INTERNATIONAL FOUNDATION FOR SCIENCE

IFS ANNUAL REPORT 2021

IFS – DEVELOPING SCIENCE, SCIENCE FOR DEVELOPMENT

The IFS Annual Report is structured to align with our Strategy 2021–2030, with three main sections on Impact – how IFS grantees' research is being put into use, Grants – the awarding of Basic and Advanced Grants, and the conclusion of our Collaborative Grants pilot projects, and Capacity-enhancing Support – or IFS's value as a scientific partner. We hope you enjoy the report!

IFS Annual Report 2021

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Cover photo: Ms Azongnide G Gwladys, Benin, collecting data in experimentation on young seedlings of *Vitellaria paradox*.
All photos according to bylines or by IFS
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Foreword

The year 2021 was certainly another challenging one for IFS. However, we continued to live and work through the COVID-19 pandemic, and did our best to adapt to the ever-changing world around us. Despite the many practical obstacles, our team at the IFS Secretariat has maintained an uninterrupted and mostly unchanged level of service for our current, prospective and former grantees. We also maintained our efforts to overcome our present financial insecurity by demonstrating the importance of and the need for IFS's work in order to attract the (renewed) interest and commitment of international donors and other strategic partners.

We take the opportunity of compiling this Annual Report to highlight and reflect on our 2021 accomplishments, in terms of the:

- Launch of our new IFS Strategy 2021–2030, *Investing in Future Scientists*
- Impacts which our grantees' research are having in their home countries, and possibly beyond
- Basic, Advanced and Collaborative Grants we have been able to award and see the results of
- Range of capacity-enhancing activities we have been able to provide in collaboration with our partners, including IFS alumni associations in a number of countries in the Global South, and
- Donors who have supported IFS.

A positive outcome of these difficult times has been witnessing the strength and determination of our Secretariat staff, Scientific Advisory Committee members, and Board of Trustees. They have remained dedicated to our work during this trying period for the organisation, supporting our grantees and each other throughout the many challenges. They have also done so with respect, integrity and compassion. We are especially humbled by the dedication of our colleagues in the Secretariat, who have remained with IFS even though their and the organisation's future is uncertain. We dare think that you share our deep appreciation for all this commitment!

As we continue to navigate through these complex times, it is crucial for us to strengthen our commitment to early career researchers in Low- and Lower-Middle-Income Countries (LLMICs). We will continue to be champions of equity, diversity and inclusion, and to ally ourselves with like-minded organisations to advocate for changes that make it easier for LLMIC scientists to do their research and make important contributions to their countries and our world.

As we look ahead, we recognise the difficulties that we face. However, with the vision and commitment of all constituents of the IFS family, we know that our future lies in co-creating a better IFS which can more effectively, efficiently and equitably be a source of support for early career researchers in LLMICs.

PHOTO: PETR ZMEK, CZU

Dr Patrick Van Damme
Chair of the IFS Board of Trustees

Dr Patrick Van Damme
Chair

PHOTO: PRIVATE

Dr Nighisty Ghezae
IFS Director

Dr Nighisty Ghezae
Director

Summary

A New Strategy and Looking Ahead

Under the theme of *Investing in Future Scientists*, 2021 was the first year under our new Strategy 2021–2030, which:

- Represents an evolution in our approach to enhancing research capacity
- Reflects changes in the contemporary context
- Focuses resources on supporting promising early career scientists, and
- Provides a foundation for IFS to move into its next chapter.

We report on our work in 2021 so that the **impact** of how grantees' research is put into use is at the forefront, followed by our **grants** provision and **capacity-enhancing support** activities, as below.

Impact

We supported and followed up with the 92 grantees of 2017 who were finishing their research. Through a representative selection of research results and achievements of grantees, IFS has documented evidence of numerous impacts from its support for the research of early career scientists. These scientists have so far published 77 articles in peer-reviewed scientific journals, and they have established numerous national and international scientific contacts. IFS grantees are putting their research into use in immediate, near-term and long-lasting ways, in villages, forests, fields, policy discussions, government practices and the global scientific community. For example, impact has been demonstrated through:

- Careers being launched
- Useful research coming from relatively small grants
- Publications resulting from research
- Women scientists succeeding at high rates
- Graduates and postgraduates returning to a science community in their home countries
- Successful alumni associating in support of each other and younger colleagues
- Like-minded scientists with common backgrounds participating in networks
- Scientists in less-resourced countries having access to a source of funding
- Influential individuals who say they owe their careers to IFS, and
- Scientists working and researching together across continents and building strong, lasting scientific relationships.

Grants

In 2021 we attracted 182 completed applications for Basic Grants. Out of the total proposed projects, 67 grants were approved for funding, with women scientists accounting for 30% of the individual research grant awardees. In addition to the early career scientists receiving research grants, the other 115 applicants were also given feedback by well-qualified IFS reviewers and advisors as part of our capacity-enhancing activities. The IFS Secretariat also processed 89 purchase orders for laboratory equipment and materials.

We implemented the new Advanced Grant scheme this year, through a collaboration with Philippines-based SEARCA[1] on a response to the COVID pandemic with a Call for Research on Accelerating Transformation through Agricultural Innovation in Southeast Asia. We received 52 Advanced Grant applications for pre-screening, with 32 then sent out for external review and to SAC members. Twenty-seven (27) applications were recommended for continued consideration.

We successfully organised and carried out the IFS-SEARCA Mentorship Program for Advanced Grants Mentoring Workshop with the 27 applicants. The workshop aimed to support them to improve the quality of their research proposals before resubmission. Based on their learning in the Mentoring Workshop, and the comments received from external reviewers and the SAC, they refined their proposals and resubmitted. Following the SAC's assessment, ten (10) successful applicants received an IFS-SEARCA Advanced Grant to carry out their research within a one- to three-year period.[2]

Since Collaborative Grants were introduced in the IFS Strategy 2011–2020, IFS has joined with a variety of strategic partners to conceive, develop, implement, manage, monitor, evaluate, audit and report on three multidisciplinary collaborative research pilot projects. These projects have involved 112 individual grants to 57 women and 55 men, 31 team grants, 17 countries, five implementing partners and four funding partners. The two pilot projects in Africa and the one in Asia have now concluded and all the grantees have submitted their final individual and team reports to IFS. The grantees from all three pilots have thus far published 32 articles in peer-reviewed journals from 2016-2021, with others also expected to be published. A policy brief on collaborative research has been produced and disseminated, as has an evolving document on mentorship guidelines.

1. Southeast Asian Regional Center for Graduate Study and Research in Agriculture.
2. Although the 2021 financial report accounts for eight Advanced Grants, in the event we were able to award ten grants. The additional two grants will be accounted for in the 2022 financial report.

Capacity-enhancing Support

In 2021, IFS jointly engaged with a variety of strategic partners on a spectrum of topics, including blogging for impact; designing online training events; preparing a research budget; food systems for new realities; gender, diversities and unconscious bias; gender in livestock research; science communication; statistical computing; and scientific publishing/proposal development and funding. These nine activities took place virtually.

