK’s world-class research capability in addressing challenges faced by the developing world, leveraging and mobilising existing networks and establish new networks of global excellence and new multidisciplinary research responses to global challenges.

One of the aims of the GCRF is to grow the research base in the UK and strengthen capacity overseas to address research challenges informed by the expressed needs of developing countries. Identifying research challenges and associated scientific and partnering opportunities between UK research organisations and researchers and other partners in developing countries is essential, and this workshop was designed with that in mind. Its outputs will help to inform potential future GCRF funding opportunities.
BBSRC AND SUSTAINABLE INTENSIFICATION

Recognising the need to respond to the global challenge of securing sustainable supplies of food for a population that is both growing and changing its consumption patterns - from the same or a smaller area of cultivated land, and with fewer inputs of water, energy and nutrients - while minimising adverse environmental impacts, BBSRC identified ‘Bioscience for sustainable and productive agriculture’¹ as one of three ‘grand challenges’ in its Strategic Plan 2010-2015.

Increasing agricultural productivity whilst improving resource use efficiency and delivering improved environmental, social and economic outcomes is sometimes described as ‘sustainable intensification’ (SI). In 2014, BBSRC published the findings of a working group² which advised on how its research could contribute to the sustainable intensification of agriculture, balancing output with other ecosystem services and maintenance of the natural capital on which it and they depend. One of the group’s recommendations was that BBSRC should provide funding for a network to bring together the relevant biological and environmental (and social) science communities. In response, BBSRC (with co-funding from the Natural Environment Research Council) set up SIRN to encourage and facilitate high-quality systems-oriented research relevant to SI, with an emphasis on multidisciplinary, interdisciplinary and trans-disciplinary approaches. SIRN provides a forum for information exchange between researchers, funders and stakeholders, about research capabilities, facilities and resources, training opportunities, funding schemes and user needs that aim to address the challenges posed by SI.

For the purpose of the workshop, SI was considered to be sustainably increasing the production of food, combined with improved resource use efficiency and better environmental (and social and economic) outcomes. The achievement of this requires balancing production (and optimising potential trade-offs) with maintenance of the natural capital on which it and other ecosystem services depend - as distinct from increasing yield per se or just “growing more with less”.

OUTPUTS OF THE WORKSHOP

The workshop was preceded by a one-day field trip to a variety of research sites around Nairobi to help set the context of existing capability and agricultural research needs (details are at Annex 3). After a series of introductory presentations, the first day of the workshop itself focused on defining opportunities. Participants identified (individually) and then developed (in breakout groups) research challenge areas, which were further refined during the afternoon and the following morning. The second day focused on exploiting the opportunities, building on the previous day’s challenge areas to discuss research translation and impact. Participants identified end-users for the priority challenge areas, and then considered potential enablers of, and barriers to, research uptake. During the final session, participants worked in small groups to draft sections of a potential academic paper based on the workshop findings. This would be taken forward by scientific participants, independently of this report, for possible publication in an appropriate journal. The outputs of the two days are detailed below.

¹ http://www.bbsrc.ac.uk/news/planning/strategy/priority-one/
² http://www.bbsrc.ac.uk/documents/1409-sustainableagriculture-workinggroupreport-pdf/
DEFINING THE SCIENTIFIC OPPORTUNITIES - IDENTIFICATION AND DEVELOPMENT OF RESEARCH CHALLENGE AREAS

During an initial brainstorming session, individual participants identified their top challenges for sustainable agriculture in sub-Saharan Africa. These challenges were grouped under four broad themes as follows, while a fifth category was developed for challenges which cut across all of the areas.

1. Management of agriculture’s impacts and dependencies on natural capital and other ecosystem services
2. Exploitation of the genetic diversity and metabolic potential of crops or farmed animals
3. Optimisation of resource use, such as nutrients and water.
4. Countering of abiotic and biotic stresses

In small groups, participants clustered and prioritised the challenges for each thematic area, before selecting the most significant and pressing challenges to discuss and develop further. The notes from the breakout sessions are provided in Annex 4. The following section presents details of the eight priority challenge areas which were further developed.

1. Integrated landscape management to deliver ecosystem services

   **Background and context**

   Integrated landscape management is needed in sub-Saharan Africa to enhance ecosystem benefits to, and from, agriculture. This increasingly depends on understanding (and accounting for) the impact of land management decisions on ecosystem goods and services. A better understanding is required of the multiple (and often competing) interactions between different elements of agricultural systems, and their implications at various scales (plot-farm-landscape-society). At the farm-scale, developing integrated farming systems that combine practices to manage soil, water, plants and livestock could help to produce crops and livestock sustainably. A key priority is to understand the cumulative impact of these practices when applied across landscapes and how to target them to increase productivity, livelihoods and nutritional diversity to supply clean water, reduce environmental degradation and protect biodiversity.

   Local conditions vary significantly across sub-Saharan Africa (different soil types, habitats and agro-ecologies etc.), but (transdisciplinary) research is particularly required in areas where managed systems are degrading sensitive habits, and where multiple stakeholders have competing interests. This research could have an impact on all types of farming systems, but the potential for positive outcomes/integration may be greater for smallholder/diversified systems, and in areas with high human and livestock populations. There are particular needs to consider fragile ecosystems such as forest margins (e.g. the Congo Basin and Montane Forest, where deforestation rates are low, but increasing) and managed wetlands. Smallholder farming landscapes are also managed for other things e.g. fuel and building material. In many areas there is also reliance on wild food and medicinal plants. Any intensification strategies therefore need to take into account impacts on natural and semi natural habitats.

   Challenges associated with research in this area include: working at multiple scales, and with multiple stakeholders with differing needs (there are big differences between
commercial farmers and subsistence farmers in terms of access to knowledge, inputs, finance, technology etc.; limited capacity in trade-off analysis across components or land use types, and a lack of evidence-based instruments and institutional capacity to manage any potential trade-offs. There is also a lack of quantified evidence that supports the role of landscape management to deliver (other) ecosystem services in landscapes that are managed primarily to produce food, though this is an active area of current research.

There are some examples of this type of research in sub-Saharan Africa, including some theoretical/process knowledge. In addition, untapped knowledge may exist in smallholder communities in areas such as pollination service delivery and knowledge of key pests and their biocontrol agents. Organisations such as the World Agroforestry Centre (ICRAF) and other CGIAR centres have a good knowledge of smallholder tree/ crop integrated cropping systems and their interactions with ecosystem management.

**Short and long-term goals**

The short-term goal should be to better understand and articulate potential trade-offs between different elements of the agri-ecosystem. The medium term goals should be to develop decision frameworks (including basic knowledge), and tools for assessing aggregated impacts in integrated systems and across land use types, and to identify appropriate entry points and incentives for people to use them. The long-term goals should be to quantify impacts, to analyse the evidence base for aggregated impacts in multi-dimensional systems, and to inform strategy and decision-making for all stakeholders.

**Research needs and scientific opportunities**

Research is needed to better understand how to develop and protect the ecosystem services needed for sustainable agro-ecological systems. This includes developing an inventory of ‘gap’ areas and metrics for sustainability (what to measure, where and when), improving knowledge of trade-offs between ecosystem services and how these affect decision-making strategies, developing strategies to preserve the biodiversity, water and carbon within farms and associated non-cultivated areas, and developing stakeholder platforms prioritising interventions at landscape scale and mechanisms to incentivise their uptake. The evidence base could be built by developing existing networks and knowledge platforms, and then gaining process understanding through modelling, parameter generation and validation.

There are opportunities for interdisciplinary research (biology, ecology, agronomy, soil science, socio-economics) to develop experimental and observation platforms across land-use and landscape gradients (e.g. the UK’s Sustainable Intensification Platform³), for partnerships with farmer networks, and to progress understanding from mechanism to implementation/decision-making. For multi-stakeholder partnerships and innovation processes to be successful, different public and private sectors need to work together to identify, prioritise and overcome their interrelated constraints. However, operating such processes requires time, energy and financial resource investments. There is significant potential to build on the integrated systems work of some of the CGIAR systems research initiatives⁴. For example, during Phase I of the CGIAR Research Programs (CRPs), several partnership processes and multi-stakeholder process tools were developed under

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Humidtropics and other systems research CRPs. These could be available to support research in this domain.

2. Improving soil health, nutrient management and nutrient use-efficiency

Background and context

Poor soil health is an issue across sub-Saharan Africa, and most soils are highly depleted in nutrients and organic matter. Traditionally, smallholder farmers cleared new land to grow their crops, leaving abandoned fields fallow, and therefore restoring soil fertility. However, high population pressure has led to continuous cropping, causing soil degradation, productivity declines and reduced crop and livestock quality - with detrimental impacts on food security, incomes, and the health of crops, animals and people, including deficiencies of micronutrients not required by crops, but needed by people.

Inorganic fertiliser use is generally very low on most smallholder farms in sub-Saharan Africa due to high costs and often unreliable supplies (because of poor distribution systems). Accessing organic fertiliser is also challenging because manure is commonly in short supply (even in areas with relatively high livestock densities such as the Sahel), and there is often competition for it from alternative uses such as fuel and building materials. Most African agricultural soils therefore lack organic matter and nutrient inputs for a wide range of potential benefits, such as feed, soil cover, soil carbon replenishment, regulating water and nutrient dynamics. Extreme low organic matter levels in a number of soils has created a phenomenon of “non-responsive” soils, which do not respond positively to nitrogen and other fertilisation, due to the chronic low organic matter levels. There are also suggestions that selective breeding for yield has reduced plant capacity for creating beneficial microbial associations in the rhizosphere, leading to further degradation of the soil in cropped areas.

The challenges associated with poor soil health in sub-Saharan Africa are geographically widespread and pervasive, but context-specific. They depend on factors such as the type of farming system, the farmer’s ability to invest, regional variability in climate, soil type and profiles, and availability of inputs. The challenges are particularly felt in areas with high human and livestock populations.

To restore soil functionality in sub-Saharan Africa, the amount of available nutrients needs to increase substantially. Fertiliser use must increase appropriately - with the right fertiliser for the right crop, applied correctly, and in combination with other good agronomic practices. Simple soil conservation measures (such as covering fields with mulch and cover crops, reduced tillage, crop selection and rotation, intercropping, etc.) can also help to increase available nutrients. A number of these approaches have been developed throughout SSA, but there has been little widespread adoption (with exceptions in East Kenya and Rwanda). Addressing the challenges will require looking beyond aggregated national/regional data to consider local spatial variation and heterogeneity - which is complex and multi-scale depending on soil type, farming system and the degree of land degradation etc.

A range of relevant expertise is available in sub-Saharan Africa amongst soil scientists, land surveyors/planners, agronomists, livestock scientists and farmers. Engaging the latter in participatory or ‘citizen science’ style projects could be of great value in harnessing practical and local knowledge.
Short and long-term goals

The short-term goals should be to monitor measure and map soil quality through assessment of below-ground soil carbon stocks, to increase available nutrients, to engage farmers to improve knowledge and awareness of the value of soil capital and ways of maintaining it.

The long-term goals should be to re-build soil fertility and minimise negative environmental impacts (which will in turn enhance crop and livestock yields and nutritional quality) by improving nutrient retention and reducing losses.

Research needs

A priority need is to understand local, regional and national soil properties and to produce accurate soil maps (which would ideally be free to use) to improve crop nutrient use efficiency and to increase biomass for multiple purposes (e.g. food, feed, wood). This can be partly achieved by joining-up different types of existing data (e.g. soil mapping) from national and international agencies, and aligning with a range of donors and NGOs to identify knowledge gaps and synergies, but it is also likely to require the collection of new data.

The development of simple, cost effective, soil testing kits (portable, user-friendly devices) and methods could help smallholder farmers to take local soil measurements (potentially via farmer organisations or extension workers), which could feed into these soil maps. Data dissemination could take place in a similar manner so that farmers have access to the new science.

Appropriate fertiliser recommendations must be developed for vulnerable zones at the appropriate scale and formulation for users. Cost is a critical issue, as is access (to tools, soil nutrient data, fertiliser, advice etc.). The required inputs must be effective and affordable, and provided via extension networks with advice on their most appropriate use. The issue of non-responsive soils also needs to be addressed as part of fertiliser use strategies.

Research to better understand the role of rhizosphere dynamics in soil health and functionality is also needed, including the effects on resource use efficiency and productivity enhancement. Restoring such functions and establishing symbiotic relationships using beneficial soil microbial populations could help to improve plant growth and health. However, this would require long-term commitment.

Landscape-level solutions to improving soil health are important, but tailored measures are also required for different agro-ecologies. This would involve understanding which nutrients are being depleted, and facilitating the supply of those nutrients within farming communities, while maximizing the use of locally available nutrient sources (such as legume N fixation).

Scientific opportunities

There are opportunities to improve soil quality and reduce environmental degradation through different management approaches. For example:

- exploiting reduced, or no-tillage soil conservation options to protect beneficial soil microbes (noting that no-till should be accompanied by soil cover through mulch in order to avoid substantial yield decline)
• planting mixes of crops (e.g. multi-purpose legumes) and trees to build fertility (bearing in mind the adoption constraints associated with integrating trees solely for soil fertility improvement)
• using appropriate (to the target communities) precision technologies and approaches to intelligently target inputs at the optimal level, exactly where they are required.

Scientific opportunities include:

• understanding the role of the soil microbiome/soil fauna in nutrient cycling in the rhizosphere (and potential for remediation of depleted soils?)
• better understanding of rhizosphere regulating processes (for example, in defining crop response to drought) and of the microbial diversity of soil/ rhizosphere
• improved understanding of nutrient-water interactions
• crop breeding for varieties with improved nutrient use efficiency and nutritional quality
• improving soil structure for nutrient retention
• ergonomics (and biosafety) of nutrient (manure) movement between and within farms
• developing effective (legume) intercropping and rotations, and mixed cropping systems
• Integrated Soil Fertility Management (ISFM) to ensure that the supply of nutrients (the ‘4Rs’\(^5\)) is aligned to the demand for those nutrients (good germplasm, good agronomic practices, use of other amendments such as lime)
• decision-support tools to improve nutrient management, suitable for different types of farm(er)s
• efficient diagnostic tools for testing soil and crop nutrient status (for target soils and crops) at multiple scales - from low-cost soil sampling and testing to satellite remote sensing
• technologies for small-scale precision farming (e.g. spatial and temporal nutrient application/release)
• capacity-building/training farmers in soil testing and monitoring

Potential research questions include:

• which crops and/ or companion plants can be used to re-build fertility, and for which soils?
• which are the most cost-effective (N-fixing) species for re-building soil fertility?
• what are the optimal combinations of organic and inorganic fertilisers for different crops at plot, farm and landscape levels?
• how do we manage non-responsive soils economically and agronomically?
• which other amendments, besides nutrients, are needed to ensure that nutrients are taken up?
• how can we exploit microbial communities to deliver improved fertility and food production?
• how can we better exploit agricultural and horticultural waste opportunities to improve soil fertility?
• how can we establish and address farming typologies? (e.g. targeting options at particular households/communities to improve their livelihoods)

\(^5\) The right type for the right purpose in the right place at the right time
3. Improving water management and water-use efficiency at multiple scales

**Background and context**

Improving agricultural water-use efficiency (WUE) in sub-Saharan Africa is important because agriculture is almost completely reliant on rain-fed cropping systems, in environments with highly variable and unpredictable rainfall patterns. The challenge is exacerbated by climate change and uncertainty, not just in terms of water shortage, but also at times of too much water (e.g. due to sudden and extreme rainfall variations). Inefficient water use depletes aquifers, reduces river flows, degrades wildlife habitats, and can cause salinisation. Competing demands for water also increase the risk of localised conflicts. Poor water management can be a driver of biodiversity decline, which can lead to a reduction in the ecosystem services on which agricultural production depends.

The challenge is widespread across sub-Saharan Africa, in many and varied situations: arid and (increasingly) non-arid areas; rain-fed and irrigated systems; smallholders and larger commercial farms (and excessive water use by the latter might have impacts on the former); crops and livestock. It is also critical to consider issues associated with (“grey”) water use for food production in urban and peri-urban areas (availability, quality, etc.).

**Short and long-term goals**

The short-term goal should be better use of available water (e.g. harvesting, filtering, channelling). The longer-term goal should be the protection of water resources, including aquifers. Research is needed to inform effective policy development.

**Research needs and scientific opportunities**

The challenge is partly about technology, but also about how to make technology deliver. Research must consider: livestock as well as crops; the role of soil organic matter and soil structure in water retention (and the role of conservation agriculture); the effects of too much/too little water on incidence and spread of pests and diseases; impact on agriculture of water quality (not currently a major issue) as well as quantity; water-nutrient interactions.

Scientific opportunities include: crop breeding for drought-, flood- (and salinity-) tolerant varieties; screening existing crop varieties for drought resistance (to identify germplasm to deploy in the short term and to identify material to feed into breeding programmes to develop higher yielding, resilient varieties), understanding the role of rhizosphere organisms in defining crop response to drought; novel (e.g. stable isotope) ways of measuring WUE to understand flow through plants; developing starch gels for seed establishment (potentially also with controlled nutrient release); partial root-zone drying; alternate wetting and drying; drip irrigation and potential new nano-pore-based water filters.

Potential management techniques to explore include: physical management of water flows on farms (e.g. terracing); catchment modelling; land-use planning and land restoration (e.g. inclusion of semi-natural features to aid water conservation); catchment-sensitive and conservation farming (e.g. improvement of soil structure for better water harvesting/retention); diversification of systems for improved WUE (e.g. alternative, more drought-tolerant crops); (sustainable) exploitation of aquifers.
4. Managing pests and diseases in the context of climate change

Background and context

Pests and diseases affect all farming systems (crop and livestock; commodity and subsistence) in sub-Saharan Africa, and can lead to reductions in yield and produce quality, economic losses and trade restrictions (affecting local and global markets). Most of the current research focus is on specific diseases or pests of major staple crops such as maize and wheat, or export commodities such as tea and coffee. Less emphasis has been given to other regionally important crops such as pigeon peas, millet, plantain and sorghum. These are largely cultivated in the same regions as the staple/commodity crops and are a major part of local communities’ diets. Understanding the problems that affect these crops can also support food security efforts.

A large proportion of farmers in sub-Saharan Africa are smallholders with little or no access to synthetic pesticides. They are disproportionately affected by pests and diseases because they rely almost entirely on ecological approaches such as biological control and agronomic measures (e.g. using indigenous pesticidal plant materials, screening for disease-resistant varieties, intercropping techniques, and building intraspecific diversity into cropping systems) that might not fully control outbreaks. Smallholders, however, play a vital role in achieving food security, and generating poverty-reducing agricultural growth. In contrast, the high use of agrochemicals by some larger-scale commercial farms, can lead to other problems such as environmental degradation, detrimental effects on the health of farm workers and consumers (e.g. if chemical exposure and residues in the food chain are not assessed and properly controlled). In addition, overuse can affect insects which are used for biocontrol, and can lead to more severe pest outbreaks, with the pests developing resistance to the chemicals used, thereby reducing their efficacy.

Climate change, increased use of monocultures and uncontrolled transboundary movements of animals, plants and seeds are also increasing the risk of alien invasive weeds, pests and diseases which threaten staple agricultural crops and livestock in Africa.

Factors which limit the development of more effective control measures include: lack of effective surveillance systems, lack of appropriate capacity (human and infrastructure) and technological capabilities, misidentification of, and misinformation about, pests and diseases (with associated geo-political implications). For livestock, in particular, there are additional problems with early diagnosis and the way information is captured and disseminated. Broader challenges include trans-boundary issues such as a lack of legal frameworks and compliance rules for transport and exchange of biological material and for animal movements.

There is a significant body of evidence-based information available within the National Agricultural Research Systems, the African university sector and CGIAR Centres, and there are opportunities to make progress in several areas, including bioinformatics and data analysis, technology transfer, extension services and participatory approaches to share local knowledge.

Short and long-term goals

The short-term goals should be to improve the identification and monitoring of pests and diseases, to understand how they spread and how they can be controlled at farm and
landscape scales and across borders. Efforts should focus on capacity building, increasing training and communication, the development of supporting technological tools (e.g. easy to use, portable and affordable diagnostic kits and electronic apps) and optimising management options with local communities.

There is potential to make better use of existing data collections to improve identification and monitoring - for example, data on insects at CABI and ICIPE, animals from national repositories and the World Organisation for Animal Health, and seed and germplasm banks at CGIAR centres and national museums etc.

The long-term goals should be to support research to develop more sustainable approaches to pest management, including, for example, biocontrol and companion cropping; to coordinate effective control measures and to develop effective and lasting, up-scaled, integrated pest and disease management across sub-Saharan Africa. This should include establishing and consolidating information networks and partnerships to provide early warnings of emerging problems. To support scientific advancement, solutions should be underpinned by a legal framework (which takes into account issues of compliance and land rights) for the exchange of biological materials, and reinforcement of rules at borders.

Research needs and scientific opportunities

There are opportunities for impactful research in a range of areas (at the farm, regional and national scale), including surveillance, data collection and curation, modelling, biological control, breeding and new technologies and approaches to crop management. It is also important to consider ‘technology maturity’ approaches; customising and optimising existing technology for African farming systems.

Some of the opportunities identified are listed below:

- greater understanding of conservation biological control, and the modification of habitats to boost populations of pests’ natural enemies
- exploring the use of orphan/marginal crops to support other systems (e.g. intercropping approaches like ‘push-pull’ to attract beneficial insects, and to repel pests)
- better understanding of the impact of landscape fragmentation on pests and diseases of crops and livestock
- better understanding the links between emerging outbreaks and environmental change
- developing epidemiological (and economic) models for mapping and forecasting pest and disease outbreaks to enable more rapid responses
- developing more reliable sample collection and preservation methods, particularly for livestock diseases
- improving surveillance by developing new and effective systems for data collection and curation (e.g. open access software) so threats (diseases and pest prevalence and severity) can be mapped and interventions can be targeted to hotspot areas
- making better use of current data (diversity, distribution and evolution)
- developing better molecular breeding and pathogen characterisation techniques
- using bar coding and other molecular techniques to identify pests
- preventive approaches e.g. new animal vaccines
developing portable and affordable diagnostic kits for early detection by farmers in the field
• developing mobile phone apps to monitor emerging threats (and for long-term monitoring)
• developing stress sensors (portable thermos cameras and multi-spectrum techniques, image recognition etc.), which could also be incorporated into mobile phones
• ‘leapfrog technology’ – e.g. second generation drones delivering services other than capturing images (e.g. spraying pesticides and planting seeds)
• improving legal/ regulatory frameworks - better border control with plant and animal passports and considering movement of livestock and wildlife in the decision making process

There are significant opportunities for transdisciplinary approaches, involving new technologies and innovative methods, mapping appropriate integrated pest management strategies to geographical data and molecular approaches. There are also opportunities for scientific exchange and partnership development between the UK and sub-Saharan Africa (particularly in the areas of GIS, remote sensing, earth imaging and molecular biology).

5. Plant breeding for multiple traits, focussed on the needs of end users

Background and context

Plant breeding for multiple traits across sub-Saharan Africa is complex, challenging, and under-resourced, but very much needed. Yields of African food crops are some of the lowest in the world, and increasing productivity through breeding is an important step towards improving food security. There is an extensive genetic resource to be explored (including centres of origin in the region for some crops), in the context of high temporal and spatial variability in agro-ecologies and climatic conditions. Plant breeding is needed across multiple farming systems and crop types (cash crops, food crops, forages, amenity crops) and would benefit many people, including key value chain actors from field to consumption, smallholders and agro-pastoral farmers.

There is currently a lack of investment in science to drive the breeding agenda and capacity-building. Long-term breeding policies and strategies need to be developed to guide the research, and they must be supported by funding. The shared needs of farmers, scientists and other end users need to be elucidated to develop successful programmes of research. There is also a need for specialisation (on particular crops or traits) to facilitate market access.

There is existing expertise in Africa (for example, the Integrated Genotyping Support and Service platform at BecA-ILRI), and there are established national and international breeding programmes that could be drawn on. National programmes and networks have the expertise to reach farmers, and the CGIAR centres work through them. National programmes, however, often have very basic resources and limited access to funding, especially for the adoption of new technologies/innovations.

Short and long-term goals

The long-term goal should be to develop a coordinated plant breeding agenda. The short-term goal should be early stage proof-of-concept projects focused on genomic selection,
genetic markers and characterising genetically important species. The impact of research in this area would be improved yields, improved nutritional status, increased incomes and reduced ‘hidden hunger’.

Research needs
There is a need for investment in capacity-building, in terms of expertise, facilities and in the national programmes’ infrastructures. Expertise is required in bioinformatics and quantitative genetics, training and capacity. An important first step would be to build an inventory of existing capabilities to identify resource gaps across sub-Saharan Africa (where, and who is breeding, specific clusters for crops, bioinformatics clusters etc.). Investment is also needed in the conservation of genetic diversity (resources of wild relatives) in the face of climate change (e.g. seed banks), and in seed production, certification, distribution and delivery systems to deliver impact to farmers and to realise the return on investment in breeding. Seed availability has been a major constraint on the adoption of improved varieties by farmers.

Other research needs include toolkits and pipelines for data analysis, access to high performance computing (HPC), knowledge, and compliance with intellectual property rights and plant variety rights (policy and ownership, governance).

Scientific opportunities
Key research opportunities include:

- developing new varieties to address user needs
- developing ‘smart’ crops that sense stress and re-programme metabolism accordingly.
- community-based and/ or participatory breeding
- harnessing farmer knowledge to develop bottom-up seed systems which include using landraces or local varieties
- crowd-sourcing trait information and farmer preferences
- sharing of crop improvement models that have been found effective in crops with similar genetics/genomics

When developing and testing new varieties, it will be crucial to take farmer preferences and local needs into account, as well as the physical and biological environments and agronomic, disease and quality traits (more targeted local selection). Improved varieties must also be accessible to farmers. Participatory approaches are a way to develop cultivars which are relevant to user needs, and more likely to be adopted.

Possible approaches for developing new and/ or improved varieties include the development and use of new breeding technologies (TILLING, CRISPR-Cas9), molecular breeding, marker-assisted breeding, mutation breeding, genomic assisted breeding, double haploid and speed breeding, bioinformatics and phenomics (targeted, high precision phenotyping). Policy-research is needed in the area of genetic modification for food crops to develop appropriate regulatory frameworks.
6. Livestock breeding for multiple traits, focussed on the needs of end users

Background and context

Livestock breeding for multiple traits is needed in sub-Saharan Africa to increase productivity to meet the growing needs of the population and overseas markets. A large proportion of the population depend on livestock for their livelihoods, and global demand for livestock products is increasing. Productivity is, however, currently low in sub-Saharan Africa because of many factors, including pests and diseases, climate change impacts, feed shortages, water shortages, a lack of organisation around livestock development, poor transportation links and a poor value chain. In addition, there are core nutrition issues amongst the human population and associated food safety issues, related to a lack of local level inspections, and unregulated use of antibiotics and drugs.

Livestock breeding research is needed for multiple agricultural systems (from coastal through to arid agro-ecological zones) and for multiple species (poultry, swine, cattle, small ruminants, aquaculture, apiculture). Different countries in sub-Saharan Africa are at different stages in relation to breeding: Kenya is advanced in policy, networks and systems.

Livestock breeding has the potential to improve the productivity of animals in a number of ways, including increased growth and reproduction, improved nutrition and feed efficiency, improved quality and safety of food, improved health and welfare of animals and improved resource use efficiency. Challenges for livestock breeding in sub-Saharan Africa include: poor potential of the genotypes, drought/extreme weather, poor market channels, shortage of resources - land, water (particularly in pastoral areas, feed), and low productivity of local breeds.

There are established breeding programs at the national and international level, with national breeders at NARS, universities and partners (e.g. ILRI). To tackle this area effectively, Africa needs human resources, improved infrastructure and breeding platforms. Expertise is also needed in training and procurement (embedded in NARS + universities), the private sector (multiplication of improved genotypes) and extension workers.

Short and long-term goals

The short-term goals of research in this area should be to identify and inventorise existing resources to map current research and capacity gaps. The long-term goals should be to develop a coordinated breeding agenda which will help to improve productivity and food security and to reduce environmental impact.

Research needs and scientific opportunities

There is a real need to develop policy and strategic frameworks for livestock breeding in sub-Saharan Africa, including national livestock breeding databases, systems of livestock identification and traceability to support breeding programmes and disease management. Genetic diversity is key to breeding for adaptability in a range of environments and agricultural systems, and selection indices must take into account farmer preferences and local needs as well as agronomic, disease and quality traits (more targeted local selection).

Scientific opportunities include:

- gene discovery and evaluation of gene expression potential as a basis for sustainable improvement in local breeds
• genetic improvement of livestock (high productivity, “climate-smart” and adapted to the local environment)
• genetic characterisation and marker development for local breeds
• better understanding genotype-environment interactions
• development of new and improved feeds, optimised forage systems, improved livestock management systems
• optimising the metabolic potential of exotic and local meat-type poultry strains
• using locally available nutrient (feed) resources
• genomics and livestock disease management
• improved understanding of secondary metabolism products
• understanding animal behaviour
• ‘precision livestock farming’

Appropriate methods include: reproductive technologies (embryo transfer, AI), molecular breeding, genomic technologies (cloning) and GIS/remote sensing for traceability and epidemiological surveillance. There is also potential to use ethno-pharmacopeia for animal health protection and disease control.

Research that could make a big difference in sub-Saharan Africa includes: understanding antibiotic resistance, developing diagnostics (molecular etc.), developing markers and improved genotypes. There is also potential to integrate crop and animal research genetics and breeding, taking a more systems-approach.

7. Exploitation of indigenous and ’orphan’ crops and farmed animals

Background and context

The exploitation of indigenous and ’orphan’ crops or livestock is important for sub-Saharan Africa because diverse farming systems are more resilient (to biotic and abiotic stresses and climate change) and more successful at enhancing food and nutritional security. Indigenous varieties tend to be better-adapted to local environmental conditions, and to the needs of farmers in marginal agricultural situations. They may also have lower input requirements, which confers them an economic advantage, and they provide important sources of vitamins, proteins and micronutrients. Historically, such crops have helped to ensure food and nutrition security as part of a balanced diet, when the main crop failed, or in between harvests.

Modern agricultural systems, however, promote the breeding and cultivation of high-input, high-yielding crops (for example, major commodity crops such as maize and wheat, and a small range of pulses), while research into indigenous crops and landraces in sub-Saharan Africa has been neglected, with a decline in agricultural and nutritional diversity. Improved varieties of orphan crops have not generally been available to farming communities, and there is currently a lack of conservation programmes for potentially important genetic resources.

There is a significant need to recognise the value of (and conserve) indigenous crops and farmed animals in sub-Saharan Africa, and to focus on improving the potential for crossing higher-yielding varieties or breeds with more resilient local landraces. Orphan crops include

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6 Defined here as ‘(largely indigenous) crops and livestock that tend to be under-researched and underfunded due to their limited importance in the global market’. They are characterised by their resilience and adaptation to environmental stress, and have local significance where they are produced and used.
sorghum, millets, taro, amaranth, shea nut, ground nut, cowpea, chickpea and pigeon pea. Neglected animals include ducks, geese, quail and guinea fowl.

