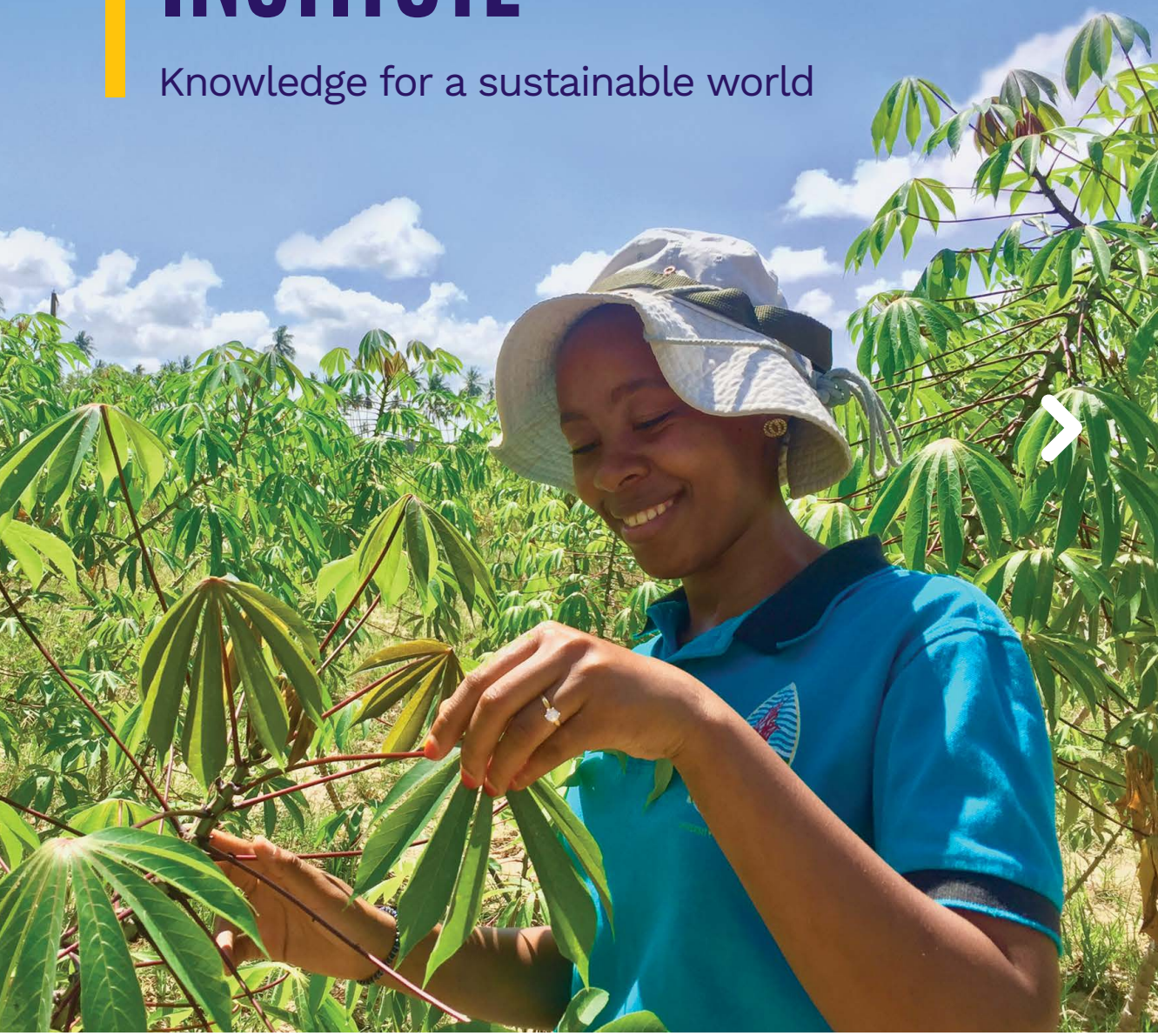
NATURAL RESOURCES INSTITUTE

Knowledge for a sustainable world



ANNUAL REVIEW
2017–2018

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Annual Review 2017–2018

The Natural Resources Institute (NRI) is a specialist institute of the University of Greenwich. Combining the expertise of natural and social scientists, we engage in research, teaching, training, and consultancy to address significant challenges and opportunities in the sectors and countries in which we work.

Among these are the challenges of food and nutrition security, agriculture and sustainable development in the face of climate change, land and environmental management, markets and responsible business, capacity strengthening, and gender and inequality. These global challenges are addressed through our thematic areas of work which are covered in this Annual Review.

www.nri.org

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Front cover photo: Research scientist Ms Leonia Mlaki (Tanzania Agricultural Research Institute – Mikocheni) inspecting cassava leaves for nymphs of whitefly *(Bemisia tabaci)* in Chambezi, Tanzania, as part of the African Cassava Whitefly Project. Photo: Sharon van Brunschot

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Foreword

Professor David Maguire, Vice Chancellor, University of Greenwich

This year's Annual Review from our Natural Resources Institute demonstrates the excellence of their research across a diversity of issues, which aims to improve the lives of some of the world's poorest people. Their teams are consistently awarded prestigious grants from major funders including the UK Department for International Development, the Bill & Melinda Gates Foundation, UK Research Councils and the European Union, in areas such as food and nutrition security, sustainable business and finance models, controlling major pests and diseases, and gender and social difference. Importantly, the world-leading researchers at NRI are also experienced lecturers, who engage their students in an exciting range of undergraduate and postgraduate programmes, and who supervise a growing group of dynamic postgraduate research students. Their teaching contributes to the University of Greenwich's silver rating in the Teaching Excellence Framework in recognition of high-quality resources, teaching and personalised provision. Enjoy reading and discover their work.

Introduction

Professor Andrew Westby, Director of NRI

A warm welcome to NRI's Annual Review 2017–2018. This year's edition is bigger and better, reflecting the broad range of work we do together with our international partners. Remaining focused on our core theme 'Knowledge for a sustainable world', this selection of our work highlights how we respond to global challenges by designing sustainable solutions that make a difference.

As NRI's portfolio of projects expands and our team continues to grow, it is important to mention and give thanks to our dedicated team of professional services and administrative staff, who consistently take on more tasks as they steadfastly support NRI's staff, students and mission – read more about this team on page 59.

Next year, 2019, will be a significant year for NRI: we will be celebrating our 125-year Anniversary. This occasion is an opportunity to recall pioneering work from our history, including locust control, safeguarding against foodborne diseases, controlling tsetse and blackfly, and the discovery of aflatoxin. We must also use this opportunity to look to the future, and engage all generations in the endeavour of creating a sustainable world. NRI's new MSc programme in Global Environmental Change focuses on what changes to our environment could mean for us, on a global level, both in the past and in the future – find out more on page 50.

More details about celebrations and activities will be announced throughout the year, and through #NRI125. Join us!

Photo: Planting cassava stem cuttings on the farm of Akutu Augustine, the 'Professor of Cassava', in Amuria District, Uganda.

HIGHLIGHTS FROM THE YEAR

FOOD SECURITY, AGRICULTURE AND NUTRITION

Better nutrition for a growing population is a major challenge of our time. However, to improve nutrition, more understanding is needed of patterns of consumption, dietary practices and food systems. By improving standards for collecting and measuring data and developing innovative methodologies for evaluating agriculture and food systems, scientists will be able to build a robust evidence base, which in turn will guide actions to improve nutrition. Examples of NRI's work in this area include two projects carried out under the research initiative known as 'IMMANA' or 'Innovative Metrics and Methods for Agriculture and Nutrition Actions', funded with UK Aid from the UK government through the Department for International Development (DFID) and coordinated by the Leverhulme Centre for Integrative Research on Agriculture and Health (LCIRAH).

Developing methods to better understand diets and access to animal-source foods in rural Tanzania

Julia de Bruyn

Information about how diets and access to nutrient-rich foods vary throughout the year is vital to inform strategies to sustainably address undernutrition in vulnerable households. Undernutrition describes the various states which may arise from inadequate dietary intake or frequent illness: including short-term outcomes such as thinness (wasting), longer-term outcomes such as short stature (stunting), as well as the diverse consequences of vitamin and mineral deficiencies.

A project funded through the UK Department for International Development's IMMANA programme is developing and testing a novel method to collect household-level information about diets and food resources, which is suitable for use in remote, low-literacy settings.

To better understand the role of animal-source foods (including milk, meat, fish and eggs) in human diets in low-income countries, there is a need for information on access to these foods across different seasons. Milk consumption has been associated with improved growth in stunted children, increased arm muscle mass and improved cognitive function, but information on the availability of milk from the indigenous cattle kept by African pastoralists and agropastoralists is currently lacking.

This project, led by Dr Julia de Bruyn, a nutrition researcher at NRI, will explore the contribution of milk to the diets, incomes and food security of cattle-owning households in villages of Manyoni District in Tanzania. These communities are located within the Rift Valley in a semi-arid area of the country. Households rely largely on subsistence farming of staple crops, supplemented by livestock-keeping, and face the chronic risk of food insecurity due to low and irregularly-timed rainfall. Picture-based record charts evaluated through this project have the potential for wider use in agriculture-nutrition research, to document variation in dietary patterns, access to food resources, and asset ownership over time.

Photo: A woman and two of her children in a remote village of Sanza Ward in central Tanzania, where cow's milk is the most commonly consumed animal-source food and meat and eggs are infrequently eaten.

Estimating the type and amount of nutrients lost, from harvest to market

Aurélie Bechoff

Across the world, vast amounts of food are lost or wasted after harvest every year. These postharvest losses happen at different stages as a food crop moves from harvest to consumption, a journey known as the 'value chain'. Significant quantities of food crops are lost postharvest even in places with high rates of food insecurity, compounding the problem; if people's diets are not rich enough in important nutrients such as proteins, vitamins or minerals, it can cause them to suffer from deficiencies. Postharvest losses associated with food insecurity could have serious health, developmental and economic consequences.

Funded by IMMANA, the NUTRI-P-LOSS project led by NRI's Aurélie Bechoff, is developing a methodology to estimate the type and amount of nutrients lost postharvest in key staple food crops in sub-Saharan African countries, from harvesting through to storage. NUTRI-P-LOSS is carried out in partnership with scientists from the National Agriculture Research Organisation in Uganda, The University of Zimbabwe, Purdue University in the USA, and the International Potato Center.