In addition to providing mentoring and coaching support to the grantees from 2017 (92 individual grants and 40 grantees with collaborative grants), 603 grantees from other sessions with ongoing research projects received support whenever needed. We also supported our alumni to associate and support other potential grantees through training and coaching.

Responding to COVID-affected Grantees

During 2021, the Secretariat spent additional time contacting and following up with 603 current grantees about their ongoing projects. Ninety grantees reached out to their IFS contact person about their projects being impacted by the pandemic and thus not being able to comply with their grant agreement. Some constraints mentioned were delays in project activities, purchase of research equipment, chemicals and supplies, and of money transfers; technical and financial difficulties; and local or national regulations limiting possibilities to move around the country.

Looking Ahead

In November 2021, IFS commissioned Nairobi-based ECI-Africa to carry out an Assessment on IFS's Next Chapter. The Assessment will make specific recommendations on developing a program that better supports early career scientists in LLMICs[3] in line with specific requirements and expectations of LLMIC partner institutions and scientists, and with evolving donor thinking. The Assessment's three objectives are to:

1. Identify the needs of early career LLMIC researchers and what role a "new" IFS (or IFS-inspired program) could have in filling them
2. Identify suitable regions, countries and institutions to host "IFS 2.0", and
3. Gauge the interest from potential funders.

Collecting phytoplankton samples in Tri An reservoir, Vietnam, for Dr Thanh Luu Pham's research.

3. Low- and Lower-Middle-Income Countries

IFS Strategy

The IFS Strategy 2021–2030 – *Investing in Future Scientists* – represents an evolution in IFS's approach to enhancing research capacity, driven by changes in the contemporary context. While IFS continues to emphasise the quality and development relevance of the research it supports, the 2021–2030 Strategy sets out the case for increased resources for the support of promising early career scientists as essential to addressing national and global challenges.

Building on five decades of experience, the Strategy reaffirms the organisation's Vision of scientists in Low- and Lower-Middle-Income Countries (LLMICs) assuming ownership and development of local and regional research agendas and contributing to a global research community committed to supporting sustainable development and building science literacy.

IFS's Theory of Change is that investing in research and complementary skills of promising early career LLMIC scientists enhances research capacity, thereby helping secure the cadre of LLMIC scientists needed to participate in the generation of the science, technology and innovation, and supporting policies, essential to eliminating poverty and hunger.

To realize its Vision, IFS's Mission is to enhance the capacity of early career women and men scientists in LLMICs to acquire the skills needed to conduct research and communicate their results, contribute to science literacy, influence science priority setting, and network and collaborate with the global research community to shape research agendas, both local and global.

The overall Objective is to enhance capacity of early career scientists in LLMICs to conduct relevant research, increase science literacy, and influence research agendas at local, regional and global levels.

Specific Objectives are:

1. Generation and dissemination of scientific knowledge by early career LLMIC scientists, and
2. Enhanced capacity of early career LLMIC scientists to influence, lead, network, fundraise and put research into use.

IFS provides tailored research capacity-enhancing support to promising early career scientists centred around the provision of individual Basic Grants and Advanced Grants.

Capacity-enhancing support includes training workshops, usually with partners, in such topics as science writing, putting research into use, data protection, and ethics in research. Support may also be provided to help grantees purchase equipment, visit laboratories, attend conferences and present research results.

IMPACT

Putting Grantee Research into Use

IFS's Vision is for scientists in Low- and Lower-Middle-Income Countries (LLMICs) to contribute fully to a global research community committed to reducing poverty and supporting sustainable development, both nationally and regionally. It monitors realisation of its Vision through a number of output- and outcome-related metrics, including:

- Increased numbers of LLMIC early career women and men scientists supported
- Increased support per scientist, in terms of grant support, mentoring and capacity-enhancing activities
- Increased numbers of publications, including in more high-impact journals
- Improved research and research-associated skills, including organisational, communication and interpersonal skills
- Greater translation of research into use, through involvement in evidence-based decision-making and uptake of STI by society
- Improvements in science literacy, via the development of research communities, including Alumni Associations, and
- Improved career pathways.

Grantee performance is monitored through project reports when the grant is finalized. These consist of a scientific report of the grant progress, any scientific publications that are a direct outcome of the IFS grant, and responses to an IFS questionnaire called a Project Completion Form (PCF). In the online PCF, grantees are asked to answer more detailed questions regarding any more "indirect" results of the IFS grant, e.g., the number of colleagues and students that benefitted from the grant, any promotion, increased scientific networks, or additional funding that has been obtained.

The PCFs capture early career scientists' own assessment of how their skills have developed as a result of IFS support; the PCFs also facilitate the assessment by scientific peers of grantee development as researchers. Data are analysed to identify the aspects of research grant support and complementary activities that can be improved to better support research capacity enhancement and validate the assumptions underpinning the approach. In addition, IFS conducts periodic country-wise surveys with grantees, in particular to more clearly understand their research and career achievements.

Evaluation of biological impacts of trace metal pollution in Ghanian estuaries and nearshore environments.

Dr Edem Mahu dosing test organisms with mercury (Hg) and her student looking on.

PHOTO: PRIVATE

A selection of research results and achievements of IFS grantees

IFS grantees are contributing significantly to changes around the world, through their commitment to scientific advancements, their enthusiasm to learn and to work with others, and their attainment in getting their research results put into use at local, national, regional and global levels. In 2021, we followed up on the results and achievements of the 92 grantees who were awarded grants in 2017. (For a detailed list of all the approved projects, refer to the list in the IFS Annual Report 2017.)

As gleaned from grantee responses to the questions on the PCFs, numerous impacts are evident from IFS's support of early career scientists, in immediate, near-term and long-lasting ways, in villages, forests, fields, policy discussions, government practices and the global scientific community. Indeed, most respondents considered that their projects contributed to several of the UN's Sustainable Development Goals (SDGs), with 14 out of the 17 SDGs mentioned. There was a strong emphasis on the SDGs on reduction of poverty and hunger reduction, improved health and well-being, responsible consumption and production, climate action, and issues related to life below water and on land. The 2017 grantees have thus far also published 77 articles in peer-reviewed scientific journals, thus reaching broader scientific communities.

Difficult though it is to choose which of the 92 projects from 2017 to highlight, presented here are ten that are representative of topics, countries, regions, women and men. These selections also represent the many early career scientists who IFS is honoured to include among those who work to support its mission. In addition to responding to the first PCF question about how their own high-quality research is being used in their home countries, grantees were also asked to indicate the wider impact of their projects, i.e., the multiplier effect of being awarded an IFS grant.

All PCF respondents mentioned that other people at their institutions benefitted from their grant, including scientists, technicians and research students. Additional institutional benefits from the IFS grant were improved quality of teaching and increased training and capacity-enhancing opportunities for students at all levels (post-doc, PhD, MSc and BSc students), and also training for technicians within and outside their home institutions. Purchased equipment widely used by other scientists and students was also often mentioned as an additional benefit of the grant. Many of the respondents also indicated that their home institutions had gained increased visibility and recognition through increased research output, new skills development and increased expertise. This generated collaboration opportunities with other institutions – both nationally and abroad – as well as more and better opportunities to compete for other grants.