Related to this is the need to exploit alternative indigenous sources of protein for food and feed. Existing sources are declining (in absolute terms, and/or being used as feed rather than food), or experiencing reductions in quality and yield due to climate change and overgrazing. There is increasing competition over land for producing food and feed, causing conflict between crop growers and livestock keepers.

There is some existing knowledge at research and development institutes (e.g. ICIPE, KARLO, SVA, TALIRI) - for example, the nutritional profiles of particular forage species (e.g. Brachiaria), and insect species with a high protein content are known (e.g. black soldier flies). There is also a significant amount of local knowledge within indigenous farming communities - which is a real opportunity.

**Short and long-term goals**

The short-term goal should be to characterise orphan African crops, to better understand their economic and social value (e.g. as food and feed sources, starch type + use in local industry), to map their existence and to identify their potential as alternative food/feed sources with equivalent, or higher, vitamin, protein and/or micronutrient contents. The long-term goal should be to protect, conserve and benefit from the genetic diversity of indigenous crops and livestock by developing relevant genomic resources and using them in breeding programmes. There is also a need to market potential alternative food and feed sources (e.g. insects, earth worms, legume crops, crop residues), and to advocate for policy change on the issue to promote their use.

**Research needs**

To fully exploit the potential of indigenous and orphan crops and livestock in sub-Saharan Africa, we need a better understanding of the available resources (location, genetic make-up, water-use, drought tolerance, disease resistance etc.), and where alternative sources are most needed. We also need to know more about what drives farmers to grow indigenous or orphan crops and to invest in alternative food and feed production (there has been very limited success with uptake of fodder banks etc.). Capacity building is needed in terms of expertise (feed and forage breeders, crop geneticists, insect geneticists), training (in genomics and marker-assisted breeding), and physical infrastructure (particularly advanced outdoor facilities and well-found laboratories).

**Scientific opportunities**

Research opportunities in this area include:

- characterising the genetic diversity of indigenous and orphan crops and farmed animals
- selecting important varieties and breeds for promotion and preservation/restoration
- developing land suitability maps for indigenous and orphan crops and livestock
- undertaking ethnobotanical studies of orphan crops to increase genetic diversity and identify genes for e.g. resistance to pathogens, or production of metabolites that enhance food security and/or nutritional value
• mapping existing food and feed sources and identifying the nutritional role they have in different parts of sub-Saharan Africa
• developing alternative and/or improving existing feed (and food) sources such as grasses and legume fodders (e.g. breeding for quality, efficiency and sustainability and digestibility, to increase nutritional value and decrease anti-nutritional factors)
• developing and testing alternative products and technologies to enhance handling of feed e.g. pelleting.

Research should be undertaken in collaboration with advanced centres in and outside Africa, and should exploit opportunities for north-south research and training partnerships to build capacity.

8. Using mobile phones on farm for agricultural development

Background and context
The use of mobile phones on farm has significant and widespread potential to contribute to agricultural development in sub-Saharan Africa, by enabling more effective knowledge transfer to and from farmers. This would involve using new mobile phone technologies with additional diagnostics, the internet and open access data to improve farming practices, enhance efficiency of resource use, and develop more productive, profitable farming systems.

New technologies, however, must be accessible, affordable, mature, easy to use, appropriate for, and understandable by, intended users, and based on knowledge of users’ situations and needs. Users must also have the capacity and the incentives to use the technologies. As we already have a mature mobile phone market, any new device should utilise the mass produced phones to keep costs down. The focus should be mainly on smallholder farmers. Appropriate power sources would be required (but network connectivity is generally good). There is potential to build on existing activities (e.g. One Acre Fund) and publicly available datasets and models. There is also potential to use phones for crowd-sourcing data collection and disseminating information.

Gender issues should be a consideration when developing or introducing any new technologies, because it is often the man who owns the ‘smart phone’, thereby excluding women/young people from the innovations.

Research needs and scientific opportunities
There is a need to identify the key information which would feed into the design of a new device (e.g. What data are needed? What management advice can we give? What local resources are available?). There is also a need to explore how the device would work (e.g. a case around existing phones to allow cost reduction or a separate device which would use Bluetooth), how it would be powered (to avoid the needs for mains charging), how it could work both online and offline, how it could support/be supported by the open source community.

Potential areas for research and dissemination include mapping - of soils, crop suitability, pests and diseases, land typologies, weather (but meteorological data for Africa is difficult and expensive to access), risks and opportunities (including understanding associated uncertainty) and testing of predictive models.
Research opportunities include:

- instrumentation of mobile phones with the addition of solid-state non-contact (e.g. XRF, infra-red) sensors
- embedded open-source knowledge for interpretation of diagnostics
- development, testing and translation of appropriate novel sensors
- development of alternative energy sources (solar charging, vehicle power or energy harvesting)
- exploring the potential contribution of satellite remote sensing.
The priority challenges identified on the first day of the workshop were grouped into four broad thematic areas (below) to facilitate discussion around research translation and impact.

1. Water, soil and nutrient management
2. Crop and livestock breeding
3. Pests, diseases and abiotic stresses
4. Integrated agricultural systems

For each thematic area, the following questions were considered:

- Who are the end-user communities?
- What would be the barriers to translation of the research outputs?
- What might be done to help overcome those barriers and enable research uptake?

A summary of the combined outputs of the discussions is provided below. More detailed notes from the individual breakout sessions are provided in Annex 5.

**Who are the end users of SI research in sub-Saharan Africa?**

There are a wide range of potential end-users of this research, but it may be useful to distinguish between *beneficiaries* (who are often unable to apply research findings directly) and *end-users* of research evidence. Beneficiaries of the research include:

- All types of farmers and local communities
- Consumers
- Multi-stakeholder forums
- Broader decision-making forums
- Agronomists
- The academic community

End users of the research include:

- Policy-makers
- Government agencies
- Regulators
- Extension workers and farmer organisations
- Development agencies/anyone developing programmes at a large scale
- NGOs and civil society
- Commercial providers (at all scales) of products or services (including advice) to farmers e.g. plant breeders, companies producing seeds, pesticides, feed, food, agricultural equipment etc.
- The academic community

The end-users and beneficiaries of any particular research project will be determined by a number of factors, including, for example, whether the demand is farmer-led or market/consumer-led, and whether the end product is for domestic or commercial use. Some research may be of more relevance to a particular gender or age group, because of the nature of farming systems in sub-Saharan Africa. For example, women may be more interested in research related to smaller animals which are traditionally kept nearer the home, while men may have more of an interest in research on cattle and larger animals;
women may be interested in research that facilitates their active role in farming, while men may have more of an interest in the market value of their produce.

For certain types of research, there may also be a distinction between end users of new technologies resulting from research, and end users of data outputs of research (i.e. data sets coming out of e.g. early-warning systems).

Extension services (public or commercial) play a key role in providing advice and services to farmers, and ensuring that the research findings have impact. It is crucial to identify organisations that have strong connections to farmers and are trusted by them.

**What will be the barriers to research uptake?**

Ensuring research uptake in sub-Saharan Africa can be challenging, and there are a significant number of potential barriers. These have been broken down into the broad categories summarised below, some of which will be easier to address than others.

**Capacity**

A lack of capacity (human, infrastructure and financial) can be a barrier to research uptake in sub-Saharan Africa. Long-term funding to support research translation is rarely available, and many groups/organisations lack the resources to facilitate this. The scale of investment costs (new technologies, new breeds, new management techniques etc.) for farmers can also prevent research uptake, as many are unwilling to take such risks.

**Social factors**

A range of social factors can limit the uptake of research. These include: a disconnect between scientists and end users (e.g. outputs are not targeted at farmers’ needs), cultural preferences for traditional varieties, lack of trust in research, perceptions of risk associated with new products (leading to lack of consumer acceptance) and gender issues related to access to, and use of, research outputs. For example, because of the gender segregation of roles, women may be excluded from discussions about what is required from research, (despite their active role in farming), meaning that some approaches may disadvantage women, or may not be tackled at all. In many countries, women have unequal access to certain (e.g. mobile phone) technologies and other resources.

Other social factors which could negatively impact research uptake include socio-cultural and political differences in decision-making frameworks across sub-Saharan Africa, political instability/conflict (animal genetic material is lost in conflict zones) and fragile relationships between farmers and commercially-motivated advisors.

**Poor communication**

Poor or ineffective communication can be a barrier to research uptake, particularly when working with multiple stakeholders (e.g. extension workers, farmer organisations, local and national governments, landscape management fora, local NGOs, development agencies) who may not ‘speak the same language’ (literally and metaphorically), or where the disconnect between scientists and end users is particularly evident. In addition, extension services are less-developed or ineffective in some parts of sub-Saharan Africa.

**Technological limitations**

Technological limitations such as a lack of access (e.g. to mobile phones), poor infrastructure or poor network coverage can hamper the uptake of research. For example,
most technologies used to detect soil-borne diseases and pests are molecular, so technical and often expensive, and there are multiple technical difficulties associated with breeding multiple traits into a single line. Even when the technology is available, factors such as time (e.g. to develop new varieties), cost and/or lack of technical understanding can be prohibitive.

The proliferation of (often unwanted) services delivered by mobile phone providers – and the costs (to farmers) associated with these is also causing resistance to some technologies.

**Data collection, curation, integration**
Various issues related to data management can act as a barrier to research uptake. Integrating disparate information sources across larger scales can be extremely challenging and costly, and it may not be clear who owns the data, who is responsible for paying and curating it, and what can be done with the information.

**Legal and regulatory constraints**
Countries in sub-Saharan Africa have different (local and national) legal and regulatory systems, which can prove challenging for undertaking and ensuring uptake of research in areas such as pesticide use and biological control. Some countries also lack in-country quality control and certification, which can result in export or import barriers. Ensuring organisations have sufficient influence to initiate change based on research findings can differ significantly from country to country, and people may be unwilling to try out new products because of the associated risk to their incomes and food security, and lack of compensation policies in Africa.

**How to overcome the barriers and enable research uptake**
There are a wide range of ways to facilitate research translation and impact in sub-Saharan Africa. First and foremost amongst these is ensuring that research is co-designed and delivered, i.e. involving stakeholders throughout the process, and using participatory approaches. Other important methods include improving communication between researchers and end-users, building collaborative partnerships, aligning with existing Government policies, building capacity, providing additional financial support and improving market access. Further details of these enabling conditions are provided in the following sections.

**Co-design and delivery of research**
Involving stakeholders in research design and delivery is crucial to ensuring impact. Participatory and demand-driven approaches can help to ensure that research outputs respond to the needs of end users (i.e. they are targeted at the right people, the right farming system and in the right way). Involving stakeholders early-on can help also help to generate a common understanding of complex issues and to encourage long-term buy-in. Multi-stakeholder processes such as R4D (Research for Development) Platforms and Innovation Platforms are examples of tools that can be leveraged for such research.

Stakeholders should include beneficiaries and end-users of research, and researchers should take into account their preferences and perceptions. The farming community can be engaged through farmer networks/ cooperatives. Research should be showcased through demonstration sites (e.g. ‘Farms of the Future’ project), ‘farmers’ field open days‘ and farmer-to-farmer exchanges to gain farmers’ trust and demonstrate the potential benefits. Case-study areas where farmers/ farmer groups can develop and test technologies in the
field are also a useful way of increasing farmers’ confidence in the research, showcasing research ‘in action’ and presenting results. It is important to provide demonstrable evidence that interventions work (knowledge alone is unlikely to effect change amongst the farming community).

Policy-makers are important stakeholders because research can provide evidence-based information to help them make management decisions, and they should be made aware of new products/ systems to be tested. Efforts should also be made to target groups (such as extension workers) that will facilitate uptake once the projects have finished.

Face-to face communication should be prioritised when co-designing research, and there should be collective decision-making at multiple scales. Ensuring built-in feedback (from end-users to researchers, e.g. validating models and outputs) throughout the research process is also important.

**Improve communication**

For research to have impact, ‘strategic communication’ is crucial. Two-way communication must be built into the research development process from the beginning. Information about the research process and research findings must be communicated in an appropriate manner (the right people, through the right channels). Skilled, culturally-aware communicators can help to bridge the gap between research and practitioners. Presenting research in an open-access forum can also help to increase confidence in the findings, and to overcome issues of trust and perceptions of risk.

It is important to tailor messages to particular audiences, and to be creative about methods of communication. The popular media can help to raise awareness amongst the general public; as can activities in schools and training programmes. Radio can often reach a wide audience, but sometimes visual information (e.g. via demonstration farms) is vital – for instance, in the identification of diseases. Extension networks are a useful way to communicate with farmers, although some countries have less-developed networks, and some may not provide impartial or independent advice. There is potential to make better use of videos and mobile phones for information dissemination).

Effective communication (e.g. for policy briefings, extension leaflets etc.) requires accessible, clear, practical, relevant messages, which should be tailored to a specific audience in mind (acknowledging potential gender, age and cultural differences in access to and uptake of research).

**Collaboration and partnership building**

In addition to leveraging added value and bringing additional skills to a research project, collaboration can also help with research translation. Multiple partnerships (e.g. public sector, private sector, NGOs) can help to effectively prioritise research, broaden the audience for research findings and facilitate research uptake by engaging with more potential users. Aligning research with development agency programmes (e.g. through ‘research in development’) can bring added benefits.

**Policy/ regulation**

Aligning research with existing Government strategies and policies can help to deliver impactful research, and to ensure that research interventions/ outputs are legally accepted. Developing decision-making frameworks can help to help guide policy-makers to make the
best decisions with the available evidence (which is very often incomplete). There are also a number of ways in which Government(s) can facilitate research, and research uptake. For example:

- Supporting demonstration farms/communities trialling new approaches
- National-level regulation of technologies (like what is done currently for biosecurity) to ensure appropriateness and suitability for each country/region
- Increasing payments for ecosystem services, and ensuring the right people benefit
- De-risking innovation to facilitate technological advances (e.g. providing an insurance system)
- Providing accreditation schemes
- Providing subsidies (e.g. for fertiliser inputs), but this may be unsustainable in the long-run
- Improving market access e.g. provide incentives, assurance, and certification for wider market access

**Capacity and capability-building**

Building capacity (human and infrastructure) can help to increase the uptake of research findings. Training programmes can be developed for end users and beneficiaries of the research to ensure the research outputs and associated technologies are used in the appropriate/most effective way. Programmes can also be developed for intermediaries - for example, extension workers, who facilitate uptake amongst the farming community. Training programmes in schools can help to deliver key messages to wider audiences, and may also encourage more children to become involved in the sector.

Infrastructure investments can also help to build capacity and facilitate research translation. Suggested areas for investment include research facilities, transport hubs, smart phones, phone networks and regional internet hubs. Investment in seed production (new/improved varieties), certification, distribution and delivery systems could help to overcome some of the typical adoption constraints, and to increase uptake.

**Funding/finance**

Long-term funding, specifically for research translation (for example, through collaborations between research and development funders) could make a big difference, as this is rarely available in sub-Saharan Africa. Providing some level of financial support for farmers (for example, subsidies for early adoption costs) could help to minimise the cost of research uptake to farmers, as many are unwilling to take such risks. Funding for short-term, proof of concept research (alongside long-term programmes) could help researchers to develop projects which are more likely to have a real impact.

Cost-benefit analyses for new technologies might increase the adoption rates if users can see the benefits they could accrue over time, and providing free access to particular apps, web pages or technologies in the initial stages may facilitate early adoption. Finally, ensuring that the research outputs are accessible and affordable (e.g. through subsidies or micro-credit) can help them to reach the right people at the right time.

**Data management**

Ensuring common metrics to enable the integration of multiple data sets can help to address some of the data management issues which can act as barriers to research uptake. It is also important to be clear from the start who owns the data, who is responsible for paying for and curating it, and what can be done with the information.
NEXT STEPS

Most of the challenges identified during this workshop have broad relevance across sub-Saharan Africa. However, the decision to address one or more of these challenges will be determined by a range of factors, including local and regional contexts and needs, costs, possible partnerships, potential for impact, national capacity and available resources.

Tackling the challenges will require a range of approaches, and when seeking to address them, it will be crucial to understand not only the biophysical characteristics of the relevant farming systems, but also their socioeconomic and political contexts.

Research will need to address multiple goals, including improving productivity, increasing food and nutritional security, reducing environmental impacts, contributing to economic growth and poverty reduction, and improving the equitability of farming and land management. This will undoubtedly require transdisciplinary, systems studies at multiple scales, with the active involvement of potential research users in its co-design.

This report of the workshop aims to help inform potential future funding opportunities from the UK’s Global Challenges Research Fund for collaborative research between UK and African scientists. BBSRC will be working with the UK Sustainable Intensification Research Network and others to bring its findings to the attention of wider audiences beyond the workshop’s participants.
ANNEX 1: WORKSHOP BOOKLET (INCLUDING ATTENDEES’ BIOGRAPHIES)

BBSRC workshop on the sustainable intensification of agricultural systems in sub-Saharan Africa

13-15 March 2017
Biosciences Eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub Nairobi, Kenya

With support from:

Sustainable Intensification Research Network
John Innes Centre
Bioversity International
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BBSRC WELCOME

On behalf of BBSRC, I would like to welcome you to this workshop. We are extremely grateful to the Biosciences eastern and central Africa-International Livestock Research Institute (BecA-ILRI) Hub for hosting us, and for its help in developing and organising the workshop. We would also like to thank the BBSRC (and NERC)-funded Sustainable Intensification Research Network (SIRN), the John Innes Centre (JIC), and Bioversity International for their support in helping to design and deliver the workshop.

The purpose of the workshop is to inform potential future funding opportunities from the UK’s Global Challenges Research Fund for collaborative research between British and African scientists, relevant to the sustainable intensification of agricultural systems in sub-Saharan Africa.

This workshop will enable you to share your knowledge in identifying and exploring research challenges relevant to sustainable agriculture in Africa. We hope that you will also benefit from the networking and partnership-building opportunities with participants in both this and a complementary workshop on climate-smart agriculture that will be taking place concurrently on the BecA-ILRI campus.

We hope that participants will bring a strategic perspective to the discussions as representatives of their broader constituencies, helping to facilitate links between wider research communities in the UK and Africa. We are very fortunate to have been able to bring together researchers from such a broad range of disciplines, institutions and countries, and hope that you will benefit from the opportunities this provides.

Following the workshop, we will be working with SIRN and others to bring the findings of the workshop to the attention of wider audiences, and would welcome your suggestions for additional ways of disseminating them. We would also welcome feedback to help enhance other events in future.

Thank you for attending. My colleagues and I look forward to meeting and working with you.

Brian Harris
(Joint) Head of Strategy - Agriculture and Food Security
BBSRC
BECA-ILRI HUB WELCOME

It is indeed a pleasure to co-organise this great workshop with BBSRC and partners, and great honour to be hosting such an important workshop. The participants, who represent broader constituencies, have been carefully identified in order to provide opportunity to harness the best and most current thinking that will respond to the purpose of the workshop. The workshop brings together experienced researchers from such a broad range of disciplines, institutions and countries, and we look forward to active engagement from everyone so that the workshop’s objective will be fully realized.

Two of BecA-ILRI Hub’s strategic partners, Kenya Livestock and Agriculture Research Organization (KALRO) and Kenya Plant Health Inspectorate Service (KEPHIS) kindly agreed to host all of us for the workshop field trip. This is highly appreciated. The field trip will be a great opportunity to set the stage for the two-day workshop by seeing and experiencing some of the sustainable intensification research and capacity building activities, challenges and opportunities.

Apart from the field trip, BecA-ILRI Hub welcomes you for a guided tour of the facilities. The scientific community working in our state of the art laboratories employs the latest biosciences tools to tackle issues related to agricultural productivity. The ultra-modern platforms – for genomics, bioinformatics, vaccine development, diagnostics, plant transformation, nutritional analysis and molecular breeding – are key enablers of cutting-edge research in Africa.

The BecA-ILRI Hub develops tripartite collaborative agreements with advanced research institutions and African national research programs. As part of one such agreement, the John Innes Centre has stationed one of their scientists in Kenya. This model of engagement is designed to enable African institutions to leverage basic research at advanced institutions in finding practical solutions to regional agricultural challenges. This addresses the capacity-building needs of the national research programs, as well as delivers on the broader CGIAR mission through the CGIAR Research Program (CRP) agenda.

A warm welcome to all workshop participants.

BecA-ILRI Hub.
WORKSHOP BACKGROUND

This BBSRC-led workshop is funded through the UK’s Global Challenges Research Fund (GCRF). It is being organised with the very active cooperation of BecA-ILRI, and additional assistance from SIRN, JIC and Bioversity International.

The purpose of the workshop is to inform potential future funding opportunities from the GCRF for collaborative research between UK and African scientists, with the objectives of:

- identifying research challenges, and associated scientific and partnering opportunities, relevant to the sustainable intensification of agricultural systems in sub-Saharan Africa
- contributing to relevant partnership-building between research organisations in the UK and countries in sub-Saharan Africa

The workshop will be attended by around 40 researchers and others from a number of African countries and the UK, together with representatives of BBSRC and its partner organisations BecA-ILRI, SIRN, JIC and Bioversity International.

BBSRC and sustainable intensification

Recognising the need to respond to the global challenge of securing sustainable supplies of food for a population that is both growing and changing its consumption patterns - from the same or a smaller area of cultivated land, and with fewer inputs of water, energy and nutrients - while minimising adverse environmental impacts, BBSRC identified “Bioscience for sustainable and productive agriculture” as one of three “grand challenges” in its Strategic Plan 2010-2015.

One of the suggested mechanisms to increase agricultural productivity whilst improving resource use efficiency and delivering improved environmental, social and economic outcomes is ‘sustainable intensification’ (SI). In 2014, BBSRC published the findings of a working group® which advised on how its research could contribute to the sustainable intensification of agriculture, balancing output with other ecosystem services and maintenance of the natural capital on which it and they depend. One of the group’s recommendations was that BBSRC should provide funding for a network to bring together the relevant biological and environmental (and social) science communities. In response, BBSRC (with co-funding from the Natural Environment Research Council) set up SIRN to encourage and facilitate high-quality systems-oriented research relevant to SI, with an emphasis on multidisciplinary, interdisciplinary and trans-disciplinary approaches. SIRN provides a forum for information exchange between researchers, funders and stakeholders, about research capabilities, facilities and resources, training opportunities, funding schemes and user needs that aim to address the challenges posed by SI.

For the purpose of this workshop, SI is considered to be sustainably increasing the production of food (or other agricultural products), combined with improved resource use efficiency and better environmental (and social and economic) outcomes: the achievement of which requires balancing production (and optimising inevitable trade-offs) with maintenance of the natural capital on which it and other ecosystem services depend - as distinct from increasing yield per se or just “growing more with less”.

® Report from BBSRC working group on Sustainable Intensification can be found on: http://www.bbsrc.ac.uk/documents/1409-sustainableagriculture-workinggroupreport-pdf/
SI is inherently complex and cross-disciplinary. Addressing the associated challenges will require a range of approaches. Some will involve action on particular aspects of production, but if widespread rhetoric about SI is to be turned into reality, most will need integrated systems approaches to address questions in broader multidisciplinary, interdisciplinary or trans-disciplinary contexts.
GLOBAL CHALLENGES RESEARCH FUND

The Global Challenges Research Fund (GCRF) is a new 5-year £1.5Bn resource funding stream, announced as part of the British Government’s 2015 spending review, to support the role of UK research in helping to address the problems faced by developing countries. Working with developing country partners, it will deploy the UK’s world-class research capability in addressing challenges faced by the developing world, leveraging and mobilising existing networks and establish new networks of global excellence and new multidisciplinary research responses to global challenges.

One of the aims of the GCRF is to grow the research base in the UK and strengthen capacity overseas to address research challenges informed by the expressed needs of developing countries. Identifying research challenges and associated scientific and partnering opportunities between UK research organisations and researchers and other partners in developing countries is essential, and this workshop has been designed with that in mind. The workshop outputs will help to inform potential future GCRF funding opportunities.
Dr Alison Bentley

**Nationality:** Australian  
**Position Title:** Director of Genetics and Breeding  
**Institution:** National Institute of Agricultural Botany (NIAB), UK  
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**Specialty Area:**  
- Crop breeding  
- Genetics and genomics  
- Agricultural biotechnology  
- Genotype x environment interactions in cropping systems

Dr Alison Bentley is Director of Genetics and Breeding at NIAB, an independent Plant Sciences organisation in Cambridge, UK. She leads a 40-strong team of scientists working across a range of applied crop science project areas with a focus on crop genetic improvement. She is Chair of the UK MonoGram small grain and grasses community. Alison studied Agricultural Science at The University of Sydney, Australia where she also completed a PhD characterizing the genetic structure of pathogen populations associated with wheat production throughout the Australian grain belt. Following her PhD Alison moved to NIAB to take up a position in the wheat pre-breeding team with a specific emphasis on characterizing adaptive and yield-related traits and their genotype-by-environment interactions. Alison leads the exploitation of novel ancestral genetic diversity for wheat improvement via the BBSRC funded Wheat Improvement Strategic Programme (WISP) and is involved in a wide-range of crop pre-breeding projects in the UK and internationally.

Alison has a strong interest in the genetic control of complex traits and in the application of genomics towards the breeding of high yielding cereals and in understanding the role of crop performance within rotations, including the dynamics of nutrient use. She and her team are interested in extending current UK- and EU-based cereals research on the use of both traditional and new breeding technologies internationally. In addition, she hopes to explore the potential for translation of findings from fundamental plant science to application across cereal species in the UK and abroad. There is also great potential to link cereal research and development with crops across rotational systems giving greater understanding of performance within farming systems.

Through the workshop, Alison hopes to develop a better understanding of the potential for strategic UK-African collaborative partnerships across the range of cereal and cropping system research and development areas.

Alison is interested in developing research partnerships in these areas:

- Plant breeding to drive genetic gain across relevant crop species including opportunities to employ molecular breeding approaches, and to re-design breeding programs to boost efficiency
- Dissection of quantitative traits with genotype x environment components to support future breeding and production
- The potential for testing and application of new breeding technologies (e.g. gene editing, genomic selection) to improve crop performance
- Future cropping systems and the role and opportunity for breeding and genomics, particularly in orphan crops
Professor Simon Blackmore

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**Specialty Area:**
- Precision farming
- Agricultural robots and smart machines
- Instrumentation systems
- Farm Management Information Systems and decision support

Professor Simon Blackmore is a key figure in the development of Precision Farming and agricultural robotics, with a worldwide reputation. Simon is currently Professor and Head of Robotics and Automation, Agri-Epi Centre at Harper Adams University, Director of the National Centre for Precision Farming and managed the European FutureFarm project. Simon has extensive experience of multidisciplinary collaboration across universities, commercial partnerships and research projects including autonomous tractors, laser weeding, robotic phenotyping and robotic harvesting. He holds seven Chairs around the world and gives many national and international keynote presentations. Simon leads the research in the UK on agricultural robotics.

Simon’s personal research focuses on improving Precision Farming by developing more intelligent machines and processes, and making crop production more efficient and sustainable.

Simon is interested in developing research partnerships in these areas:
- Precision Farming systems for Africa
- Low energy wireless sensors
- Management Information Systems
- Smart phone technologies for farmers
- Drone farming
Professor Martin Broadley

**Nationality:** British  
**Position Title:** Professor of Plant Nutrition  
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**Speciality Area:** plant mineral nutrition, with a particular focus on optimising the nutritional quality and nutrient-use efficiency of crops using agronomic and genetic approaches. Scopus Author ID 7003414033.

Martin is Professor of Plant Nutrition, at the University of Nottingham. His research seeks to increase our understanding of mineral nutrient dynamics in agriculture and food systems, with a particular focus on improving the nutritional quality of crops. This work involves much collaboration with soil and crop scientists, social scientists, and human/animal nutritionists. These include long-term research and training partnerships with higher education and government research institutes in sub-Saharan Africa. Recent research has led to the identification and characterisation of spatial controls of micronutrient dynamics in Malawian food systems, and the development of novel approaches to assess the potential of dietary diversification and agronomy to alleviate dietary micronutrient deficiencies ('hidden hunger').

Current projects include:

1. a capacity strengthening project, *Soil Geochemistry for Improving Agriculture and Public Health*, in collaboration with colleagues in Ethiopia, Malawi, Zambia and Zimbabwe. This project is part of a wider programme which seeks to increase doctoral training opportunities for students in sub-Saharan Africa.
2. a project to improve forage nutrient management for improved animal health, spanning soil science, agronomy, crop breeding, and veterinary science.
3. multi-institute projects to improve fertiliser-use efficiency in UK-grown field Brassica.
4. projects using wild relatives of wheat to produce varieties adapted to sub-tropical soils.

Martin is interested in developing research partnerships in these areas:

- Increasing doctoral training opportunities within sub-Saharan Africa
- Understanding the links between mineral fluxes and biomarkers in food systems, and health and socio-economic outcomes
- Testing the effectiveness of fertiliser-use strategies to improve crop production, crop quality, and human health
The main aim of Toby’s research is to improve scientific understanding of insect-plant interactions and to use this knowledge to develop novel approaches to manage pests. He developed the theory of how insects use ratios of ubiquitous volatiles for host location and mechanisms of plant defence priming. His previous collaborative research successes include development of orange wheat blossom midge pheromone traps and resistant wheat cultivars, which greatly improved management of that insect. He is an Ecologist and is very interested in plant responses to stresses such as attack by herbivores and biological interactions between organisms.

Currently Toby leads three projects:

1. One on a lure-and-kill system for beetle pests of beans that involves formulating an aggregation pheromone with an entomopathogenic fungus;
2. The “Smart cereals for management of stemborer pests in staple cereals in Africa” SCPRID project on maize that responds to insect egg laying by emitting odours that attract natural enemies of the pest (collaboration with icipe and ICRISAT)
3. CROPROTECT which is developing an innovative online resource for knowledge exchange with farmers and agronomists in the UK. His expertise spans high quality basic and translational science.

Toby is Convenor of the Association of Applied Biologists Biocontrol and IPM group, visiting Professor at the University of Greenwich and a visiting Lecturer at the University of Nottingham. He will shortly be starting a new research group focussing on insect-plant interactions within the Faculty of Natural Sciences at Keele University. This will provide an exciting opportunity for new collaborations.