The Zimbabwean and Ugandan project teams conducted surveys with farmers and different stakeholders to discuss their perceptions of the amount of food lost at different postharvest stages, and the causes of this loss. Samples from key crops (cowpea, maize and sweet potato) were collected and are being analysed to identify the changes in nutrients as they move from harvest to consumption.

Across sub-Saharan Africa, insects are a major cause of postharvest losses. They multiply quickly in crops that are not well-protected during storage and consume and damage significant quantities of stored crops intended for use as household food. Additional studies in the NRI laboratories have analysed the effect of storage duration and the presence of different types of stored product insect pests on the nutrient content of stored cowpea and maize.

Photo: Cowpeas on sale at a market in Accra, Ghana.

ROOT AND TUBER CROPS IN DEVELOPMENT

Root and tuber crops, including cassava, sweet potato, yams, potato, cocoyams and other minor root crops, are important to agriculture, food security and income for 2.2 billion people in developing countries. Several factors constrain the contribution of root and tuber crops to development; they are are often affected by pests and diseases passed on through vegetative propagation and, compared to cereal crops, they are bulky and have a relatively short shelf-life. NRI's team of experts undertakes world-leading research and development activities to address key challenges at all stages of root and tuber crop value chains, from farm to fork. NRI's strategies for root and tuber crop development are economically sound, environmentally, culturally and socially appropriate and gender sensitive, to ensure broad-based beneficial development outcomes. This snapshot of our work looks at managing yams to safeguard against biodiversity loss, adding value through farm production, processing and business development, and mitigating the impacts of El Niño and crop diseases on cassava production.

Managing yams in Madagascar

Ben Bennett and Debbie Rees

Since the 1950s when aerial photographs were more widely taken in Madagascar, the east African island has lost approximately 40–50 percent of its forest cover, of which a large area is habitat to a globally unique biodiversity. The tragedy of this is the pressure it is putting on much-loved mammalian species like the lemur, but the loss is much wider than one species.

What causes forest destruction? Well, it is a complex mixture of population growth, pressure for farming land, extraction of timber and minerals combined with extreme poverty (Madagascar is 207 of 213 countries in the World Bank ranking of Gross National Income) and severe governance problems resulting in weak internal security.

What links forest and biodiversity loss to yams? The diversity of yams is particularly interesting because it covers many different climatic zones of the country and so represents an important national (and global) resource against future environmental change. A team from the Royal Botanic Gardens, Kew, led by Dr Paul Wilkin, and supported by a grant from the Darwin Initiative has been working in Madagascar to identify species of yam. So far, they have located 40 species of which 33 are endemic and at least 12 are threatened.

The future of Madagascar's yams depends upon finding a way to either manage the resource *in situ* or discouraging wild harvesting by promoting yams as a food for cultivation by small-scale farmers. Kew Gardens approached NRI for the latest phase of their project to seek expert advice from Professor Ben Bennett on developing markets for indigenous plants, and from Dr Debbie Rees on the storage of roots and tubers. Ben and Debbie have been helping to develop a commercialisation plan which will see farmers growing and selling more yams, while also storing yams for food during the lean season when previously they might have gone to the forest to harvest rare indigenous plants.

Photo: The NRI & Kew Gardens team, along with local NGO Feedback Madagascar, trekking across country to carry out fieldwork on sustainable yam markets in rural southern Madagascar. Forest communities are isolated, so the team carried sleeping equipment along with their fieldwork gear.

Developing cassava value chains in Africa

Andrew Westby and Gillian Summers

Across Africa, the tropical root crop cassava is used for a multitude of purposes. In many places it is prepared and eaten daily, providing an important source of carbohydrates, while processing the roots offers a whole range of other possibilities for farmers and entrepreneurs.

Traditionally, cassava is processed into a wide range of products, many of which are fermented. Since 2014, the project 'Cassava Adding Value for Africa Phase II' (CAVA2) has focused on the development of value chains for non-traditional uses of the crop, such as High Quality Cassava Flour (HQCF), starch and ethanol. Led by NRI and Nigeria's Federal University of Agriculture, Abeokuta, and funded by the Bill & Melinda Gates Foundation, the project works in Ghana, Malawi, Nigeria, Tanzania and Uganda.

Now in its final year of implementation, the project has surpassed its overall target of mobilising 2.1 million tonnes of fresh cassava roots from smallholder farmers with a value of over $89 million. CAVA2 has introduced new varieties and management practices to smallholder farmers and set up linkages between farmers and markets. Smallholders have responded to the market opportunities by adopting improved production techniques and varieties, and increasing their yields by between 33 and 110 percent depending on the country. CAVA2 has worked with enterprises to improve processing techniques and technologies. By facilitating enterprises to acquire machines such as 'flash dryers', for rapid drying of large volumes of cassava, the project has expanded and developed processing capacity which in turn offers farmers more 'avenues for sales' for their cassava roots.

In Bukedea, eastern Uganda, cassava farmer Amugu Emutu Zaitun proudly displays one of her three cassava gardens which she planted with a high-yielding variety provided by CAVA2. The project linked her and fellow members of the P'kwi cooperative to a number of companies, including Uganda Breweries Ltd, where she sells her improved cassava. Through CAVA training on good agronomic practices, Zaitun's yield increased, as did the size of her plots. "We found adding value to cassava was good. Number 1 you get clean cassava for eating, and it is used as a cash crop," she explains. She went on to train others using the knowledge she'd gained from CAVA, which gave her extra income to construct a better house, save money, buy animals and educate her son up to university level. "Now my livelihood is improved, we're peaceful, we do things in a unique way. There's happiness," concludes Zaitun, smiling. Further project information: **www.cava2.org**

Photo: Zaitun in one of her cassava gardens in Bukedea district, eastern Uganda.

Making farmers doubly resilient to 'El Niño' and cassava diseases: DualCassava

Maruthi Gowda

Over the last three years, the 'El Niño' weather pattern has resulted in prolonged droughts, crop failures and severe food shortages in large swathes of eastern and southern Africa. NRI is currently leading the 'DualCassava' project which aims to mitigate the impacts of El Niño and two cassava diseases on the food security and economic development of smallholder farmers.

Cassava is highly tolerant to drought which makes it one of the most resilient food crops grown in Africa, with annual production estimated at over 250 million tonnes, though this total is increasingly constrained by two serious virus diseases: cassava mosaic disease (CMD) and cassava brown streak disease (CBSD).

Funded by the African Union, the project is led by NRI's Professor Maruthi Gowda and implemented in collaboration with local partners in Malawi and Tanzania and aims to use a holistic approach to address issues along the entire cassava value chain. DualCassava will introduce drought-tolerant, virus-free cassava in predominantly maize-growing, drought-prone areas as a way of promoting crop diversification and thus increasing food security.

This year the project team has trained 220 farming families on how to grow and process cassava and distributed over 60,000 improved cassava stem cuttings for growing on approximately 150 acres of land in affected areas in Malawi and Tanzania. In the coming cropping season, the aim is to distribute stem cuttings to grow cassava on over 750 acres of land. The project aims to catalyse value addition by training farmers and industrial partners to use cassava for economic gains by using it as a substitute for expensive maize in poultry feed production, and by connecting farmers to processing factories to produce high quality cassava flour.

The team is also investigating the social and economic impact of droughts and viral diseases on farmers, developing disease-resistant varieties, and using advanced tissue culture and molecular biology techniques such as Next Generation Sequencing to speed up the process of identifying virus resistance genes in African cassava germplasm.

The physical and human capacity of local partners will be enhanced by training PhD students at NRI, conducting local workshops and setting up a molecular virus diagnostic laboratory in Malawi.

Photo: Symptoms of Cassava Mosaic Disease (CMD) on cassava leaves in Tanzania.

INSECTS, PESTS, AND HUMAN AND PLANT HEALTH

At NRI, we deal with both beneficial and harmful insects, and other pests including rodents and birds, which have an impact on human and plant health. Here we highlight four examples that show how our work in this area is exploring the use of naturally derived repellents to protect crops from being eaten by insects, generating sustainable technologies for rodent pest management in Africa, and building on recent discoveries to control pests that severely hamper crop production and threaten human health.

Protecting crops at home and abroad using naturally derived repellents

David Hall, Daniel Bray, Steven Harte, Dudley Farman and Mandela Fernandez-Grandon

Insect repellents are widely used to protect people and their animals against biting insects. Staff from NRI's Chemical Ecology Group are exploring how similar chemicals can be used as a safe way to protect fruit and vegetable crops from insect pests.

Protecting crops from being eaten by insects is one of the many challenges faced by growers of fruit and vegetables. It is a worldwide problem, which threatens the economic sustainability of horticulture, and the growing demand for more healthy food that is free from pesticide residues.

In collaboration with staff at the horticultural research institute, NIAB EMR, and businesses in the UK and abroad, the team has been developing nature-identical repellents to protect crops from insect pests, with minimal risk to the environment. These chemicals are produced naturally by plants to ward off herbivorous insects, and to attract predator insects which feed on crop pests.

Through a project funded by Innovate UK, the team has tested repellents for use in protecting fruit and vegetable crops in the UK and Bangladesh. Formulations were developed by project partners at Russell IPM, designers and manufacturers of pheromone lures and biopesticides, and local micro-encapsulation technology company, Celessence Technologies Limited. Micro-encapsulation is a means of formulating chemicals inside microscopic beads, from which the active ingredients are released slowly over time. This early-stage project has already led to the development of one commercial product, the MagiPal attractant for beneficial insects, produced and marketed by Russell IPM.

Work has continued this year, exploring how repellents could protect fruit against a fruit fly commonly called 'spotted wing drosophila'. After arriving in the UK in 2012, this invasive pest is now one of the biggest threats to UK horticulture. The team is working with NIAB-EMR to develop a 'push-pull' system which uses insect repellents and attractants to provide year-round crop protection against spotted wing drosophila.