As said by Dr Olaniran Hamed Odountan of Benin: *"The fact that I got the IFS grant at 26 years old surprised my colleagues and motivated the other PhD students and colleagues working on aquatic ecosystem ecology and conservation to develop research projects and apply for grants."*

Dr Symphorien Agbahoungba, also from Benin, reports: *"Our Applied Ecology Laboratory has organised the West African Cowpea Consortium through my cowpea breeding programme and has increased the visibility of the University of Abomey-Calavi in West Africa. In addition, many articles have been published in high impact factor journals and others are under preparation. An active collaboration has been created between our group and the West African Centre for Crop Improvement of the University of Ghana, where germplasms are shared and respective students' mobility is established for training and supervision."*

Most of the responding grantees noted that they had increased their scientific contacts through the IFS grant, with IFS advisors and other grantees, as well as other scientists. Most of them also listed one or several scientific networks they are involved in, at individual, institutional, national, regional and international levels. All but one respondent are still active in research, with one person employed by a national research centre, and most of the others affiliated with one or more universities as faculty members, lecturers, researchers or research assistants, or post-doc research fellows, and thus engaged full-time in teaching and research activities. Three people have left academia but remain in research, two for a private company, and another as manager of a global water supply network. Several are heads of departments, sections or research laboratories.

Thirty-two respondents reported that they have obtained higher academic degrees, or were promoted, had received awards or fellowships, or travel grants. Thirty-five grantees mentioned other sources of research funding obtained, either for themselves or their institutions. These (sometimes multiple) national, bilateral and international grants were for research, capacity enhancement or travel.

In terms of the significance that the IFS support had for their careers, ten respondents explicitly stated that the IFS funding was instrumental for them to finalise their PhD degrees. All highlighted different ways in which their careers had been strengthened, such as increased research skills, opportunities for research collaboration (both nationally and interna-

tionally), and the possibilities to publish their research results. Others mentioned their improved skills in grant writing and management, teaching and leadership. Also mentioned were that they were more respected by having obtained a prestigious international competitive grant, and for some, their promotion was a direct result of the IFS grant. Also significant were the opportunity to have MSc students participating in field work and being able to obtain scientific equipment for their institutions.

Dr Nhung Thi Nguyen of Vietnam describes the significance of an IFS grant to her:

"The IFS support was a chance to continue my PhD research in a field that had not been supported by my institution due to different interests. I could implement new techniques in molecular biology that I had not used before, and I could supervise students who were interested in molecular biology and needed internships for their graduating theses. In Vietnam, women scientists often start their careers later than men do, and then have difficulty in finding research funds, also finding it harder than men to focus on doing research because of social roles and prejudice. IFS supports woman like me in my research and career, which has encouraged other women scientists in my institute to be confident and develop themselves as research scientists."

A soil sampling session in a quadrant at Banco National Park, Dr Akaffou Sopie Elvire Vanessa (left) and Dr Gouli Gnanazan Zinsi Roseline.

DR ROSELINE ZINSI GNANAZAN GOULI

University Félix Houphouët-Boigny, Ivory Coast

A multivariate approach to identify plant species indicative of invaded ecosystems: Case of Chromolaena odorata (L.) R.M. King & Robinson (Asteraceae) *in Côte d'Ivoire*

The main objective of the project was to contribute to a better understanding of the biotopes invaded by *Chromolaena odorata.* More specifically, we studied the characteristics of the biotopes invaded by this exotic, the plant groups of the environments invaded and not invaded by *C. odorata*, and the indicator species of each plant group. The results are currently being used by the Parks Management Office to examine invasion by several invasive alien species and in particular *Chromolaena odorata.*

Dr Marcel Houngbédji biobanking for long-term conservation of microbial culture being used for freeze-dried or oven-dried starter culture development.

DR MARCEL HOUNGBEDJI

University of Abomey-Calavi, Benin

Safety assessment of lactic acid bacteria and yeasts and development of multifunctional starter culture for the production of nutritious and safe cereal-based fermented foods

The developed starter culture was tested at Small and Medium Enterprises (SME) in specific conditions (e.g., temperature, dose and fermentation duration). The successful valorisation of the results through the use of the starter at SMEs needs further investigation to allow the efficient use of the starter at SME level for large scale production.

Dr Edem Mahu dosing test organisms with mercury (Hg) with her student looking on.

DR EDEM MAHU
University of Ghana, Ghana
Human health risk assessment and evaluation of biological impacts of trace metal pollution in major Ghanaian estuaries and nearshore environments

We now have important information regarding safety as far as seafood consumption in Ghana is concerned. I have been hosted on a radio programme in the country where I had the opportunity to discuss the relevant findings of the research with the people of Ghana. On this show, I discussed the impact of heavy metal pollution on seafood safety and security in Ghana based on data collected through the research.

Hands-on-training with Claude Mande, Raymond Lokeka and Euphrem Mpaka, in the assembly of harp traps with conservation officers in the buffer zone of Lomami National Park, Democratic Republic of the Congo, for Mr Claude Mande's research.

MR CLAUDE NDJABU MANDE
Biodiversity Monitoring Center, Democratic Republic of the Congo
Afrotropical bats' functional variability as a disturbance impact indicator

The previous practice of bat trapping resulted in almost 100% mortality. In view of new agreements on biodiversity, and the restriction of certain specialized scientific journals to publish studies that have not sacrificed animals, we have entered an updated context of acquiring biological samples according to non-invasive and ethical approaches. Through the established wildlife and habitat monitoring system, we combine mist netting, harp trapping and acoustic surveying to optimise bat monitoring. We take biological samples by wing punching and swabs. To apply this new approach, three students from the University of Kisangani were trained in these methods; they now participate in field missions to share experiences in the application of these methods.

Design of innovative market gardening system in Senegal.

DR MAME FARMA NDIAYE
Senegalese Institute of Agricultural Research, Senegal
Design of innovative market gardening systems for improved nematode and nutrient management

The results of the biogas compost trials have helped promote their use in crops. Indeed, these tests showed that the addition of biogas compost gave a production comparable to that obtained in conventional crops (with chemicals).

Thanh Thai Tran, Huynh Nhi Dinh and Thi Hoang Yen Tran collecting phytoplankton samples in Tri An reservoir, Vietnam, for Dr Thanh Luu Pham's research.

DR THANH-LUU PHAM
Institute of Tropical Biology, Vietnam Academy of Science and Technology, Vietnam
Does artificial dam stimulate toxic cyanobacterial blooms? A case study in the Tri An dam and reservoir, Vietnam

This study has addressed water eutrophication and enhanced the early warning toxic effects in a drinking water supply reservoir. It also enabled regional authorities to identify multi-

hazards on the regionally specific biota as well as strengthen management capacity at technical and institutional levels. The study results have increased the exchange of information among institutions and nations, and enhanced scientific knowledge communication through publications. Our institution will provide public authorities and policy makers with valuable information leading to the establishment of regulations for cyanotoxins management.

Dr Vonimihaingo Ramaroson Rakotsamimanana working in preparation room.