Toby is interested in developing research partnerships in these areas:

- Crop resistance to herbivore insects (pests)
- Identification and characterisation of phytochemicals involved in insect-plant interactions
- Enhancing biocontrol of herbivore insects
- Improving stress resilience of crops
- Understanding how scientific information can be used as a resource to assist farmers
Professor Duncan D Cameron

Nationality: British
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Prof Duncan Cameron is Professor of Plant and Soil Biology in the Department of Animal and Plant Sciences at the University of Sheffield where he holds a Royal Society University Research Fellowship. Duncan is also Director of the P3 centre of excellence for translational plant and soil biology and is lead academic of the £16 million N8 AgriFood program for the University of Sheffield. After receiving his BSc in Zoology and Botany from The University of Sheffield and his PhD in Plant and Soil Sciences from the University of Aberdeen, Duncan undertook post-doctoral research in Sheffield and at the Julius von Sachs Institute at the University of Wurzburg, Germany. He is an environmental physiologist/biochemist and his research focuses on resolving resource fluxes in plant-microbe interactions in both agricultural and natural systems using a combination of methods including metabolomics, isotope tracers and molecular biology to understand the mechanisms underpinning multi species interactions. Duncan has extensive experience in translational research in the UK and overseas where he has taken his basic research findings into agricultural practice. He received the World Economic Forum’s Young Scientist Award for his work in translating fundamental advances in plant science into practical agricultural solutions in 2013. In the same year Duncan chaired the Royal Society Frontiers of Science meeting in Beijing. He is active in defining agricultural policy and in 2015 he addressed the United Nations at COP21 in Paris discussing his work on soil security. He was subsequently invited to address UN COP22 in Marrakesh in 2017. Currently, Duncan is subject editor for ‘Plant and Soil’, editorial board member for ‘Food and Energy Security’ and associate editor of ‘The Journal of Ecology’. He is a member of the NERC peer review college.

Duncan is interested in developing research partnerships in these areas:
- Harnessing beneficial soil microorganisms for sustainable crop production and crop protection through small scale to landscape-scale management interventions.
- Developing novel germplasm to take advantage of the agronomic benefits provided by soil microbes.
- Using ‘omics’ biology and high throughput disease phenotyping to define functional breeding traits for disease resistance and drought tolerance in crops.
- Developing integrated strategies for sustainable soil management to enhance carbon storage water storage and nutrient storage in agricultural soils.
- Mitigating the effects of parasitic plants on crops using the soil microbiome.
Christopher Darby

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**Position:** Director of International Strategy and Liaison  
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**Specialty Area:** international science policy and partnerships

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Chris Darby is Director of International Strategy at the John Innes Centre. His work ensures that the impact of JIC science is strengthened through international engagement, in particular in sub-Saharan Africa where he works closely with the BecA-ILRI research hub. Chris will oversee the launch of “A Centre for Accelerated Crop Improvement in Africa” (ACACIA) in 2017. Chris was formerly a Civil Servant, working in a number of different UK home departments, for the Foreign and Commonwealth Office and for the European Commission. He was Secretary to the UK Government’s Global Science and Innovation Forum and author of the UK’s Strategy for International Engagement in R&D. He has served as the UK’s Sherpa to the G8 Carnegie Group of science ministers and as Head of Science and Innovation for the FCO in India. On the international stage, Chris was closely involved with the policy shift towards joint research programming with key partner countries, including the creation of RCUK offices overseas. On the European stage, Chris played a key role, during the last UK Presidency of the EU, in the establishment of a European Research Council (ERC). Chris has an initial scientific background in nutrition and was Chief Executive of the UK Nutrition Society.

Chris is interested in developing partnerships in a broad range of areas.
Dr Adélia de Paula

**Nationality:** Brazilian and British  
**Position:** Coordinator of the Sustainable Intensification Research Network (SIRN)  
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Adélia is the Sustainable Intensification Research Network (SIRN) Coordinator, a project funded by the UK Research Councils BBSRC and NERC. SIRN facilitates integration across disciplines enabling different combinations of researchers and other stakeholders to share ideas, skills, expertise and capabilities to maximise the UK's capacity to meet current and future Sustainable Intensification challenges. Adélia is responsible for managing communication between partners, the programme of events, website, identification of opportunities, and development of new collaborations with a wide range of stakeholders.

Adélia, originally from Brazil, has lived in the UK since 2000. She has a strong science background and in previous university posts, carried out research as a synthetic inorganic chemist, and taught undergraduate and post-graduate students on a variety of courses, including Agriculture and Forestry Sciences. Since 2007, Adélia has worked at Rothamsted Research as a Science Communicator, prior to her current role.
Dr Kerry Firth

**Nationality:** British

**Position:** Strategy and Policy Manager for agriculture and food security

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Kerry is a Strategy and Policy Manager for Agriculture and Food Security in BBSRC’s Science Group. Kerry is responsible for providing strategic advice and assisting the development of BBSRC strategy, and she manages a number of cross-council initiatives. Her portfolio covers the sustainable enhancement of agricultural production, agri-ecosystems, environmental science, ecosystem services and natural capital and soil science.

Kerry’s first degree was a BA in Geography from the University of Sheffield, England, after which she spent a number of years teaching (English and skiing) and volunteering in various countries in Europe, North, Central and South America. Kerry then moved to New Zealand, where she worked for the Department of Conservation for several years, alongside various consultancy projects related to national park management. Kerry completed her PhD in the Social Dimensions of Natural Resource Management at Lincoln University New Zealand in 2009.

Prior to joining BBSRC in 2013, Kerry worked in community development, resource management and for the Natural Environment Research Council.
Professor Jeremy Haggar

Nationality: British
Position Title: Professor of Agroecology
Institution: Natural Resources Institute at the University of Greenwich, UK
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Specialty Area: plant-soil interactions and ecosystem services, capacity building

Professor Haggar is a Professor of Agroecology at the Natural Resources Institute and leader of the Ecosystem Services Research Group. His background is in plant-soil interactions in agroecosystems, which has developed into an interest into the ecological, economic and social dimensions of sustainability of agricultural and forestry systems. He lived for twenty years in Costa Rica, Mexico and Nicaragua working for ICRAF (World Agroforestry Centre) and CATIE (Tropical Agricultural Research and Higher Education Centre). During this time, he managed regional research and development projects building capacity amongst farmers, their organizations and agricultural services in ecological and entrepreneurial management of agroforestry production. At the same time, he developed research to evaluate the environmental impacts and benefits of sustainable production systems. At NRI, Jeremy has applied his experience in Central America to African agricultural development with projects on rehabilitation of coffee production in Sierra Leone.

Currently, Jeremy is research lead on a DFID funded programme Sustainable Agricultural Intensification Research and Learning in Africa (www.nri.sairla.org), that funds research projects on equity, environmental/economic trade-offs, and services for smallholder, women and youth farmers to engage with and benefit from SAI. SAIRLA is forming an SAI learning alliance within the six African countries where they fund projects (Burkina Faso, Ghana, Ethiopia, Malawi, Tanzania and Zambia), and internationally across these countries and African and European research and development organizations. The learning alliance aims to engage researchers, decision-makers and other stakeholders in a process of social learning about the enabling environment for participation of disadvantaged smallholders in SAI.

Prof Haggar’s interest in this meeting is to identify research approaches that integrate or complement biotechnological research with the evaluation of environmental and socioeconomic conditions and impacts of that technology to improve sustainability of increased agricultural productivity.
Mr Brian Harris

**Nationality:** British  
**Position:** (joint) Head of science strategy for agriculture and food security (AFS) in BBSRC's Science Group  
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Brian Harris is (joint - along with Dr Adam Staines) head of science strategy for agriculture and food security (AFS) in BBSRC’s Science Group. Brian leads on “pre-harvest” aspects of AFS, including crops, plant health, soils and farming systems, with a particular current emphasis on the Council’s contribution to the sustainable intensification of agriculture. Brian joined BBSRC’s predecessor, the then Agricultural and Food Research Council (AFRC), in 1989. During his 28 years with BBSRC and AFRC, he has worked in a variety of functions - including science strategy and policy, management of peer review, research institute assessment, studentships and fellowships, and liaison with Government departments - and in roles similar to his current one since 2002.

Over the past ten years, one of Brian’s main responsibilities has been leading the negotiation, design, implementation and management of multi-agency research initiatives. These included the first three of BBSRC’s four joint funding schemes with the UK’s Department for International Development (DFID) and others: Sustainable Agriculture Research for International Development (SARID), Combating Infectious Diseases of Livestock for International Development (CIDLID - with DFID and the Scottish Government), and Sustainable Crop Production Research for International Development (SCPRID - with DFID, the Bill & Melinda Gates Foundation and the Indian Government’s Department of Biotechnology). Before the establishment of the Global Challenges Research Fund, those programmes provided the bulk of BBSRC’s support for partnerships between UK scientists and colleagues in sub-Saharan Africa or South Asia. More recently, Brian has led two UK multi-partner funding initiatives of research on insect pollinators, and tree health and plant biosecurity.

Brian previously represented BBSRC’s interests in the cross-Research Council 10-year RELU programme of interdisciplinary (biological, environmental and social science) research on the Rural Economy and Land Use. He has also worked in partnership with the USA’s National Science Foundation on basic research with the long-term aims of enhancing nitrogen use in agriculture and, very recently, countering threats to plant health. Earlier in his career, after studying food science at the University of Reading, Brian was employed for seven years by Unilever PLC in its corporate food research laboratories at Colworth House, Bedfordshire.
Professor Sue Hartley

**Nationality:** British  
**Position:** Director, York Environmental Sustainability Institute  
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**Specialty Area:** The ecology and biochemistry of crop-pest interactions, including: plant secondary metabolites and the biochemical basis of crop resistance; silicon as a defence against pests and pathogens; the ecology of foliar-feeding and root-feeding crop pests; impacts of climate change on plant resistance to pests; plant resistance to abiotic stress e.g. drought.

Prof Sue Hartley studied Biochemistry at the University of Oxford (1980-84), before moving to the University of York to apply her chemical knowledge to the study of plant defences against insect herbivores in a PhD and a NERC personal postdoctoral fellowship (1984-1990). She then moved to the Centre for Ecology and Hydrology near Aberdeen before joining the University of Sussex in 2001 to work on the impacts of climate change on plant-herbivore interactions and to begin her long-standing interest in silicon as a plant defence, testing its impacts on populations of mammalian herbivores and exploring the use of silicon as a crop defence against insect pests. In 2010 she moved to the University of York to become Director of the York Environmental Sustainability Institute, an innovative partnership bringing together leading researchers from a broad range of disciplines to tackle key global challenges, such as climate change, biodiversity loss and threats to food security. Sue was the founding Director of the £16M Hefce Agri-Food Resilience Programme, a collaborative project on food security across the N8 group of northern research-intensive Universities, and she is currently a co-Investigator at CECAN, an ESRC large center pioneering innovative approaches to policy evaluation where food, energy, water and environmental issues intersect. Sue is a member of the BBSRC’s Strategic Advisory Panel on Agriculture and Food Security, Chair of the Sustainable Agriculture Research Innovation Club, Co-lead of the Sustainable Intensification Research Network, a Fellow of the Royal Entomological Society, a Trustee of the Royal Botanic Gardens, Kew, and the President of the British Ecological Society.

Sue’s research aims to develop novel ways to increase crop resilience to drought, disease and insect pests. She has worked on a range of crop systems including rice, alfalfa, soybean, wheat, barley, potatoes and oil seed rape, and on a range of pests including aphids, locusts, armyworms, potato cyst nematodes, free-living nematodes and plant viruses. Sue is interested in developing research partnerships in these areas:

- Maximizing the efficient use of natural plant defences as a sustainable means of crop protection, either through a better understanding of the chemical mechanisms responsible and/or plant breeding to enhance these mechanisms;
- Exploring the use of silicon in agriculture. Silicon is accumulated to high levels in many cereals and effective against shoot and root feeding herbivores and pathogens, and in mitigating environmental stresses such as drought and salinity;
- Understanding how crop resistance against pests might be compromised by climate change;
- Testing the effectiveness of techniques such as co-cropping and biofumigation and understanding the biochemical basis of these (e.g. secondary metabolites and/or the release of leaf and root volatiles).
Dr Matthew Heard was born in Southampton, England and earned a PhD in Ecology at Imperial College, Silwood Park (1999). He is a senior member of the Community & Restoration Ecology Group within CEH Wallingford, UK. His main interests are: i) to understand what the key drivers causing declines in wildlife, ii) developing and evaluating actions to halt or reverse these declines and iii) improving the utilisation of biodiversity functioning at multiple scales to improve system productivity and resilience. He tackles these questions through experimentation, fieldwork, use of molecular techniques, analyses of large datasets, and modelling. Current research themes include interactions between agriculture and biodiversity, pollination ecology, pollinator molecular ecology and ecotoxicology, ecosystem function, restoration ecology and plant community dynamics.

He is a co-lead of the BBSRC Sustainable Intensification Research Network (SIRN), a work programme lead on the cross council ASSIST sustainable intensification project, has recently led major collaborative long-term field experiments funded by Defra, Natural England and industry, was PI on an EFSA pollinator ecotoxicology grant (£250k), an ESPA Tansley Working Group grant, a work package leader and mentor on an ERC grant (£1.5 million), and was co-PI on a recent Insect Pollinator Initiative grant (BBSRC, NERC, Defra, Wellcome Trust, Scottish Government) which used a novel combination of microsatellite analysis and landscape modelling to investigate bumblebee foraging and dynamics. He has made direct contributions to winning over £10 million of research funding in the last 7 years. Results from his projects have had direct impacts on policy (e.g. ecological impacts of GM cropping in the UK, management and effectiveness of agri-environment options (e.g. Natural England MESME)). He is a member of Defra's Advisory Committee on Releases to the Environment (ACRE), a member of the NERC Peer Review College, and BBSRC Panel of Experts. He manages 3 PDRAs and 3 PhD students. Since 2000, he has authored >90 peer-reviewed publications and >30 contract reports and has a current H' index of 28 based on >4000 citations).

Matt is interested in developing research partnerships in these areas:

- Developing innovative farming systems to increase/maintain crop production while reducing environmental impact
- Understanding how interactions between landscape context and farming system affect ecosystem service provision (especially pollination and pest control) and trade-offs
- Impacts of biodiversity loss on ecosystem resilience and function
- Understanding and developing routes to mitigate the effects of multiple abiotic and biotic stressors on bees: from the molecular level through to population and pollination impacts.
Dr Daniel McGonigle

Nationality: British  
Position Title: Research Initiative Manager: Sustainable and Resilient Farms, Forests and Landscapes  
Institution: Bioversity International  
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Specialty Area: Management of trade-offs between ecosystem services in the context of agricultural and environmental policy. Sustainable intensification of agricultural production whilst minimizing environmental externalities, particularly through landscape and river basin-scale initiatives.

Dr Daniel McGonigle studied Biology at Southampton University with a particular focus on ecology and the environment. In 2002 he completed a PhD in entomology, also at Southampton, focusing on integrated pest management approaches using entomopathogenic fungi. After his PhD he worked for an environmental NGO for three years on a river catchment management project in the southwest of England. There he developed GIS risk mapping approaches and advised farmers on diffuse water pollution. After that, he moved to the UK Department of Environment, Food and Rural Affairs (Defra), where he worked for nine years commissioning and managing research and providing scientific policy advice on the environmental impacts of agriculture. At Defra he led research and monitoring programmes on agricultural impacts on water quality, water use, soil, air quality, greenhouse gasses and biodiversity. He played a leading role in setting up national research programmes: the Demonstration Test Catchments and the Sustainable Intensification Research Platform. Since January 2015, Daniel has been based in Rome, where he leads Bioversity International's research on the management of farms, forests and landscapes.

Daniel is interested in developing research partnerships in these areas:

• Developing landscape-scale research observatories to understand the impact of multiple on-farm interventions on Sustainable Development Goal outcomes.
• Understanding trade-offs between ecosystem services at landscape scale.
• Rural-urban linkages in value-chains and human health (via dietary and environmental pathways) mediated by markets and city food policy.
• The effect of intraspecific and interspecific crop diversity on agricultural resilience to biotic and abiotic pressures.
• The role of agricultural and tree biodiversity in land restoration.
• Agroecological intensification of banana systems (including integrated management of pest and diseases, and value chains for small-holder farmers).
• Healthy and diverse diets.
Professor Mariana C. Rufino

**Nationality:** Argentinean  
**Position Title:** Professor of Agricultural Systems  
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**Speciality area:** Farming systems, Food security, Crop and livestock production, Climate change mitigation, Adaptation, Environmental impacts of agriculture, Modelling at field, farm, landscape level

Professor Rufino was appointed chair for N8 AgriFood programme in 2016. The N8 Research Partnership is a collaboration of the eight most research intensive Universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York.

Professor Rufino’s work focuses on farming systems with a special interest on livestock, forests and climate change mitigation and adaptation. Previously, she was a Senior Scientist at the Centre for International Forestry Research (CIFOR), where she led the work under the Climate Change Agriculture and Food Security (CCAFS) (2013-2016). Mariana began her international career working for Wageningen University in The Netherlands conducting research in smallholder agricultural systems of East and Southern Africa. She earned a PhD in Production Ecology and Resource Conservation in 2008. Mariana held positions at Plant Research International in The Netherlands (2004-2007), and the International Livestock Research Institute (ILRI) with headquarters in Kenya (2010-2013). Most of this work focused on N and C cycles at field, farm and landscape levels to understand how land use change relates to food insecurity, poverty and environmental problems such as water scarcity and climate change.

Mariana is interested in developing research partnerships in these areas:

- Analysing management options for intensification of smallholder farms and the impacts on natural ecosystems (forest and grasslands)
- Identifying incentives for livestock keepers to reduce the climate footprint of livestock production in Africa
- The use of models for integrated land use planning to support water provisioning and climate adaptation in agricultural systems
- The management of forest and tree cover to offset the climate impact of crop and livestock production
- The use of leguminous plants to supply food, livestock feed and to restore degraded forest and grassland ecosystems
- Building capacity to estimate GHG emissions from agricultural systems and to identify mitigation options
Professor Nigel D. Scollan

**Nationality:** British  
**Position Title:** Director Institute for Global Food Security and Professor of Animal Science  
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**Specialty Area:** Nutrition, pasture; rumen function; nutritive value of livestock products (meat and milk); design of improved livestock production systems with lower environmental footprint

Professor Scollan was born in Enniskillen, Northern Ireland and gained a PhD in Nutritional Biochemistry at University of Edinburgh. This was followed by a postdoctoral appointment at the University of Guelph, Ontario, Canada before joining Institute of Grassland and Environmental Research, Aberystwyth in 1993 and subsequently Institute of Biological, Environmental and Rural Sciences (IBERS) Aberystwyth University in 2008. He held a numbers of posts at IBERS including Waitrose Professor of Sustainable Agriculture and Professor of Public Engagement with Science at Aberystwyth University, group leader Animal Systems and Director of Enterprise.

Nigel is Director of The Institute for Global Food Security and Professor of Animal Science at Queens University, Belfast. The Institute addresses key challenges around (1) Farms of the Future: developing paradigm shifts in agricultural practices to enhance profitability and sustainability without compromising biodiversity and ecological function; (2) Global Food Integrity: use of state-of-the-art approaches (analytical, molecular, computational) to improve the safety of global food supply chains and prevent fraud and (3) Nutritional challenges of the twenty-first century: better understanding of how human diet impacts a range of health outcomes and development of intervention strategies to maximize wellbeing. His research is primarily related to designing improved systems for ruminant livestock, through the use of improved nutrition and genetics to enhance the sustainability and efficiency of the production systems. Improving nutritional quality is an important aspect of the research. Professor Scollan has initiated and managed many national and European-Commission-funded projects and developed links with key strategic science partners in UK, Europe and further afield. Professor Scollan works closely with producers and other key stakeholders across value chains. Nigel is a Past President of the British Society of Animal Science and a Fellow of the Royal Agricultural Society in the UK and a Director of the Oxford Farming Conference.

Professor Scollan is interested in developing research partnerships in these areas:

- Improved nutrition - quality and availability of feed resources (sown forages, forage conservation, fibrous crop residues, alternative feeds for energy and protein and strategic supplementation)
- Enhanced understanding of impact of diet on rumen function and effect of animal productivity and environmental impact of ruminant production systems
- The application of improved nutrition and genetics on carcass growth and meat quality
- The role of animal products, meat and milk, in relation to the health and well-being of people
- Assessing challenges in future livestock production systems and the tradeoffs between food security, poverty, equity, environmental sustainability and economic development
- Studying the likely impacts of different climate change parameters on livestock production systems
Dr. Wellington Ekaya

**Nationality:** Kenya  
**Position:** Senior Scientist & Head, ABCF Program  
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**Specialty Area:** Plant Ecology; Capacity Building; Program Management; Group Facilitation

Wellington Ekaya is a Senior Scientist at the BecA-ILRI Hub, leading the Africa Biosciences Challenge Fund (ABCF) program which is BecA-ILRI Hub's main capacity building delivery mechanism. He is responsible for coordination; strategy development and program implementation; resource mobilization; reporting to donors; design of training programs; mentorship; and co-managing BecA-ILRI Hub's monitoring, evaluation and learning framework.

Prior to joining the BecA-ILRI Hub in 2014, he was Program Manager, Training and Quality Assurance at Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) from 2008 to 2013. He led the establishment of 4 regional coursework-based PhD programs and 4 regional MSc. programs. His portfolio involved strong collaboration with national, regional and international institutions responding to agriculture-related research and capacity building challenges and opportunities in Africa. He has extensive practical experience in agricultural issues and opportunities in Africa including national, regional and continental frameworks aiming at attaining food and nutritional security.

Wellington has 20 years’ experience in capacity building across African NARS. He taught at the Faculty of Agriculture, University of Nairobi for 15 years. As Senior Lecturer he conducted research, carried out numerous consultancies and successfully supervised 25 MSc. and 4 PhD candidates. He has had key roles in 12 donor-funded capacity building and research projects, with a total investment of over US$. 25 million. In the last ten years, he successfully led, as PI, the implementation of 8 multi-country / multi-partner capacity building programs funded by among others, Rockefeller Foundation, IDRC-Canada, BMGF, Carnegie Corporation of New York, USAID, World Bank, DAAD, and EU-ACP (S&T).

Wellington holds a PhD (1998) from University of Nairobi’s Faculty of Science in Plant Ecology. He attended universities in France, United Kingdom, USA and Thailand for PhD coursework. He won the prestigious African Career Awards postdoctoral fellowship of the Rockefeller Foundation for two years (2001-2003) to conduct research on pastoral systems ecology. He is holder of Master of Science (1992) from University of Nairobi, specializing in ruminant and pasture nutrition. He obtained Bachelor of Science in 1989 from the same University. Wellington has published over 30 papers in international refereed journals, five book chapters and presented over 50 papers in conferences and workshops.

His main interests in the BBSRC-BecA workshop include;
- Mainstreaming capacity building into the discussions
- Contributing capacity building and research partnership issues from the ARD landscape in Africa
- Seeking opportunities for partnerships to support the ABCF Program.
Dr. Hailu Dadi

**Nationality:** Ethiopian  
**Position Title:** Deputy Director General  
**Institution:** Ethiopian Biotechnology Institute  
**Email:** edenhailu@yahoo.com  
**Tel:** 251911210539

**Specialty Area:** Animal breeding, Genomics and Animal Biotechnology.

Dr Hailu Dadi was born in Ethiopia and earned a PhD in animal science at Tokyo University of Agriculture in 2009. His research in Ethiopia focused on genetic diversity studies using high-density marker (SNPs) and microsatellite markers. He is also currently working on genetic improvement of Boran cattle in Ethiopia. He moved to South Korea in 2011, becoming, research associate (2011) and assistant professor (2012-2015) in the department of Animal Biotechnology at Konkuk University. During this period, his research work was focused on MHC genes polymorphisms and expression patterns in different tissues in pigs; and detection of selective loci in cattle breeds, developing high resolution DNA typing method. Currently, he is working for Ethiopian Biotechnology Institute as a Deputy Director general and also staff of Addis Ababa Science and Technology University. He uses basic and applied research to address livestock related problems in Ethiopia and is recognized for his contributions addressing practical aspects of livestock development.

Dr. Hailu is a fellow of the Ethiopian Society of Animal Production (1996) and Ethiopian Biological society (2015). He is interested in developing research partnerships in these areas:

- Application of genomic tool in African livestock genetic improvement programs for selected livestock breeds in different countries
- Generating information from genomic data on the disease resistance and heat tolerance of different livestock species
- Identifying genetic markers for genomic selection
- Developing or utilizing advanced bioinformatics methods for genomic data
- Application of reproductive biotechnologies (Artificial insemination, sex control, embryo sexing, multiple ovulation and embryo transfer, in vitro fertilization) in livestock improvement programs in the context Africa.
- Vaccines development, drugs development, biological products and probiotics development
- Improving the efficiency of rumen microbes to enhance feed utilization
Dr. Josephine Birungi

Nationality: Ugandan  
Position Title: Technology Manager  
Institution: BecA-ILRI Hub, Nairobi, Kenya  
Email: J.Birungi@cgiar.org  
Tel: +254 20 422 3384

Specialty Area: Molecular genetics, Evolutionary Biology, Conservation genetics, Zoology (Entomology, Animals), Laboratory management and accreditation.

Josephine is the Technology Manager at the Biosciences eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub, a shared research platform and regional bioscience facility for Africa. Her responsibilities include management of laboratory operations, research facilitation and research related services, monitoring and acquisition of new technologies and technology platform management. She has vast experience setting up laboratories including molecular biology and vaccine trial facilities in Africa, from structural design to laboratory accreditation. She is keen on formulating partnerships/collaborations that will enable the transfer of technologies that can be used by African scientists to drive innovation and sustainably address agricultural challenges in Africa.

Josephine holds a BSc (Hons) (Zoology/Psychology) and MSc (Zoology) from Makerere University Kampala, Uganda and a PhD in Molecular Genetics, Evolutionary Biology and Conservation genetics at Makerere University/ University of Copenhagen, Denmark. She conducted postdoctoral research at Yale University School of Medicine and is an honorary Senior Lecturer at Makerere University Kampala.

Her research experience includes population genetics and phylogenetics of wildlife populations in Africa, genetics and invasion biology of the dengue fever vector *Aedes albopictus* in the US, Brazil and Asia, population genetics of sand-fly species of South America. More recent research involved studies on the ecology, behaviour and genetics of mosquito vectors (*Aedes* sp, *Anopheles* sp, *Mansonia* sp). She has trained several graduate students and scientists and served as external examiner to masters and PhD candidates for close to 10 years. She has published over 25 articles in peer-reviewed journals, presented in international meetings, facilitated at several workshops in molecular biology, laboratory management and accreditation. She has been principal investigator, co-investigator and collaborator to over 10 research projects with funds of up to $25 million.

Her main interests in the BBSRC-BecA workshop include:

- Partnerships to transfer technologies applicable to scientists or farmers in Africa
- Vector biology/genetics in relation to disease transmission
- Animal genetics for improved productivity
Dr. Aissatou Diddi

**Nationality**: Cameroonian  
**Position title**: Deputy Director of Vaccine Production  
**Institution**: National Veterinary Laboratory  
**Email**: aissatoudiddi@yahoo.fr  
**Tel**: +237696972574 / +254788633996

**Specialty area**: Vaccine production in particular viral vaccines production, epidemiology, animal disease diagnosis by using molecular biology techniques, serological diagnosis.

Dr. Aissatou Diddi completed her DVM in 2012 at University of Antananarivo. She is a scientist researcher and Deputy Head of Vaccine Production at the National Veterinary Laboratory (LANAVET), Garoua, Cameroon. She has been involved in research activities on "clinical and subclinical study FMD virus circulating in the northern regions of Cameroon" and study research on “Presence and Prevalence of Crimean Congo Hemorrhagic Fever, Rift Valley Fever and Nipah (-like) viruses” (2013 – 2016). Dr. Aissatou Diddi is currently working on peste des petits ruminants, which is one of the diseases targeted to be eradicated. Her research topic “Epidemiology of Peste des Petits Ruminants in northern part of Cameroon” has a national priority in Cameroon for the economy of smallholders. The study focuses on epidemiological situation in the northern areas and characterization of PPRV by molecular biology methods in order to propose appropriate control measures. She won ABCF Fellowship to conduct the research at BecA - ILRI Hub (September 2016 – April 2017).

Aissatou Diddi is interested in developing partnership in these areas:

- Development of new vaccines.
- The application of new technologies to enhance data collection in epidemiology and control studies with economically important virus diseases.
- Studying the likely impacts of different breeding systems on development of virus epidemics.
- Understanding virus emergence in order to propose appropriate control measures.
- Clinical trials.
Dr. Cyprian Ebong

Nationality: Ugandan
Position: Interim Executive Secretary
Institution: ASARECA
Email: c.ebong@asareca.org
Tel: +256-777-165535

Specialty Area: Crop Livestock Integration; Intensification;

Cyprian graduated with MSc and PhD from Aberdeen University Scotland United Kingdom in Animal Nutrition in 1989. Since then he has been engaged in research for development (R4D) with a passion for packaging technology and policy options for intensification and crop-livestock integration as strategies for climate-smart agriculture. He has particular interest in microbes and rumen metabolism, their use in in-vitro feed evaluation; and role in enteric methane emission.

Intensification through using high biomass fodder species, concurrent production of food and feed and utilization straw-based total mixed rations has been his major pre-occupation in Rwanda; one of the most densely populated countries in Sub-Saharan Africa. In this context he supervised PhD student who evaluated Brachiaria cultivars for adaptability, productivity and nutritional under Collaborative Climate Smart Brachiaria project with CIAT, ILRI-BeCA and Rwanda Agriculture Board (RAB). In collaboration with CIP he supervised an MSc program where sweet-potato cultivars were evaluated for food (roots) and feed (vines) production. Together with his mentees he evaluated straw-based ration for dairy and feedlot beef production focusing on the economics feasibility under Rwandan conditions. Cyprian also believes that breeding for feed efficiency using marker-assisted breeding for cattle genetic improvement can enhance effectiveness of intensification. He encourages breeders and nutritionists to exploit the phenomenon of residual feed intake (RFI) for MAS and rapid genetic gains. He continues to pursue the option of intensification and integration straw-based rations and breeding for feed efficiency feedlots. A proposal for a wider study that will include Tanzania was submitted an EU/AU call currently under review. If successful, it shall also attract a Danish counterpart from Aarhus University, and scientists from ILRI-BeCA and CIAT- Nairobi.

He has a wide experience in coordination and research management, occasioned by training in Research Management at Oakland Virginia USA; coordination Danida supported Livestock Systems Research Project in Uganda; USAID-CRISP on Livestock Early Warning as a collaborative project with Texas A&M University with selected research institutions in Uganda, Tanzania, Kenya and Ethiopia. Before joined RAB as Senior Scientist/Expert in Animal Nutrition, he was the Deputy Director General in charge Quality Assurance. Currently he is the Interim Executive Secretary ASARECA, charged with the responsibility of managing the transition of organization from Operational Plan II to Operational Plan III.
Dr. Julius Ecuru

Nationality: Uganda  
Institution: International Centre of Insect Physiology and Ecology  
Position: Programme Manager  
Email: jecuru@icipe.org  
Tel: +254 705 877 315

Specialty Area: Technological Innovation Systems, Agricultural and Environmental Sustainability, Regulatory Science, Program Management, Mentorship

Julius Ecuru is an expert in technological innovation systems. He is currently head of the Bioresources Innovation Network for eastern Africa Development Programme (BioInnovate Africa), which is based at the International Centre of Insect Physiology and Ecology (icipe) in Nairobi, Kenya. BioInnovate is a regional initiative supported by the Swedish International Development Cooperation Agency (Sida) to assist countries in eastern Africa gain from the revolutionary advances in biosciences, converting these into innovations for inclusive growth and sustainable development. Julius has previously worked for the Uganda National Council for Science and Technology as Assistant Executive Secretary handling research and innovation, and as strategy advisor for the BecA-ILRI Hub. He holds a BSc Honours in Chemistry and MSc in Environmental Science from Makerere University, and a PhD in Innovation Systems and Development from Blekinge Institute of Technology, Sweden. He also has a Postgraduate Diploma in International Research from the University of Cape Town, South Africa.