This collaborative work is funded by the Agriculture and Horticulture Development Board (AHDB) and through a studentship from the Biotechnology and Biological Sciences Research Council (BBSRC) awarded to NRI PhD student, Christine Faulder, and is part of NRI's ongoing commitment to research in support of UK horticulture.

Photo: A prototype repellent dispenser being tested in a pear orchard at NIAB-EMR in East Malling, Kent, UK.

Managing rodents in Africa, the eco-friendly way

Steve Belmain

Many farmers are aware that rodents are a problem, causing damage to crops, stored food and personal possessions. However, knowledge among farmers about the level and scope of damage is often limited. For example, rodents can transmit more than 60 different diseases; the symptoms of many may be confused with other more familiar diseases such as malaria.

NRI's Steve Belmain, Professor of Ecology, is collaborating on a multidisciplinary, international project entitled 'Ecologically Based Rodent Management for Sustainable Agriculture and Food Security in Africa' or 'EcoRodMan'. This project aims to strengthen the generation of appropriate, cost-effective and sustainable technologies for rodent pest management in small-scale, rural farming communities across sub-Saharan Africa. Ecologically sustainable methods of rodent control include the use of fertility control and investigating the ecosystem services provided by predators such as owls, genets and domestic cats and dogs.

Most importantly, the project's objectives are to build Africa's research capacities across a range of specialities related to ecologically based rodent management including population dynamics, chemical ecology, animal behaviour, taxonomy, social anthropology, economics, agronomy, value chains and quality assurance, technology adoption, and end-user participatory research. The project team involves researchers based in Ethiopia, Namibia, South Africa, Swaziland, Tanzania, Uganda and the UK.

During the past year, Professor Belmain led a training workshop with 30 new PhD students from seven African countries as part of the EcoRodMan and RatTech projects, providing information on ecological research methods, experimental design and more practical issues such as how to give a scientific presentation and write a scientific research paper.

More about the project can be found here: **ecorodman.nri.org**

EcoRodMan is funded by the African Union through their Food, Nutrition Security and Sustainable Agriculture research programme.

Photo: The Bushveld gerbil *(Gerbilliscus leucogaster)* is a rodent often causing more than 50% losses to maize soon after germination. It is found across southern Africa, particularly in dry savannah grasslands and deserts.

African cassava whitefly: Phase I success and Phase II follow-up

John Colvin

Since the 1990s, an unprecedented increase in the abundance of African cassava whitefly (ACW), *(Bemisia tabaci)* has occurred in East and Central Africa. Associated losses in cassava production in nine East and Central African countries were estimated to be as high as 47 percent and the areas affected are continuing to expand. The key driver(s) of the increased ACW pest-pressure – called 'superabundance' – remained unknown.

Four years ago, the African Cassava Whitefly project began to address this problem, bringing together a specialist team of researchers from 17 institutions based in 13 countries. Funded by the Bill & Melinda Gates Foundation, this project aimed to provide a rigorous understanding of the cause(s) of superabundance and to build human capacity in Africa to boost vector entomology expertise in National Agricultural Research Organisations.

The project team has invested over 120 person-years of effort by the participants since 2014, including twelve full-time MPhil/PhD students working under project scholarships.

Key discoveries were that:

- there are at least three 'cryptic' species of *B. tabaci* that colonise cassava in sub-Saharan Africa, but only one is frequently associated with super-abundance. Cryptic species are distinct and separate, yet appear indistinguishable from each other.
- this species has extremely high survival on cassava, particularly the 'elite' disease-resistant, cassava varieties that were distributed to control the Cassava Mosaic Disease pandemic.
- 10–15 African and Latin American cassava genotypes with good whitefly resistance were identified and candidate resistance genes have been identified in cassava.

Based on these discoveries and new understanding, a second phase of the African Cassava Whitefly project was recently approved. This new four-year phase aims to take key discoveries from Phase I and use them to begin to implement ACW control. It will also create and field-test a pipeline of novel control technologies, thus ensuring that new solutions become available in the future. Through these discovery and implementation activities, the new project's goal is to increase cassava productivity and reduce food insecurity for millions of farmers and their families in sub-Saharan Africa.

Photo: Student Ms Sarah Mieulet (École d'Ingénieurs de Purpan, Toulouse) working in the laboratories at NRI, as part of an internship on the African Cassava Whitefly Project. Sarah is using molecular tools to differentiate populations of whitefly *(B. tabaci)* from across east Africa.

Dealing with dengue: understanding mosquito egg-laying sites

Richard Hopkins

Mosquitoes are the vectors of many diseases. The yellow fever mosquito, *Aedes aegypti*, transmits several viruses including dengue, Zika and chikungunya, as well as yellow fever. The World Health Organization estimates that 50 million cases of dengue occur every year, with more than 2.5 billion people living at risk of contracting the disease in over one hundred countries. *Ae. aegypti* is the main vector of dengue virus, which is transmitted by female mosquitoes when they take a blood meal. There is no vaccine to protect against dengue, and vector control is the main recourse to reduce the spread of this disease.

A team from NRI, led by Professor Richard Hopkins, is currently working on a project to understand more about *Ae. aegypti*, and to ultimately develop solutions to control their spread. Together with the Oswaldo Cruz Foundation (FIOCRUZ) in Rio de Janeiro, Brazil, the team is investigating *Ae. aegypti* egg laying.

Ae. aegypti are found in urban environments, and lay eggs in a wide range of containers. Adult female *Ae. aegypti* lay their eggs on the inner, moist walls of containers, usually above the waterline. Females lay around 100 eggs at a time, which stick to the container walls where they dry out, and where they can survive for months. Once an egg hatches it can take as little as 8–10 days from an egg to an adult, and this rapid reproduction makes understanding the choice of oviposition sites a key stage in vector control. This year, the team has been working on the chemical composition of the water that *Ae. aegypti* lay eggs in and on the containers that they choose.

This understanding will inform future development of targeted traps or repellents to reduce the incidence of people getting bitten by this mosquito and minimise the risk of being infected by dengue or other dangerous diseases.

Funded by the UK's Medical Research Council, the project comes under the umbrella of 'research on neglected tropical diseases'.

Photo: Blood-feeding *Aedes aegypti*, the main vector of dengue virus, which is transmitted by female mosquitoes when they take a blood meal.

SUSTAINABLE AGRICULTURAL INTENSIFICATION

Increasing agricultural productivity is essential to feeding a fast-growing population and has the potential to lift rural families out of poverty. Sustainable Agricultural Intensification (SAI) provides the means to do this with limited available resources, while protecting our living environment and conserving natural and agricultural biodiversity. NRI's work in this field includes managing agroecosystems to enhance natural pest regulation and reduce dependence on agrochemicals, and farmer-led research to improve nutrition, incomes and food safety.

Improving agroecosystems management: enhancing natural enemies of legume pests in Africa

Phil Stevenson, Sarah Arnold and Steve Belmain

Producing adequate food sustainably for a growing population requires interventions that function with natural habitats rather than deplete them. Legumes such as beans, pigeonpea and lablab are important crops for nutrition security providing protein, micronutrients and vitamins and are grown and consumed by millions of farming families across eastern Africa. However, although they are regionally very important food plants, they are known as 'orphan crops' as they are not traded around the world and receive little attention by research networks to improve them. Yield gaps – the difference between potential and actual yield – are severe, owing to various constraints including pest damage which disproportionately affects poor farmers. Pest control is usually dependent on agrochemicals that have negative impacts on users, consumers and on the beneficial insects that provide pollination or natural pest regulation (NPR).

Natural enemies include a broad range of arthropods including spiders, mites, ladybirds, hoverflies and parasitoid and predatory wasps as well as bats, birds, toads and turtles, among others. They naturally diminish pest populations, which reduces farmers' reliance on synthetic insecticides. As with pollinators, non-crop habitats such as field margins provide food resources like nectar and alternative prey, and refuge to support populations of predators and parasitoids of pests. Their occurrence and biology in smallholder ecosystems, however, are poorly understood, particularly in Africa.

Led by Professor Phil Stevenson of NRI and Royal Botanic Gardens, Kew, a new research project aims to identify the important species that deliver effective NPR, taking forward recent findings with research colleagues in Kenya, Malawi and Tanzania. Entitled 'Natural Pest Regulation on Orphan Crop Legumes in Africa', the project will develop approaches that augment NPR through improved agroecosystems management. The research will provide key evidence for the benefits of NPR and establish how this can be optimised through better landscape management or manipulation and how natural pest regulation can function alongside other management practices. More about the project can be found here **www.agriculturalecosystems.org**

Funded by GCRF-BBSRC under the Sustainable Agriculture in Sub-Saharan Africa (SASSA) call.

Photo: A ladybird feeds on an aphid infestation on beans in Tanzania.

Farmers leading the way: PAEPARD Multi-Stakeholder Partnerships in Malawi and Uganda

Tim Chancellor

Enabling farmer organisations to lead the identification of research priorities and engage actively in the research process is crucial to ensure that research directly addresses local needs and environmental conditions, and has the potential for significant impact in rural communities. The Platform for an Africa-Europe Partnership for Agricultural Research for Development (PAEPARD) is a multi-stakeholder agricultural research initiative which aims to do just that. Supported by the European Commission, PAEPARD facilitates partnerships between organisations in Africa and Europe in the field of agricultural research for development with a view to contributing to the achievement of the Sustainable Development Goals. Most of these partnerships involve collaboration between researchers, farmer organisations, non-government organisations and the private sector.

NRI has been a member of the PAEPARD consortium since its inception in 2009, through its membership of the Agrinatura network, and has participated in two of the four projects supported through a Competitive Research Fund. One of the projects, led by the Uganda Christian University, is promoting the use of indigenous leafy vegetables to enhance nutrition and increase income for farmers in Uganda. Dr Debbie Rees is leading NRI's inputs to the project which, over the past three years, has contributed to a 12 percent increase in consumption of leafy vegetables such as Nakati *(Solanum aethiopicum)*, which resembles a tomato or an eggplant, in the target areas in Central and Eastern Uganda. At the same time, the income of 300 farmers involved in the research has doubled.