DR VONIMIHAINGO RAMAROSON RAKOTOSAMIMANANA
National Center for Applied Research in Rural Development, Madagascar
Incorporation of moringa and stevia leaf powders into root/tuber flour biscuits for protein fortification and sucrose substitution

One formulation was selected from among the formulations tested and analysed during this project. Prototype cookies were made and presented via the MIKASA platform during national events. These aim to promote good nutrition in regions most affected by malnutrition in Madagascar. In August 2021, two Open Door Days on Nutrition were organized in Fianarantsoa (one of the regions with a high rate of chronic malnutrition). This presentation of research products aimed to sensitize organizations working in the fight against malnutrition in Madagascar in the large-scale distribution of cookies. These organizations come from various sectors: UN organizations such as WFP, FAO and private sector manufacturers of cookies.

The landscape of Vakinankaratra, Madagascar.

DR HANITRINIAINA MAMY RAZAFIMAHATRATRA
National Center for Applied Research on Rural Development, Madagascar
Agroecology, a lever for poverty reduction

The farm model developed could be used as a decision support tool for policy-makers and development professionals when it comes to promoting agroecological innovations, particularly conservation agriculture at farm level in the western part of Vakinankaratra. The model could also be improved and calibrated to test different agroecological innovations and/or be used in other areas of Madagascar to tackle poverty in rural areas.

Dr François Tapsoba , Assistant Professor.

DR FRANÇOIS TAPSOBA
Joseph Ki-Zerbo University, Burkina Faso
Improvement of the production process, sanitary and sensory quality of Borassus akeassii *wines*

The results are being used to improve the production process, and the sanitary and sensory quality of *Borassus akeassii* (palm) wines, thus contributing to the diversification of the cold drinks available to consumers.

GRANTS

IFS aims to enhance the research capacity of promising early career scientists in Low- and Lower-Middle-Income Countries (LLMICs) as the most important contribution the organisation can make in addressing local and regional aspects of global challenges such as the conservation and sustainable use of natural resources, both terrestrial and aquatic, and in food security and nutrition, including social and economic aspects. IFS does this by providing tailored research capacity-enhancing support centred around the provision of competitive individual Basic Grants and Advanced Grants, and Collaborative Grants.

Basic Grants
Basic Grants (up to US$15,000 for each) cover costs of additional manpower, consumables, equipment, literature and travel for field work. Basic Grant applicants receive feedback from reviewers, scientific advisors and the IFS Secretariat. Successful applicants also receive help with purchasing of equipment and consumables. Individual capacity-enhancement support is determined by the needs of the grantee and the nature of the research being conducted.

Advanced Grants
Advanced Grants (up to US$20,000) are available to those who have successfully completed a Basic Grant and who are within five years of having completed their PhDs. Their purpose is to support not only further research, thereby strengthening research skills, but also the development of a wider suite of skills essential to the development of a scientist. This includes helping foster an awareness of the role of Information and Communications Technology in society by requiring applicants to elaborate both a Theory of Change and a Research-Into-Use Plan in the application form. On completion of an Advanced Grant, IFS seeks evidence of development of skills in networking, collaborative research, web presence, producing media pieces for general audiences, conference presentations, influencing (e.g., involvement in policy development) and science leadership (e.g., membership on science committees, leadership of research teams). Whenever grantees identify a need, IFS will also connect them to advisors who are willing to mentor them in areas such as experimental design, data collection, analysis and interpretation, and publication.

Does artificial dam stimulate toxic cyanobacterial blooms?

Thanh Thai Tran, Huynh Nhi Dinh and Thi Hoang Yen Tran collecting phytoplankton samples in Tri An reservoir, Vietnam, for Dr Thanh Luu Pham's research.

PHOTO: PRIVATE

A selection of new Basic Grants awarded in 2021

IFS supports original research proposals that are innovative and/or relevant to local or national development needs and problems, and that aim to generate fundamental and/or applicable scientific knowledge. The three research clusters are:

Since many topics within the three areas are overlapping, research projects that integrate or cut across them are encouraged. Although the research areas are given certain boundaries, they are circumscribed by the overarching and broader context of climate change which is of urgent and global concern. Thus, the funded research projects are also intended to provide knowledge and suggest its application in support of the realisation of sustainable development locally, regionally and globally in line with the UN's Sustainable Development Goals.

Biological Resources in Terrestrial Systems

Biological Resources in Terrestrial Systems includes biodiversity, forestry, animal production, crop science, underutilized species, natural products, renewable energy and climate change.

DR MOBOLADE AKINBULUMA, NIGERIA

Semiochemical-based strategy in the sustainable management of the invasive pest Spodoptera frugiperda (Lepidoptera: Noctuidae) *in Nigeria*

The fall armyworm, *Spodoptera frugiperda,* causes severe yield loss to maize, thereby posing eminent risk to food security in Nigeria. Semiochemicals have potential for insect pest management as they are considered safe and environmentally friendly, but their use has not been explored against *S. frugiperda* in Nigeria. The study aims to develop monitoring lures from pheromones and host plant volatiles against the Nigeria population of *Spodoptera frugiperda*. Pheromone extractions will be performed on the abdomens of virgin females obtained from three zones in Southwestern Nigeria. The pheromones will be analysed using gas chromatography coupled with mass spectrometry. Lures will be developed from the identified pheromone and attraction to *S. frugiperda* males compared in field trials. Field experiments with established pheromone lures and candidate plant attractant blends will be tested for behavioral responses of *S. frugiperda*. Results obtained on responses of *Spodoptera frugiperda* to the monitoring lures and plant volatiles would be elucidated to provide the platform for the management of *Spodoptera frugiperda* in Nigeria.

DR KOFFI KIBALOU PALANGA, TOGO

Genetic diversity and agro-morphological characteristics of cultivated pigeon pea (Cajanus cajan L.) *in Togo*

Pigeon pea is a multipurpose legume crop cultivated mainly for its edible seeds which are high in dietary protein. In Togo, neither agro-morphological nor molecular approaches have been used to characterize pigeon pea accessions present in the country. Besides, there is a lack of information on farmers' knowledge on the crop cultivation and uses. Adequate information on the genetic diversity and population structure of a crop added to indigenous knowledge on its cultural practices and uses are prerequisite to develop an efficient breeding and conservation program. The main goal of this project is to contribute to an efficient conservation of pigeon pea accessions cultivated in Togo. We will focus on the documentation of the endogenous knowledge of the cultural practices and uses the crops and on making an agro-

Dr Mobolade Akinbuluma, collection of FAW larvae in Ibadan, Nigeria.

Mr Sangay Tshering, measuring forearm (FA) of Woolly Horseshoe Bat *(Rhinolophus luctus).*

Ms Azongnide G Gwladys collecting data in experimentation on young seedlings of *Vitellaria paradox.*

morphological, molecular and physico-chemical characterization of the different accessions. Based on the results, dynamic and sustainable management will be proposed to decision makers of the country's agricultural policies.