Julius has published several peer-reviewed papers in international journals and as well as book chapters. He is also an external examiner for Makerere University College of Engineering, Design, Art and Technology postgraduate programme in Innovation and Industrial Development. His research work has focused on technological innovation systems, cluster development and bioscience innovation policies (including regulatory science) in Uganda and in eastern Africa. Julius embraces a transdisciplinary research approach, which requires a broad mix of expertise; and his work is at the nexus of industry, agriculture, health and the environment. He has served as Principal Investigator and co-Investigator for several Projects funded by among others, Swedish International Development Cooperation Agency, World Bank, U.S. National Institutes of Health, The European and Developing Country Clinical Trials Partnership (EDCTP) and Government of Uganda.

Dr Ecuru’s interests in the current workshop include;

- Meeting and learning what peers across the region are doing;
- Understanding roles of different partners in the agricultural innovation system;
- Identifying potential partners and collaborative activities
Benedicta Nsiah Frimpong

**Nationality:** Ghanaian  
**Position Title:** Research Scientist (Agricultural Economist)  
**Institution:** CSIR- Crops Research Institute  
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**Specialty area:** Production economics; resource economics; gender analysis; value chain analysis; market research; policy analysis; project appraisals; and adoption and impact assessment of promising technologies and project interventions

Benedicta Nsiah Frimpong is a true Ghanaian who holds a masters degree in MPhil Agricultural Economics from Kwame Nkrumah University of Science and Technology (KNUST), Ghana. She has been working with the scientific community for the past eight (8) years; first as a Principal Technical Officer and now a Research Scientist since 2013. She applies economic concepts in addressing emerging agricultural issues. She has been partnering researchers from several international institutions such as NRI, CYMMT, IITA, AfricaRice Center and IFPRI to conduct joint research. Her research work cuts across all commodities. Her aim is to see research outputs contribute to the improvement of rural livelihoods, and resource poor smallholder farmers becoming independent. She has contributed to these goals through capacity building for women parboilers in improved parboiling technologies, organizing farmers and group formation, training value chain actors on various commodity innovation platforms on marketing and seed producers on business plan development to be independent and competitive. Benedicta Nsiah Frimpong’s present research covers the following:

- Market standardization, grading and pricing in maize markets in Ghana
- Trait preferences and perception of Yellow Root Cassava by men and women chain actors
- Participatory evaluation of rice genotypes with farmers across multi-environments
- Mainstreaming gender in project activities in the promotion of disease free community seed production

She held an AWARD (African Women in Agricultural Research and Development) fellowship from the Bill and Melinda Gates Foundation from 2010-2012 and part of the Ghana Chapter (GhaWARD). She is part of the team that drafted a proposal on “Towards a long-term Africa-EU partnership to raise sustainable food and nutrition security in Africa”. This is a consortium which comprises 23 Agricultural research and development organizations drawn from Europe and Africa and seeks to address the development of the research agenda for long term partnership, the governance structure, the finance mechanisms and the rules and regulations for participation. She is also part of the team that worked on the final document for strategic research and innovation partnership on “Sustainable intensification of the agri-food systems in Africa”.

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Dr. Geoffrey Onaga

**Nationality:** Ugandan  
**Position Title:** Doctorate in Phytopathology  
**Institution:** International Rice Research Institute, East and Southern Africa (IRRI-ESA), ILRI Kenya, P.O. Box 30709 Nairobi 00100, Kenya  
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Dr. Geoffrey Onaga was born in Ngora, Uganda on 23rd February 1978. In 2010, he received his M.Sc. in Plant Breeding and Seed Systems at Makerere University, Kampala, Uganda. On the same year, he pursued internship at the International Rice Research Institute (IRRI), on phenotyping and genotyping rice accessions using hydroponics and SSR markers, respectively. In January 2011, he started a PhD entitled ‘Genomic studies on rice-rice blast interaction at elevated temperature at Georg-August University, Goettingen, Germany (2011-2014). He has attended several courses, including Breeding management Systems, Molecular Breeding, advanced genomics and Bioinformatics, Bioinformatics approaches for Next Generation Sequencing analysis, Marker Assisted Selection in Rice Breeding, Drought screening for rice genetic improvement, Variety Selection Techniques, Integrated Rice Management for Rice Production, Agricultural Research Data and Records Management, Computer applications and Statistical data analysis, intermediate R software for data analysis, Participatory Variety Selection, Varietal Testing and Release approaches, Impact Assessment Methodologies, Group development, Business management and Leadership. Furthermore, he has participated in several conferences, and was awarded a prize for the best presentation in 2014 at the Deutsche Pflanzenschutztagung, Freiburg, Germany, on the title “High temperature induced changes in the rice transcriptome under infection with Magnaporthe oryzae”.

He has worked as a Plant pathologist at National Crops Resources Research Institute, Uganda (2007-2014), where he developed survey methodologies and field screening techniques for common pathogens on rice and maize; conducted research on rice and maize germplasm development and improvement, including planning of crosses involved, and organization and planting of breeding trials. He was a plant pathologist under the project “Mitigating the Impact of Climate Change on Rice Disease resistance in East Africa” funded by the Germany government through GIZ/BMZ. Currently he is a Post-Doctoral Research Fellow at International Rice Research Institute- Eastern and Southern Africa, and conducts research on Plant pathology survey methodologies and field screening; isolation, identification, culture maintenance, and molecular characterization of rice pathogens.

Dr. Onaga is interested in integrating molecular, cell biology, genomic, and genetic analyses with plant pathology to improve our understanding of how pathogens, plants and environment interact, and ultimately exploit this knowledge for improved disease management. Furthermore, he is interested in understanding the dynamics associated with the likely impacts of climate change parameters on development of plant disease epidemics; and identifying new sources of stable disease resistance in the face of altering climatic conditions.
Dr. Sita Ram Ghimire

**Nationality:** The United State of America  
**Position Title:** Senior Scientist – Plant Pathology  
**Institution:** Biosciences Eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub  
**Email:** s.ghimire@cgiar.org  
**Tel:** +254 20 422 3820  
**Specialty Area:** Plant Pathology, Beneficial microbes, Plant Microbe Interaction, International Agriculture, Genomics, Molecular Biology and Tropical Forage

Sita Ghimire was borne in the western hills of Nepal. He earned his Ph.D. in Mycology from the University of Hong Kong researching on phenotypic and genetic diversity of potato late blight pathogen in Nepal. He started his career as Asst. Plant Pathologist with Nepal Agricultural Research Council and researched on the management of crop and vegetable diseases. In 2003 he took a postdoctoral scientist position with Mississippi State University and later moved to Virginia Polytechnic Institute and State University, Samuel Roberts Noble Foundation and RTI International. Sita joined BecA-ILRI Hub in 2013, as technical lead for Climate smart Brachiaria (CSB) grass program that aimed at increasing livestock production in East Africa. The program successfully identified suitable Brachiaria variety for East Africa, integrated these varieties in to mixed crop livestock system, and enhanced forage availability and livestock productivity (milk and meat production). The Brachiaria technologies developed through CSB program are highly preferred by farmers and are being promoted across sub Saharan Africa through various livestock development initiatives including though the USAID’s Feed the Future Program in Kenya and Mali. These programs are using Brachiaria as a major forage option and aim to reach 280,000 households in Kenya and Mali by the end of 2018. Sita provides technical inputs to these livestock development initiative in the region. Besides his involvement in forage research and development activities he leads Research Program at BecA-ILRI Hub and supervise research associates, postdoctoral fellows and visiting scientists from various institution in Africa and abroad.
Dr. Rudovic Kazwala

Nationality: Tanzanian  
Position: Professor of Ecosystems and Public Health in the Department of Veterinary Medicine and Public Health, College of Veterinary and Medical Sciences  
Institution: Sokoine University of Agriculture, Morogoro, Tanzania  
Email: kazwala@gmail.com

Prof. Kazwala is the Chairman of Veterinary Council of Tanzania, is a member of the International Health Regulations, Roster of Experts in Veterinary Issues, Zoonoses, and coordinates the Bovine Tuberculosis Network for Africa.

For the past one decade, Professor Kazwala is the Tanzanian Director of Health for Animals and Livelihood Improvement (HALI) Project, a collaborative research between College of Veterinary Medicine at University of California, Davis and Sokoine University of Agriculture.

Since 2009, Prof. Kazwala has led the USAID Emerging Pandemic Threats Program PREDICT Project in Tanzania, supporting the development of a wildlife disease surveillance and early warning system for high-risk viral pathogens, and heads a new molecular laboratory for emerging infectious diseases and pathogen discovery.

Prof. Kazwala is also involved in the implementation of SEEDZ, HAZEL and Brucella Projects supported by ZELS initiative. Also leads AfriqueOne ASPIRE Thematic Training Programme on Brucellosis in East and West Africa.

Area of interest
- Ecosystems health in respect of interfaces of human, wildlife and livestock populations
- Wildlife disease surveillance
- Early warning system for high-risk zoonotic pathogens,
- Molecular epidemiology of emerging and re-emerging zoonotic diseases
- Animal pathogen discovery
- Mitigation of climate change in pastoralist communities
Dr. Asfaw Kifle Wadollo

**Nationality:** Ethiopian  
**Institute:** Southern Agricultural Research Institute, Ethiopia  
**E-mail:** akifle2003@gmail.com  
**Tel:** +251911984042

**Specialty Area:** Horticulture, breeding root and tuber crops, agronomic research on several horticultural crops including taro, sweet potato, potato, ginger, yam, molecular profiling of Ethiopian taro accessions.

Asfaw Kifle Wadollo was born in Southern Ethiopia (1662) and earned his MSc in plant sciences (Horticulture) (2006) at Alemaya University. Currently he is a PhD student at Jima University College of Agriculture and Veterinary Medicine, Ethiopia. His research mainly focused on breeding, Agronomy, morphological and molecular profiling of Ethiopian taro (*Colocasia esculenta*) accessions. He also conducted research on several other horticultural crops. Apart from these Asfaw also served as a Section Head of Horticultural Crops Research. In addition, He was a Center Manager in the same Institute at Areka Agricultural Research Center.

The Ethiopian Federal Democratic Republic Ministry of Science and Technology through the Country’s Prime Minister issued him an award for the meritorious national achievement of Generating and Scaling up of Improved Taro Variety, which was considered to be an outstanding problem solving research output in research category (2016).

Asfaw is interested in developing research partnerships in these areas:
- Regional taro germplasm exchange and management network through Taro Community of Practice
- Breeding taro to improve eating quality, to increase productivity, to control several diseases affecting taro
- Enhancing Marker Assisted Selection in taro improvement
- Association mapping of phenotypic traits and molecular markers in Ethiopian taro accessions
Dr. Patrick Karangwa was born in Kigali, Rwanda, on 16 September 1974. He was educated at the University of Stellenbosch (PhD in Plant Pathology), the University of Wageningen (MSc in Cellular and Molecular Biotechnology) and the University of Rwanda (BSc in Biology, Biotechnology Option).

Dr. Patrick Karangwa is currently the Head of Research Department at Rwanda Agriculture Board (RAB), from August 2015 until present. This is a position in the Senior Management of Rwanda Agriculture Board (RAB) and the Ministry of Agriculture and Animal Resources of Rwanda, to which he was appointed by the Cabinet of Rwanda on 5 August 2015. The position entails overseeing and managing the national agricultural research under the country’s agricultural research and extension organization, RAB. This organization has got a total of 189 research scientists and technicians working on various agricultural research areas: agronomy, plant and animal breeding, plant and animal health, soil sciences, agrometeorology and climate change, conservation of genetic resources, postharvest processing and value addition, socioeconomics, forestry and agroforestry.

Dr. Patrick Karangwa has served as a Research Scientist at Rwanda Agriculture Board (RAB) since May 2004. His research interests (as a scientist) include the development of disease-free seed systems, through use of plant tissue culture and disease diagnostics for accurate and early detection of plant pathogens; breeding for disease resistance through mutation breeding and the use of molecular markers in crop improvement. As the manager of national agricultural research, Dr. Patrick Karangwa is mainly interested in developing in developing research partnerships in following areas:

- Upgrading Rwanda’s capacity in agricultural biotechnology: crop and animal improvement, crop and animal protection;
- Building Rwanda’s capacity in climate resilient / climate smart agriculture.
Ethel Makila

Nationality: Kenyan
Position title: Communications Officer
Institution: Biosciences eastern and central Africa-International Livestock Research (BecA-ILRI) Hub, Kenya
Email: e.makila@cgiar.org
Tel: +254-20-4223821

Specialty: Communication strategy; media and social media engagements; web and print-based publishing.

Ethel Makila provides leadership and coordination for all communication, public and media engagements for the BecA-ILRI Hub, ensuring a significant growth in its regional and international profile. She is responsible for developing and implementing strategic and tactical communications plans that amplify the impact of the BecA-ILR Hub’s research, capacity building and research related services, and help position the Hub as a world class research facility enhancing agricultural biosciences research capacity of African scientists for improved food and nutritional safety and security and income.

Before joining the BecA-ILRI Hub, Ethel worked at Action Aid Kenya, Buru-Buru Institute of Fine Arts, Nation Media Group and Development Communications. She has acquired diverse experience in the field of development communication, media and education.

She holds a BA degree in Graphic Design from the University of Nairobi and is currently pursuing an MSc in Agricultural Information and Communication Management from the same institution.

A graphic designer, writer and nature lover, she has developed innovative visual communication materials for development issues and continues to contribute to the publicity and fund raising efforts of various non-profits.
Dr. Mercy. N Kitavi

Nationality: Kenyan
Position title: Molecular breeder & Capacity building Scientist
Institution: International Potato Center (CIP)
Email: m.kitavi@cgiar.org
Tel: +254722913723

Specialty Area: Plants genomics and marker assisted breeding, Epigenomes and epigenetic control of important agronomic traits, population’s evolutionary history, capacity building and training

Dr. Kitavi was born in Eastern Kenya and earned a PhD in Plant genetics at the National University of Ireland, Galway (NUIG) in 2015. Her research in International Institute of Tropical Agriculture (IITA) - BecA focused on understanding the genetic diversity and epigenetic polymorphism behind the phenotypically diverse East African Highland bananas presumed to be clones and unearthing their evolutionary history (2010-2014). Prior, Kitavi significantly contributed to crop molecular research as a capacity building assistant at Biosciences east and Central Africa (BecA)-hub (2008-2010) and International Crop Research Institute for Semi-Arid Tropics (ICRISAT; 2007-2008). She is currently a molecular breeder and capacity building scientist at CIP. Her work focuses on the use of genomics and marker assisted breeding for accelerating sweet potato cultivar improvement and variety release. Supporting and building molecular capacity of sweet potato breeders in Sub-Saharan Africa through training workshops, webinars and online tutorials. She is a member of the European Plants Science organization (EPSO) and has spoken at several international conferences.

Mercy is interested in developing research partnerships in these areas:-
- Integrated genomics assisted crop breeding for cultivar improvement and variety release.
- The application of new and modern technologies to enhance collection of phenotypic data.
- Evolution of genomes, epigenomes and populations.
- Studying the likely impacts of in vitro technologies to disease and our ability to control them.
- Understanding the role of epigenetics in expression of genes controlling agronomically important traits for economic crops.
- Increasing the impact of plant research to meet global challenges.
Dr. Josiah Musembi Mutuku

**Nationality:** Kenyan  
**Position Title:** Postdoctoral Scientist  
**Institution:** Biosciences Eastern and Central Africa-International Livestock Research Institute (BecA-ILRI) Hub  
**Email:** J.Mutuku@cgiar.org  
**Tel:** +254 20 422 3805  
**Specialty Area:** Plant-Pathogen Interactions, Plant Pathology, International Agriculture, Molecular biology

J. Musembi Mutuku is a Postdoctoral Scientist with the BecA-ILRI Hub ‘*Leaving a bad taste in aphids’ mouths*’ bean project. He is characterizing the genetic regulation of the plant virus-mediated manipulation of plant-aphid interactions. With a keen interest in crop improvement, Musembi studies molecular plant-pathogen interactions aiming to understand host plant immunity.

Musembi was trained as a molecular biologist at Saga University (MSc) before joining Kagoshima University for his PhD. His PhD work examined the interaction between rice and *Rhizoctonia solani* the pathogen that causes rice sheath blight disease under the supervision of Prof. Akihiro Nose. After his PhD, Musembi joined RIKEN as a Japan Society for the Promotion of Science (JSPS) Fellow studying the rice-*Striga hermonthica* interaction at the Ken Shirasu lab at RIKEN, Center for Sustainable Resource Science, Yokohama Japan. Musembi joined the BecA-ILRI Hub in July 2015, where he has successfully established a rhizotron-based *Striga* screening platform that is currently being used as a training tool for visiting national agricultural research systems scientists from the eastern and central Africa region.
Dr. Kwesi ATTA-KRAH

Nationality: Ghanaian  
Position Title: Director, Country Collaboration and Site Integration  
Institution: International Institute of Tropical Agriculture  
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Tel: +2348039784433

Specialty Area: Research management, Integrated Systems research, natural resources management, sustainable intensification, multi-stakeholder processes in R4D, collaboration and integration of research towards impact.

Dr. Kwesi Atta-Krah, a Ghana national, is currently Director, Systems and Site Integration, at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria - a position he has only recently assumed in January 2017. Prior to this, in the period January 2013 to December 2016, he was Executive Director of Humidtropics - the CGIAR Research Program on Integrated Systems for the Humid Tropics, based at IITA Ibadan Until January 2013, Dr. Atta-Krah was Deputy Director General of Bioversity International, a position he held from June 2005 up till 31 December, 2013. Earlier, he had worked with International Plant Genetic Resources Institute (IPGRI); International Livestock Centre for Africa (ILCA) – now ILRI; and with the International Institute of Tropical Agriculture, IITA.

He holds a BSc. in Crop Science from the University of Ghana, Legon (1977), and MSc and PhD degrees in Agroforestry/Natural Resources Management from the University of Ibadan in Nigeria. His professional interests and expertise spans Agronomy, Food Security and Natural Resources Management, and their linkages with environmental sustainability. Sustainable intensification is a key philosophy that guides this area of research. He has expertise in integrated systems research aimed at livelihoods enhancement for farmers and actors within production systems, and has experience in multi-disciplinary and multi-stakeholder research and development processes, for enhanced efficiencies and synergies.

Dr. Atta-Krah currently oversees research on the theme of integrated systems and sustainable intensification at IITA. He is interested in developing research partnerships related to:

- Innovation systems development through multi-stakeholder processes
- Integrated systems improvement for livelihoods enhancement. This would include situation and systems analysis, Sustainable productivity enhancement; trade off analysis and synergies development.
- Institutional Innovation and Scaling. This dimension of research will require use of multi-stakeholder processes, and using R4D and Innovation Platforms as mechanisms of engagement.
Dr. Rufaro Madakadze

Nationality: Zimbabwean
Position Title: Program Officer
Institution: AGRA
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Telephone: + 254 737 440 080

Area of specialty: Horticulture, Plant Breeding Traditional indigenous vegetables, Vegetable and Flower production, Seed Production and Physiology, Food safety, Codes of Practice for Horticulture Crop Production and Marketing, Capacity Building of from Farmers to PhD students in Agriculture and Youth in Agriculture.

Dr Rufaro Madakadze is a Zimbabwean national and a horticultural scientist trained in Michigan State University (USA) and the University of Guelph, Ontario (Canada) majoring in seed physiology and technology. She has taught crop sciences at the University of Zululand, South Africa and the University of Zimbabwe for 18 years and has mentored many postgraduate students. She was the Head of the Department of Crop Science at the University of Zimbabwe before moving to South Africa in 2005. She sat on the Agriculture Panel of the National Research Foundation (an institution that supports most of the research in South Africa) evaluating proposals for funding. She was also a member of the CTA Advisory Committee on Science and Technology for African, Caribbean and Pacific (ACP) countries for 5 years and was on the planning committee of the African Crop Science Society. Dr Madakadze has worked on various projects in Horticultural Sciences that included under and post graduate students training, commercial and smallholder farmers supported by DFID, EU, UNU/INRA and the Rockefeller Forum Foundation.

Dr Madakadze is currently in charge of Capacity Building at the Alliance for a Green Revolution in Africa (AGRA). The Capacity Building initiatives of AGRA aims to develop the skill sets and capabilities required to promote a value-chain driven transformation of the smallholder based agriculture in SSA. Before this she managed the Education for Africa’s Crop Improvement (since 2008) a sub-program that managed the training of plant scientists responsible for developing improved crop varieties and improving seed systems in Africa. She has managed over 17 training programs in Africa overseeing the training of over 1500 people, (500 post graduate students (MSc and PhD) and +1000 people trained in short term courses ranging from 1 week to 5 weeks in the African seed sector). She is a seed scientist with a passion for working with smallholder farmers and has +30 publications in refereed journals including book chapters in horticulture, seed science and capacity building.
Professor Naomi W Maina

**Nationality:** Kenyan  
**Position title:** Associate Professor of Biochemistry  
**Institution:** Jomo Kenyatta University of Agriculture and Technology  
**Email:** nmaina@jkuat.ac.ke  
**Tel:** +254 727 726 785

**Speciality Area:** Parasitology, Biochemistry, Molecular Biology and Toxicology.

Professor Naomi Maina was born in Nyeri, Kenya and earned PhD in Cell Biology (2006) from University of Basel, Switzerland. Her PhD thesis was on isolation, propagation, and characterization of *T. b. gambiense* isolated from sleeping sickness patients in South Sudan.

She has worked in Kenya Trypanosomiasis Research Institute (KETRI), Kenya as a senior research officer. Her research in KETR mainly geared towards improvement of chemotherapy and diagnosis of both animal and human trypanosomiasis. In 2005, she moved to Jomo Kenyatta University of Agriculture and Technology (JKUAT), Biochemistry Department and in July 2013 was promoted to Associate Professor in Biochemistry. She is also the Program Coordinator of Molecular Biology and Biotechnology (MSC and PhD) program in the Pan African University Institute of Science, Technology, and Innovation (PAUSTI), Pan African University under the African Union (from 2012 to date). She is a key player in a JKUAT project funded by JICA Technical Cooperation (2013 to date). The project aims at creating stable foundation of research and Education towards innovation in JKUAT.

Among others, she has guided towards development of both a molecular biology laboratory and a small animal facility. Her research is currently on Toxoplasmosis a ‘forgotten’ zoonotic disease in Kenya. The investigation on risk factors and the prevalence of the disease in cattle and slaughterhouse workers is funded by JKUAT-RPE. In addition, with extra funding from Canada-Africa Research Exchange Grants (CAREG) and in collaboration Prof Mutharia of University of Guelph she is investigating the genetic diversity of *Toxoplasma gondii* isolates from chickens and cats in Thika sub county, Kenya. She has published widely in peer-reviewed journals and presented her findings in many international conferences.

Professor Maina is interested in developing partnerships that would lead to improvement of management of parasitic infections by:

- Drug development utilizing the traditional African knowledge
- Development of molecular diagnostics test for diseases that can be used in rural Africa
- Creating awareness of Toxoplasmosis in Kenya by training healthcare providers and students in medical colleges.
Florence M. Munguti

Position: Ag. Officer-In-Charge-KEPHIS-Plant Quarantine & Bio-Security Station
Institution: KEPHIS
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Specialty Area: Plant disease diagnostics, phytosanitary regulations and pest management.

Florence Munguti is currently coordinating KEPHIS-Plant Quarantine & Bio-security station activities including coordination of all plant pest and disease diagnostic activities, coordination of quarantine imports including participation in Pest Risk Analysis and approval and issuance of plant import permits. She carried out her MSc Research work at BecA-ILRI Hub under the ABCF program. Her research work entailed utilization of next generation sequencing in identification of woodiness disease causal viruses. Out of her research work she was able to develop quick diagnostic protocol based on Loop Mediated isothermal amplification (LAMP) for use in passion fruit nursery certification. She has contributed to the ISO 17025 accreditation of the Plant Quarantine & Biosecurity laboratories at KEPHIS and has as well participated in review of diagnostic protocols at regional Plant Protection Convention. Florence and the team she coordinates have participated in training of participants from Eastern Africa and Kenya on plant disease diagnostics and phytosanitary regulations under a program called Centre of Phytosanitary Excellence (COPE), which KEPHIS coordinates.

The station she coordinates is also the Centre of excellence in germplasm exchange and distribution whereby it hosts projects in collaboration with IITA for cassava clean germplasm exchange, and International Potato Centre (CIP) for sweet potato and irish potato germplasm. These contribute to solving food insecurity in the region.

Florence is interested in developing partnership in these areas:
- Strengthening capacity in surveillances system for both quarantine and regulated non-quarantine diseases.
- Increase capacity to detect, diagnose, forecast and map plant pathologies in the field
- Increase capacity in remote sensing to estimate the establishment and spread of such pests
- Support for method validation, protocol development and laboratory accreditation
- Increased capacity in accurate, timely and reliable diagnosis system which allow appropriate phytosanitary decision making
- Increase capacity in diagnostics of new and emerging diseases especially viral diseases, and understanding the role of vectors in the transmission of the disease.
- Adoption of advanced diagnostic methods for new pests and pathogen discovery like next generation sequencing
- Develop Pest Risk Analysis information for market access
- Strengthen capacity of import regulation systems
Dr. Sam Mwangi

**Nationality:** Kenya  
**Position Title:** Regional Evidence Advisor, Africa  
**Institution:** Ecosystem Services for Poverty Alleviation (ESPA)  
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**Specialty Area:** Ecosystem Services, Multi-Dimensional Poverty, Dryland Resource Management, Environmental Law and Policy, Environmental Ethics, Project Management,

Sam’s foundation is in engineering, with a BSc in Appropriate Technology from Kenyatta University. The course content included, among others, renewable energy, water and sanitation, agricultural technology and innovation. He later studied for an MSc in Environmental Policy at the International University of Andalusia, Spain. He is now doing a PhD in Dryland Resource Management at the University of Nairobi.

Sam has worked in research, academia and programme management in various capacities in Kenya and the region. He has worked on research and documentation of indigenous knowledge, natural resource management and environmental policy. He has worked on ecosystem services research, such as pollination and carbon sequestration.

Sam started his career at the National Museums of Kenya to join the Utafiti Centre for Research and Technology, where he led a team in carrying out innovative work in developing local adaptive capacity to climate change. He left to teach at the University of Nairobi before heading out to head several NGO programs, including Team Leader at the Arid Lands Information Network and VACID Africa.

The ESPA Programme, where Sam works, aims to deliver high-quality, cutting-edge research that will improve understanding of the way ecosystems function, the services they provide and their relationship with the political economy and sustainable growth. ESPA's research provides the evidence and tools to enable decision-makers to manage ecosystems sustainably and in a way that contributes to poverty alleviation.

ESPA is a global interdisciplinary research programme funded by the United Kingdom’s Department for International Development (DFID), the Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC). **ESPA’s goal is to ensure that, in developing countries, ecosystems are being sustainably managed in a way that contributes to poverty alleviation as well as to inclusive and sustainable growth. Sam works as the Regional Evidence Advisor (Africa Region) for the Programme.**
Agnes Mwang’ombe is a full professor of plant pathology and who served as Principal, the College of Agriculture and Veterinary Sciences, University of Nairobi, Kenya. She served as Dean of Faculty of Agriculture, University of Nairobi (2003-2005). She holds a BSc Agriculture and MSc Plant Pathology from University of Nairobi and PhD in Plant Pathology and DIC from Imperial College of Science, Technology and Medicine, University of London.

Agnes has published several peer-reviewed papers in international journals and supervised several graduate students. During her career, she attracted several grants for basic and applied Agricultural research and capacity building. Her research work has focused on her core competency in addition to sustainable agriculture as influenced by climate change and economic empowerment. The research approach is multidisciplinary / multi-sectoral while bringing on board multi-institutionality. She has served as Principal Investigator for a number of Projects funded by among others, The Rockefeller Foundation; USAID project coordinated by CIAT, RAIN-ASARECA funded projects; Agricultural Innovation Dryland Africa (AIDA)- EU (INCO) project; Advancing Capacity to support Climate Change Adaptation (ACCCA) pilot project funded by UNITAR; SEMIs which includes Iowa State University, CYMMIT and University of Nairobi plus other partners; other projects are given in http://cavs.uonbi.ac.ke. The SEMIs project is dealing with capacity building of personnel mainly from private seed companies and the program has been a success for the last seven years (2010-2016). Visit: www.semis-africa.org and for further details visit http://cavs.uonbi.ac.ke
Dr. Martin Kiogora Mwirigi

Nationality: Kenyan  
Position Title: Biotechnology Research Scientist  
Institution: Kenya Agricultural and Livestock Research Organization (KALRO) – Biotechnology Research Institute, Nairobi, Kenya  
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Specialty area: Development and validation of livestock diseases diagnostic tests and vaccines.

Dr. Kiogora is a research scientist at the Kenya Agricultural and Livestock Research Organization (KALRO), Biotechnology Research Institute. He holds a BSc in Biochemistry and Chemistry, MSc in Applied Parasitology and PhD in Applied Parasitology (Immunology) from the University of Nairobi. He has 13 years of experience in research involving development of vaccines and diagnostic tests for livestock diseases. He has actively participated in various projects with the most current being, “Development of a vaccine for eradicating Contagious Bovine Pleuropneumonia in Africa”. The project is funded by the International Development Research Centre (IDRC) - Canadian International Food Security Research Fund (CFSRF). His PhD thesis is titled, “Determination of Mycoplasma mycoides subsp. mycoides components that confer protection against contagious bovine pleuropneumonia and understanding of immunological responses”. Dr. Kiogora is also the chair of the Biotechnology Technical Committee at the Kenya Bureau of Standards. Currently, he has been awarded ABCF Fellowship to conduct research at the BecA-ILRI Hub on, “Development of improved diagnostics for Capripoxvirus infections” (August, 2016- August, 2017).

Dr. Kiogora is interested in developing research partnerships in these areas:-

- Development of livestock diseases diagnostic tests that is fast and cost effective.
- Development of livestock diseases vaccines using modern biotechnology tools.
- Production and delivery of diagnostic tests to livestock farmers.
- Food and feed safety standards and guidelines development for Biotechnology derived products.
Professor Joshua O. Ogendo

Nationality: Kenyan
Position Title: Associate Professor of Crop Protection
Institution: Egerton University
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Specialty Area: Stored Product Entomology, bio intensive pest management, bio-prospecting for pesticidal plants, field plot techniques for agronomic evaluations in smallholder agriculture and biostatistics.