The second project is led by the National Smallholder Farmers' Association of Malawi (NASFAM) in partnership with Lilongwe University of Agriculture and Natural Resources (LUANAR), and in collaboration with organisations in Zambia and South Africa. NRI's Dr Bruno Tran and Professor Ben Bennett are providing technical support. The project has identified and tested several pre- and post-harvest practices that are reducing the risk of aflatoxin in groundnut. Aflatoxin is a dangerous toxin produced by fungi that can occur in some food crops and poses serious health risks to consumers, especially to pregnant women and young children. The project has so far worked with over 6,000 farmers in Malawi and Zambia with encouraging results.

Photo: Farmers in Uganda evaluating indigenous leafy vegetables including Nakati (*Solanum aethiopicum*).

FOOD LOSS, WASTE REDUCTION AND VALUE ADDITION

NRI has been working to reduce losses and waste after harvest since the food crisis of the 1970s. Experts from our Food Loss and Waste Innovation Centre use their experience, technical insight and capability to devise solutions to postharvest loss through innovative technologies, strategies and information systems.

Understanding postharvest losses to help design strategies to reduce them

Tanya Stathers

Growing and protecting a crop during its field stages is just the initial part of farming. Knowing when and how to harvest, transport, dry, thresh and store the crop ensures a family's food and nutrition security. This knowledge allows the farming household to maintain the crop's quality as a nourishing source of food until the next harvest season, or as seed to be planted, or as a commodity that can be sold to generate income, without experiencing high postharvest losses.

The 2008 food crisis led development agencies involved in improving food security across sub-Saharan Africa (SSA) to seek a more accurate understanding of the level of losses occurring postharvest. In response and with funding from the European Commission, an NRI-led research team screened and extracted postharvest loss (PHL) figures from the scientific literature and created an algorithm which combined these with contextual data – such as the weather during harvesting and drying, production figures, proportion of grain stored on farm or marketed, and presence of key storage pests such as the larger grain borer *Prostephanus truncatus*, which can double storage losses of maize. This contextual data was supplied by a network of colleagues from across 37 SSA countries to create the African Postharvest Loss Information System (APHLIS). APHLIS provided science-based estimates of the weight losses occurring at each stage along the postharvest value chain for nine cereal crops.

As realisation of the importance of reducing postharvest losses increased, the demand for science-based estimates of PHLs occurring along the value chains of key legume and root and tuber food crops grew. With financial support from the Bill & Melinda Gates Foundation, APHLIS **www.aphlis.net** is being expanded to include these important staple food crops, to provide data on the nutritional and financial value of the PHLs which occur, and to offer user-friendly tools for the rapid measurement of PHLs, and warning systems for food safety risks such as aflatoxin, a dangerous toxin produced by fungi that can occur in some food crops. APHLIS enables users to understand how much of each focal crop their country or province is losing at each postharvest stage, and to then design their postharvest loss reduction investment strategies.

Photo: Maize in Ghana being loaded for transportation, one of the steps in the crop's value chain where postharvest losses can occur.

NRICassavaBag: a simple solution to a global food loss and waste problem

Ben Bennett and Keith Tomlins

Whilst cassava has many advantages for small-scale farmers as a resilient source of food security and income, particularly in drought-prone areas, commercialisation in some countries has been stymied by the very short shelf-life – as little as 72 hours – of roots after harvest. In hot climates like Nigeria with poor infrastructure, many farmers simply cannot get their cassava to market before it starts to spoil. In 2017, the 'NRICassavaBag' was chosen as the preferred solution in the global Cassava Innovation Challenge funded by the Rockefeller Foundation, which sought to develop and test an innovative way to manage Postharvest Physical Deterioration (PPD) in fresh cassava. NRI's solution is a polypropylene bag that cures the cassava naturally, heals wounds sustained during harvesting and slows down the 'ticking clock' of the deteriorating cassava.

In the past year, the NRI team and colleagues at Nigeria's Federal University of Agriculture, Abeokuta (FUNAAB), have been conducting experiments and commercial field trials based on the NRICassavaBag approach. Initial scoping studies show that many cassava roots are handled up to 15 times between harvest and use in a factory. The NRICassavaBag method builds on earlier knowledge that cassava's deterioration after harvest can be managed if product temperature and humidity are controlled, and the handling improved.

Starting with small bags of fresh cassava and working towards large, 'Jumbo' 0.6mt bags, the team has now developed an approach that can assure at least eight days of storage and minimal loss in starch which is critical for commercial operations. Working closely with two Nigerian cassava processing factories and a Nigerian bag making company, the team now has a solution for PPD that works and appears to be cost effective. If taken up on a wide scale, the technique could bring massive benefits across the cassava-growing world with minimum costs.

Photo: The NRICassavaBag 'Jumbo' version being tested for the first time at Psaltry Starch Ltd, Oyo State, Nigeria. This was the first time the team tried out the new discharge mechanism to allow cassava stored in the bag to be dropped straight into the factory feed hopper for processing.

Reducing the impact of plastic packaging: innovations, research and advice

Lori Fisher

The impact of plastic on the planet urgently needs to be controlled, whether by ending littering, preventing further contributions to the eight million tonnes of plastics dumped in the oceans or reducing dependence on fossil fuels. In response to public pressure, major UK producers and retailers have rallied behind the UK Plastics Pact. This agreement includes pledges to make all packaging reusable, recyclable or compostable by 2025.

The priority now is to reduce packaging, either by adopting reusable alternatives or by redesigning products. When these options are not viable, due to food safety or perishability reasons, alternative sustainable packaging applications, such as edible coatings and bioplastics are being researched.

NRI plant biologists, Dr Lori Fisher and Dr Debbie Rees, have recently collaborated with AgriCoat Natureseal UK, a developer of innovative edible coatings. Variants of Semperfresh, a coating based on a mix of sugar and fatty acids (sucrose esters), were tested at the Produce Quality Centre (PQC) – a collaboration between the Natural Resources Institute (NRI) at the University of Greenwich and NIAB EMR, a horticultural research institute, at East Malling, Kent. The results verified the effectiveness of coatings on avocados and pears, providing retailers with the option to sell unpackaged fruits with a longer shelf life.

Specialist understanding of plant postharvest responses combined with NRI's experience working within global supply chains, and a recent investment in the facilities at the PQC, have well positioned the team to provide the necessary impartial advice growers and suppliers now need. The team provides support to test novel solutions and determine their effects on the quality of fresh produce to prevent unwanted food waste.

Photo: Test results of the innovative edible coating 'Semperfresh' verified its effectiveness on avocados and pears, providing retailers with the option to sell unpackaged fruits with a longer shelf life.

CAPACITY STRENGTHENING

NRI recognises that capacity strengthening for agricultural development and food security is fundamental for lasting development impact and to achieve the Sustainable Development Goals. Researchers and other stakeholders in smallholder agricultural systems need new skills to work together effectively, to engage in high-quality demand-led research and learning, and to deliver innovative solutions to promote sustainable development – especially in the face of climate change. Policy makers and civil society organisations require enhanced capacity to demand, evaluate and utilise evidence so that impact is achieved. This section includes a selection of NRI's activities in this field.

Focus on food quality: NRI and the World Food Programme

Linda Nicolaides

The World Food Programme (WFP) of the United Nations assists 80 million people in around 80 countries each year, delivering food assistance in emergencies and working with communities to improve nutrition and build resilience. WFP staff are often the first people on the ground after an emergency, delivering assistance in some of the world's most difficult, hard-to-reach areas.

For many years, NRI has been collaborating with WFP, providing specialist advice on the storage management of products used as part of WFP's global food assistance programmes. Over this time, NRI staff have also developed a range of training programmes to support WFP staff and suppliers responsible for maintaining the quality and shelf-life of locally produced stored food and commodities.

During the past year, staff from the NRI's Food and Markets Department have been working with WFP's Food Safety and Quality Unit to strengthen the quality assurance system that is used by WFP globally to ensure food meets specified safety and nutritional requirements of the beneficiaries – people who are living through dangerous and difficult crises such as wars, natural disasters and displacement.

The NRI team gave a series of training sessions for WFP staff working in the last mile of the food assistance operation, to enhance the knowledge and understanding of the Hazard Analysis and Critical Control Point (HACCP) approach used to manage food safety. Courses were given in Cameroon, Ethiopia, Kenya, Rwanda, South Africa, Togo and Uganda.

Additionally, in Madagascar, NRI and WFP have been exploring the potential for developing the value chains of breadfruit and cassava. Led by the Madagascar Ministry of Agriculture and Livestock, WFP is supporting development projects which aim to improve the conservation and processing of these two crops. It is hoped that this will provide a stock of healthy food during the lean season and offer an alternative, diverse diet. The team identified opportunities for strengthening community capacity and technical services of Madagascar's National Office for Nutrition and seeks to strengthen the technical and managerial capacities of women's groups and farmers' organisations to manage and pursue the project.

Photo: Strengthening community capacity in Madagascar, where NRI and WFP have been exploring the potential for developing the value chains of breadfruit and cassava.

Enhancing research capacity through SENTINEL: highlighting trade-offs along pathways to agricultural development

Adrienne Martin

The increasing pressure on the world's resources to meet food security and nutritional needs and to create wealth, is a serious threat to biodiversity, the environment, and ecosystem services. For development to be sustainable, the achievement of food security, improved nutrition, and the protection of ecosystem services are needed. Recognising and understanding the trade-offs and potential conflicts between social, economic and environmental objectives is essential if policy makers are to reach informed decisions on appropriate agricultural development pathways and investments.

NRI, together with four other UK Universities and partners from the University of Ghana, Copperbelt University Zambia, the Ethiopian Development Research Institute, and the Regional Universities Forum for Capacity Building in Agriculture (RUFORM) are collaborating on a project led by the International Institute of Environment and Development (IIED), funded under the UKRI Global Challenges Research Fund 'Growing Research Capability' call. Entitled 'Social and Environmental Trade-offs in African Agriculture' (SENTINEL), the four-year project aims to enhance the capacity of UK and African researchers to co-develop excellent and relevant interdisciplinary research on impacts, risks and trade-offs of different agricultural development pathways.