MR SANGAY TSHERING, BHUTAN

Diversity and distribution of bat communities along an elevational gradient in the districts of Haa and Gasa, Western Bhutan

Bats constitute the second most diverse order of mammals with >1400 species globally. In 2004, Bhutan was reported to have 65 species which represents 33% of mammal taxa. Subsequently in 2010, Bhutan had the second highest (51%) total bat diversity after India among the countries in South Asia. The exact number of bat species present in Bhutan still remains uncertain as the information on many of the species is solely based on literature surveys. At present, diversity and distributional information is available only for species recorded from seven districts, with 13 districts unexplored and data deficient. As bat studies are still lacking, the main objective of this project is to document diversity and determine distributional pattern of bat communities along elevational gradients. This project is expected to document new bat records and to prepare a call library for the country.

MS AZONGNIDE GBÈDOTCHITCHÉ GWLADYS, BENIN

Morphological characterization and early growth improvement of Vitellaria paradoxa C. F. Gaertn *in Benin*

Forest resources contribute to the well-being of local communities, among which is *Vitellaria paradoxa* (shea tree), a native species of Sudano-Sahelian Africa. Classified as a vulnerable species by the IUCN, it is semi-domesticated, taking into account the constraints which hinder its domestication, including the slowness of its early growth. Its productivity rests solely on trees growing in fields and fallows. This project aims to study local communities' perception on morphological characterisation of shea tree in Benin; evaluate morphological variabilities of shea tree in the three climatic zones in Benin; and evaluate the effect of seed provenance on early growth of shea in its natural environment in three zones. This knowledge will make it possible to select plant material for improving early growth and to establish a shea reforestation program to ensure its sustainable production for the actors of this sector, in particular the women transforming the nuts into butter.

DR ABYOT DIBABA, ETHIOPIA

Ethnobotanical study of medicinal plants used by local people around Gerba Dima forest: Implication for sustainable natural resources management and traditional health care systems

Traditional plant remedies are the most important source of therapeutics for nearly 80% of the developing world's population. The knowledge on traditional medicinal plants of Ethiopia which was developed for millennia is now subject to loss since it has mainly been stored in the memories of elderly people and handed down mostly by word of mouth to successive generations. Moreover, deforestation, overexploitation, overgrazing, habitat loss and degradation, agricultural land expansion and acculturation continuously threaten Ethiopian traditional medicinal plants and linked knowledge. Hence, it is a timely endeavour to investigate, document and analyse traditional knowledge on medicinal plants and associated knowledge drivers, so that sound medicinal plant utilization and management practices can be maintained. The results will provide the opportunity for recognition, promotion, management and protection of indigenous knowledge of a community on medicinal plants as a vital part of a nation's heritage.

MR BISMARK OFOSU-BAMFO, GHANA

Liana community structure in relation to climatic and edaphic factors across five forest ecosystem types in Ghana

Whereas lianas are increasing in density and abundance in the neotropics, the status of liana ecology in most African forests remains unknown. Data on how climatic factors, edaphic variables and forest structure shape liana ecology and distribution remain scant on the continent of Africa. Considering the ability of lianas to alter forest structure by negatively affecting tree growth and reproduction through competition for below and above ground resources, it is important to establish the factors that shape their ecology so as to enable long-term and large-scale monitoring of lianas. The aim of this project is to determine how liana communities are shaped by climatic factors, edaphic variables and forest structure across five forest ecosystem types in Ghana which exhibit variations in mean annual rainfall and forest structure. Information generated will be useful for developing ecological models applicable across different jurisdictions. Data will also be useful in making forest management decisions that incorporate liana ecology tailored for specific ecosystem types.

MR DÈDÉOU APOCALYPSE TCHOKPONHOUÉ, BENIN

Elite genotypes selection and development of vegetative propagation techniques for enhanced production and fruit quality attributes in the miracle plant Synsepalum dulcificum

The miracle plant *Synsepalum dulcificum* is a West African orphan tree crop of the Sapotaceae family. Its fruit (miracle berry) is a first-class sweetener with va-

Ethnobotanical survey Group discussion in the village of Lama-Tessi, Tchaoudjo prefecture.

Mr Dèdéou Apocalypse Tchokponhoué appreciating the level of budding on a a juvenile of miracle plant [Synsepalum dulcificum (Schumach & Daniell) juvenile on the experimental site of Sekou (Guineo-congolian region of Benin).

Mr Asso Armel Asso, observation of a stall in the small market of Koumassi (Ivory Coast).

Mr Bismark Ofosu-Bamfo using the Nikon D3500 camera to take pictures of plants observed in Boabeng Fiema Monkey Sanctuary (dry semi-deciduous forest).

Dr Krichen Khouloud researching plant richness in bare soil, Tunisia.

rious applications in food and beverage industries, cosmetics, and diabetes and cancer treatments. The species has tremendous economic value and can serve as leverage for poverty alleviation in West Africa. Unfortunately, the paucity of knowledge on its genetics and genomics, locking cultivar development, combined with its improper cultivation, is currently hampering the realization of this potential. The current project will identify elite parental lines in the species and profile a farmer-friendly vegetative propagation method to promote increased production of quality fruits in the species. Information on the species' diversity and population structure will be generated for the first time; core collection representing the West African diversity in the species will be developed; elite parental genotypes for fruit yield, pulp production and seed exploitation will be identified; and an effective vegetative propagation protocol will be profiled.

DR KRICHEN KHOULOUD, TUNISIA

Impact of human activity on degradation of North African Stipa tenacissima L. *ecosystems: Case of Tunisia*

Anthropogenic activities and concomitant land cover change have become an issue, accentuating the risks of environmental degradation and loss of biodiversity. Therefore, information on land cover, changing trends and optimal use of land resources have become criteria for land use and effective natural resources management. In North Africa, *Stipa tenacissima* steppes have been experiencing widespread land cover changes over the past few years due to the convergence of social and economic interests. For Tunisian steppes, a large area of *S. tenacissima* has been changed to agro-ecosystem land use, especially after the 2011 Tunisian revolution. The project will study the human and climate impact and create a management program to preserve Alfa-grass steppes in Tunisia by land cover mapping and studying the biodiversity and ecosystem functioning on these steppes. The estimation of current Alfa-grass steppes land cover change over space and time will provide better understanding of the extent and pattern of Stipa land cover change.

MR ASSO ARMEL ASSO, IVORY COAST

Poaching, trade and role of critically endangered vulture species in traditional medicine in Côte d'Ivoire (West Africa)

Vultures provide important ecosystem services by foraging on carcasses of large

Dr Mark Kimani carrying out concentration of crude extracts from *Teclea nobilis* using a rotary evaporator at the University of Embu.

Ms Elodie Gisèle Anoumedem Mouafo performing the isolation of fungal compounds.

mammals and therefore reducing the spread of diseases. Throughout Africa, vultures declined rapidly during the last decades with some populations showing decreases of over 90% within three generations, and are now at the brink of extinction. The goal of this project is to assess the threats to vultures in Côte d'Ivoire by determining the importance of their exploitation for traditional medicine. We will assess the abundance of the trade in vultures or parts of vultures in markets of larger cities and identify the trade circuit and its actors, evaluate the poaching pressure generated by the demand for vultures in traditional medicine, evaluate the socio-economic value of poached vultures and potential international trade affecting the Ivorian bird diversity, and identify the role of vultures in different ethnic groups in Côte d'Ivoire. The results should help in implementing a vulture conservation strategy that takes aspects of local cultures into account.