Prof. Ogendo is currently an Associate Professor of Crop Protection and Dean, Faculty of Agriculture, Egerton University. He earned a PhD in Agronomy (Crop Protection) at Egerton University (2008), MSc degrees in Agronomy and Grain Storage Management from University of Nairobi (Kenya; 1992) and University of Greenwich (UK; 2001), respectively and a Bachelor of Science degree in Agriculture from University of Nairobi, Kenya (1988).

Prof Ogendo has wealth of experience in participatory adaptive research and consultancy services focusing on bio-intensive pest management, enhanced food and nutrition security and livelihoods in smallholder agriculture. In the recent years, he has widened his research domain to span neglected species of crops, climate change and agro-biodiversity. He has been involved, as PI and collaborator, in 15 donor-funded research projects.

Prof Ogendo has published 29 papers in refereed journals, 3 book chapters/ book editorial and 40 conference papers. He is currently the Interim Chair, Pesticidal Plant Technologies Network (PEPTEN), a recently registered national NGO and member of 6 professional associations. He has supervised graduate students in agronomy (crop production, crop protection, plant breeding and weed science), horticulture, stored products entomology (botanical pesticides) and agriculture and rural innovation studies.

Prof Ogendo is interested in developing research partnerships in the following areas:

- Ecologically sound integrated pest management options for food crops in smallholder agriculture.
- Application of molecular techniques for development and promotion of new crop varieties with enhanced resistance / tolerance to specific pests and diseases in smallholder agriculture
- Identify new sources of resistance / tolerance to various pests and diseases of major food crops grown by smallholder farmers.
- Development of viable plant based products as alternatives to synthetic pesticides in smallholder agriculture and phytosanitary applications.
- Climate smart agriculture solutions in the marginal smallholder farming systems.
Dr. Gospel Omanya

**Position:** Senior Manager – Deployment, Directorate of Commercialization  
**Institution:** African Agricultural Technology Foundation (AATF)  
**Email:** g.omanya@aatf-africa.org  
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**Specialty Area:** Plant Genetics and Breeding, Technology Transfer, Product Deployment

Dr. Omanya is a Kenyan national, with 20 years of experience in agricultural research and development, including crop variety improvement, projects portfolio management, seed systems, product stewardship and delivery to farmers, especially to resource-limited small-scale farmers in Africa. He is a founder member of the Plant Breeders’ Association of Kenya. He holds a Ph.D. degree in Plant Genetics and breeding from the University of Hohenheim, Germany; M.Sc. in Plant Breeding and B.Sc. (Honors) in Agriculture, from the University of Nairobi, Kenya. He was also awarded Post-Graduate Diploma in Management of Agricultural Technologies, from Galilee College, Israel.

Before joining the African Agricultural Technology Foundation (AATF), Dr. Omanya was a Scientist at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Sahelian Center in Niamey, Niger, responsible for the Pearl millet improvement Program for West and Central Africa. His work on participatory variety selection with smallholder farmers in West Africa, led to dissemination of farmer-preferred improved pearl millet varieties to over 500 farmers in West Africa. Further, his previous work with ICRISAT validated laboratory and field techniques that are now available as multiple selection criteria for screening for *Striga* weed resistance in cereals.

At AATF, his key responsibilities have been in projects portfolio development and management, coordination and capacity building of seed system stakeholders, product stewardship, and deployment of herbicide-tolerant maize seed technology and drought tolerant maize hybrids in eight countries across Africa. These responsibilities have further accorded him rich experience in coordinating research and development networks and partnerships along the product delivery pathways, for sustainable out-scaling and technology transfer of crop productivity improvement technologies to farmers in Sub-Saharan Africa.
Dr. Tilly Eldridge

Nationality: British
Position title: Post-Doctoral Scientist
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Speciality Area: Plant development, Plant beneficial microbes, Genomics, Plant genetics, Molecular Biology, Synthetic Biology, Microscopy and Imaging.

Tilly Eldridge was born in Worcestershire in the UK and earned her PhD in Plant Development at the John Innes Centre, UK. Tilly is the first Post-Doctoral scientist from the John Innes Centre (JIC) to be posted at the BecA-ILRI Hub in May 2015. Over the last couple of years she have been responsible for developing relations between the two institutes and increasing the contributions of JIC to capacity building programmes at the BecA-ILRI Hub. She has mentored visiting scientists, developed and co-ordinated training workshops and been involved in transferring technologies such a synthetic biology platform from JIC to BecA. Tilly also plays a role in linking visiting scientists from African national programs to JIC scientists (and the broader UK scientific community) and in supporting any visitors from JIC that visit BecA, this has included students on 3 months placements and JIC faculty on short visits. Tilly’s Ph.D. focus was on model plants however she is now moving into research on the microbiome of crop species.
Claudine Razanaboahirana

**Nationality:** Malagasy  
**Position Title:** Research Assistant  
**Institution:** National Research Center for the Rural Development (FOFIFA)  
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**Tel:** +261340439134, +254739938065

**Specialty Area:** Rice breeding, climate change, molecular biology.

Ms Claudine Razanaboahirana was born in Fianarantsoa, Madagascar and earned a Master in agronomy at ASJA University.

Four years’ experience working on rice research field in the central highland in Madagascar, she has been actively involved in Rice Breeding area and in various activities such as « Multi-Environment Trial, Participatory Evaluation Trial and Participatory Advanced Trial », evaluation of the newly introduced rice on Cold tolerance, Iron toxicity tolerance and flood tolerance funded by STRASA (2013-2017). She conducted trials for Participatory Varietal Selection (PVS) to determine varieties preferred by farmers funded by AfricaRice (2013-2016). She is currently involved in the new project called « Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa » with partner JIRCAS (2016-2022).

Her research topic is “Genetic diversity of rice with red caryopsis in Madagascar and O glaberrima of Togo” and its improvement. This research area is very important because this rice with red caryopsis is very appreciated by the Malagasy people and it is a staple crop in Madagascar. Ms Claudine Razanaboahirana won ABCF Fellowship to conduct the research at the BecA-ILRI Hub to do molecular characterization of rice (September, 2016- February, 2017).

Claudine is interested in developing research partnerships in the following areas:

- The application of new technologies to enhance phenotypic data collection in the field.
- The application of the technology on breeding program (molecular breeding).
- Studying the impact of the climate change on production.
- Identify and create a new cultivar with high performance, high yield, resistant on pest and diseases.
Dr. Ivan Rwomushana

**Nationality:** Ugandan  
**Position Title:** Research Scientist, Plant Health Theme  
**Institution:** icipe-African Insect Science for Food and Health, Nairobi, Kenya  
**Email:** irwomushana@icipe.org  
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**Specialty Area:** Entomology, ecology and design of Integrated Pest Management options for the management of arthropod pests

Dr. Ivan Rwomushana was born in Kampala, Uganda and obtained a PhD in Agricultural Entomology from Kenyatta University (2008) under the African Regional Postgraduate Programme in Insect Science hosted at icipe (Kenya). His research focused on managing an invasive fruit fly pest, *Bactrocera dorsalis* in Kenya. He worked on temperature effects on this pest including optimization of mass rearing procedures, development and evaluating attractants and interspecific competition studies of invasives with native species.

Thereafter he moved to the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), a Sub Regional Organization for Eastern and Central Africa where he was Manager for the Staple Crops Programme and later the Theme Manager for Sustainable Agriculture, Food Security and Nutrition (SAFSN). His portfolio at ASARECA covered Agricultural Research and Development on 9 Staple Crops commodities. He moved back to icipe in 2015 as a Research Scientist with the IPM cluster in the Plant Health Theme and is currently the Interim Head, Plant Health Theme. His research activities involve development of sustainable IPM options for the management of fruit flies and other arthropod pests that constrain fruit production in sub-Saharan Africa. His work involves employing balanced basic and applied research based on the use of baiting and male annihilation techniques, biopesticides, natural enemies’ conservation and classical biological control methods and use of soft pesticide for suppression of the tree crop pests. Ivan has interacted widely with national and international R&D organisations in Africa and presented in various high level forums.

Ivan is interested in developing research partnerships in these areas:

- Applying ecological research and IPM approaches to develop eco-friendly interventions to manage horticultural crops pests
- Integrating IPM and pollination services for enhanced system productivity
- Invasion pathways for invasive pests (vectors) of horticultural crops
Dr. Francesca Stomeo

**Nationality:** Italian  
**Position Title:** Scientist – Capacity Building  
**Institution:** BecA-ILRI Hub  
**Email:** f.stomeo@cgiar.org  
**Tel:** +254 20 422 3859  

**Specialty Area:** Genomics, microbial ecology, crops improvement and diagnostics, plant diseases, viral/pathogens diversity and discovery.

Originally from the South of Italy, Francesca obtained a BSc in Biology from the University of Pavia in the North of Italy, an Advanced Studies Diploma (DEA) in Genetics and Microbial Technologies from the University of Seville (Spain) and a European Marie Curie Ph.D. in Microbiology and Molecular Biology at the Institute of Natural Resources and Agrobiology of Seville (IRNASE), part of the Superior Council of Scientific Investigations (CSIC), in Spain. Before joining the BecA-ILRI Hub in 2012 she was a post doc at the Institute for Microbial Biotechnology and Metagenomics (IMBM) at the University of the Western Cape, (UWC), Cape Town, South Africa. Francesca Stomeo was appointed as a Scientist – Capacity Building at BecA-ILRI Hub, in January 2015 after the completion of a three-year post-doctoral fellowship in genomics. She has worked extensively on microbial diversity studies in different environments, crop diagnostics and improvement, including the understanding of emerging diseases using genomics tool. At the BecA-ILRI Hub she established the genomics platform, currently used routinely for metagenomics, transcriptomics and gene expression analysis in crops and livestock systems and in environmental research projects. As a capacity building scientist, she mentors and supervises visiting scientists and research staff providing them the right environment for their research. She has expertise in microbiology, molecular biology, bio-technology and genomics.
Dr. Christian Keambou Tiambo

Nationality: Cameroonian
Position: Senior Lecturer of Animal Breeding and Genetics Improvement, Coordinator of Animal Science Programmes
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Specialty Area: Animal Breeding and Genetics Improvement

Dr Christian Keambou Tiambo studied Animal eco-parasitology at the Faculty of Science and Animal Breeding and Genetics Improvement at the Faculty of Agronomy and Agricultural Sciences of the University of Dschang (Cameroon). He is a Senior Lecturer at the University of Buea and Universite des Montagnes in Cameroon, and Part time Lecturer at the Pan African University Institute of Science, technology and Innovation (PAUISTI) in Kenya. Coordinator of Animal Science Programme at the University of Buea, and steward of the Local Chicken Community of Practice (CoP) hosted by BecA-ILRI Hub, a group bringing together local chicken scientists based in 12 countries of Western, Central and Eastern Africa. Member of Animal Genetic Resources Taxonomy Advisory Group for the African Union InterAfrican Bureau for Animal Resources (AnGR-TAG/AU-IBAR).

His laboratory and field research, over the past 10 years, seeks to characterize local chicken populations and improvement of their productivity, with the overall goal of improving livelihoods in rural Africa. He also focused on the best use of locally available resources for animal feed and health protection, gene expression profiling of those animals in response to natural substances used as prebiotics and growth promoters, and participatory approaches in community-based livestock programme to generate and/or contributed advancing knowledge in livestock genetic research for development.

His research team of students, postdoctoral fellows, technicians and senior scientists work with expert livestock genetic/genomic co-investigators to discover and exploit novel genes with potential impact on productivity, adaptability and disease resistance. His multidisciplinary and multinational research team takes a participatory and integrated approach in identifying the issues affecting local chicken productivity across the regions, including:

- Local chicken genetics research for improvement of productivity, added value development and business planning,
- Pathogenic strains characterization and identification,
- Diagnostics tools development and disease control,
- Capacity building and management,
- Livestock nutrigenomics (special focus on chicken),
- Gene discovery and Marker Assisted selection for productivity and disease control
- Conservation, breeding and dissemination
- Sustainability and environmentally friendly production systems, etc.
Santie de Villiers

**Nationality**: South African  
**Position**: Associate Professor in Biotechnology,  
**Institution**: Pwani University, Kilifi, Kenya  
Science Advisor to AWARD, Nairobi, Kenya  
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Website: www.pu.ac.ke

Santie de Villiers is a South African national living in Kenya since 2002. She is a faculty member of Pwani University (PU) on the Kenya Coast since 2013. She teaches Biotechnology and Biochemistry, supervises students on research projects and coordinate local, national, regional and international research projects. Prior to joining Pwani University, Santie was a senior scientist with ICRISAT-Nairobi where she worked with international collaborators and national program partners in Africa, doing research on crop Biotechnology, mostly in genomics, genetic engineering and marker assisted breeding applications of ICRISAT mandate crops (sorghum, millets, pigeon pea and groundnut).

Santie currently coordinates research projects on characterizing the finger millet blast pathogen in eastern Africa (supported by the BMGF PEARL programme) and is working towards establishing capacity in Genomics and Bioinformatics at PU. Part of this involves the establishment of a semi-autonomous Biosciences Research facility at PU in collaboration with the KEMRI-Wellcome Trust Research Programme.

She also serves as Science advisor to the African Women in Agricultural Research and Development (AWARD) programme, which builds science leadership and expertise amongst African women in Agriculture.
Dr. Bernard Vanlauwe

Nationality: Belgium

Position Title: R4D Director Central Africa and Natural Resource Management

Institution: International Institute of Tropical Agriculture (IITA)

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Specialty Area: Sustainable intensification of smallholder farming systems in sub-Saharan Africa; integrated soil fertility management; maize, legume, and cassava agronomy; integrated striga management; farming system analysis; soil organic matter and nutrient dynamics

Dr. Bernard Vanlauwe joined IITA in Kenya in March 2012 to lead the Central Africa hub and the Natural Resource Management research area. In this capacity, he is also having an oversight role in the Humidtropics, the Water, Land, and Ecosystems, and the CCAFS CGIAR Research Programs. Prior to this recent appointment, he was the leader of the Integrated Soil Fertility Management (ISFM) program of the Tropical Soil Biology and Fertility research area of CIAT (TSBF-CIAT). He joined CIAT-TSBF in 2001 and led the development, adaptation, and dissemination of best ISFM options in various agro-ecological zones in sub-Saharan Africa. In September 2010, the obtained a Visiting Professor position at the Swedish Agricultural University in Uppsala in the Soils and Environment Department. Before, he worked at IITA in Nigeria (1991 – 2000) and the Catholic University of Leuven, Belgium (1989-1991), focusing on unraveling the mechanisms underlying nutrient and soil organic matter dynamics in tropical agro-ecosystems. In that context, he obtained his PhD in 1996 in Applied Biological Sciences. He has published over 150 papers in scientific journals and over 160 in other forms and has (co-) supervised over 40 PhD and over 60 MSc students.

Bernard is interested in developing research partnerships in these areas:

- Sustainable intensification of smallholder farming systems in sub-Saharan Africa
- Integrated soil fertility management, including aspects of appropriate fertilizer and organic input management and soil acidity management
- Farming system analysis, including targeting production resources, trade-off analysis, and integration of farmer typologies in R4D processes
- Maize, legume, and cassava agronomy, including aspects of intercropping, managing planting windows to manage climate variability, integration of improved germplasm in combination with good agronomic practices
- PhD-related capacity development projects in the context of the above
Dr. Gnamien Sylvain TRAORE

**Nationality:** Ivorian  
**Position Title:** Doctor in Microbiology and food security  
**Institution:** Centre Suisse de Recherches Scientifiques en Côte d’Ivoire (CSRS)  
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**Specialty Areas:** Epidemiology, Zoonosis, neglected tropical diseases, foodborne diseases and risk assessment of animal foods in informal sector ecology.

Dr. Gnamien Sylvain TRAORE was born in Abidjan, Côte d’Ivoire on 16th May 1976. In 2006, he received his Master of Microbiology at University of Nangui Abrogoua. In January 2009, he started a PhD entitled ‘Risk of *Vibrio* and *Paragonimus* transmission linked to the consumption of shellfish sold on informal markets of Abidjan and Dabou’ at CSRS. From September 2010 to June 2011 he took courses in Epidemiology and Biostatistics at the University of Basel and the Epidemiology & Public Health Department of the Swiss Tropical and Public Health Institute in Basel (Swiss TPH), Switzerland. In September 2012, he took part in a training course on participatory risk analysis at Rakuno Gakuen University, Japan. He has acted as assistant coordinator in three projects in the last five years: 1) Afrique One ‘Ecosystem and population health: expanding the frontiers in health’ financed by the Wellcome Trust, UK; 2) the risk characterization of *Streptococcus infantarius* subsp. *infantarius* (Sii) isolated from African fermented dairy products: Options for dairy development in Côte d’Ivoire; 3) Safe Food Fair Food: from capacity building to implementation. Risk-based approaches to improving food safety and market access in smallholder meat, milk and fish value chains in four African countries. Furthermore, he was member of the team of expert on backstopping in a project financed by the Swiss Cooperation on support for the modernization of family farms in the rice, market gardening and input sectors. He was a fellow of the International Foundation for Science (IFS) and a fellow of the Swiss Confederation at University of Basel and Swiss TPH. In addition, he was a fellow of a strategic programme to support scientific research in Côte d’Ivoire. In this frame he was awarded the third prize for the best action to enhance research and innovation, at the national level, by introduction of Participatory Risk Analysis in curricula of Licence 3 at University Peleforo Gon Coulibaly, in 2016. Currently he is assistant coordinator of the project ‘Estimating the impact of canine rabies on human health and determining the need for post-exposure prophylaxis case of Côte d’Ivoire’ and lecturer at Université Péléforo Gon Coulibaly (Côte d’Ivoire) in Microbiology and Food Security.

Dr Traore is interested in developing research partnerships in the following areas:

- Enhancing livestock keepers livelihoods through healthier animals and milk safety in northern Côte d’Ivoire  
- Organizing livestock keepers and establishing a dairy unit in northern Côte d’Ivoire for the improvement of the dairy unit value chain
Dr. Roger Pelle

**Nationality:** Cameroonian  
**Position Title:** Principal scientist, molecular parasitology  
**Institution:** BecA-ILRI Hub  
**Email:** r.pelle@cgiar.org

**Specialty Area:** animal health, molecular epidemiology, molecular parasitology, subunit vaccine and diagnostics development, host-pathogen interaction and population diversity, zoonoses, capacity building

Roger Pelle was born in Cameroon and after a Master degree in biochemistry at the University of Yaounde he pursued his education at the University of Louvain, Belgium, where he obtained an M.Phil. degree in environment and applied biology in 1985 and a PhD degree in molecular biology on onco-embryogenes expression profiling and fingerprinting characterization of cloned malignant cell lines in 1989. He then joint ILRI in 1990 as a Postdoc scientist working on characterization of African trypanosome genes involved in immunosuppression and parasite differentiation. In this field, he developed a simple and efficient technique published in the Nucleic Acid Research journal to electrophoreose RNA as easily as DNA. In addition, he published a simple method to differentiate trypanosome species using their electrophoretic RNA profiles. He also co-developed a new molecular technique (RADES-PCR, published in peer reviewed journal and as a book chapter) to accelerate the rate of identification of important genes and their products in protozoa. He was promoted at the position of research scientist level 1 in 1993. Subsequently he became research scientist level 2, then senior scientist. In 2001, he moved into the ILRI East Coast fever research program on vaccine development. During the avian influenza outbreaks in 2006-07, he co-organized and conducted laboratory diagnostic hands-on training on HPAI virus in several regions for over 90 Veterinary and Medical Laboratory Staff from 36 African countries. Since 2015, he hold the position of principal scientist. In that regard, he has been instrumental in the collaborative research effort that has led to the identification of CD8 T-cell antigens from Theileria parva, which are now being characterized as candidate vaccine antigens against East Coast fever and tropical theileriosis. He has supervised/ co-supervised over 10 PhD students and much more at the level of MSc and MPhil. In addition, he has supervised over 100 African scientists through hands-on training workshops and short research trainings of up to 10 months. He has supervised/ co-supervised over 10 PhD and 20 at MSc and MPhil students. He is author and co-author of over 45 books, book chapters and publications in peer-reviewed journals and of a research patent on ECF vaccine antigens. Since 1997, he has served as a member of the Steering Committee and adviser of WHO programs, a scientific adviser for the International Foundation for Science (IFS), an editorial board of the African Union - Interfafrican Bureau for Animal Resources (AU-IBAR) bulletin of Animal Health and Production in Africa, a member of the working group that drafted the current Kenya National Guidelines on animal care and use in research and training, and as chair of the ILRI's Institute Animal Care and Use Committee (IACUC).

Roger Pelle is interesting in developing research partnerships in these areas:

- Improved control of priority African livestock and crop diseases, including orphan / underutilized species;
- Exploiting genetic diversity for conservation, resistance to disease and improving productivity of crops and livestock Host-pathogen interactions; epidemi-surveillance; rapid diagnostics for crop and livestock diseases.
Mr. Philip Kiriro

Nationality: Kenyan
Position Title: President
Institution: Eastern Africa Farmers Federation
Email: info@eaffu.org
Tel: +254 20 451691

Mr Kiriro is the founder of Eastern Africa Farmers Federation (EAFF). He is also founder and board member of the Pan-African Farmers Organization (PAFO). He is a member of CAADP-partnership committee and up to 2013, he has been a board member of ASARECA. Mr Kiriro has been involved in farmer organizations’ leadership for the last twelve years, focusing on farmer organization and capacity building. He has worked closely with international institutions and government (i.e. FAO, IFAD, CTA IFDC, AGRA, DFID, IFPRI, AGRITERA, SCC, GIZ, SDC, USAID, COMESA, EAC) and many others, on capacity building of produce organizations, policy, trade and food security issues. Mr Kiriro is a farmer and holds a BSC and MSC in animal science from Texas A&M university USA. He is currently the president of the Eastern Africa Farmers Federation (EAFF).

Mr Kiriro is interested in developing research partnerships in these areas:

- Alfatoxin
- Livestock development
- Women and youth in Agriculture
- Climate change, mitigation and adaptation
- Documentation of Agricultural projects especially impacts areas and upscaling
- ICT 4 Ag services
Josie Maidment

**Nationality:** British  
**Position Title:** PhD Student (BBSRC DTP)  
**Institution:** John Innes Centre  
**E-mail:** josephine.maidment@jic.ac.uk  
**Tel.:** +447857390594 (UK), +2557990120177 (Kenya)  
**Speciality Area:** Molecular plant pathology, effector biology, protein biochemistry, structural biology and macromolecular crystallography.

Josie is originally from South West Wales, and gained a BA (Hons) First Class in Natural Sciences from Queens’ College, University of Cambridge (2014). In 2013, she obtained a BSPP studentship to investigate how trichome patterning in tomato affects aphid feeding behaviour and fecundity in the lab of Dr John Carr (Department of Plant Sciences, University of Cambridge). During the final year of her undergraduate degree, she specialised in Plant Sciences and became interested in the activities of effector proteins and the molecular interactions underlying disease and susceptibility. Josie is a postgraduate student in the lab of Professor Mark Banfield in the Department of Biochemistry at the John Innes Centre. Her research uses a range of biochemical and biophysical techniques to characterise the functions of a widespread family of effector proteins produced by the rice blast fungus *Magnaporthe oryzae* and elucidate the structural basis of their interactions with rice proteins. She is particularly interested in research with applications to agriculture in developing countries. She is funded by the BBSRC DTP, and is currently supporting capacity building activities at the BecA-ILRI as part of the BBSRC PIPS (Professional Internships for PhD Students) scheme.

As an early career researcher with a broad interest in plant pathology, Josie would welcome the opportunity to speak to scientists working in molecular plant pathology, particularly those involved in projects with translational impact in Sub-Saharan Africa.
Eleni Vikeli

**Nationality:** Greek  
**Position Title:** PhD Researcher  
**Institution:** John Innes Centre /University of East Anglia  
**Email:** eleni.vikeli@jic.ac.uk  
**Tel:** +44 7477 120094/ +254 798985517

**Specialty area:** Antibiotics, Antibiotic Resistance, Natural Products from Microbes, Molecular Microbiology, Biotechnology, Genome mining, Metabolomics, and Bioassays.

Eleni Vikeli was born in Pireas, Athens, Greece and did her undergraduate degree in Biotechnology (equivalent to MSc in Agricultural Engineering) in the Agricultural University of Athens (A.U.A.)(2007-2013). Her dissertation research was focused on the development of a cellular biosensor based on *Lactobacillus brevis*, for the detection of 2, 4, 6-trichloroanisole (TCA). During her studies, she had various placements working on tissue culture of aromatic herbs, biomolecular analysis of natural compounds and biosensors. Before completing her undergraduate studies, she completed an Erasmus placement in Professor Malone’s Lab at the John Innes Centre, UK. There she worked on characterizing the role played by the bacterial intracellular signalling molecule cyclic-di-GMP in colonisation of the wheat root environment (the rhizosphere) by the commensal soil bacterium *Pseudomonas fluorescens* SBW25. Back in Athens she gained an MSc in Applications of Biotechnology in Agriculture (2013-2014) working on Bioactive compounds and Protein Technology at the Agricultural University of Athens.

Currently she is pursuing a PhD on the discovery of novel antimicrobials from the nests of Kenyan fungus growing ants, in the lab of Barrie Wilkinson at the John Innes Centre (JIC), UK with funding by the BBSRC DTP (2014-today). Her research focuses on using a combination of methods and techniques such as metabolomics (unbiased and non), chemical characterisation genome mining and analysis as well as bioassays to discover and characterise antimicrobial compounds. The main interest of this research is the battle against multidrug resistant microorganisms and the exploring of uncharacterised species of microbes with a great number of active or silent biosynthetic gene clusters (BCG’s).

Furthermore, she is interested in science communication and outreach events. She has been a participant/organiser to various projects such as the Antibiotic Hunters Team in JIC/University of East Anglia (UEA), UK as well as in events promoting youth awareness on science matters.

In Nairobi, she is working on supporting capacity building activities as a communications assistant at the BecA- ILRI hub as part of the BBSRC PIPS (Professional Internships for PhD Students) scheme, delivering material on courses and organising her own presentation skills workshop for the ABCF Fellows group, for effective presentations to various audiences that make a difference and stay memorable.

She would be interested in meeting anyone with an interest in emerging dangers of multi-drug resistance in developed and developing countries as well as people involved in science communication.
Blessing Adanta Odogwu

Nationality: Nigerian  
Position Title: Lecturer  
Institution: University of Port Harcourt, Nigeria  
Email: blessing.odogwu@uniport.edu.ng  
Telephone: +256 78389763

Specialty Area: Blessing A. Odogwu is an Assistant lecturer in the department of Plant Science and Biotechnology, University of Port Harcourt, Nigeria. She has 9 years of experience in teaching and research in basic and applied plant sciences. She is an African Women in Agricultural Research and Development (AWARD) fellow. She is also a recipient of the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM)/ Carnegie Corporation of New York, USA Scholarship and the Norman Borlaug Leadership Enhancement in Agricultural Programme (LEAP) fellowship.

Odogwu Blessing A. is currently enrolled as a PhD student in Plant Breeding and Biotechnology at Makerere University, Uganda (2013-2016). Her research study is on “Resistance to common bean rust *Uromyces appendiculatus* Pers. (Pers.) Unger in Uganda”. This research was recently initiated to provide information for the national legume programme in Uganda. She won an ABCF Fellowship to conduct part of the research at the BecA-ILRI Hub (August, 2016- May, 2017).

Blessing is interested in developing partnerships in the following areas:
- Crop resistance to disease and pest
- The application of modern technologies to enhance phenotypic data collection
- Enhancement of skills, and integration of genomic tools in plant breeding and crop improvement
- Crop improvement and development of new varieties with resilience to abiotic and biotic stresses
Oluwafunmilayo Oluwanifemi Adeleye

Nationality: Nigerian
Position: Lecturer/Researcher, Agricultural Biochemistry and Nutrition
Institution: Department of Animal Science, University of Ibadan, Nigeria
Email: ooadeleye@rocketmail.com
Tel: +234 803 707 4723

Specialty area: carbohydrate nutrition, carbohydrate-protein interactions and their influence on gut health, monogastric feeds and feeding

Oluwafunmilayo O. Adeleye is a Lecturer/Researcher in the Agricultural Biochemistry and Nutrition Unit of the Department of Animal Science at the University of Ibadan, Nigeria, a position which she has held for 5 years. She teaches courses in starch/protein biochemistry and their nutritional implications/interactions in foods and livestock feedingstuffs. She is also a 2015 fellow of African Women in Agricultural Research and Development (AWARD).

Funmi holds a B. Agric (Hons) in Animal Science from the Obafemi Awolowo University, Ile Ife, Nigeria and an MSc and PhD in Agricultural Biochemistry and Nutrition from the University of Ibadan, Nigeria. Funmi has been involved in studying the prebiotic potential of selected carbohydrate-rich feedstuffs for broiler chicks, effectiveness of resistant starches of potatoes and green bananas in improving mineral bioavailability, absorption and bone integrity of broiler chicks as well as the impact of non-conventional starches on digestion, metabolism, gut environment and microbial diversity in broiler chickens funded by the International Foundation for Science, IFS (2013-2016). She is currently researching the use of high temperature-short time extrusion cooking in processing grain legumes for livestock feeding.

Funmi is currently conducting research at the BecA-ILRI Hub to assess the influence of high temperature-short time extrusion of Bambara groundnut (*Vigna subterranea*) and pigeon pea (*Cajanus cajan*) on gastrointestinal microbial communities of broiler chicks under an ABCF Fellowship from October, 2016 to May, 2017.

Funmi is interested in developing research partnerships and collaborations in solving nutritional challenges using molecular tools and exploring molecular –level interaction between nutrition and genes towards efficient and sufficient anima livestock production.
Dr. Shirima, Eligy J. Mussa

Nationality: Tanzanian  
Position Title: Director General - TALIRI  
Institution: Tanzania Livestock Research Institute (TALIRI)  
Email: shirimamussa@yahoo.co.uk

Specialty Area: Research Scientist in Meat Sciences basically of feedlot of indigenous sheep, goats and cattle, farming system research in Tanzania, Fodder production and Utilization

Dr. Eligy J. Mussa Shirima earned his PhD in Meat Sciences in year 2013 from Sokoine University of Agriculture (SUA), in Morogoro Tanzania. His major research study was on feedlot study for quality and quantity meat production from indigenous sheep of Tanzania using Molasses-based concentrate as the main source of energy and protein.

Between 1992-1994, Dr. Shirima also studied MSc in Sustainable Animal Production System from Swedish University of Agricultural Sciences in Uppsala Sweden, where he researched on Utilization of cereal foliage for dry season feeding using early harvesting and conservation techniques.