NRI developed the methodology for the initial capacity assessment in African partner research organisations and contributed to the overall capacity-development strategy. The focus covered individual, organisational and institutional capacities. In addition, a short questionnaire to assess capacities and gaps in African agricultural universities was completed by over 50 senior managers attending the 2017 RUFORUM Annual General Meeting in Malawi. They particularly highlighted the need for support and mentorship for researchers, and enhanced communication to non-academic audiences. A capacity needs assessment workshop held at the University of Ghana in January 2018 identified research team leadership, interdisciplinary collaboration, managing partnerships, communication with end users of research and influencing policy, as capacity needs. These suggestions are being incorporated into the project's capacity-development activities.

Read more about the project at:
www.sentinel-gcrf.org

Photo: Intensive irrigated maize and residues of the previous season's rain-fed maize crop: what are the impacts of these different systems?

SUSTAINABLE TRADE AND RESPONSIBLE BUSINESS

Processes of economic globalisation are leading to changing patterns of international trade, with an expansion in global value chains and production networks, growing south-south trade, and expanding regional and domestic markets. NRI's Sustainable Trade & Responsible Business programme aims to generate knowledge on the development potential, limitations and implications of a growing range of sustainable production and trade initiatives. These include sustainability standards, corporate sustainability supply chain strategies, responsible business initiatives, sector and landscape transformation approaches, pro-poor and sustainable value chains and inclusive economic development. The programme focuses principally upon agriculture and forestry, but also covers other sectors, such as apparel. There is a specific emphasis on smallholders and workers, and on issues of poverty reduction and inequality, human and labour rights and environmental impacts. The programme responds to several of the Sustainable Development Goals (SDGs).

Sustainable global supply chains, responsible business and forest-agriculture landscape initiatives

Valerie Nelson

Significantly increasing the sustainability of global production, trade and consumption is critical for the achievement of the UN Sustainable Development Goals. Under the Sustainable Trade and Responsible Business programme, NRI explores diverse dimensions of sustainable production and trade, particularly in the agriculture, forestry and apparel sectors.

Corporate behaviour change approaches and responsible business initiatives are expanding, moving beyond product sustainability certification and guidance on corporate reporting to include new legal forms for enterprises, public benchmarks rating corporate performance, impact-oriented corporate reporting standards, and new digital technologies for increasing worker voice. Cutting-edge NRI research unpacks how these responsible business initiatives work and if they are effective in influencing corporate sustainability performance and impact.

NRI is currently leading the Monitoring, Evaluation and Learning (MEL) of the DFID Responsible, Accountable and Transparent Enterprise (RATE) Programme. This includes evaluating the programme and strengthening the MEL capacity of the 12 partner organisations: Global Reporting Initiative, Ethical Trading Initiative, B Lab, UN Global Compact, ShareAction, Shift, Fairtrade, ISEAL, UK National Contact Point, British Academy Research Programme on Modern Slavery and Human Rights, and World Benchmarking Alliance.

Landscape-based and jurisdictional approaches balance competing stakeholder interests and the delivery of multiple social, economic and environmental goals, and are increasingly seen as important for achieving forest conservation and sustainable agriculture. The initiatives are relatively young and NRI evaluation activities are contributing to understanding of their potential and limitations.

DFID's 'Partnerships for Forests Programme' catalyses investment in forest partnerships for sustainable forests and land use. NRI led the evaluative learning design team and is currently delivering thematic studies on high-value, low-intensity forest products, restoration mechanisms, and 'Produce-Protect' which sources products from areas producing sustainably and protecting forests and livelihoods, and engaging in evaluative studies on individual Forest Partnerships. MEL for this programme is led by development consulting firm, LTS International.

Photo: Tea picking on a certified Nilgiris Tea Estate, Tamil Nadu, India – one of the studies from a multi-country sustainability standards impact assessment carried out by NRI.

Cattle value chains in Southern Africa

John Morton and Ben Bennett

For much of the population of Southern Africa, cattle have huge economic, social and cultural significance, being valued for a range of products and services, including milk, manure for vegetable gardens, draught power, sale for cash, their role as a form of savings, and their role in marriages and other ceremonies. At the same time, in some countries of the region, especially Botswana and Namibia, cattle are a major current source of export earnings, and in other countries could become so, especially if animal health regulations for access to European markets can be put in place, or if the lucrative South African market can be properly tapped.

As part of a long-running arrangement through the Agrinatura consortium to provide studies of key value chains in developing countries, NRI staff have recently looked at cattle marketing and its broader context in eSwatini (formerly Swaziland) and Zimbabwe. In eSwatini, Professor John Morton looked at social aspects of the cattle value chain. Around 40–50 percent of the rural population own cattle, benefitting from the multiple products and services they provide, and there is some evidence that cattle owners are better nourished and more food secure than other rural people. However, there are currently low levels of trust between farmers, cattle traders and abattoir owners. If both exports and the contribution of cattle to smallholders' well-being are to be increased, trust will need to be improved through better communication of information on markets and prices, and the establishment of forums where all actors in the value chain can be represented.

In Zimbabwe, Professor Ben Bennett, an NRI marketing economist, working with a rural sociologist and an environmentalist, found that the beef economy has undergone massive changes in response to land reform. The change of focus from commercial export beef production to communal and small-scale method using local breeds and subsequent loss of global markets has dramatically changed the national beef production system. A model developed by the project team shows how important the new small-scale abattoirs are for sector development.

This study was carried out as part of the 'Value Chain Analysis for Development' (VCA4D) project funded by the European Commission.

Photo: Cattle being led through a dip-tank in Cota, in the eSwatini middleveld.

GENDER AND SOCIAL DIFFERENCE

Our innovative and high-quality research and practice in gender and social difference aims to make a demonstrable impact by reducing inequalities and achieving gender justice in sustainable development. The ultimate aim is to contribute to theory, policy and practice to benefit the lives of women, men, girls and boys, as a matter of human rights, gender justice and good development. This selection of our work includes projects identifying and integrating different user preferences for roots, tubers and bananas (RTB) products into breeding programmes, improving understanding of women's time and maternal and child dietary intake to guide actions to improve nutrition, and exploring farmers' decision making in cassava value chains.

Discovering different user preferences for breeding RTB crops

Lora Forsythe

Root, Tuber and Banana (RTB) crops play vital roles in food security and income generation across sub-Saharan Africa. To date, breeding programmes have focused on improving the yield potential and pest and disease resistance of RTB crops. Despite considerable progress in the past decade, there is a gap in understanding of which varietal traits are preferred by which users, and for which specific food products. Such preferences can be used to inform breeding practices, which in turn, influence the adoption of new RTB varieties by farmers. There is also limited understanding of the socio-cultural differences and influences on RTB product preferences involved in RTB food chains in Africa.

NRI and international partners are currently working on a project to address these issues. Led by CIRAD, the project entitled 'Breeding RTB Products for End User Preferences', aims to link local consumer preferences with breeders' selection criteria to ensure adoption along the value chains of cassava, yam, sweet potato and cooking banana products, in focus countries Benin, Cameroon, Ivory Coast, Nigeria, and Uganda.

Working with an interdisciplinary team of food technologists, economists and gender specialists, NRI's Dr Lora Forsythe is leading Work Package 1, to create a methodology and evidence base for RTB product preferences by factors of gender and social difference. One example from southwest Nigeria shows how male smallholder farmers tend to prefer to sell their cassava to starch factories requiring varieties with high starch content. Female smallholder farmers are more likely to process the crop into a range of food products, which are then sold at market or consumed in their household. Therefore, women's preferences for varietal characteristics may be more reflective of their role in processing and household consumption, such as a high preference for peelability of the cassava root, or a specific taste, smell or texture of the final product.

Profiling the preferences of value chain actors with their gender-differentiated trait and product preferences is expected to support breeding programmes in improving the adoption of new varieties and to help ensure food security and income generation across sub-Saharan Africa.

Photo: Bananas being taken to market.

Using innovative tools to measure women's time use and mother and child nutrition

Kate Wellard

Rural women in sub-Saharan Africa carry a double burden of productive and reproductive work – farming and taking care of the household. Managing this workload often involves women making trade-offs which may affect their ability to feed and take care of themselves and their children. Better understanding of women's time and maternal and child dietary intake is important for agricultural programmes seeking to improve women's empowerment and nutrition outcomes. However, time use and dietary practices are difficult to measure – current methods are labour-intensive, such as direct observation and diaries, or prone to errors, such as recall.

NRI's Dr Kate Wellard, Jan Priebe and Dr Lora Forsythe, in collaboration with researchers from the London School of Hygiene and Tropical Medicine and the Africa Innovations Institute in Uganda, are testing two low-cost innovative tools with women in Eastern Uganda. Mobile phones send an automated interactive response call every four hours asking about each woman's activities and about the foods that she and her infant have eaten since the last call. Wearable cameras automatically take images every 30 seconds, capturing the woman's activities, the food she is eating and her interactions with her infant throughout the day. The images are reviewed by the participating women and project team the following day in an enjoyable interactive session to reconstruct their activities and dietary practices.

Preliminary findings show that study participants found use of both the wearable cameras and mobile phones acceptable; the project team is finding that the tools provide a richer picture of opportunities and constraints of the food environment. The two innovative methods are currently being validated against traditional methods of direct observation and 24-hour recall to assess their efficacy. Next steps would be to evaluate them in different country contexts. Ultimately, the data collected will be used to guide actions to ensure that agricultural activities are more nutrition and gender sensitive.

This project is funded through the UK Department for International Development's IMMANA programme.

Photo: Preparing a meal in Busoga, eastern Uganda. This shot was captured with a wearable camera, worn by one of the women participating in the project.

Exploring farmers' decision making in cassava value chains: who produces, who consumes, who sells?

Ola Ogunyinka, Richard Lamboll and Lora Forsythe

Nigeria is the world's largest cassava producer, with 55 million tonnes of roots and 21 percent of global supply. A marked expansion in total cassava production, particularly since 2011, has been accompanied by increasing, and often competing, demands for fresh roots. Diverse smallholder farmers – men and women – need to make informed decisions on what to do with the fresh cassava roots produced from their farms; how much to retain for home consumption versus what volume to sell and into which value chain to meet immediate family financial and other needs.