DR BUDDHA BASNET, NEPAL

Bioprospecting, extraction, screening, isolation and characterization of novel antibiotics from endolichenic fungi isolated from lichen of Butwal-Basantapur trekking trail area of Nepal

Lichens have been used for numerous purposes such as dyes, perfumes and cosmetics, including folk medicine. Well-known examples include *Usnea dillenius* which was used for curing diseases of the scalp and treating sore eyes. Similarly, *Usnea subfloridana* and *Parmelia omphalodes* are used as a lotion and anti-inflammation for cuts and burns. It is believed that these important properties of lichen are because of the compounds biosynthesized by them, as conglomerates of fungi and algae. More than 150 compounds have been isolated from the fungal partner of lichen, indicating endolichenic fungi as a propitious source of bioactive compounds against microbes. The emergence of multidrug-resistant bugs makes urgent the discovery, development and commercialization of new drugs. This project will explore the Nepalese endolichenic fungi for isolating the novel structures with novel antimicrobial from the Nepalese lichen flora. The compounds isolated might form baseline research for the discovery and development of antibiotics to treat superbugs.

MS ELODIE GISELE ANOUMEDEM MOUAFO, CAMEROON

Search for antibacterial secondary metabolites from endophytic fungi associated with the Cameroonian medicinal plant Garcinia lucida

Infectious diseases remain a public health concern in Africa due to antimicrobial resistance. For several years, chemists and biologists have used plants in the search for effective antibiotics resulting in an upswing in the study of plants, and a considerable decrease in the discovery of new leads. Several studies have proven endophytic fungi to be an alternative source for the discovery of new antibacterial compounds.

Dr Abel Joël Yaya Gbaweng using column chromatography.

Cameroon has a rich biodiversity and the literature indicates that endophytes associated with Cameroonian medicinal plants have barely been investigated. Plants from the genus Garcinia have been used for several years in the treatment of typhoid, dysentery and diarrhea, and researchers have shown the antimicrobial activities of their extracts and isolated compounds. Although the literature indicated the importance of endophytes associated with plants, fungi associated with *Garcinia lucida* are poorly studied. The main objective of our study is to isolate and characterize new antibacterial compounds from three endophytic fungi associated with *Garcinia lucida*.

DR MARK NJOGU KIMANI, KENYA

Search for antiprotozoal agents from Flueggea virosa *and* Teclea nobilis

Protozoan parasites are major contributors to neglected tropical diseases, affecting millions of people in Sub-Saharan Africa with high mortality and morbidity. The people bearing the burden of these infections are marginalised and form a non-lucrative sector for drug development investments. For decades, plant metabolites have been considered for use as drugs or as leads in the development of drugs. In this study, the search for antiprotozoal agents from two plants used in folk medicine, *Flueggea virosa* and *Teclea nobilis*, will be carried out.

DR ABEL JOËL YAYA GBAWENG, CAMEROON

Phytochemical investigation of Phragmanthera capitata S. Balle (Loranthaceae) *and* Commiphora kerstingii Engl (Burseraceae) *for their anti-proliferative constituents*

About 70% of cancer deaths occur in low- and middle-income countries. The detection of advanced cancer and the inability of the population to access diagnosis and treatment are common problems. The aim of this project is to investigate *Phragmanthera capitata S. Balle (Loranthaceae)* and *Commiphora kerstingii Engl (Burseraceae)* to manage and eliminate breast cancer. Phytochemical screening and chemical investigations performed on the former revealed that it produces various secondary metabolites including tannins, saponines and flavonoids. The latter plant contains classes of natural chemical constituents like saponins, tannins and volatile oils. Promising substances will be pharmacologically characterized using cell-based bio-assays to test their effects on cell life cycle, cell death mechanism, and cell migration/invasion, as well as apoptosis and cell cycle regulating protein content in breast cancer cells.

DR JUBRIL AKOLADE, NIGERIA

Development of antimalarial formulation from citrus essential oils

As the world faces a resurgence of infectious diseases due to the rise in resistance, there is a need for agents to control the transmission of causative agents such as the malaria Plasmodium parasite. In parallel with the resistance crisis, is an increased usage of natural product-based medicines such as terpene-based compounds known as essential oils used in traditional herbal infusions for the treatment of malaria. However, essential oil constituents with excellent in vitro antiplasmodial activities failed to replicate when administered in vivo at minimum non-toxic doses due to low bioavailability resulting from their hydrophobic, volatile and unstable chemical structure. Thus, there is need for appropriate technology to encapsulate these bioactives into compatible formulation to mitigate uncontrolled vaporization, low bioavailability in plasma and in vivo inefficacies when minimum safe therapeutic doses are administered. This study seeks to improve the antimalarial activities of essential oil constituents from Citrus spp. using supercritical fluid encapsulation technology. The goal is to valorise citrus essential oil into commercially viable formulations for the treatment of malaria.

Water and Aquatic Resources

Water and Aquatic Resources includes availability of water resources, and their conservation and use; issues associated with water-related institutions; and freshwater, brackish and marine aquatic organisms and their environments.

MR TAMIRAT HAILEGEBRIEL WOLDEKIROS, ETHIOPIA

Distribution, genetic diversity and population structure of intermediate hosts of schistosomiasis (Biomphalaria spp.) *of Lake Tana, Ethiopia, and its tributary rivers*

Schistosomiasis is a neglected tropical disease endemic to tropical and subtropical regions. Ethiopia is one of the endemic countries for schistosomiasis mainly caused by *Schistosoma mansoni*, which uses Biomphalaria snails as an intermediate host. Existing information on Biomphalaria snails of the country is so far solely based on shell morphology, which is inefficient to identify related snail species, even by experienced personnel. Molecular based studies of snail species are lacking in the country despite its vital role for assessment of genetic diversity as well as their evolutionary relationships. Therefore, this study aims to assess the genetic diversity and population structure of Biomphalaria snails around Lake Tana. The information generated during this study will be helpful to increase our understanding about Biomphalaria snails, particularly species identity, genetic diversity and population structure in Ethiopia. As such, better informed mitigation or eradication programs to combat schistosomiasis can be developed.

MS PAULINE ORONDO, KENYA

Determination of biotic and abiotic factors in the larval habitats affecting mosquito larval development and vector competency

Biotic and abiotic conditions of aquatic larval breeding habitats influence the growth, development and survival of malaria vectors. These provide nourishment and essential components for their survival. The objective of this study is to determine the larval habitat metagenomics that support the survival of immature malaria vectors and survey potential aquatic habitats for presence of immature malaria vectors in the irrigated and non-irrigated areas of Homa Bay County. The data generated from this study will provide information on the suitable conditions that support malaria vector breeding which in turn will be useful in vector control (larval source management).