Dr. Shirima has also an experience of 30 years of livestock research working with Tanzania Livestock Research Institutes and for the last five years at the Ministry’s headquarter as the National Coordinator for Meat Research in Tanzania until October 2016, when he was appointed as the Director General (DG) of TALIRI by H.E. Hon. John P. Magufuli (President of the United Republic of Tanzania). Throughout his working period, Dr. Shirima has over 50 peer reviewed publications in local and international journals and he has been a Principal Investigator and Co-Investigator to over 10 donor funded agriculture-related projects in Tanzania especially in the semi-arid regions of Tanzania.

As the DG of TALIRI, Dr. Shirima is interested in developing research partnerships in these areas:

- Integrated livestock-crop management for commercial livestock and crops production especially in semi-arid and pastoral areas of Tanzania where there is critical grazing and cropping land conflicts
- The application of new technologies to enhance data collection in livestock and forage production
- Forecasting livestock feed shortage in major livestock keeping areas of Tanzania
- Biotechnology research in animal breeding and production using modern technologies like MOET, AI techniques and Bull Selection
- Identifying new areas of capacity building for TALIRI staff for future research in Tanzania
- Studying the likely impacts of different climate change parameters on development of feed shortage mitigations in livestock in both arid and semi-arid areas of Tanzania
- Sustainable means of value addition to livestock products and by-products for livelihood of small scale livestock keepers
PARTNER ORGANISATION PROFILES

Biotechnology and Biological Sciences Research Council (BBSRC)

The Biotechnology and Biological Sciences Research Council (BBSRC) is the UK’s leading funder of academic research and training in the non-clinical life sciences. BBSRC invests in world-class bioscience research and training on behalf of the UK public. Our aim is to further scientific knowledge, to promote economic growth, wealth and job creation and to improve quality of life in the UK and beyond.

Funded by Government, BBSRC invested over £473M in world-class bioscience in 2015-16. We support research and training in universities and strategically funded institutes. BBSRC research and the people we fund are helping society to meet major challenges, including food security, green energy and healthier, longer lives. Our investments underpin important UK economic sectors, such as farming, food, industrial biotechnology and pharmaceuticals.

For more information about BBSRC, our science and our impact see: http://www.bbsrc.ac.uk

For more information about BBSRC strategically funded institutes see: http://www.bbsrc.ac.uk/institutes

The BecA-ILRI Hub

The Biosciences eastern and central Africa-International Livestock Research Institute (BecA-ILRI) Hub is a shared agricultural research and biosciences platform located at and managed by ILRI in Nairobi, Kenya. The platform increases access to world class laboratories for African and international scientists conducting research on African agricultural challenges. The BecA-ILRI Hub was established as part of the African Union/New Partnership for Africa’s Development (AU/NEPAD) African Biosciences Initiative (ABI). It was developed within the framework of NEPAD’s Centers of Excellence for Science and Technology and the Comprehensive African Agricultural Development Programme (CAADP), and in alignment with regional priorities. All research projects implemented at the BecA-ILRI Hub are directed towards delivering products to help improve food and nutritional security in Africa.

**BecA Countries**

The countries include Burundi, Cameroon, Central Africa Republic, Congo Brazzaville, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Kenya, Madagascar, Rwanda, Sao Tome and Principe, Somalia, South Sudan, Sudan, Tanzania, Uganda. Although these are the main countries of focus, BecA-ILRI Hub’s activities go beyond these countries.

More information is available at: hub.africabiosciences.org
The Sustainable Intensification Research Network (SIRN)
SIRN is a UK community-led network to encourage and facilitate high-quality systems-orientated research relevant to the sustainable intensification (SI) of agriculture. This network provides a forum for information exchange between researchers, funders and stakeholders, about research capabilities, facilities and resources, training opportunities, funding schemes and user needs that aim to address the challenges posed by SI. The SI Network is funded by the Biological and Biotechnology Sciences Research Council (BBSRC) and the Natural Environmental Research Council (NERC).

For further information, see: www.sirn.org.uk

The John Innes Centre (JIC)
The John Innes Centre (JIC), located in Norwich, UK, is an international centre of excellence in plant science and microbiology. Research at JIC encompasses a broad range of disciplines in the biological and chemical sciences, and aims to address global challenges in food security, human health and industrial biotechnology. JIC endeavours to generate knowledge of plants and microbes through innovative research strategies, and to apply this knowledge to benefit human health, agriculture and the environment. The John Innes Centre has four Institute Strategic Programmes funded by the BBSRC; Growth and Development Underpinning Yield, Biotic Interactions for Crop Productivity (in partnership with The Sainsbury Laboratory, Norwich), Understanding Plant and Microbial Metabolism, and Wheat Improvement (a cross-institute strategic programme). JIC benefits from strong links with the other institutes on the Norwich Research Park (Earlham Institute, The Institute for Food Research, and The Sainsbury Laboratory), and enjoys successful collaborations with universities and research institutes worldwide. More information available at: www.jic.ac.uk

Bioversity International
Bioversity International is a global research-for-development organization. We have a vision – that agricultural biodiversity nourishes people and sustains the planet. We deliver scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security. We work with partners in low-income countries in different regions where agricultural and tree biodiversity can contribute to improved nutrition, resilience, productivity and climate change adaptation.

Bioversity International is a CGIAR Research Centre. CGIAR is a global research partnership for a food-secure future.
www.bioversityinternational.org
CONTACTS

If you have any questions during, or following the workshop, please speak to one of the following colleagues:

**Biotechnology and Biological Sciences Research Council (BBSRC)**

**Brian Harris:** (joint) Head of Agriculture and Food Security  
Email: brian.harris@bbsrc.ac.uk  
Telephone: +44 (0) 1793 413249

**Kerry Firth:** Strategy and Policy Manager  
Email: Kerry.firth@bbsrc.ac.uk  
Telephone: +44 (0) 1793 442526

@BBSRC

**Biosciences eastern and central Africa-International Livestock Research Institute (BecA-ILRI) Hub**

**Wellington Ekaya:** Lead, Africa Biosciences Challenge Fund (ABCF) Program  
Email: w.ukaya@cgiar.org  
Telephone: +254 722 278249  
Twitter: @EkayaEkaya

**The Sustainable Intensification Research Network (SIRN)**

**Adélia de Paula:** Sustainable Intensification Research Network Coordinator  
Email: info@sirn.org.uk  
Telephone: +44 (0) 1582 938260

**John Innes Centre**

**Tilly Eldridge:** Visiting Scientist at the BecA-ILRI Hub  
Email: Tilly.Eldridge@jic.ac.uk / T.Eldridge@cgiar.org  
Telephone: +254 703 201137

**Bioversity International**

**Daniel McGonigle:** Initiative Manager: Farms, Forests and Landscapes  
Email: d.mcgonigle@cgiar.org  
Tel (+39) 06 6118 269
# ANNEX 2: WORKSHOP PROGRAMME

**Monday 13 March 2017**

## Day 0: (optional) field visits and welcome reception

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depart from Pride Inn for BecA-ILRI</td>
<td>08:00</td>
</tr>
<tr>
<td>Field trip briefing and general introductions</td>
<td>09:00</td>
</tr>
<tr>
<td>Field visits (including lunch) organised by Kenya Agricultural and Livestock Research Organisation (KALRO) and Kenya Plant Health Inspectorate Service (KEPHIS)</td>
<td>10:00</td>
</tr>
<tr>
<td>Return to Pride Inn</td>
<td>16:00</td>
</tr>
<tr>
<td>Depart from Pride Inn for ILRI</td>
<td>17:00</td>
</tr>
<tr>
<td>Welcome reception and buffet at ILRI, including introductions from all participants</td>
<td>18:00</td>
</tr>
<tr>
<td>Depart for Pride Inn</td>
<td>20:00</td>
</tr>
</tbody>
</table>

**Tuesday 14 March 2017**

## Day 1: defining the opportunities - identification and development of research challenge areas

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depart from Pride Inn for ILRI</td>
<td>07:30</td>
</tr>
<tr>
<td>Coffee/tea available on arrival</td>
<td>08:00</td>
</tr>
<tr>
<td>Welcomes from ILRI and BecA (jointly with ‘Earth imaging and remote sensing for climate smart agriculture’ workshop):</td>
<td>08:15</td>
</tr>
<tr>
<td>- Dr Appolinaire Djikeng, Director, Biosciences Eastern and Central Africa Hub</td>
<td></td>
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<tr>
<td>- Dr Jimmy Smith, Director General, International Livestock Research Institute</td>
<td></td>
</tr>
<tr>
<td>Background to and aims of the workshop, including Global Challenges Research Fund (jointly with ‘Earth imaging and remote sensing’ workshop):</td>
<td>08:30</td>
</tr>
<tr>
<td>- Mr Brian Harris, BBSRC</td>
<td></td>
</tr>
<tr>
<td>The challenges for agriculture in sub-Saharan Africa (jointly with ‘Earth imaging and remote sensing’ workshop):</td>
<td>08:50</td>
</tr>
<tr>
<td>- Experiences from the ASARECA region – Dr. Cyprian Ebong, Interim Executive Secretary, Association for Strengthening Agricultural Research In Eastern and Central Africa (ASARECA)</td>
<td></td>
</tr>
<tr>
<td>- African farmers’ voice – Dr. Philip Kiriro, President of the Eastern Africa Farmers Federation</td>
<td></td>
</tr>
<tr>
<td>- Reflections on partnership working – Professor Mariana Rufino, Lancaster University</td>
<td></td>
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<tr>
<td>- Panel Discussion (Chaired by: Prof Rudovic Kazwala)</td>
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<tr>
<td>Break for tea/ coffee + group photo</td>
<td>10:00</td>
</tr>
</tbody>
</table>

89
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.30</td>
<td>Brainstorming session: identification of research challenges for sustainable agriculture in sub-Saharan Africa</td>
</tr>
<tr>
<td>11.15</td>
<td>Introduction to breakout session: research challenge development</td>
</tr>
<tr>
<td>11.20</td>
<td>Breakout session: clustering, prioritisation and development of challenges</td>
</tr>
<tr>
<td>12.30</td>
<td>Lunch</td>
</tr>
<tr>
<td>13:30</td>
<td>Breakout session continued: further development and refining of priority challenges</td>
</tr>
<tr>
<td>14.30</td>
<td>Input to other breakout groups: continued development of research challenges</td>
</tr>
<tr>
<td>15.30</td>
<td><strong>Break for tea/coffee</strong></td>
</tr>
<tr>
<td>16.00</td>
<td>Feedback and discussion of challenges developed during break-out sessions (Chair by Dr Daniel McGonigle)</td>
</tr>
<tr>
<td>16.45</td>
<td>A research platform for sub-Saharan Africa</td>
</tr>
<tr>
<td></td>
<td>- Dr Daniel McGonigle, Bioversity International</td>
</tr>
<tr>
<td>17.00</td>
<td>Summary and reflections of day 1</td>
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<tr>
<td></td>
<td>- Dr Kwesi Atta-Krah and Professor Sue Hartley</td>
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<tr>
<td>17.30</td>
<td><strong>Close of day 1</strong></td>
</tr>
<tr>
<td>17.30</td>
<td>Networking reception and poster session (jointly with ‘Earth imaging and remote sensing’ workshop).</td>
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<tr>
<td>19.30</td>
<td>Depart for Pride Inn</td>
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</tbody>
</table>
### Activity

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.00</td>
<td>Depart from Pride Inn for BecA-ILRI</td>
</tr>
<tr>
<td>08.30</td>
<td>Coffee/tea available on arrival</td>
</tr>
<tr>
<td>09.00</td>
<td>Additional input to day 1 breakout sessions and introduction to day 2</td>
</tr>
<tr>
<td>09.30</td>
<td>Introduction to break-out groups</td>
</tr>
<tr>
<td>09.35</td>
<td>Breakout session 1: exploiting the opportunities from the challenges identified on day 1</td>
</tr>
<tr>
<td>10:10</td>
<td>Breakout session 2: exploiting the opportunities from the challenges identified on day 1</td>
</tr>
<tr>
<td>10.45</td>
<td>Break for tea/ coffee</td>
</tr>
<tr>
<td>11.15</td>
<td>Feedback from break-out groups and discussion (Chaired by Dr Bernard Vanlauwe)</td>
</tr>
<tr>
<td>11.45</td>
<td>Tour of BecA laboratories (Josephine Birungi, BecA-ILRI Hub)</td>
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<tr>
<td>13.15</td>
<td>Lunch</td>
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<tr>
<td>14.15</td>
<td>Writing session</td>
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<tr>
<td></td>
<td>- Chaired by Dr Matt Heard</td>
</tr>
<tr>
<td>15.30</td>
<td>Break for tea/coffee</td>
</tr>
<tr>
<td>16.00</td>
<td>Reflections and take-home messages (Chaired by Dr Sylvain Traore):</td>
</tr>
<tr>
<td></td>
<td>- Professor Agnes Mwang’ombe and Professor Sue Hartley</td>
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<tr>
<td></td>
<td>- Responses from other participants</td>
</tr>
<tr>
<td>16.45</td>
<td>Closing remarks:</td>
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<tr>
<td></td>
<td>- Brian Harris</td>
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<tr>
<td></td>
<td>- Kerry Firth – next steps</td>
</tr>
<tr>
<td></td>
<td>- Wellington Ekaya – vote of thanks</td>
</tr>
<tr>
<td>17.00</td>
<td>Close of day 2</td>
</tr>
<tr>
<td>17:15</td>
<td>Depart for airport or return to Pride Inn for dinner</td>
</tr>
</tbody>
</table>
ANNEX 3: FIELD TRIP DETAILS

Kenya Agricultural and Livestock Research Organization (KALRO)

Kenya Agricultural and Livestock Research Organization (KALRO) is a corporate body created under the Kenya Agricultural and Livestock Research Act of 2013 to establish suitable legal and institutional framework for coordination of agricultural research in Kenya with the following goals:

- Promote, streamline, co-ordinate and regulate research in crops, livestock, genetic resources and biotechnology in Kenya.
- Expedite equitable access to research information, resources and technology and promote the application of research findings and technology in the field of agriculture.

There are 16 research institutes under the umbrella of KALRO.

Institutes and Centres to be visited:
- Food Crops Research Institute – Kabete and Muguga Centres
- Biotechnology Research Institute – Kabete and Muguga Centres
- Veterinary Research Institute – Muguga Centre

Location:
Muguga KALRO Campus is situated in Kiambu County. Muguga is approximately 40 km from Nairobi, off Nakuru-Nairobi Highway in an environment that is conducive for research and training. Kabete Centres are along Waiyaki Highway, approximately 6 Km from ILRI

About the Institutes
1) Food Crops Research Institute

The Institute's main focus is to generate, validate and release technologies on food crops to clients. It focuses on cereals (maize, wheat, sorghum, millet, and rice), grain legumes (dry beans, pigeon peas, green grams, dolichos) and root and tuber crops (potatoes, sweet potatoes, cassava, yams and arrow roots). In order to contribute to food security, the Institute has seven Centres which conduct research on basic, strategic, applied and adaptive research using the value chain approach from production, market and use.

Irrigation and greenhouse demonstration at Kalro kabete

Centres: Alupe, Embu, Kabete, Katumani, Kisii, Muguga, Njoro

Institute Director, Food Crops Research Institute, P.O. Box 450-30200 Kitale Kenya,
Tel.: 020-2029637, Email: Director.fcri@kalro.org
2) Biotechnology Research Institute (BRI)

Scientists in a tissue culture lab at Biotechnology Centre, Kabete

BRI works with county governments and other stakeholders, to sustainably exploit the country resources to make new products or provide new methods of production using modern biotechnology. This is in line with the National Biotechnology Development Policy (2006) that recognized that biotechnology requires a close working relationship with multiple stakeholders.

The institute achieves its objectives through the well-structured research programs covering animal, plant and environmental biotechnology

**Contacts:** Institute Director, Biotechnology Research Institute, KALRO, P.O Box 362-00902 Kikuyu, email: Director.biori@kalro.org

3) Veterinary Research Institute

Students on attachment at the Veterinary Research Institute Lab

The core business of the institute is research geared towards alleviating the impact of livestock diseases and thus contributing to reduction of poverty and improvement of livelihoods and food security in Kenyan households. Priority diseases in the country include Foot and mouth disease (FMD), tick-borne diseases (East Coast fever, Anaplasmosis, Babesiosis, Heartwater), rinderpest-like diseases (malignant catarrhal fever, bovine viral diarrhoea and peste des petits ruminants), contagious bovine and caprine pleuro-pneumonia (CBPP), capripox virus infections, trypanosomiasis and helminthosis. The Institute also
addresses aspects related to development and validation of novel livestock vaccines. It is estimated that 75% of the pathogens that afflict humans originate from animals, both wild and domesticated. Animal health research will of necessity have to embrace multi-disciplinary approaches in order to have positive contributions to human, animal and environmental health. Packages for management and control of these diseases undergo adaptive research to validate their effectiveness in various agro-ecological zones and livestock production systems.

**Contacts:** Institute Director, Veterinary Research Institute, P.O. Box 32-00902 Kikuyu, Kenya  
Tel. +254-20-2524616/2519769, Tel/fax +254-20-2020512, email: Director.vsri@kalro.org

### Kenya Plant Health Inspectorate Service (KEPHIS)


The mission of KEPHIS is to provide a science-based regulatory service by assuring quality of agricultural inputs and produce to promote food security, market access at ultimately to sustainable economic development. The corporation has 20 service offices across the country, especially at border points and the major agricultural production areas. KEPHIS’ activities range from coordination on issues of plant pests and diseases; seed certification; border inspections; chemical analysis of pesticide residues; quality of water, fertilizer and pesticides; sensitization of stakeholders and setting of policies at the national and international level.

**KEPHIS station to be visited: KEPHIS-Plant Quarantine & Biosecurity Station**

KEPHIS-Plant Quarantine & Biosecurity Station (PQBS) is located 30 Km west of on Kenya’s capital Nairobi and 6Km off Zambezi junction along Nairobi- Nakuru Highway.

**About the station**

KEPHIS-PQBS has a full mandate on issues related to quarantine and plant biosecurity especially in prevention of introduction and spread of plant pest, disease and noxious weeds, hence protecting agriculture and the environment.

At the KEPHIS PQBS, high risk plant materials which have been imported are grown under observation for a certain period of time before they are released. The station has specialized laboratories to identify various types of pests and diseases of quarantine importance. These include Virology, Tissue culture, Bacteriology, Nematology, Entomology, Mycology and Molecular laboratories. The laboratories are ISO/IEC 17025:2005 accredited and are designated as the COMESA reference Laboratory in Plant health.

**Services offered in the laboratory**

- **Disease diagnosis** (utilizing techniques such as ELISA, Microscopy, Cultural, Biochemical, and PCR)
- **Training** (from basic diagnosis, Pest Risk Analysis, Quality Management Systems, etc.)
- Done through Centre of Phytosanitary Excellence (COPE) framework, launched in 2010 (through an STDF initiative)
  - **Handling of high value tissue culture material** (including Virus clean-up, multiplication and distribution)

*KEPHIS molecular laboratory staff carrying out PCR for detection of plant pathogens*

*KEPHIS Tissue Culture Technologist carrying out virus clean-up of high value crops*
Greenhouse containment facilities at KEPHIS-PQBS for holding Plant materials with high risk of transmitting pests including latent infection e.g. viruses (Clonally propagated, seed)

For further information Please contact;

The Managing Director, KEPHIS
e.mail: director@kephis.org; kephisinfo@kephis.org
Tel: 0722-516221; 0734-874141
Fax: 254-020-3536175
**Scope of the challenge**
- Who/ what does this affect? (people, areas, crops, livestock etc.)
- Why is it a problem? (impact of the challenge)
- What do we want to achieve in the short-term and long-term?
- What would be the impact of these solutions?

- Who?: Everyone
- Why is it a problem?: Multiple stake holder; multiple needs; objectives and impacts; lack of evidence based instruments and institutional capacity to manage trade-offs; Smallholder farming systems in sub-Saharan Africa lack organic resources for all sorts of benefits (feed, soil cover, soil carbon replenishment, regulating water and nutrient dynamics, etc.).
- Short-term goal: understanding and articulate trade-offs; medium- decision frameworks including basic knowledge; Development of tools for assessment of aggregated impacts in integrated systems and across land use types; identify appropriate entry points (and incentives for people to take these on)
- Long-term goal: quantify impacts and use to inform strategy and decision making for all stake holders; development and analysis of evidence base for aggregated impacts in multi-dimensional systems
- Potential impact: enhanced ecosystem benefits to and from agriculture

**Location of the challenge**
- Which part of Africa has this problem?
- What type of farming systems are involved?
- What are the local conditions? (climate, soil, transport, infrastructure)

- Where?: Everywhere, especially where managed systems are degrading sensitive habits. Especially important to focus on are forest margins (e.g. the Congo Basin, Montane Forest) where forest degradation and deforestation rates are low but increasing
- Types of farming systems: All, but potential for positive outcomes/ integration may be greater for smallholder/ diversified systems or highly simplified production systems
- Smallholder farming - integrating different crops, livestock, and other components within same piece of land
- Local conditions: varied climate in different agroecologies, different soil types and fairly developed infrastructure
## Knowledge and resources needs

- What scientific/technical information do we have so far?
- Who has this expertise? Where are they?
- What information/resources do we need?
- What additional expertise do we need? Can we identify appropriate people?

- What do we know?: Isolated and fragmented examples for SSA. Some theoretical/process knowledge. Potentially untapped/unquantified in small holder communities e.g. pollination service delivery, knowledge of key pests but management with natural pest control is limited, good knowledge of small holder integrated cropping systems, ICRAF e.g. Agroforestry farmer networks
- Need inventory of ‘gap’ areas and to preserve the biodiversity, water and carbon within farms and in associated non-cultivated areas
- Need stakeholder platforms to decide on priority interventions at landscape scale and incentive mechanisms (goals of different stakeholder groups are not necessarily aligned at landscape level)
- What do we need?:
  - Build evidence base- 1st goal build network (capitalising on existing networks and knowledge platforms to deliver crop and livestock specific technologies) to inform, 2nd goal gain process understanding
  - Modelling, parameter generation and validation (Multi discipline)
  - Capacities in trade-offs analysis across components or land use types remains limited.

## Define the opportunity

- What are the scientific opportunities for addressing those research challenges (and on what timescale)?
- What methods are appropriate? Are there any novel methods?
- What are the partnering opportunities for African and UK researchers?
- What research could make the biggest difference (where, how and when)?

- Opportunities: Farmer experiment platform across land-use and landscape gradient. Process understanding from mechanism to implementation/decision making.
- Methods: Biology/ecology, agronomy, soil sciences, socio-economics
- Good opportunities for partnership integrating existing knowledge and farmer frameworks
- Need to consider scale of the research question – at project level, can it be SSA?
- Assessment of below-ground soil C stocks and soil biodiversity is critical
- Possibility of ‘international ecosystem services’ in the context of UK-SSA partnerships?
- Understanding agro-ecological systems; build on integrated systems work of Humidtropics and other CGIAR systems research initiatives. There is an opportunity of engaging CGIAR centres such as ICRAF, IITA, Bioversity, etc. as partners.
- Understanding trade-offs between ecosystem services and decision-making process for various stakeholder groups

## Additional comments

- Metrics for sustainability will be crucial – need to know what to measure, where and when to assess how successful various interventions are
- Importance of looking at the broader context and taking account of a variety of scales
- There is a big distinction between commercial farmers and subsistence farmers in terms of access to finance etc. Commercial farmers can be the entry point for agro-input suppliers to invest in input supply chains (seed, fertiliser, etc.).
- Focus on areas with high human and livestock population for threatened biodiversity, and fragile ecosystems (forest margins, managed wetlands)
- Case studies with empirical evidence contact local and regional institutions to select places

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## Management of agriculture’s impact and dependencies on natural capital and other ecosystem services. Challenge 2: Soil and water management, including soil nutrient management

### Scope of the challenge
- **Who/ what does this affect?** (people, areas, crops, livestock etc.)
- **Why is it a problem?** (impact of the challenge)
- **What do we want to achieve in the short-term and long-term?**
- **What would be the impact of these solutions?**
- **Who/what does this affect?**
  - Large impacts on people: poor (crops and livestock) yields, pollution (spill-over of nutrients and pesticides), high production costs and therefore low incomes; degradation in case of low use of nutrient inputs
  - Short-term; management of vegetation cover to increase nutrient plus water use
  - Long-term; to re-build soil fertility
    - Fertiliser use needs to increase substantially but the right fertiliser for the right crop, applied correctly, and in combination with other good agronomic practices
  - Impacts: increased food self-sufficiency, increased resource use efficiency, biodiversity
  - Healthy soils host more biodiversity and vice versa; more biodiversity needed for soil health

### Location of the challenge
- **Which part of Africa has this problem?**
- **What type of farming systems are involved?**
- **What are the local conditions?** (climate, soil, transport, infrastructure)
- **Where:** Across Africa - High-potential areas and high human and livestock population; most smallholder agriculture in SSA is based on nutrient mining; slash-and-burn systems are gradually replaced with sedentary agriculture but nutrients removed are hardly ever replaced in sufficient quantities
- **Systems:** Mixed highland farming systems, agro-pastoralist areas
  - Cereals, livestock (cattle, small stock), vegetables and pulses
  - Agro-pastoralist systems are intensifying cropping (cereals and vegetables)

### Knowledge and resources needs
- **What scientific/technical information do we have so far?**
- **Who has this expertise?** Where are they?
- **What information/resources do we need?**
- **What additional expertise do we need?** Can we identify appropriate people?
- **Many soil conservation measures have been developed with no widespread adoption (with some remarkable exceptions such as in East Kenya or large parts of Rwanda). We propose tailored measures for different agro-ecologies**
- **Need to look at which nutrients are being depleted, and facilitate the supply of those nutrients within farming communities (while maximizing the use of locally available nutrient sources (e.g. legume N fixation)**
- **The issue of non-responsive soils needs to be addressed as part of fertiliser use strategies in soil fertility management.**
- **Local measurements (plus dissemination via smartphone applications) so that farmers have access to the new science; noting that knowledge needs to go hand in hand with access to agro-inputs (no need to tell a farmer that he/ she has a P problem if that same farmer cannot purchase P fertiliser)**
- **The mix of crops and trees should include (preferably multi-purpose) legumes (research to identify most cost-effective legume species);**
- **Collection of data to produce accurate soil maps (which are free) to improve nutrient use efficiency and biomass for multiple purposes (wood, fruits, feeds).**
- **Trees can be used to build fertility through litter deposition (but integrating trees solely**
for soil fertility improvement has known many adoption constraints)
- Expertise is available, research needed for the landscape level solutions: Soil science, land surveyors/planners, agronomists and livestock scientists. Farmers should be included as citizen scientists.
- Information / resources needed: simple cost effective soil testing kits or procedures to be used by the small holder farmers

<table>
<thead>
<tr>
<th>Define the opportunity</th>
<th>Research questions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- What are the scientific opportunities for addressing those research challenges (and on what timescale)?</td>
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<tr>
<td>- What methods are appropriate? Are there any novel methods?</td>
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<tr>
<td>- What are the partnering opportunities for African and UK researchers?</td>
<td></td>
</tr>
<tr>
<td>- What research could make the biggest difference (where, how and when)?</td>
<td>- Which plants for which soils and what are the costs? Income; NB: Access to soil nutrient data expensive for farmers?</td>
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<tr>
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<td>- Which plants can be used to re-build fertility at what costs?</td>
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<td>- What are the optimum combinations of organic + inorganic fertilizers for different crops at plot, farms and landscape level? (e.g. Integrated Soil Fertility Management (ISFM) has targeting and maximizing resource use efficiencies as entry points). Farmers’ access + costs?</td>
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<tr>
<td></td>
<td>- Exploring agricultural and horticultural waste opportunities</td>
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<td></td>
<td>- How do we manage non-responsive soils economically and agronomically?</td>
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<tr>
<td></td>
<td>- How do we manage fertiliser-use domains in non-responsive soils?</td>
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<td>- Which other amendments besides nutrients are needed to ensure that nutrients are taken up (e.g. lime in areas with acidic, Al-containing soils)?</td>
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<td>- How can we exploit microbial communities to deliver on production of food and building fertility (characterise microbial diversity of soil/ rhizosphere)</td>
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<td>- How to address farming typologies (farming communities are very diverse and different types of households will require different options to improve their livelihoods (See recent DFID report ‘DFID’s Conceptual Framework on Agriculture, 2015’).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Research to make a big difference:</th>
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<tbody>
<tr>
<td>- Farmers learn to value and maintain (farmers value outputs in the long term) soil capital (in monetary terms), to reverse (new techniques for water management/capture) soil mining (erosion and nutrient removal)</td>
<td></td>
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<tr>
<td>- New techniques for water management/ capture</td>
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<tr>
<td>- Facilitation of access to required agro-inputs (effective and affordable agro-input supply chains and related knowledge networks on their most appropriate use)</td>
<td></td>
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<tr>
<td>- Which low-cost and efficient diagnostic tools can be deployed to assess major limiting nutrients for target soils and crops?</td>
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<tr>
<td>- A better understanding of rhizosphere regulating processes could add substantial value to soil management practices; this part of the soil is poorly understood and requires strategic investments (IITA is very interested to engage with UK institutes in this</td>
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</tbody>
</table>
This page contains text about research areas and additional comments. The main points are:

- **Research Area:**
  - Capacity building of farmers in soil health using simple techniques

- **Additional Comments:**
  - Short term achievement – exploiting no-tillage soil conservation options to protect beneficial soil microbes; noting that no-till should be accompanied by soil cover through mulch in order not to have substantial yield decline.
  - Portable user-friendly devices to check soil quality and provide open data to the larger community by phone apps.
  - The issue with chemical/pesticide use is over-application/mis-use. Precision technologies can help us to overcome these issues:
    - Intelligently targeted inputs using smart technologies to use optimum levels of inputs and target them exactly where they are needed.
    - Context for technology use in SSA is different to Europe, so need to consider appropriate technologies which could make African agricultural systems work better (e.g. drones in backpacks on motorbikes).
    - Possibility of employment generation in developing agricultural technologies in Africa (service delivery).
Management of agriculture's impact and dependencies on natural capital and other ecosystem services. Challenge 3: Managing pests and diseases in the context of climate change