The 'Cassava Adding Value for Africa Phase II' project (CAVA2) is working to strengthen cassava value chains, with the aim of increasing the incomes of smallholder farmers. An important objective is to ensure the reliable supply of fresh cassava roots produced by smallholder farmers, through understanding the socio-economic and market factors influencing supply and establishing farmer supply networks. A study of decision making among farmers in three Nigerian states (Kwara, Ogun and Oyo states) was undertaken in order to unravel the factors influencing decision-making processes within the family setting on production, utilisation and market sales.

The study found that there were different scales of farmer participation in cassava markets, with farm sizes ranging from less than one, to well over 40 acres. There are high and increasing levels of commercialisation amongst all farmers in terms of high levels of land rental, external input use (particularly herbicides), and hired labour (almost all farmers). Contrary to current perceptions, farmers of all scales were not primarily growing cassava for household consumption, but growing for the market. Most farmers, even the larger farmers, were mainly selling to local food markets, with limited sales into industries, such as ethanol, although new opportunities are growing in some areas.

Important factors informing farmers' decisions on cassava sales include: availability and/or awareness of market options, prompt payment in cash, price and trust in the buyer. Decision making differs between men and women, and depends on land access and management norms and opportunities for the sale of locally processed cassava products which are a speciality of women. The study confirms the importance of a targeted and well-integrated approach to value chain-based interventions and sustainability.

Photo: Farmers arrive to take part in a group discussion on farmer decision making in relation to cassava market participation in south-west Nigeria.

LAND, RURAL INSTITUTIONS, GOVERNANCE AND FINANCE

NRI's work in this field aims to assist policy and institutional innovation for sustainable, socially inclusive economic development in rural areas, particularly in Africa, with a focus on improved governance of land and natural resources, extending market participation by small farmers, strengthening rural advisory services and the social impact of agricultural and other investments. Examples of NRI's current work in this area includes the development of a market-based, innovative risk financing solution called Risk-Contingent Credit (RCC), and progress on making agri-investment more inclusive and responsible, while protecting rural communities' land rights through DFID's LEGEND programme.

Promoting resilience and climate risk financing in sub-Saharan Africa

Apurba Shee

Uninsured drought-related agricultural risks and limited access to credit are serious impediments to agricultural productivity, and they are considered major sources of poverty among smallholder farmers in sub-Saharan Africa. Against this backdrop, Dr Apurba Shee, a Business Development Economist at NRI, and Calum Turvey, Professor of Agricultural Finance at Cornell University, have developed a market-based, innovative risk financing solution called Risk-Contingent Credit (RCC). It appears to be the first to develop scientific bundling of rainfall-based index insurance and an agricultural term loan through actuarially fair pricing. Dr Shee has been co-leading a project that is implementing RCC with smallholder farmers in Kenya funded by the Global Resilience Partnership (jointly supported by the Rockefeller Foundation, USAID, and Sida) and a multi-year impact evaluation supported by 3ie. The objective of this project is to promote resilience and investment opportunities that impact the livelihoods and food security of vulnerable communities.

RCC is a linked or 'bundled' credit product that embeds within its structure an insurance protection which, when triggered, offsets loan payments due to the lender providing a risk-efficient balance between business and financial risks. RCC has many innovative features. By reducing credit default risk, it provides trust in the lender-borrower relationship. It eliminates the drawbacks of standalone index insurance products by not requiring the farmers to pay a premium upfront and out of pocket. By removing liquidity constraints, combined with transfer of climate risk, RCC can achieve better targeting of poorer farmers, increase economic efficiency, provide climate resilience, and eliminate climate-based poverty traps.

The project is currently being implemented in Kenya in collaboration with the International Food Policy Research Institute (IFPRI), with Equity Bank fronting the credit product, and with insurance underwritten by APA Insurance. The team has set up a multi-arm randomised controlled trial to assess unbiased impact of RCC on agricultural investment, productivity, resilience, and farmer welfare. 1150 sample households were randomly assigned to one of three research groups, each of 350 households: treatment 1 (farmers offered traditional credit), treatment 2 (farmers offered RCC) or control (farmers not offered credit; 350 households). By September 2017, the project had distributed approximately $35,000 in loans to over 266 farmers who mostly had no previous access to credit. The team has found that the uptake rate of RCC loans in treatment 2 is about 40 percent, whereas the uptake rate of traditional credit in treatment 1 is about 35 percent. These uptake figures are significant and much higher than in any previous studies. The team has conducted a baseline and a follow-up household survey and is in the process of evaluating the impact of RCC and comparing it with the effect of traditional credit.

Photo: Playing a risk-contingent credit game as part of financial education in Kenya.

Protecting land rights whilst promoting sustainable agri-investment: LEGEND

Julian Quan

As private sector investment in agribusiness expands and market participation of smallholder farmers increases, uncertain and insecure land rights continue to prevent vulnerable rural people from taking opportunities and overcoming poverty, particularly in Africa.

NRI provides the technical leadership for LEGEND, DFID's programme on Land: Enhancing Governance for Economic Development. Led by Julian Quan, Professor of Land and Development Practice at NRI, the team has been making progress this year on how to make agri-investment more inclusive and responsible, while protecting rural communities' land rights.

Assisted by LEGEND, high-profile companies in East and southern Africa, including Illovo Sugar, Africa's major sugar producer, and forestry investor Portucel, are now developing sustainable business plans and strengthening community engagement practices. In West Africa, investors are also scaling back on overambitious plans to transform whole districts into oil palm plantations, and developing smaller estates by leasing land from local communities on equitable terms, while creating new opportunities for small-scale farmers as outgrowers. LEGEND is also assisting emerging social investors to build community enterprises in projects that utilise untapped potential of degraded savannah woodlands as sources of high-value natural products through marketing products such as baobab fruit in Mozambique and providing tourism services in northern Tanzania, while strengthening women's participation.

Initiatives like these cannot be pursued at scale unless rural people's land rights are documented and secured, and the governance of land investments improved. Through LEGEND, NRI has worked with consortium partners ODI and IIED to assess how governments, donors, civil society and private sector partners can work together and to empower communities legally, ensure investors and rural people understand the risks of land investment, eliminate corrupt practice, reduce land conflicts, and map and secure land rights. The team is currently undertaking a major study to inform donor policy and practice on how to document and deliver land rights at scale, learning lessons from DFID's major programmes in Ethiopia and Rwanda and building long-term sustainable land and property registers to support development needs in Africa for decades to come.

For more information, see: **landportal.info/partners/legend**

Photo: Sugar cane in east Africa. Assisted by LEGEND, high-profile companies, including sugar producers in east and southern Africa, are developing sustainable business plans and strengthening community engagement practices.

CLIMATE CHANGE, AGRICULTURE AND NATURAL RESOURCES

Responding to climate change is one of the most urgent challenges facing humankind. The most severe impacts are likely to be suffered by the poorest and most vulnerable in society who live in more fragile environments and have the least resources to adapt and recover. The majority of the world's poor continue to live in rural areas and their livelihoods are heavily dependent upon agriculture and natural resources, which will be severely affected by climate change. Therefore, there are serious implications for their food security, health and well-being. NRI's work in this field aims to understand these challenges better, to build adaptive capacities, and to develop appropriate strategies for sustainable and equitable rural adaptation. Highlights of our work include contributing to the IPCC's Special Report on Climate Change and Land, and training the next generation of scientists through one of our dedicated postgraduate programmes.

The IPCC Special Report on Climate Change and Land

John Morton

Set up in 1988 by the World Meteorological Organization and the United Nations Environment Programme, the Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The Panel provides policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

NRI's Professor John Morton is currently working on the IPCC's Special Report on Climate Change and Land. Professor Morton previously wrote sections on smallholder and subsistence agriculture for the Nobel Prize-winning Fourth Assessment Report (2007) and jointly led the chapter on rural areas for the Fifth Assessment Report (2014). The current report covers the interactions between climate change, land degradation and food security. Land degradation processes like desertification are both exacerbated by climate change while also exacerbating it. Similarly, climate change adds to the threat of food insecurity for huge numbers of the world's population, but the ways in which food is produced and distributed in the world contribute to climate change through emissions of greenhouse gases.

There are potential policies that can address combinations of these problems while contributing to sustainable development, but discussion is needed on the decision-making and governance under which such policies can be identified and implemented. Professor Morton is working on the final chapter of the report, 'Chapter 7: Risk Management and Decision Making in Relation to Sustainable Development', together with colleagues from India, Canada, Ecuador, France, Latvia, New Zealand, South Korea, Sudan, Sweden, UK, and USA. The chapter synthesises findings from earlier chapters of the report on key risks from the interactions of climate change, responses to climate change, land degradation, and food insecurity, and identifies policy responses to those risks. It then discusses both formal and informal decision-making processes in the face of climate-related risks, and modes of governance which are needed to strengthen climate action.

Photo: Maize field under the effects of drought in Ghana.