DR JULIET KARISA, KENYA

Spatial pattern in the resilience of coral reefs from climatic disturbances in Kenya

Coral reefs are declining at an alarming rate all over the world with climate change being recognised as one of the greatest threats to this ecosystem. There are still limited global efforts to abate climate change, making 99% of coral reefs likely to disappear in this century. The persistence of coral reefs will rely heavily on their resilience to climatic disturbances. Coral reefs in Kenya have undergone consecutive bleaching that was heightened by an unprecedented mass coral bleaching in 1998, followed by less severe bleaching in 2010 and 2016. Following substantial bleaching mortality, recovery has been slow with some coral populations losing their dominance. Subsequently, coral reef managers are becoming more concerned about the resilience of coral reefs. This study will determine the spatial pattern in resilience of coral reefs in Kenya and identify the key drivers of resilience. Information on the spatial pattern in resilience of coral reefs will form an important contribution for Marine Spatial Planning (MSP) processes in Kenya, especially in the ongoing efforts to re-design and create new Marine Protected Areas (MPAs). Information from this study will help inform national efforts to increase MPA area within the wider national MSP framework.

MS EMILY NGENO, KENYA

Investigating the concentration levels of selected endocrine disrupting chemicals in wastewater and their removal through phytoremediation using Eicchornia crassipes *in constructed wetlands*

Endocrine Disrupting Chemicals (EDCs) are exogenous chemicals that, at certain doses, interfere with the production, secretion, metabolism or transport of endogenous hormones in biota. This interference causes adverse health effects such as congenital anomalies, tumors, metabolic disorders, neurological dysfunctions and behavioral disorders. They have also been found to influence germ cells, consequently affecting up to the fourth generation. The effects associated with EDCs, coupled with the inability of conventional treatment plants in removing them, necessitates further studies, particularly regarding their occurrence in the environment and their sequestration. Studies determining their environmental concentration have been carried out successfully in many parts of the world except in Kenya and most of Africa. Consequently, there is scarce data on these compounds and generating data on their levels in water and sludge samples will be the primary objective. This gap will be bridged by selecting model compounds from the various synthetic and natural EDCs. The second objective will be developing a cost-effective method of removing these EDCs from wastewater by phytoremediation to *Eicchornia crassipes* in constructed wetlands.

MR KIRUBEL MEKONNEN GEBREYESUS, ETHIOPIA

Integrating satellite rainfall estimates and

Mr Tamirat Hailegebriel Woldekiros collecting snail from Dek Island.

Ms Pauline Orondo and Ms Sally Musalia working in the laboratory.

Ms Emily Ngeno performing soxhlet extraction.

Dr Juliet Karisa conducting underwater assessment on ecological resilience of coral reefs in Msambweni area on south Kenya coast.

daily rain gauge observations to improve flood simulations in poorly gauged Upper Awash Basin, Ethiopia

The Upper Awash River Basin is the most intensively developed river basin in Ethiopia. Despite this, extreme rainfall and associated flood events cause tremendous socio-economic impacts, causalities and loss of property in the basin. To reduce these flood risks, the Awash Basin Authority have often used long-term continuous rain gauge data to force hydrological models for flood simulations. However, the sparseness and uneven distribution of rain gauge stations limit our ability to understand the spatial variability of extreme rainfall events, which in turn affect the existing flood simulation results. The Satellite Rainfall Estimates (SREs) provide data with high spatial and temporal resolutions but their accuracy varies from region to region. Therefore, this study aims to compare satellite rainfall estimates against high-density rain gauge networks in estimating extreme rainfall rates; identify a reliable calibration scheme that achieves the most realistic modelling for the data available; examine the performance of SREs in simulating flood under different hydrological model calibration schemes; and build the best integrated satellite rainfall estimates and daily rain gauge observations to improve flood simulations.

DR QUENTIN FIACRE TOGBEVI HONFIN, BENIN

Hydro-climatic modelling of a tropical West African catchment under land use and climate changes (Tiélé, Benin)

Climate change information at local scale is necessary in evaluating its impacts to develop appropriate adaptation and suitable mitigation strategies. In addition, land use change due to anthropogenic activities and climate change are projected to impact surface flows in West Africa, especially in Benin. This study aims to assess both land use and climate change impacts on the catchment water availability in Tiélé. This project will contribute to effective adaptation strategies for water resources management plans and decisions for water shortage prevention and flooding risk reduction.

MR HIGEMENGIST ASTATKIE, ETHIOPIA

Development of fluoride filter: An electro-sorption approach

Contamination of surface and groundwater using fluoride, mostly of geogenic sources, is a global concern. It is problematic in Ethiopia, especially in the Rift Valley, where most inhabitants rely on drinking fluoride-contaminated groundwater. This study aims to investigate the defluoridation capacity of fluoride with the ultimate goal of producing point of use electro-sorption technology. Conventional water treatment processes

Mr Kirubel Mekonnen Gebreyesus, focus group discussion with the community about flood risks and management.

involving precipitation-coagulation-flocculation and advanced fluoride removal technologies are mainly limited due to several hindering factors from their practical applications, especially in developing countries. Electro-sorption has been extensively applied in ion removal due to the advantages of sorption and electrochemical processes. Although promising for its relative cost effectiveness and being environmentally benign, electro-sorption is limited for its lower selectivity among ions, its efficiency being dependent on the type and shape of electrodes, and ionic or hydrated size. The effect of electrochemical assisted sorption and underlying mechanisms will be investigated using graphene prepared from graphite and Ca-intercalated graphene for selective sorption of fluoride. Electro-sorption technology will have a vital role in producing point-of-use water treatment filter targeting fluoride removal.

DR M M MAJEDUL ISLAM, BANGLADESH

Monitoring and quantifying health risks of antibiotic resistant bacteria in urban surface water

Development of antibiotic resistance bacteria (ARB) in the aquatic environment is a serious concern for human health in recent years. Antibiotic resistance genes (ARG) can be transferred from one organism to another in water environments by horizontal gene transfer. It is important to assess the impact of ARB/ARG on human health. However, studies on antibiotic resistance have been scarce, particularly in developing countries like Bangladesh, where antibiotics are widely consumed and diarrheal diseases are endemic *E. coli* is one of the leading causes of enteric infection in Bangladesh and their resistance to antibiotic drugs is of particular concern. In this study *E. coli* strains isolated from surface waters around Khulna City, Bangladesh, will be characterized for their antibiotic resistance, and associated health risks will be quantified. This study will provide information on the dynamics of ARB in surface water, and the health risks associated with the exposure to these etiological agents. The developed method and findings of this study will be helpful for water managers to ensure safe uses of the river.

DR ELIEZER BIAO, BENIN

Assessing the impacts of climate change on water resources and sustainable adaptation strategies in two climate regions in Benin (West Africa)

Impacts of climate change in West Africa and more particularly in Benin include an increase of atmospheric temperatures, floods, sea level rise, acceleration of coas-

Dr Quentin Fiacre Togbevi Honfin, Benin, conducting in-situ soil infiltration measurement.

tal erosion, modification of monsoon precipitation and droughts. These effects, among others, can have dramatic socio-economic consequences due to their impact on agriculture, water resources and human health. Thus, understanding the heterogeneity of climate change and its impacts on water resources in different climate regions is important for successful water management. This study will develop sustainable adaptation strategies through the integration of science-based facts with information and knowledge from local stakeholders and communities to reduce current and future impacts of climate change and sustain development in two climate regions in Benin. Sustainable adaptation strategies in both the wet and dry seasons will be suggested to cope with the future impacts of climate change in the Oueme at Bétérou and Bonou catchments.