<table>
<thead>
<tr>
<th>Scope of the challenge</th>
<th>Producers and consumers (crop and livestock value chain actors), across Africa, crops and livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Who/ what does this affect? (people, areas, crops, livestock etc.)</td>
<td>• Reduction in yields and quality, incomes and food insecurity, environmental pollution from pesticides</td>
</tr>
<tr>
<td>• Why is it a problem? (impact of the challenge)</td>
<td>• Short term: increase surveillance and diagnosis of pests and diseases</td>
</tr>
<tr>
<td>• What do we want to achieve in the short-term and long-term?</td>
<td>• Identification and optimisation of management options with communities</td>
</tr>
<tr>
<td>• What would be the impact of these solutions?</td>
<td>• Long term: Effective and lasting integrated pest and diseases management, upscaling</td>
</tr>
<tr>
<td>• Producers and consumers (crop and livestock value chain actors), across Africa, crops and livestock</td>
<td>• Impact: Maximize yields to improve incomes and food security.</td>
</tr>
<tr>
<td>• Reduction in yields and quality, incomes and food insecurity, environmental pollution from pesticides</td>
<td>• Impact: Other value chains’ actors (e.g. traders…..)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location of the challenge</th>
<th>Across Africa (Cassava viruses, rice yellow mottle, maize lethal necrosis, including banana bacterial wilt, cash crop, yam beetles and nematodes (S. bradys), UG 90 food crop) . Livestock: African Swine flu, Bird flu and Vector borne diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Which part of Africa has this problem?</td>
<td>• All farming systems(Crop and Livestock)</td>
</tr>
<tr>
<td>• What type of farming systems are involved?</td>
<td>• Climate varies, Soil: Different soil types, Transport: Much better</td>
</tr>
<tr>
<td>• What are the local conditions? (climate, soil, transport, infrastructure)</td>
<td>• Infrastructure: Needs improvement, Expertise: including private sectors and extension workers</td>
</tr>
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<td></td>
<td>• Regulatory issues and compliance</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge and resources needs</th>
<th>What do we know? Lots of evidence based information</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What scientific/technical information do we have so far?</td>
<td>• Who has the information? NARS, universities, CGIAR</td>
</tr>
<tr>
<td>• Who has this expertise? Where are they?</td>
<td>• What do we need? Mapping out of diseases and pests prevalence and severity – targeting; early warning systems</td>
</tr>
<tr>
<td>• What information/resources do we need?</td>
<td>• Impact of landscape fragmentation on pests and diseases of crops and livestock</td>
</tr>
<tr>
<td>• What additional expertise do we need? Can we identify appropriate people?</td>
<td>• Efficient and cost-effective methodologies and tools for diagnosis and management</td>
</tr>
<tr>
<td></td>
<td>• Simple disease diagnosis techniques that can be applied by end users</td>
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<tr>
<td></td>
<td>• Adoption and impact studies</td>
</tr>
<tr>
<td></td>
<td>• Remote sensing and GIS, Social research, Biocontrol experts(IPCM)</td>
</tr>
<tr>
<td></td>
<td>• Including private sector and extension workers</td>
</tr>
</tbody>
</table>
Define the opportunity

- What are the scientific opportunities for addressing those research challenges (and on what timescale)?
- What methods are appropriate? Are there any novel methods?
- What are the partnering opportunities for African and UK researchers?
- What research could make the biggest difference (where, how and when)?

| Opportunities: Transdisciplinary approach |
| Drone technologies, satellites Copernicus(EU), Partnerships(EU-Africa) |
| Availability of baseline information |
| Methods: Systematic review, mapping appropriate IMP to geographical, molecular approaches |
| Partnering opportunities: Scientific exchanges: GIS and remote sensing, molecular Biology |
| Research which could make big impact: Remote Sensing, GIS and Earth Imaging (AU affected areas, customization through partnership immediately) |
| Molecular breeding and Pathogen characterization, Social research |

Additional comments:

- Conservation biological control: Could natural enemies of pests be an ecosystem service? Modify habitat to boost their population
- Land rights as a big issue – women’s’ empowerment e.g. weeding done by ladies on the farm
- Relationship between insects and climate change – intensely grazed areas tend to have proliferation of termites, which contributes to GHG emissions
- Emulating Western monocultures is exacerbating issues related to pest and disease outbreaks.
  - Traditional diversified systems face these problems less
  - Need to find optimal balance between traditional diversified systems and growing certain crops on a larger scale; ensuring that mechanization options will be possible
- Epidemiology modelling to predict pathogen spread
  - Curated, accessible database for forecasting – early warning systems for farmers
Management of agriculture's impact and dependencies on natural capital and other ecosystem services. Challenge 4: Alternative feed sources

### Scope of the challenge
- **Who/what does this affect?** (people, areas, crops, livestock etc.)
- **Why is it a problem?** (impact of the challenge)
- **What do we want to achieve in the short-term and long-term?**
- **What would be the impact of these solutions?**

| People | People - malnutrition (small holder farmers); Livestock (chicken, cattle, etc.), aquaculture
|--------|---|
|        | Scope for African smallholders to produce alternative feed sources for income
|        | Also feed manufacturers/big companies in charge of feed production (e.g. Ugachick, Unga feed)
|        | Available sources (e.g. fish) are declining, grass affected by climate change and overgrazing, competition for food e.g. soya, maize/cereals, and competition for land
|        | Problem of conflict between crop farmers and livestock keepers
|        | How best can we exploit edible insects for societal and economic benefit in SSA?
|        | Short-term goal - identity sources with equivalent or higher protein content; sources of cheap protein such as soybean are having increasing market demand
|        | Long-term: develop new products; breeding new feed sources (e.g. black soldier flies, other insects, halogenic sources). change policy on the issue;
|        | Impact: improved i) nutrition for livestock, knock on effect for human nutrition ii) productivity with economic benefit

### Location of the challenge
- **Which part of Africa has this problem?**
- **What type of farming systems are involved?**
- **What are the local conditions?** (climate, soil, transport, infrastructure)

| Where? | Where?: Most of Africa; (though the density and types of livestock vary strongly across the continent); pastoral systems; urban areas and rural areas
|--------|---|
| Type of system? | Type of system?: Both commercial and small holder farmers

### Knowledge and resources needs
- **What scientific/technical information do we have so far?**
- **Who has this expertise? Where are they?**
- **What information/resources do we need?**
- **What additional expertise do we need? Can we identify appropriate people?**

| We know | We know: Forage species with known nutritional profiles e.g. Brachaira; insect species with higher protein content known e.g. black soldier flies
|--------|---|
| Better understanding | Better understanding and what drives farmers to invest in fodder production (very limited success with uptake of fodder banks, etc.); problem is likely more of an institutional than an agronomic nature
| Limited scientific farmer knowledge and research and development institutes (e.g. ICIPE, KARLO, SVA, TALIRI)
| Existing laboratories but little or no chemicals and reagents – TALIRI – Tanzania
| We need | We need: Infrastructure for capacity building (replace/use more advanced facilities outside)
| We need | We need: Feed and forage breeders, insect geneticists

### Define the opportunity
- **What are the scientific opportunities for addressing**

| Developing/improving existing and new/alternative feed sources | Developing/improving existing and new/alternative feed sources
|------------------|------------------|
| Collaboration with advanced centres in and outside Africa | Collaboration with advanced centres in and outside Africa
<table>
<thead>
<tr>
<th>Research Challenges and Partnersing Opportunities</th>
<th>Additional Comments</th>
</tr>
</thead>
</table>
| - What methods are appropriate? Are there any novel methods?  
- What are the partnering opportunities for African and UK researchers?  
- What research could make the biggest difference (where, how and when)? | - Development and improvement of existing feed sources (such as grasses and legume fodders) is also very important – improving the quality and making them more efficient and sustainable  
- Do not limit to feed. Expand to food since it is Agriculture as a whole. The best chances for increasing feed supply is through increased food crop production and use of the crop residues  
- Insects are a good source of fats, as well as protein  
- Many cultures in Africa already eat insects  
- Opportunities (TALIRI): mandate to conduct livestock research in Tanzania + National Livestock Policy of T2. Indigenous livestock available, land, manpower |

**Time scale:** next five years (breeding, training etc.)

**Partnering opportunities:** Research, breeding, training, infrastructure
- Various institutions already working in the field of alternative food and feed (e.g. Wageningen, Netherlands, FERA, UK, Jomo Kenyatta University of Agriculture and Technology - breeding crickets)
- Small holder and commercial farmers (through capacity building and input support)
- R & D institutions through capacity building, instruments

- Indigenous knowledge from local communities is a real opportunity
- Better understanding of what drives farmers to invest in feed production
- What research could make a difference?:
  - Mapping of alternative or availability of feed source; developing and testing products
  - Understanding where alternative feed sources are needed, and where more biomass of existing feed can be produced
  - Crops – genetics, breeding, upgrading to increase nutritional value factors, processes to decrease antinutritional factors
  - Technologies to enhance handling of feed e.g. pelleting
Clustered challenges: Management of agriculture’s impact and dependencies on natural capital and other ecosystem services

1. Landscape and biodiversity management to deliver ecosystem services (including modelling and decision support tools)
   - Informing landscape management to increase ecosystem resilience to impacts and climate variability
   - How best can agricultural intensification contribute to conservation of natural ecosystems (forests, rangelands, wetlands)?
   - Changes in availability of ecosystem services as early warning system for improvement of crop and livestock production
   - Biological strategies for dealing with the changing environment (climate change)
   - How do we integrate “natural” ecosystem functions into agri-systems? E.g. natural pest control, pollination services, landscape context
   - Strategies to externalise ecosystem service benefits to broader society
   - Minimising environmental degradation
   - Ecosystem service modelling under different land use management scenarios
   - Developing decision tools for land use planning
   - Land use planning – local, regional, national
   - Mapping value chains and economics, now and in future scenarios
   - Assessment of total factor productivity as an indicator in integrated systems research

2. Soil water and nutrient management, including soil nutrient mining and carbon storage/GHG emissions
   - Explore/ develop/ elucidate plant-microbe symbiosis for improved water use and nutrient uptake
   - Enhancing soil health – microbial C storage and aggregate formation
   - Methods to reduce soil degradation and erosion and improve water retention
   - Increasing soil organic matter (companion crops, cover crops)
   - Examining the phenomenon of nutrient mining from agricultural systems

3. Pests and diseases (in the context of climate change) – biocontrol mechanisms, using the natural environment
   - Reduced use of pesticides through better use of natural products
   - Habitat modification to boost biocontrol of pests

4. Livestock management
   - Alternative feed and food sources (including feed quality)
   - Grasslands management to increase diversity and feed quality
   - Low quantity and quality of meat production associated with poor feeding in rangelands
   - Disappearance of valuable pasture species due to over-grazing, especially in rangelands

5. Optimising input use (fertilisers, pesticides, climate-smart agriculture)
   - Overuse and/ or misuse of pesticides and related impacts on pollination services and crop productivity
   - Improper use of inorganic fertilisers in crop production
   - Agricultural and horticultural waste opportunities
6. **Trade-offs, including metrics for sustainability** as a measure of progress (assessment across scales, across components; societal trade-offs i.e. replacing particular foods)
   - Trade-offs analysis related to integrated farming systems
   - Ecosystem services trade-offs – land sparing vs land sharing
   - Tools and analysis of total farm or factor productivity

7. **Socio-economic challenges**
   - How family farming can persist in the context of the harmonisation of agribusinesses in SSA
   - Farmer perceptions of the changing environment (climate change), and the effect on available management strategies
   - Conflicts between crop farmers and livestock keepers on grazing/ cropping land

8. **Cross cutting theme**: Understanding the agri-ecosystem (interactions between different elements of the system)

9. **Underpinning theme**: Building capacity and multidisciplinary working
Countering of abiotic and biotic stresses. Challenge 1: Emerging pests and diseases surveillance

**Scope of the challenge**
- **Who/ what does this affect? (people, areas, crops, livestock etc.)**
- **Why is it a problem? (impact of the challenge)**
- **What do we want to achieve in the short-term and long-term?**
- **What would be the impact of these solutions?**

| Most affected are smallholder farmers. For commercial vegetable farmers, there are issues regarding top high use of chemical control (residues in the food chain and resistance to pesticides). This can impact on trade and human health. |
| Lack of understanding of problems, getting information out and capacity building (especially training to make accurate diagnostics) are seem as major barriers. |
| Connections between pests and diseases and livestock are not well explored. Issues on trans-boundaries, lack of legal framework and compliance of rules in exchange of samples/biological materials. For livestock in particular, there are additional problems in early diagnostic and on the way information on events are captured and recorded. |
| Emerging weeds becoming a big issue |
| There is a need for both crop and animal science for diagnostic kits for early detections, portable, easy to use at fields, affordable. Refrigeration and preservation of samples were also seen as a problem. Cryo preservation is needed to support identification. |
| Also important is on how up-take of these tools are can implemented/ improved. |
| A major concern is regarding misidentification and misinformation that can have implications for how issues can be perceived and amplified, leading to trade barriers and causing geo-political conflicts and economic loss. |

**Location of the challenge**
- **Which part of Africa has this problem?**
- **What type of farming systems are involved?**
- **What are the local conditions? (climate, soil, transport, infrastructure)**

| All SSA |
| Focus on tropical specific diseases (neglected diseases) |
| Surveillance needs to be considered both internally in a particular country but also at borders and externally. This is particular problem for seed trade. |
| There is a need for integrated models for mapping/ forecasting to enhance fast response. |

**Knowledge and resources needs**
- **What scientific/technical information do we have so far?**
- **Who has this expertise? Where are they?**
- **What information/resources do we need?**
- **What additional expertise do we need? Can we identify appropriate people?**

| Scientific and technical needs involve: |
| Improve ability and capacity to accurate identify and monitor pests and diseases |
| Data collection/ data curation/ data access (encourage open access)/ data reporting |
| As problem is identified, it is vital to provide guidance on potential interventions |
| Development for supporting technological tools (for instance Apps) |

**In addition:**
- **Legal framework for exchange of biological materials and reinforcement or rules at border**
<table>
<thead>
<tr>
<th>Define the opportunity</th>
<th>Need to improve communication and capacity building</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What are the scientific opportunities for addressing those research challenges (and on what timescale)?</td>
<td>• There are several opportunities with the current funding landscape</td>
</tr>
<tr>
<td>• What methods are appropriate? Are there any novel methods?</td>
<td>• Focus should be on partnerships - Identification of key partners aiming to better integration of joint efforts. This will avoid duplication and waste of time and resources. CABI was considered an important partner.</td>
</tr>
<tr>
<td>• What are the partnering opportunities for African and UK researchers?</td>
<td>• Designing low cost technology such as bar coding and other molecular techniques for identification that can be useful for not only emerging but long-term monitoring. In some cases, linking morphology to species level</td>
</tr>
<tr>
<td>• What research could make the biggest difference (where, how and when)?</td>
<td>• Establish or consolidate systems for better data curation with free online access to high quality of data. Mapping of systems already available (for instance, data on insects at CABI and ICEPE, animals from all national repositories and World Organisation for Animal Health in Paris, and seed and germplasm banks at CYMMIT and National Museums) can be a starting point exploring ways to integrate information available.</td>
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</tbody>
</table>
### Countering of abiotic and biotic stresses. Challenge 2: Novel Solutions to current and emerging pests and diseases

**Scope of the challenge**

- Who/ what does this affect? (people, areas, crops, livestock etc.)
- Why is it a problem? (impact of the challenge)
- What do we want to achieve in the short-term and long-term?
- What would be the impact of these solutions?

- Challenges are quite similar to challenge 1 (Emerging pest information out and capacity building and diseases + surveillance)
- Most affected are small holder farmers. For commercial vegetable farmers, there are issues regarding too high use of chemical controls (residues in the food chain and resistance to pesticides). This can impact on trade and human health.
- Lack of understanding of problems, getting training to make accurate diagnostics are seem as major barriers
- Genetic modification was presented as a potential solution but it is important to understand the limitations (infrastructure, skills, etc) and barriers for participation

**Location of the challenge**

- Which part of Africa has this problem?
- What type of farming systems are involved?
- What are the local conditions? (climate, soil, transport, infrastructure)

- All SSA with hot spots areas – surveillance can define these problem areas

**Knowledge and resources needs**

- What scientific/technical information do we have so far?
- Who has this expertise? Where are they?
- What information/resources do we need?
- What additional expertise do we need? Can we identify appropriate people?

- Capacity building
- Strengthening old and consolidating new partnerships, for instance model of BecA-HUB in the facilitation and support to researchers to problem solutions
- IT developers for implementing data curation open access software/hardware
- Need to develop tools/training for Bioinformatics and data analyse
- Need for better technology transfer, extension and participatory approaches to share local information and knowledge
- Improve scientists’ and farmers’ ability to determine the effect of chemical residue in food supply
- Challenge = lack of appropriate capacity (human and infrastructure), technology capabilities
| Define the opportunity | • Exploring role for orphan/marginal crops to support other systems – systems can be ‘modernized’ for instance, using intercropping like ‘push-pull’
| | • There are opportunities for development of new vaccines to improve animal health
| | • Make better use of mobile phone (widely used by farmers) for disease diagnostic
| | • Develop technology to be able to sense stress (portable thermos cameras and multi-spectrum techniques, image recognition, etc). This sensors could be incorporated to mobile phones and data added to the cloud (open source) with recommendations on potential solutions to farmers. Considering optimising (access, training, costs) of technology already available customized for African farm systems – ‘technology maturity’
| | • Explore ways for better data curation – by using and developing open access software (very powerful tools)
| | • Using leap frog technology, for instance 2nd generation of drones (not only taking photos but also spraying and seeding)
| | • Considering engaging UK Agri-tech centres and use this model of improving capital for equipment |
| | • What are the scientific opportunities for addressing those research challenges (and on what timescale)?
| | • What methods are appropriate? Are there any novel methods?
| | • What are the partnering opportunities for African and UK researchers?
| | • What research could make the biggest difference (where, how and when)? |
Countering of abiotic and biotic stresses. Challenge 3: Symbiosis and Soil Health

**Scope of the challenge**
- Who/what does this affect? (people, areas, crops, livestock etc.)
- Why is it a problem? (impact of the challenge)
- What do we want to achieve in the short-term and long-term?
- What would be the impact of these solutions?

- African soils are highly depleted. There are simple solutions to restore soil functionality (not mega-tech fix) such as crop selection, intercropping, crop rotation and use of cover crops. (The simplest solution is appropriate rates and types of fertilizer; experiences with cover crops on smallholder farms have been very disappointing in most parts of Africa). These options bring issues regarding short- or long-term gain and trade-offs.
- Artificial selection of increasing yields in plants may reduce the capacity for creating rhizospheres.
- EU view is to reduce input. Needs for better understanding of African’s perspective to improve.
- NB Biotic interactions not just in soil – also foliar symbioses, gut flora in livestock, etc. – should consider how these can promote tolerance/resistance to biotic and abiotic stresses.

**Location of the challenge**
- Which part of Africa has this problem?
- What type of farming systems are involved?
- What are the local conditions? (climate, soil, transport, infrastructure)

- Focus broadly on SSA, but issues might be regional
- Is prominent in areas with high population densities and lack of investments in nutrient applications

**Knowledge and resources needs**
- What scientific/technical information do we have so far?
- Who has this expertise? Where are they?
- What information/resources do we need?
- What additional expertise do we need? Can we identify appropriate people?

- A better understanding of the functionality of soil health and rhizosphere dynamics – what does it all mean in the end in terms of resource use efficiencies, productivity enhancement, etc
- Need to understand the best ways to collate (and obtain better) information, curate and make it available in simple ways.
- Need development of smart technology (taking advantage of good mobile phone cover in SSA)
- Challenge = lack of appropriate infrastructure, technology capabilities
<table>
<thead>
<tr>
<th>Define the opportunity</th>
<th>Design rotation system looking at different services that plant can help, for instance soil structure, mining nutrients (short-term fix)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What are the scientific opportunities for addressing those research challenges (and on what timescale)?</td>
<td>• Managing agro-systems in order to balance inputs and benefits</td>
</tr>
<tr>
<td>• What methods are appropriate? Are there any novel methods?</td>
<td>• Consider symbiosis not only to protect but also for beneficial purposes</td>
</tr>
<tr>
<td>• What are the partnering opportunities for African and UK researchers?</td>
<td>• Make better use of metagenomics for explaining microbial behaviour and variability across soil fertility, drought tolerance and salinity.</td>
</tr>
<tr>
<td>• What research could make the biggest difference (where, how and when)?</td>
<td>• Practical solutions to inoculation with bio-fertilizers (very well demonstrated for rhizobia; problematic for AMF; unknown for many other beneficial micro-organisms)</td>
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<tr>
<td></td>
<td>• Regulatory systems to validate/screen bio-fertilizers before these are entering the hands of farmers</td>
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<td>• Sharing best practice and learning with farmers on the ground</td>
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<td></td>
<td>• Engagement with UK Agri-tech centre Agrimetrics</td>
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<tr>
<td></td>
<td>• IITA is very interested in engaging in functional soil microbiology</td>
</tr>
</tbody>
</table>
Clustered challenges: countering of abiotic and biotic stresses

1. Emerging pests and diseases and surveillance
   - Crop disease management and epidemiology: disease surveillance to identify emerging pathogens using NGS
   - Tools for diagnostics that can be used cheaply and easily by farmers in the field
   - Understanding pests and disease spread and control at landscape scales
   - Sustainable epidemi-surveillance
   - Mapping biotic threats so that interventions can be targeted to hotspot areas
   - Developed affordable sensing systems for early recognition of stress
   - Lack of background information
   - Weak surveillance and data management systems for emerging constraints
   - How do we improve disease surveillance, reporting, diagnostic, database management to enable preemptive action to stop disease spread. Needs to be across borders
   - Emerging plant pests and diseases
   - Need for enhance pest forecasting and early warning systems
   - Improve exchange of materials-Phyto sanitation
   - Rapid diagnostics (point of care diagnostics)
   - Better surveillance methods for emerging diseases and pest
   - Database for diseases and associated pathogens (diversity, distribution and evolution)
   - Identification of emerging pathogens, characterization of methods and transmission, identification of causes of resistance
   - Alien invasive pest species afflicting key staples and horticulture crops in Africa
   - Emerging wheat rust
   - Emerging new pests and diseases in agricultural systems done to climate change

2. Novel solutions to current and emerging pests and diseases
   - Development of tools to combat diseases in livestock and crop
   - Combine high yield and drought resistance into farmers preferred crops and varieties
   - Role of inter/intra specific diversity in resilience to biotic and abiotic stress
   - Novel interventions to control pests
   - Using chemical ecology to devise novel pest management interventions (as with push-pull)
   - Breeding for increased resistance to emerging pests and diseases
   - Unravel plant-pathogen interactions in traditional and nutritious crops to allow breeding for resistance
   - Development of new sources of resistance to pests and diseases in staple crops
   - New vaccines and improved existing vaccines
   - Integrated pest management in integrated farming systems
   - Crop improvements to address productivity, pests and disease problems
   - Novel solutions to pest and diseases: genetics, agronomy and IPM
   - Developing smart crops that sense stress and reprogram metabolism accordingly
   - Introduce new resistant varieties to (a)biotic stresses using genetic modification
   - Post-harvest management
• Habitat modification to boost biocontrol of pests
• How to improve biological control in small holding settings?
• Plant-insect interaction and immune response
• Improve used of natural plant defenses (zym metabolites, silicon) for pest and disease resistance

3. Symbiosis and soil health
• Understanding organisms associated with crop that could have symbiotic effect
• Soil health
• Role of soil microbes in drought alleviation
• Exploiting microbial communities for the improvement of crop production and protection from pathogens
• Extending drought tolerance of crops using microbial communities at the same time as increasing plant nutrition and yield
• Support water shed management ecosystems
• Integrating understanding of host pathogen interaction with environmental variables: effect on susceptibility and resistance
• Drought and wind deteriorating the soil- limiting the rhizosphere- solution: introduce plants such as brachiaria, dense rhizosphere water uptake of P&N as well as feed for livestock

4. Climate change and abiotic stress
• Climate change and its impact on crop and animal productivity
• Environmentally friendly crop production
• Decreasing greenhouse gas emission from livestock and crop production systems
• Impact of water constraints on diversity of resource use at ecosystem level
• Lack of improved climate smart crop varieties
• Climate change and variability in crops and livestock

5. Cross cutting
• How can sustainability of sub-Saharan Africa agricultural systems be improved by greater resistance to biotic and abiotic stresses: crop and livestock
• Improved capacity and expertise
• Networking
### Scope of the challenge

- **Who/what does this affect?** (people, areas, crops, livestock etc.)
- **Why is it a problem?** (impact of the challenge)
- **What do we want to achieve in the short-term and long-term?**
- **What would be the impact of these solutions?**

<table>
<thead>
<tr>
<th>Availability of sufficient water affects all types of farmers in rain-fed and irrigated systems in SSA. It is also critical to consider issues associated with (&quot;grey&quot;) water use for food production in urban and peri-urban areas (availability, quality, etc.). The challenge is exacerbated by climate change and uncertainty, not just in terms of water shortage, but also of too much water, e.g. due to sudden and extreme rainfall variations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term aim: better use of available water (e.g. harvesting, filtering, channeling).</td>
</tr>
<tr>
<td>Longer-term aim: protection of water resources, including aquifers.</td>
</tr>
</tbody>
</table>

### Location of the challenge

- **Which part of Africa has this problem?**
- **What type of farming systems are involved?**
- **What are the local conditions?** (climate, soil, transport, infrastructure)

| Widespread across SSA, in many and varied situations: arid and (increasingly) non-arid areas; rain-fed and irrigated systems; smallholders and larger commercial farms (and excessive water use by the latter might have impacts on the former); crops and livestock. |

### Knowledge and resources needs

- **What scientific/technical information do we have so far?**
- **Who has this expertise? Where are they?**
- **What information/resources do we need?**
- **What additional expertise do we need? Can we identify appropriate people?**

<table>
<thead>
<tr>
<th>The challenge is “1/3 technology, 2/3 other issues” about how to make technology deliver.</th>
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<tbody>
<tr>
<td>Need research to inform effective policy development.</td>
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<tr>
<td>Need to consider: livestock as well as crops; role of SOM and soil structure in water retention (and role of conservation agriculture); effects of too much/too little water on incidence and spread of pests and diseases; impact on agriculture of water quality (not currently a major issue) as well as quantity; water-nutrient interactions.</td>
</tr>
</tbody>
</table>

### Define the opportunity

- **What are the scientific opportunities for addressing those research challenges (and on what timescale)?**
- **What methods are appropriate? Are there any novel methods?**
- **What are the partnering opportunities for African and UK researchers?**
- **What research could make the biggest difference (where, how and when)?**

<table>
<thead>
<tr>
<th>Starch gels for seed establishment (potentially also with controlled nutrient release).</th>
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<tr>
<td>Partial root-zone drying; alternate wetting and drying; drip irrigation; potential new nanopore-based water filters.</td>
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<tr>
<td>Crop breeding for drought- (and salinity-) tolerant varieties.</td>
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<tr>
<td>Physical management of water flows on farms, e.g. terracing etc.</td>
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<tr>
<td>Catchment-sensitive and conservation farming, e.g. improvement of soil structure for better water harvesting/retention.</td>
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<tr>
<td>Diversification of systems for improved WUE (e.g. alternative, more drought-tolerant crops).</td>
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</tbody>
</table>
| | (Sustainable) exploitation of aquifers.  
| | Novel (e.g. stable isotope) ways of measuring WUE to understand flow through plants.  
| | Catchment modelling and land-use planning (and land restoration, e.g. inclusion of semi-natural features to aid water conservation).  
<p>| | Rhizosphere organisms play a major role in defining crop response to drought – strong G crops X G microbe |</p>
<table>
<thead>
<tr>
<th>Scope of the challenge</th>
<th>Location of the challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who/ what does this affect? (people, areas, crops, livestock etc.)</td>
<td>Inorganic fertiliser use is very low across SSA (except on commercial farms), and there is often competition for manures from alternative uses (fuel, building materials); also insufficient use of lime in acid soils (this is very correct and a real limitation for acid soils; that said, soils with acidity-related limitations are not that widespread)</td>
</tr>
<tr>
<td>Why is it a problem? (impact of the challenge)</td>
<td>Challenge is widespread across SSA, but need to look beyond aggregated national/regional data at more local spatial variation and heterogeneity, which is complex and multi-scale depending on soil type, farming system (e.g. different crops with different quantitative nutrient requirements) and degree of land degradation etc.</td>
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<tr>
<td>What do we want to achieve in the short-term and long-term?</td>
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<tr>
<td>What would be the impact of these solutions?</td>
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<tr>
<td>Widespread and pervasive in SSA, but context-specific. Challenges/ solutions are different for different types of farmers: subsistence (and sub-subsistence) smallholders v. larger commercial farms with ability to invest.</td>
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<tr>
<td>Insufficient nutrients in most farming systems reduce yields and quality of plant and animal products, with impacts of food security, incomes, crop, animal and human health (including deficiencies of micronutrients not required by crops, but needed by people).</td>
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<tr>
<td>Short-term: need access to more nutrients, e.g. legume cropping, manures (Note: is commonly in short supply, even in areas with relatively larger livestock densities such as the Sahel), fertilisers, to enhance crop and livestock yields and nutritional quality; specific focus on aiming at high/maximum nutrient use efficiencies</td>
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<tr>
<td>Long-term: need improved nutrient retention/reduced losses and better sustainability.</td>
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<table>
<thead>
<tr>
<th>Knowledge and resources needs</th>
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</thead>
<tbody>
<tr>
<td>What scientific/technical information do we have so far?</td>
<td>Better joining up of different types of data (e.g. soil mapping) by different national and international agencies to identify knowledge gaps and synergies. Need to align with range of donors, NGOs, etc.</td>
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<tr>
<td>Who has this expertise? Where are they?</td>
<td>Development of appropriate fertilizer recommendations and formulations at the scales appropriate for users (larger for fertilizer manufactures than for rural service providers)</td>
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<tr>
<td>What information/resources do we need?</td>
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<tr>
<td>What additional expertise do we need? Can we identify appropriate people?</td>
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</tbody>
</table>
**Define the opportunity**

- What are the scientific opportunities for addressing those research challenges (and on what timescale)?
- What methods are appropriate? Are there any novel methods?
- What are the partnering opportunities for African and UK researchers?
- What research could make the biggest difference (where, how and when)?

<table>
<thead>
<tr>
<th></th>
<th>Diagnostics for testing soil and crop nutrient status at multiple scales from low-cost soil sampling and testing to satellite remote sensing.</th>
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<tbody>
<tr>
<td></td>
<td>Decision-support tools to improve nutrient management, suitable for different types of farm(er)s.</td>
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<td></td>
<td>The “4Rs” for fertiliser use: the right type for the right purpose in the right place at the right time.</td>
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<td></td>
<td>Integrated Soil Fertility Management (ISFM) to ensure that the supply of nutrients (the ‘4Rs’) is aligned to the demand for those nutrients (good germplasm, good agronomic practices, use of other amendments such as lime).</td>
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<td></td>
<td>Technologies for small-scale precision farming e.g. spatial and temporal nutrient application/release (targeting farmers’ resource endowments and soil fertility gradients is embedded in the ISFM framework).</td>
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<td></td>
<td>(Legume) intercropping/rotations and mixed cropping systems.</td>
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<td></td>
<td>Ergonomics (and biosafety) of nutrient (manure) movement between and with farms.</td>
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<td></td>
<td>Crop breeding for varieties with improved nutrient use efficiency, drought tolerance and nutritional quality.</td>
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<td></td>
<td>Understanding the role of the soil microbiome/soil fauna in nutrient cycling in the rhizosphere (potential for “bioremediation” of depleted soils?).</td>
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<td></td>
<td>Improvement of soil structure for nutrient retention.</td>
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</table>
## Optimisation of resource use – nutrients, water, etc. Challenge 3: Mobile phones on farm for agricultural development

### Scope of the challenge
- Who/what does this affect? (people, areas, crops, livestock etc.)
- Why is it a problem? (impact of the challenge)
- What do we want to achieve in the short-term and long-term?
- What would be the impact of these solutions?