Act now: discover Global Environmental Change MSc at NRI

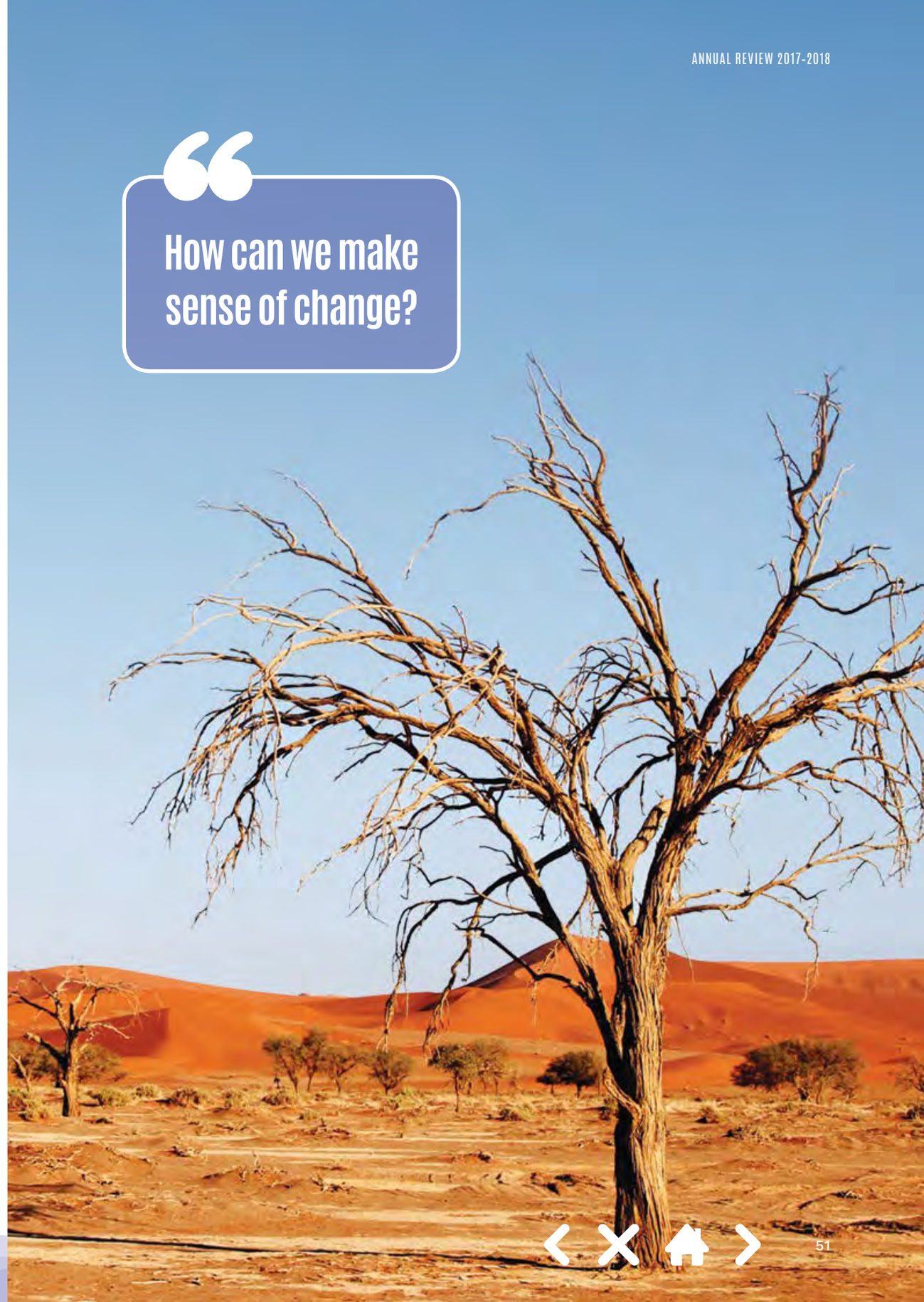
Conor Walsh

The timeframe for action in maintaining global average temperatures within 1.5°C of pre-industrial levels is rapidly diminishing, as emphasised in a recent report from the International Panel on Climate Change (IPCC). The report highlights that this action must be far-reaching, requiring unprecedented changes in all aspects of society. "We are already seeing the consequences of 1°C of global warming through more extreme weather, rising sea levels and diminishing Arctic sea ice, among other changes," said Panmao Zhai, Co-Chair of IPCC Working Group I. It is becoming apparent that adapting to climate change will become increasingly important in the future.

Building on the Institute's established reputation in climate change research, NRI is launching an MSc programme entitled 'Global Environmental Change', which focuses on exploring the dual challenges of reducing emissions as well as preparing for varied impacts of climate change. How can we make sense of change? This programme looks at what changes to our environment could mean for us, on a global level, both in the past and in the future.

Designed around the concept of the 'land-water-energy' nexus, this programme seeks to provide the necessary skills and knowledge base to join global efforts to manage impacts and find solutions at different scales. Built around core modules which focus on climate change, ecological and carbon footprinting and climate adaptation, this programme gives students the opportunity to choose from modules ranging from 'Conservation Ecology' to 'Environmental Law and Policy'. Fundamentally, this programme offers both a strong theoretical foundation along with modules such as 'Geographic Information Systems' and 'Environmental Footprinting' which focus on transferring practical skills to enhance employability.

Class interaction, peer support and review are fundamental aspects of teaching and learning at NRI, whilst the independent research project affords students an opportunity to showcase their ideas to their peers, demonstrating the breadth of subjects, methods and expertise that can be brought to bear within this challenging field. **www.gre.ac.uk/postgraduate-courses/engsci/glob-envi-change**



RESEARCH-LED TEACHING

NRI's research responds to global challenges. Our researchers also teach on our undergraduate and postgraduate programmes, with new elements from their research and enterprise work being rapidly introduced into individual courses and lectures. This section highlights how students' own research is championed throughout their courses, culminating in award-winning research at all levels of study.

Issues-inspired, research-led teaching at NRI

Claire Coote

"I find it really exciting being taught by someone who has just come back from a farming community in Malawi or presenting at an international conference and is giving us the latest knowledge on how our subject is being applied in the world," says Katie James, a third-year student on NRI's BSc in Environmental Science. "My degree has been really hands-on from the start, with regular field trips, laboratory work and data analysis," she adds.

Along with Environmental Science, NRI also offers BScs in Geography, and, jointly with the University of Greenwich's School of Science, Biology. "This degree allows me to see how I can personally make a difference to environmental problems affecting the world through research-based solutions," continues Katie. "Food security is a sector I find particularly interesting and by developing a career in this field, I can undertake research which creates a positive physical change."

With a range of MScs including Agriculture for Sustainable Development, Global Environmental Change, Food Innovation, Applied Food Safety and Quality Management, and Food Safety and Quality Management by e-learning, NRI students can work towards a world-changing career and help devise solutions to global challenges.

Inspired by one of her lecturers, Katie would love to continue studying at NRI and work towards a PhD in food security and pollination services. Postgraduate research students become part of NRI's thriving research community, benefitting from specialist supervision, support and membership of a dedicated Research Group, whilst undertaking structured training in research methods, methodology and core skills. NRI's MPhil/PhD programmes cover Agriculture, Health and Environment, Development Studies, and Food Science and Marketing Economics.

NRI's postgraduate research students have created their own 'NRI Postgraduate Society' (NRIPS) which organises an Annual Postgraduate Symposium. This initiative highlights the students' research, providing them a professional platform to discuss their work, sharpen their communication skills and network with the NRI community. Other NRIPS activities include monthly presentations by PhD students, academic sessions and workshops, social gatherings to celebrate academic and personal milestones, and seasonal gatherings for the whole Institute.

Study with us and build a world-changing career.

Photo: Katie James, a third-year student on NRI's BSc in Environmental Science, at work in the laboratory.

The student journey: from learners to award-winning researchers

Claire Coote

At NRI, our students find a stimulating and supportive environment for their learning experience. As undergraduates near the end of their three-year programme, they develop from learners into young professionals.

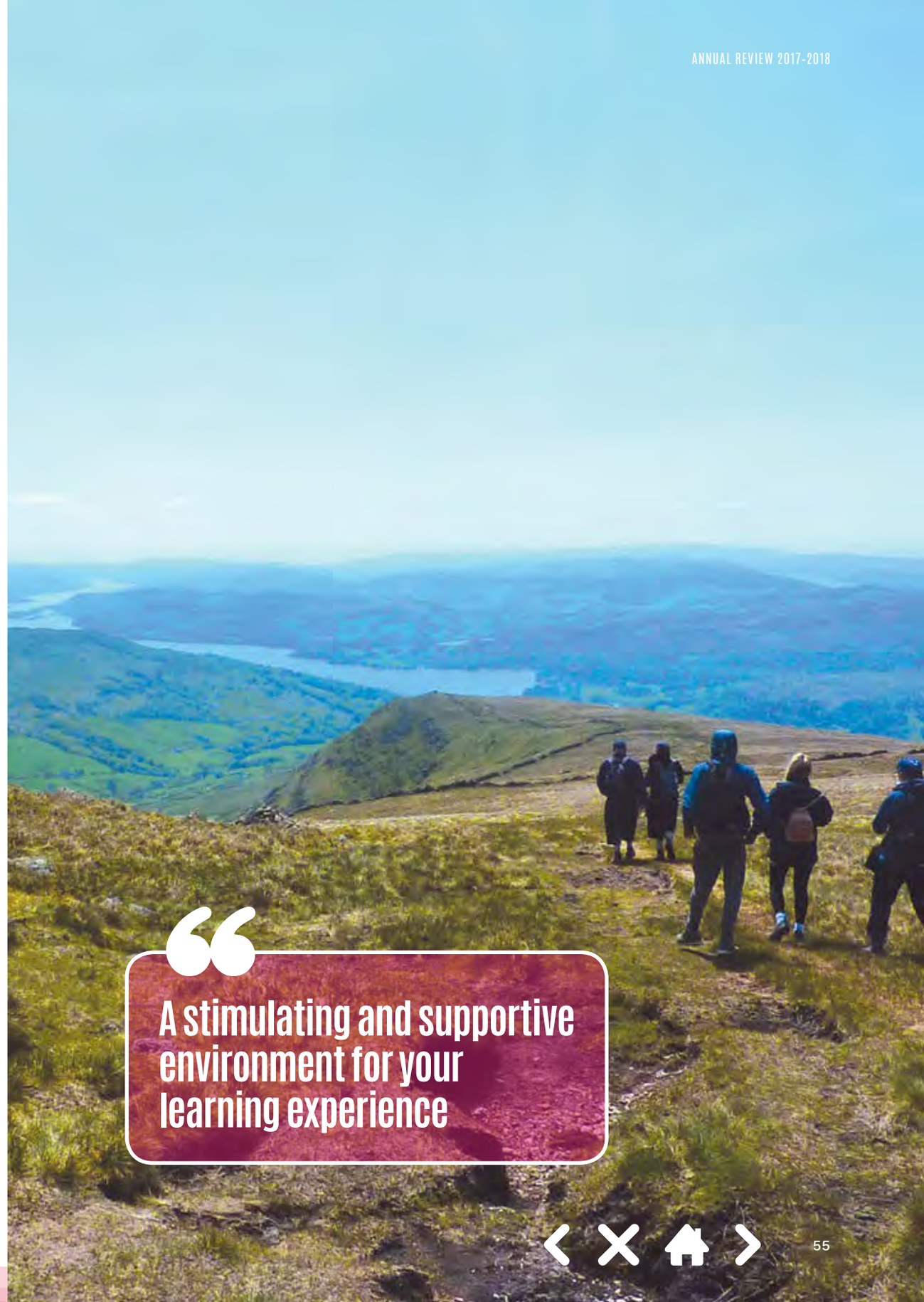
Students undertake a research project which allows them to develop their own ideas and to improve their skills in generating and using real data, and to consider interdisciplinary working. After data collection in the field, lab or library, students hone their skills in critical data analysis and graphical presentation, academic writing and effective presentations, allowing them to appreciate, in a practical way, the different tools used to research real-life problems. The best research projects are considered for the NRI Awards for Best Dissertation.

Being able to communicate results is an important part of the journey towards graduate employment or further study. Final-year undergraduates present the findings of their research to NRI researchers during 'Poster Day' at NRI.

This year, several of the undergraduate students' dissertation topics focused on environmental issues in Medway and Kent, while others examined issues further afield. Two prizes were awarded for the best Geography dissertation. These went to Jessica Sanders and Katie Sanders, who undertook research into different aspects of the Medway environment and their implications for human health. Jessica studied the effects of weather systems on particulate matter (PM10) and nitrous oxide concentrations along a linear transect from Maidstone to Rochester, whilst Katie investigated whether the Medway Towns are an urban heat island. Both students were supervised by NRI Biometeorologist, Dr Peter Burt, who leads the BSc programmes in Environmental Science and Geography.

Every year, a group of students from Hunan Agricultural University, China, join the BSc Environmental Science programme in Year 3. This year, the NRI prize for best BSc Environmental Science dissertation went to Zitong Sun for her work on diatoms – a photosynthetic single-celled organism and common form of phytoplankton, used as an environmental indicator – and water nutrient levels at 12 sites on the River Medway between Tonbridge and Maidstone, supervised by Dr Andrew Haggart.

Photo: Students and staff contemplate Lake Windermere and the Solway Firth in the distance, from the top of the mountain called Red Screes. The team was studying mountain weather and environments during the First Year Geography/Environmental Science field trip to the Lake District in May 2018.



Award-winning student research

Claire Coote and John Orchard

At Master's level, this year's prize-winners were:

- Jamila Abou Saleh: Best MSc dissertation – joint winner, MSc Food Innovation
- Paul Britten: Best MSc dissertation, MSc Sustainable Environmental Management
- Ayben Kara: Best MSc dissertation, MSc Food Safety and Quality Management
- Daniele Pond: Best MSc dissertation – joint winner, MSc Food Innovation
- Daria Popkova: Merit Award for Outstanding Achievement, MSc Food Safety and Quality Management
- Zachary Thomas: Best MSc dissertation, MSc Agriculture for Sustainable Development
- Diana Tixi Verdugo: 2016/17 Prize – Tessa Blackstone Achievement Award (for self-funded international NRI Master's student making the most progress), MSc Agriculture for Sustainable Development

At PhD level, Kate Denton was the winner of the 2018 Three Minute Thesis Competition (3MT®), run by the University of Greenwich's Faculty of Science and Engineering.

At the NRIPS Annual Postgraduate Symposium, prize-winners for best presentation and poster were:

- Early-stage researcher: Christina Faulder, studying synthetic compounds to create a control strategy on the fruit fly *Drosophila Suzuki*, a pest species causing £20–30 million of damage to fruit crops every year.
- Intermediate-stage researcher: Steven Sewe, whose work is examining Next Generation Sequencing characterisation of plant viral diversity and host interactions in West African yam.
- Late-stage researchers: Jackie Atim and Kate Denton
  - Jackie is researching *Bemisia tabaci* (whitefly) resistance in Latin America cassava genotypes, as part of the African Cassava Whitefly Project.
  - Kate's research focuses on the potential of UK bats as insect pest controllers in the agricultural industry by gathering information on the composition of bats' diets, using DNA sequencing to find out the species of insects that bats eat.

Photo: Students and staff discuss their research during a break at the 2018 Annual Postgraduate Symposium. (L–R: Anthony Abbott, Soňa Vyskočilová, Tim Chancellor, Juan Paolo A. Sicat, Steven Harte and Jill Joiner).

PROFESSIONAL SERVICES

NRI's Professional Services team is made up of technicians and specialists in project management, administration, finance, IT, communication, and other fields, working together with natural and social scientists to deliver our mission.

Delivering quality: Professional Services and Administration

Mark Parnell

NRI and our global network of partners contribute to delivery of the United Nations Sustainable Development Goals (SDGs) on a daily basis. Our contribution to the SDGs through delivery of world-class research, teaching and development work is supported by the bedrock of our human capital, our dedicated team of professional services and administrative staff.

As a team, we ensure NRI's portfolio of business is appropriately budgeted for, effectively managed and fully supported both technically, through a team of dedicated laboratory support staff, and administratively, through an award-winning team of professional administrators. We ensure NRI's project contracts, grants and agreements are fit for purpose and continually strive to guarantee that our archived material and research facilities meet all regulatory concerns. All of this work is undertaken against a backdrop of genuine concern for safeguarding NRI's employees, and fulfilling NRI's mission.

In 2017–18, we delivered on contracts worth over £12 million and worked in every continent on the planet except Antarctica. Our professional services and administration team ensured people, physical resources and formalities were all in place to enable us to work in the far-reaching corners of the globe and meet our contractual obligations. This does not happen by accident; we maintain order within the competing priorities and demands of over 100 active projects by continually striving to evolve management systems, improve service provision and generally make things happen that need to happen, when they need to happen.

We maintain a bespoke in-house Quality Management System accredited to ISO9001 which keeps the entire workforce of NRI on the straight and narrow, delivering outputs to the quality and standard required of an internationally recognised, award-winning institution.

We ensure our messages, core values and achievements reach our audiences through digital and print media channels. Without our dedicated team of marketing, communications, IT, accounting, executive and budgeting specialists, this publication would not exist in its current form – just one example of how professional services complement and strengthen the achievements of NRI.

Annual Review story contributors

Food security, agriculture and nutrition

- Dr Julia de Bruyn, Lecturer/Researcher in Nutrition
- Dr Aurélie Bechoff, Research Fellow: Food Technologist

Root and tuber crops in development

- Professor Ben Bennett, Professor of International Trade and Marketing Economics
- Dr Debbie Rees, Principal Scientist, Reader in Plant Physiology
- Professor Andrew Westby, Professor of Food Technology
- Gillian Summers, Communications Specialist
- Professor Maruthi Gowda, Professor in Molecular Plant Pathology

Insects, pests, and human and plant health

- Professor David Hall, Professor of Chemical Ecology
- Dr Daniel Bray, Senior Research Fellow in Chemical Ecology
- Dr Steven Harte, Post-doctoral organic chemist/ chemical ecologist
- Dudley Farman, Analytical Chemist
- Dr Mandela Fernandez-Grandon, Research Fellow: Behavioural Entomologist
- Professor Steve Belmain, Professor of Ecology
- Professor John Colvin, Professor of Entomology and Plant-Virus Epidemiology
- Professor Richard Hopkins, Professor of Behavioural Entomology

Sustainable Agricultural Intensification

- Professor Phil Stevenson, Professor of Plant Chemistry
- Dr Sarah Arnold, Research Fellow – Insect Behaviour and Ecology
- Professor Steve Belmain, Professor of Ecology
- Dr Tim Chancellor, Director of Capacity Strengthening and Partnerships

Food loss, waste reduction and value addition

- Dr Tanya Stathers, Principal Scientist: Postharvest Systems, Food Security and Adaptation
- Professor Ben Bennett, Professor of International Trade and Marketing Economics
- Professor Keith Tomlins, Professor of Food Science
- Dr Lori Fisher, Enterprise Development Fellow

Capacity strengthening

- Linda Nicolaides, Food Safety & Quality Management, Microbiologist
- Professor Adrienne Martin, Professor of Development Studies, Social and Institutional Development and Evaluation Specialist

Sustainable trade and responsible business

- Professor Valerie Nelson, Professor of Sustainable Development, Social Development, Learning and Evaluation Specialist
- Professor John Morton, Professor of Development Anthropology
- Professor Ben Bennett, Professor of International Trade and Marketing Economics

Gender and social difference

- Dr Lora Forsythe, Senior Research Fellow, Gender and Livelihoods
- Dr Kate Wellard, Principal Research Fellow – Natural Resource Management and Innovations
- Dr Ola Ogunyinka, Monitoring, Evaluation and Impact Specialist
- Richard Lamboll, Principal Scientist: Socio-Economist

Land, rural institutions, governance and finance

- Dr Apurba Shee, Business Development Economist
- Professor Julian Quan, Professor of Land and Development Practice

Climate change, agriculture and natural resources

- Professor John Morton, Professor of Development Anthropology
- Dr Conor Walsh, Environmental Scientist

Research-led teaching

- Claire Coote, Principal Economist, Teaching & Learning Leader
- Dr John Orchard, Director of Postgraduate Research Studies

Professional Services

- Mark Parnell, Commercial Manager

The NRI Team

NRI's team is made up of over 100 members of staff including natural and social scientists, technicians, and specialists in project management and administration, communication, finance, IT and other fields. We are based at the University of Greenwich Medway campus in Chatham, UK, with many of our staff undertaking overseas assignments all over the world, working with international partners to achieve our mission.

To see the full list of staff and their contact details, visit www.nri.org/about/organisation-and-staff/all-staff

Senior Management Team

Professor Andrew Westby, Director of NRI

Professor Ben Bennett, Deputy Director of NRI, Deputy Faculty Director, Research & Enterprise

Professor Adrienne Martin, Director of Programme Development

John Linton, Commercial Director

Dr John Orchard, Director of Postgraduate Research Studies

Dr Tim Chancellor, Director of Capacity Strengthening and Partnerships

Claire Coote, NRI Teaching and Learning Leader

Professor Vegard Iverson, Head of Livelihoods and Institutions Department

Dr Andy Frost, Head of Food and Markets Department

Professor Richard Hopkins, Head of Agriculture, Health and Environment Department

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