- How to get knowledge to and from farmers more effectively than currently, using new mobile phone technologies with additional diagnostics, to improve farming practices and enhance efficiency of resource use.
- In the household is often the man that owns the ‘smart phone’ and so it is easy for the women/young to miss out on innovation. Should be considered in experiment design.

### Location of the challenge
- Which part of Africa has this problem?
- What type of farming systems are involved?
- What are the local conditions? (climate, soil, transport, infrastructure)

- Widespread.
- Focus mainly on smallholder farmers.
- Need appropriate power sources (but network connectivity is generally good).

### Knowledge and resources needs
- What scientific/technical information do we have so far?
- Who has this expertise? Where are they?
- What information/resources do we need?
- What additional expertise do we need? Can we identify appropriate people?

- New technologies must be based on the right assumptions for their intended applications: affordable, mature, easy to use and appropriate for and understandable by intended users, and based on knowledge of their situations and needs.
- Build on existing activities (e.g. One Acre Fund) using phones for crowd-sourcing of data collection and dissemination of information.
- Potential areas of knowledge dissemination/collection include:
  - soil mapping;
  - crop suitability mapping for different areas;
  - pest and disease mapping;
  - land typology;
  - weather (but meteorological data for Africa hard to get and expensive);
  - risk and opportunity mapping (but need understanding of associated uncertainty);
  - testing of predictive models.
**Define the opportunity**

- What are the scientific opportunities for addressing those research challenges (and on what timescale)?
- What methods are appropriate? Are there any novel methods?
- What are the partnering opportunities for African and UK researchers?
- What research could make the biggest difference (where, how and when)?

| • Instrumentation of mobile phones with addition of solid-state non-contact (e.g. infra-red) sensors and embedded open-source knowledge for interpretation of diagnostics. |
| • Development, testing and translation of appropriate novel sensors. |
| • Also potential contribution of satellite remote sensing. |
Clustered challenges: Optimization of resource use

1. Water
   - Drip irrigation systems
   - Water resource efficiency
   - Aquifer exploitation (there are massive untapped ground water resources in areas where people are starving)
   - Water use shortage in agro-ecosystems

2. Fertilisers
   - Sustainable (balanced use of organic mineral nutrients – fertilizers)
   - Role of input subsidies (irrigation and fertilizers – in S.I. delivery)
   - Delivering higher crop yields and improved crop quality with fertilizers
   - Reducing organic nutrient inputs by enhancing biological cycles/BIOGEOCHEMICAL cycles
   - Managing nutrient budgets across scales: Field farm, community, landscape, country
   - Improved crop and livestock nutrition to enhance production and reduce environmental footprint
   - Organic/bio-fertilizers as ecologically, benign alternatives to inorganic fertilizers in smallholder agriculture
   - Closed-loop nutrient use/cycling
   - Misuse of fertilizers and pesticides
   - Increasing local capacity for agricultural input manufacture
   - Limited information on nutrient use efficiency of most crops

3. Soil/ Inorganic
   - Ensuring nutrient availability for crops of choice
   - Maximizing use of beneficial soil microbes for improved crop nutrient use efficiency
   - How do we regulate degraded soils towards increased resource use efficiency?
   - How can we increase the availability of organic resources on-farm?
   - Bio-control mechanisms (promotion of use organic manure and less of chemicals)
   - Tools for soil/nutrients in soil analysis that can be applied quickly in the field - +cheaply, + easily
   - Sustainable use of locally available resources for feed and health protection

4. Animals
   - Understanding and maximizing feed use efficient into food matrix
   - Alternative animal feed ingredient for sustainability, cost effectiveness, environment and wealth creation
   - Overgrazing/improper stocking density in rangelands – soil degradation
   - Integration of crop farming and livestock keep in land stresses regions
5. Conservation
- Conservation agriculture
  - Soil, water and plant nutrient management
  - Implementing conservation agriculture at scale

6. Technology
- Efficiency Vs Yield
- Identify possible leapfrogs technologies
  - Now: Phone
  - Future: Farmer-phone
  - Drones?
- What is the most appropriate scale for targeting agro-inputs?
- Investigate and learn from methods of successful technology adoption
- Move from products to services
- Explore how embedded knowledge in smart machines can help farmers directly
- Develop methods to make crop production more efficient (sustainable through "intelligently targeted inputs")
- Develop mobile phones with added solid state sailors
  - Artificial nose
  - Multi-spectral
  - Machine vision
  - Cloud based services

7. Other
- How do we move to system redesign rather than just “tinkering” with increasing efficiency
- Use modern bioscience tools to improve/add value
- Cash crops that generate incomes to smallholder farmers
- Climate smart control of pests and diseases in crops
Exploitation of the genetic diversity and metabolic potential of crops or farmed animals. Challenge 1: Plant breeding for multiple traits focussed on end users (robustness)

<table>
<thead>
<tr>
<th>Scope of the challenge</th>
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<tbody>
<tr>
<td>a) Who/ what does this affect? (people, areas, crops, livestock etc.)</td>
<td>a) Cash crops, food crops, forages, amenity crops</td>
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<tr>
<td>b) Why is it a problem? (impact of the challenge)</td>
<td>People: Whole spectrum (key value chain actors from field to consumption</td>
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<tr>
<td>c) What do we want to achieve in the short-term and long-term?</td>
<td>Small holder (First focus, community based addressing women and youth),</td>
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<tr>
<td>d) What would be the impact of these solutions?</td>
<td>Agropastoral farmers (harsh environment),</td>
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<td>Medium scale for income</td>
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<td></td>
<td>Entrepreneurs</td>
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<tr>
<td>b) Lack of investment in science to drive agenda and capacity building</td>
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<td></td>
<td>Expertise</td>
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<td>Defined policies and strategies</td>
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<td>Finance and funding</td>
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<td>Long term and strategy missing</td>
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<td></td>
<td>Shared need of farmer, scientist and end user because of disconnect</td>
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<td>Need for specialization for access to market</td>
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<td></td>
<td>Genomic selection, genetic marker, (identify easy wins). Characterize genetically important species</td>
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<tr>
<td></td>
<td>How many lives have been transformed? (big picture), nutritional status, child mortality</td>
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<table>
<thead>
<tr>
<th>Location of the challenge</th>
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<tbody>
<tr>
<td>a) Which part of Africa has this problem?</td>
<td>a) SSA</td>
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<tr>
<td>b) What type of farming systems are involved?</td>
<td>b) All farming systems</td>
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<tr>
<td>c) What are the local conditions? (climate, soil, transport, infrastructure)</td>
<td>c) Infrastructure investment and maintenance of existing. All of above</td>
<td></td>
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</tr>
<tr>
<td>d) How many lives have been transformed? (big picture), nutritional status, child mortality</td>
<td>d) Seed production and seed certification and delivery systems are needed to deliver impact to farmers and to realise return on investment in breeding</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Knowledge and resources needs</th>
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</tr>
</thead>
<tbody>
<tr>
<td>a) What scientific/technical information do we have so far?</td>
<td>a) Established breeding programs-International and national programs</td>
<td></td>
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<td>b) Who has this expertise? Where are they?</td>
<td>b) National programs have the expertise to reach farmers. CGs work through them. National programs have very basic resources and limited access to funding especially for adoption of new technologies/innovations. BecA-ILRI, IGSS platform</td>
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<td>c) What information/resources do we need?</td>
<td>c) Investing in expertise, facilities, and infrastructures in the national programs. Inventory of resource gaps, where and who is breeding, specific clusters for crops, bioinformatics clusters- Toolkits and analysis pipelines for data analysis</td>
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<td>d) What additional expertise do we need? Can we identify appropriate people?</td>
<td>Access to HPC knowledge and compliance with intellectual property rights and plant variety rights (policy and ownership, governance)</td>
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<td>Define the opportunity</td>
<td>d) Bioinformatics, quantitative genetics</td>
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<tr>
<td>a) What are the scientific opportunities for addressing those research challenges (and on what timescale)?</td>
<td>a) Optimal allocation of resources, widespread application of molecular breeding, New breeding technologies (TILLING, CRISPR-Cas9), Bioinformatics, phenomics, (Targeted high precision phenotyping)</td>
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<td>b) What methods are appropriate? Are there any novel methods?</td>
<td>b) Bottom up seed systems using land races or local varieties.</td>
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<td>c) What are the partnering opportunities for African and UK researchers?</td>
<td>c) Community based and/or participatory breeding and crowd sourcing trait information and farmer preferences</td>
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<td>d) What research could make the biggest difference (where, how and when)?</td>
<td>d) Sharing of crop improvement models that have been found effective in crops with similar genetics/genomics</td>
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<td>e)</td>
<td>e) Marker assisted breeding. Mutation breeding, (GM not accepted, yet for food crops needs policy - Research only (Regulatory framework required)) Genomic assisted breeding. Double haploid. Speed breeding</td>
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<td>f) UK with national institutes (Bilateral)</td>
<td>f) UK with national institutes (Bilateral) UK with national institutes (Higher education PhD, MSc.- Split arrangements. Visiting scientists longer placements, Short term placements</td>
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<tr>
<td>g) Bioinformatics, training and capacity</td>
<td>g) Bioinformatics, training and capacity</td>
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- Selection indices needed to take into account farmer preferences and local needs as well as agronomic, disease and quality traits (more targeted local selection)
Exploitation of the genetic diversity and metabolic potential of crops or farmed animals. Challenge 2: Livestock breeding for multiple traits focussed on end users (robustness)

### Scope of the challenge

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| a) | Who/ what does this affect? (people, areas, crops, livestock etc.)  
   |   |
| b) | Why is it a problem? (impact of the challenge)  
   |   |
| c) | What do we want to achieve in the short-term and long-term?  
   |   |
| d) | What would be the impact of these solutions?  
   |   |
| a) | Monogastric, swine, cattle, small ruminants, others, aquaculture, apiculture  
   | People: 1) pastoralist (meat and milk sup maize) 2) mixed (both) 3) all consumers (food safety issues)  
   |   |
| b) | Can’t meet production needs (low productivity) diseases, climate, conservation/efficiency is low: human problem is nutrition is low / core nutrition issues: poor value chain: poor intensification: feed shortage, lack of organisation around livestock development. Transportation is challenging. Local level not inspections (possibilities at cities) unregulated use of antibiotics + drugs  
   |   |
| c) | Improved productivity : reduce environmental impact (long term) resource identification (inventories (short terms) : map gaps  
   |   |
| d) | All of above – food security, environment / sustainable intensification  

### Location of the challenge

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| a) | Which part of Africa has this problem?  
   |   |
| b) | What type of farming systems are involved?  
   |   |
| c) | What are the local conditions? (climate, soil, transport, infrastructure)  
   |   |
| a) | All: coastal all the way to arid agro ecological zones  
   |   |
| b) | Small holders, pastoral, medium scale, pastoral less + less land (encouraged to mixed farms)  
   |   |
| c) | Different countries are at different stages : Kenya advanced in policy, networks and systems  

### Knowledge and resources needs

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| a) | What scientific/technical information do we have so far?  
   |   |
| b) | Who has this expertise? Where are they?  
   |   |
| c) | What information/resources do we need?  
   |   |
| d) | What additional expertise do we need? Can we identify appropriate people?  
   |   |
| a) | Established breeding programs at national and international level  
   |   |
| b) | National breeders at NARS, Universities and partners (e.g. ILRI)  
   |   |
| c) | Human resources, infrastructure, breeding platforms  
   |   |
| d) | Additional training, procurement, imbedded in NARS + Universities, private sector (multiplication of improved genotypes) extension workers  

### Define the opportunity

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| a) | What are the scientific opportunities for addressing those research challenges (and on what timescale)?  
   |   |
| b) | What methods are appropriate? Are there any novel methods?  
   |   |
| c) | What are the partnering opportunities for African and UK researchers?  
   |   |
| d) | What research could make the biggest difference (where, how and when)?  
   |   |
| a) | Reproductive technologies (embryo transfer, AI), molecular breeding, genomic technologies (cloning), "precision livestock farming", understanding animal behaviour  
   | o Policy strategy framework for livestock  
   | o Development of national breeding database (livestock)  
   | o Develop systems of livestock identification and traceability to support breeding programmes and disease management  
   | o Potential of ethno pharmacopeia for animal health protection and disease control  
   |   |
| b) | Advanced technology, emphasis on driving policies, GIS/Remote sensing for traceability and epidemio-surveillance  
   |   |
| c) | Antibiotic resistance (strong in UK) develop diagnostics (molecular etc.) developing  

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• Selection indices needed to take into account farmer preferences and local needs as well as agronomic, disease and quality traits (more targeted local selection)

**Challenges**
- Gene discovery and evaluation of gene expression potential as basis for sustainable improvement in local breeds
- Feeds and nutrition, animal health, poor production, poor potential of the genotypes (population), drought, poor market channel
- Optimised forage systems, breeding, management e.g. bracharia
- Genetic improvement of livestock, high production and adapted to the environment
- Shortage of animal foods, shortage of water particularly in pastoral area, low productivity of local animals, shortage of resources (land, water)
- Optimizing to metabolic potential of exotic and local meat-type poultry strains in SSA using locally available nutrient (feed) resources
- Livestock breeds which are “climate-smart” and suitable for African conditions
- Genomics and livestock disease management
- Marker development for SSA breeds for genetic characterization, gene environment interaction
- Importance of 2nd metabolism products
Exploitation of the genetic diversity and metabolic potential of crops or farmed animals. Challenge 3: Exploitation of under-utilised crops / livestock species + conservation of these resources (pre-breeding)

Challenges

- Indigenous livestock promotion and preservation
- Recognition of value of indigenous animals and focus on improving the potential outside cross-breeding
- Neglected animals (duck, geese, quail, guinea fowl)
- Lack of conservation programmes for some genetically important breeds
- During plant breeding emphasis is on selection of materials with desired traits, how do we control genetic erosion / conservation of under-utilised crops
- Restore populations + genetic selection - a useful new approach
- Capitalising on crop diversity – exploitation of under-utilised native species / landraces of crops : genetics , breeding
- Improving neglected crops
- Lack of appropriate crops for sustainable agriculture intensification
- Characterising genetic material: developing land suitability maps
- Climate change (drought), temperature
- Emerging diseases of livestock
- Ethnobotanical study for more orphan crops genetic diversity and genes for resistance to pathogens / products of metabolites that enhance food security and reserve in nutrients
- Value addition of under-utilised crops, e.g. starch type + use in local industry of neglected species
Exploitation of the genetic diversity and metabolic potential of crops or farmed animals. Challenge 4: plant microbial communities for beneficial applications

- Development of disease diagnosis kits that can be used in areas with minimal resource settings
- Understanding variability in germplasm interactions with beneficial microbes (below and above ground)
- Efficient N-fixing legumes suitable for African conditions
- Plant-microbe interactions and nitrogen
- Understanding the microbial communities in African soil-plant systems
- Nitrogen and yield (microbiome)
Exploitation of the genetic diversity and metabolic potential of crops or farmed animals: Additional, general challenges discussed during the session

- How do we increase resilience of crop and livestock varieties? Variety selection (traits of specific outcomes) VS Heterogeneous (resilient) mixtures (climate change)
- Effective and sustainable use of resources to exploit metabolic potential of crops and livestock
- Alternative protein sources animal feed - novel beneficial insects for food and feed – e.g. Earthworms
- Modification of pathways dry of metabolite production for better crop production
- Food waste and post-harvest losses
- Lack of systems approach to animal use and care guidelines
- Long distance transport
- Welfare standards
- Public health issues
- How to encourage public-private partnerships (currently lacking match funding from industry model?)
- Improving diets in humans by matching crop/food stuff to the livestock and then into the food matrix (nutrition in the meat /milk)
Clustered challenges: Exploitation of the genetic diversity and metabolic potential of crops or farmed animals

- Genomics applications in marker assisted breeding for livestock improvement
- Plant breeding to meet the nutritional needs of livestock
- Improve crop nutrition by using genetic engineering techniques
- Breeding crops more resilient to climatic variability and extremes
- Crop diversification (specific crops for specific agro-ecology)
- Narrow genetic base of most crops limits breeding for stress tolerance
- Narrow genetic diversity in important staple crops in SSA
- Identifying suitable varieties for climatic change
- Improving nutritional content of staples
- Crop germplasm tailored to requirements of smallholder farmers (Not high input)
- Lack of appropriate crops adapted to resilient to cc impacts
- Integrating genetics and diversity within cropping systems
- Less research attention given to root and tuber crops
- Mining farmer preferred varieties for stress resistant traits
- Use /exploitation of genes related to locally adapted traits for productivity and disease resistance
- Introduce appropriate resilient crops in marginal lands
- Temperature, climate and yield in cereals
- Several breeds of populations and unidentified (genetic and phenotypic characterization)
- Crop breeding for specific livestock needs
- Development of striga-tolerant resistant cereal crops
ANNEX 5: DAY 2 BREAKOUT SESSION NOTES: RESEARCH TRANSLATION AND IMPACT

Research translation and impact: Integrated agricultural systems (landscape and biodiversity management)

Who are the end users?

- Landscape-level decision-makers/ top-down mechanisms
  - Policy-makers
  - Development agencies
  - Civil society
  - Anyone developing management programmes at a large scale
- Community-led/ bottom-up mechanisms
  - Farmers
  - Multi-stakeholder forums
  - Broader decision-making forums
- Very broad spectrum/ scale of end-users
- Ultimately, end users are the farmers (policy-makers, industry, landscape-level decision-makers etc. are intermediaries), but often difficult for farmers to apply research findings directly.
  - Key role of extension services
  - Need to identify organisations which have strong connections to farmers
- Distinction between beneficiaries and end-users of research evidence. Farmers and local communities are beneficiaries of the research, but landscape-level organisations/ agencies/ policy-makers/ G’ment are the end users

What will be the barriers to research uptake?

- Integrating disparate information sources across larger scales. Need to ensure some common metrics to enable their integration.
- Generating a common understanding of complex issues and conceptualisation of systems research (it is everything and nothing!) – need to decide what is in and what is out
- Challenges and high costs of working with multiple stakeholders and getting them to ‘speak the same language’
- Ensuring organisations have sufficient influence to initiate change based on research findings
- Breaking down science silos to integrate knowledge across disciplines and more effectively inform policy

What will enable uptake of the research

- Ensuring that research outputs are responding to the needs of end users (through co-designed research, action research implementation)
- Collective decision-making at multiple scales (with the same end goal)
- Anything which involves payment for ecosystem services, and ensuring that the right people benefit – SSA does not have a good track record for this
- An underlying structure to deliver the research findings
  - Common metrics across countries
- Ensuring confidence in the research (design and findings)
- Validating models in the 'real world' by end-users
- Need credible partner organizations to facilitate engagement with end-users
- Demonstration sites/ farmer-to-farmer exchanges – either small plot on farm with collective of farmers and neighbours, or taking farmers to demonstration sites so they can see for themselves what can be achieved
  - e.g. 'Farms of the Future' project, using the climate analogues tool – taking farmers to locations which have a similar climate to the one projected by the tool
- Mechanisms for multi-stakeholder engagement – stakeholders working at different levels within the landscape, to facilitate understanding on all levels
  - 'Research for development' platforms/ 'Innovation platforms' (Africa RISING programme):

![Image credit: ILRI/ Bonaventure Nyotumba](image-url)
Research translation and impact: Integrated agricultural systems (mobile phones for agricultural development)

Who are the end users?

- Farmers and local communities
- Extension agencies
- Distinction between end users of the technologies and end users of the data outputs (i.e. data sets coming out of e.g. early-warning systems)
- Importance of targeting groups that will facilitate uptake once the projects have finished – i.e. aligning with existing Government strategies and policies
  - Which are the relevant Government agencies?
- Importance of case-study areas where farmers/ farmer groups can develop and test technologies in the field (this is the research question)

What will be the barriers to research uptake?

- Poor network coverage/ infrastructure in particular countries in SSA (Kenya has quite an advanced infrastructure)
- Availability of smart phones
- Cost of using smart phones
- Lack of knowledge of using smart phones and associated technologies/ apps
- Convincing telecommunications agencies to enable free access to certain sites could be challenging
- Gender issues related to access to, and use of, technologies
- Proliferation of (often unwanted) services delivered by mobile phone providers – and the costs (to farmers) associated with these – causing resistance to some technologies
- Differences between social, cultural and political aspects and decision-making frameworks between countries in SSA

What will enable uptake of the research?

- Farmer participation in research design and adaptation – learn the limitations to co-design of research
- Involving different stakeholders, working together in a systems fashion
- Demonstrating to farmers what their neighbours are using
- Improved phone network coverage/ infrastructure
  - Regional ‘hubs’ to provide internet access
- Wider availability of smart phones
- Capacity-building and training in the use of smart phones/ particular apps and associated technologies
- National-level regulation of technologies (like what is done currently for biosecurity) to ensure appropriateness and suitability for each country/ region
- Ensure built-in feedback process from end-users to managers of system
- Early discussions with farmers regarding the types of mobile services they want/ need
  - Co-creation and co-design to ensure research outputs are targeted at the right people and in the right way
- Researchers working with public and private sector extension services
- Initially free access to particular apps/web pages (e.g. through aid funding) to facilitate early adoption of technologies
  - Then cost benefit analysis of the technology
  - Ongoing access funded through net benefits accrued to farmers by using the technology
Research translation and impact: Countering abiotic and biotic stresses

Who are the end users?

- Primarily farmers but all consumers
- Researchers
- Agronomists
- Regulators and Policy Makers
- Extension agents
- Companies (pesticides, seeds, etc)
- Not only farmers but the whole food chain
- Technology providers, entrepreneurial – It is important to consider the value chain linked with the development pipeline. If you rely on market for novelty, sometimes this will not happen. People usually don’t take risks.

Enablers of research uptake:

- it is important to have effective communication, prioritize face-to-face and co-design participatory approaches
- effective communication for policy briefing, extension leaflets, etc requires simple, short, practical, key relevant messages and should be written with a specific audience in mind (extension agents, public and private, NGOs, etc)
- Make better use of farmers networks, demonstrations, open day, farmers’ fields –
- Researchers tend to look at more general problems while farmers want to see real solutions. Farmers will believe when they see ‘in action’ and results.
- Schools, training programmes – encouraging children to be educated and to eventually to become farmers
- Radio, videos
- Great potential with mobile phone technology
- Provide financial support for early adoption costs – subsidies
- Evidence-based solutions – it helps if you have something to back up for policy makers. But it is important to understand what will be accepted for different groups and who do you trust to provide evidence? For instance, farmers don’t trust evidence by commercial agronomists.
- Utilizing farming networks to showcase their own innovation. Farmers might not be interested in yields solely and, in some cases, they just want a crop that won’t die. It is important to understand the trade-offs.
- Embedding resilience on farming innovations and attend users’ needs.

Barriers to uptake:

- The way key messages are written can be detrimental. It is important to adapt messages to different groups.
- There are issued on how to reach millions of farmers, how to adapt message to different groups and what is the appropriated media to use. A good example cited is Shamba Shape up TV.
- Take into consideration social cultural practices, for instance it is important to understand how different gender engage at face-to-face meetings. In some meeting, women may be sitting at the back with not voice. This is in contrast with their active role at the farming. There is also a gender difference in the way mobile phone is used.
In some countries, women don’t have access. The conclusion is that we need to understand more these issues and what does work.

- Radio is good but on particular occasions, visual information is vital – for instance, in the identification of diseases.
- In some cases, for instance, advice on pesticide use it is important to understand the regulation constraints. The same applies to biological control. Each country will have different regulation and the regulatory boards need to be informed on new products to be tested in research. This is an issue that demonstrate the importance of engaging all the key stakeholders to facilitate the process.
- Technical constraints and need for capacity building, for instance It is harder to detect problems of soil health. Most technology to detect soil-borne diseases and pests are molecular and difficult to explain. The detection of problem can arise when it is too late, and soil problems are persistent.
- You need to have a quality offer for intervention. The example was in the molecular technology to identify beneficial and non-beneficial organisms in soil and issues related to quality control. This is not easy for farmers to do.
- How risk (or perception of risk) affects the adoption of technology? The challenge is on how do you facilitate technology adoption when there is a perceived risk?
- Gap in quality control resulting in export barriers due to the lack of certification
- Surveillance – who is responsible to pay and curate? Who owns it? And what can be done with the information?
- Perceived gap of the capacity to do the research, and the need for their research. Also, there are regional difference to carry out research.

How to overcome these barriers?

- Capacity building was presented as a way to overcome barriers.
- For cultural aspects, involve the farming community in dialogue and demonstrate the importance of the issue to be discussed. It is important to take into consideration their perception of actual problems.
- We need to advocate for the importance of translation and different research areas.
- Importance of collaboration and partnerships.
- To have a contingency plan that everybody should be aware and to communicate this to all. For instance, during an outbreak of diseases there is a need for prioritization (especially from Government) and flexibility.
- It is important to have short- and long-term strategies. In crises, priorities changes hence the important role for GCRF in providing long-term priority directions across several regions. In particularly those in conflicts.
- Questions:
  - How do we make long-term prediction under geo-political uncertainties for Agriculture? How do we develop a strategic framework that allow us to have short- and long-term gains at the same time? We need to bring social sciences…
  - Is there a common goal? Should we look at multiple trajectories, scenario generation, validation? It is important to bridge the gaps
- De-risking innovation to facilitate accessibility of technology = interventions need to facilitate
- Make better use of farmers’ phone as a 2-way process, not only providing information but also capturing data but keeping in mind ethics concerns regarding to who hold the data and how the information is disseminated
1. **Who are the end users?**

   - Potential beneficiaries are all types of farmers.
   - Main end-users of research would be providers of advice and services to farmers - not just traditional extension services, but also commercial providers (at all scales) of products or services to farmers.

2. **What will be the barriers to research uptake?**

   - Need for intermediate institutions between researchers and farmers to help deliver impact.
   - Extension services not available or not effective in some places.
   - Lack of trust and risk aversion - need open access to research and open interpretation of research.
   - Fragile relationships between farmers and commercially-motivated agronomists.
   - Farmers need impartial, independent advice.
   - Lack of trust in some existing commercial products, e.g. poor quality biofertilisers or conventional fertilisers.

3. **What will enable uptake of the research?**

   - Need to provide demonstrable evidence that interventions work (knowledge alone won't effect change).
   - Training (particularly Masters level) for extension service staff.
   - People with skills to communicate and work with beneficiaries, and cultural awareness, able to bridge the gap between research and practitioners.
   - Accreditation schemes.
   - Better joining up of research with development agency programmes, e.g. World Bank.
   - Robust and critical evaluation (theory of change).
   - Legislation.
   - Fertiliser input subsidies (but issues of sustainability, if discontinued).
   - Also links between micronutrient fertilisers and human nutrition and health.
Research translation and impact: Exploitation of genetic diversity and metabolic potential

1. Who are the end users?
   - Whole value chain from field to consumption (effects will vary along the value chain)
     - Primarily farmers, but ultimately consumers
     - Policy makers
     - Plant breeders and seed companies
     - Government agencies
     - Businesses that are developing new breeds
     - Seed producers
   - Effect of gender – some research/ crops/ livestock may be more relevant to women and youth (e.g. women owning small ruminants)
   - Depends on where the demand is – market/ consumer-led research may have different end-users to farmer-led research
   - Depends on whether the end product is for domestic or commercial use

2. What will enable uptake of the research?
   - Increased capacity
     - Infrastructure, long-term investment
       - Improved logistics
     - Sufficient capacity (human and infrastructure)
     - Inventory of existing knowledge
     - Availability of seeds and genetic resources
     - Improved seed systems / new breeds
       - Approval of new breeds/ varieties
   - Low cost/ affordability
     - Cost-benefit analysis of new technologies
     - Minimised cost of research uptake to farmers
     - Availability of micro-credit for smallholders/ farmers
       - Better financial services for farmers to improve yield
     - Affordability of seeds and genetic resources
   - Co-design/ working with stakeholders
     - Well-developed extension system (incorporated into research design and delivery)
     - Co-designed research – ensuring farmer preferences are integrated into research design and product development
       - Needs to be a two-way process
       - Networking to keep all stakeholders connected throughout the research process
     - Cultural acceptance of local varieties
     - Working with farmer cooperatives/ farmer organisations and networks
   - Demand-driven approach
     - Appropriate research/ product design for the specific farming system – e.g. high-yielding varieties need high inputs
     - Demand-driven approach - suitability of the research/ product for the end-user
       - Demand-driven research
       - Understanding user-needs
Designing product for particular end-user (e.g. men want high yielding rice/ women prefer rice that is easier to process)
Can’t design a product that fits everybody’s needs

Other
- Legal acceptance of interventions/ research outputs
- NB need high-risk and low-risk research. If research just responded to farmers’ needs, it would be very conservative. Scientists are able to explore future possibilities (i.e. 20-30 years into the future)
- Youth for sustainability – include phones in the methodology as young people will be more responsive
- Raised awareness/ media

3. What will be the barriers to uptake?
- Legal and regulatory frameworks – local and national
- Cost
  - Investment costs for farmer
  - Seed availability at an affordable price
- Capacity
  - Lack of resources
  - Lack of long-term funding
- Technical difficulties related to breeding multiple traits into a single line
- Length of time to develop new varieties (breeding and testing) - 1 decade
- Political instability/ conflict – animal genetic material is lost in conflict zones
- Disconnect between scientists and policy-makers
- Technologies/ outputs not targeted at farmers’ interests/ the end user
  - Preference of traditional varieties - growth conditions optimised for those and not for high yield varieties. Also cultural problem - some varieties are preferred. Cultural biases
  - Consumer acceptance
- Cooperatives/ organisations not very good in Africa
- Language and communication challenges
- No compensation policy

4. What can be done to help overcome these barriers?
- Education
- Good communication/ extension networks
- Involve stakeholders throughout long-term projects (co-design and delivery)
  - Invite stakeholders to inception workshops to help inform and encourage long-term investment
- Communication with policy-makers – providing evidence-based information to help them make management decisions
- Capacity building (human and infrastructure)
- Seed systems - bulking up
  - Crop genetics resources of wild relatives (seed bank) before they are lost by climate change, negligibility or replacement
  - Conservation of genetic diversity (in the face of climate change) – need to build a bank of seed lines
- Investment – balance between short-term (e.g. agronomy) and long-term (e.g. breeding) research funding
  - Short-term funding for proof-of concept research
- Private sector involvement/ private sector partnerships – make breeding an industrial process
  - Partnerships to leverage added value and bring additional skills to the table
• Clear organisation to increase confidence in the research
• Market access
  o Market incentives (e.g. poultry private sector sell chicks to young farmers and promise to buy-back at a set price)
  o Market assurance
  o Certification for wider market access
• Risk-management – insurance system to make more sustainable
• Adaptation to climate change