MR GODFREY WANGI, UGANDA

Development of zeolite-based nanocomposite water filters for removal of heavy metals and Escherichia coli *from drinking water*

Clean and safe water is vital for the survival of human beings as it is for industrialization, urbanization and agricultural activities. Globally, over 80% of all wastewater from such activities is estimated to be released to water bodies without treatment. For the Sub-Saharan region, 79% of the rural population lack access to improved water sources causing diseases such as typhoid and diarrhea, and hence deaths. Uganda relies on conveyance and centralized systems for water treatment, which are no longer sustainable for the scattered population, as 80% of Uganda's population live in rural and suburban communities not connected to the national water supply.

The proposed solution is to develop zeolite nanocomposite adsorbent material from Ugandan zeolite capable of treating water to international standards. Natural and affordable zeolite mixed with silver nanoparticles has high cation exchange for removal of inorganic contaminants and disinfection of water. The purpose of this research therefore is to test the potential of Ugandan natural zeolite to remove heavy metals and *Escherichia coli* from contaminated water.

Food Security, Dietary Diversity and Healthy Livelihoods

Food Security, Dietary Diversity and Healthy Livelihoods includes agricultural and/or livestock production, food security, primary health care, extension services, irrigation, sustainable agricultural practices, markets and trading systems, food value chains and vulnerability and resilience.

MS TEMITAYO OHEMU, NIGERIA

Bioactivity guided isolation of bioactive principles with male fertility activity from the whole plant of Loudetia phragmitoides (Poaceae)

Loudetia phragmitoides (Poaceae) is a plant used by traditional medicine practitioners in Nigeria to treat infertility and various ailments. The study aims at isolating and characterizing the bioactive principles responsible for the aphrodisiac and/or fertility property of *Loudetia phragmitoides.* The study is expected to provide potential drug compounds which could be useful in the management of male infertility as well as provide a scientific basis for the use of these plants in traditional medicine.

MR JOSHUA MULI, KENYA

Evaluation of phosphorous scavenging genes in cultivated and wild crotalaria species

Slender leaf *(Crotalaria spp)* is a vegetable of importance in East Africa because of its uses as a food crop, a soil improvement legume and its role in *Striga hermonthica* control. These plants have been observed to thrive in poor soils and confer the ability to cereal crops to evade the witch weed. However, the genetics of phosphorous mobilization and the SNPs associated with this phenomenon in Crotalaria remain unknown. This study therefore aims to establish the genes associated with phosphorus use efficiency in both cultivated and wild species of Crotalaria in Kenya. Findings from this study will enhance efforts towards conserving and improving *Crotalaria spp*, as well contribute to food security by identifying potential genes which can help plants thrive in poor soils.

DR TONG THI ANH NGOC, VIETNAM

Food nutrition and safety evaluation of cooked and ready-to-eat food products from online platform in Vietnam

The recent development of the Internet has boosted the extension of online food services, leading to fast-growing online purchases of food products. Currently, the online food platform has become vital to minimize the impacts of the COVID-19 crisis on food systems and public health. Although the online food platform can provide a massive opportunity for the food delivery industry, it is difficult to guarantee food safety and food nutrition of online food products as regulations have not existed until recently in Vietnam. Additionally, there is no study evaluating the nutritional value and safety of cooked and ready-to-eat foods from online platforms in Vietnam. This project aims to examine the behavior and concern of customers purchasing food products online; and evaluate the nutritional value and microbial safety of cooked and ready-to-eat food products through online platforms. The data obtained from the research can contribute to improving the policies and prompt actions of the Vietnamese government regarding the nutrition and safety of food products from online platforms.

DR HIPPOLYTE TENE MOUAFO, CAMEROON

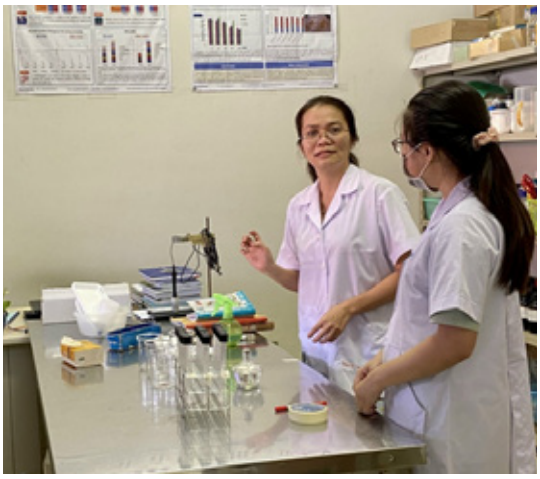
Assessment of the presence of biofilms in recovered plastic bottles used as traditional food packaging in Cameroon and associated sanitary risks

In Cameroon, many traditional foods are packaged in plastic bottles collected from the garbage and drains where they might have stayed for long and therefore exposed to microbial pathogens. In these conditions, biofilms can easily be formed inside the bottles. Once formed, they become difficult to remove through the normal cleaning process and might lead to contamination of the manufactured product. To our knowledge, the poor microbiological quality of traditional foods is generally associated with poor hygiene, not packaging bottles. This project aims to assess the presence of biofilms and dominant microflora in recovered plastic bottles reused for food packaging in Cameroon; evaluate the effect of cleaning processes on the biofilm content of bottles; determine the effect of the presence of biofilm in bottles on the microbiological quality and the stability of foods; and propose a cleaning process leading to complete elimination of biofilms in recovered bottles.

DR JOHN EDEM KONGOR, GHANA

Process development and product characteristics of beetroot dark chocolate using the melanger in an alternative chocolate production technique

Beetroot *(Beta vulgaris)* is receiving increased recognition for the development of functional foods due to the presence of essential health-promoting components such as vitamins, minerals, phenolics, carotenoids, nitrate and betalains. The use of alternative equipment for



Dr Tong Thi Anh Ngoc's team working on the IFS project.

Dr John Edem Kongor (Principal Investigator) sieving the milled beetroot sample.

Dr Hussaini Majiya performing the research project in the lab.

Dr Hippolyte Tene Mouafo, conducting experiment.

chocolate production is also receiving increased attention by researchers and technologists mainly due to the lower cost of investment, maintenance and multi-functionality of the equipment. This project seeks to develop beetroot dark chocolate using the melanger as an alternative chocolate production technique and study the effect of beetroot powder concentration and processing time on the physico-chemical, nutritional, particle size distribution, hardness, microbial safety, mouthfeel, aroma, taste, consumer acceptability and shelf life of the product. The project is expected to diversify and increase the utilization of beetroot in Ghana to reduce post-harvest losses and improve the nutritional and health-promoting properties of dark chocolate for improved well-being of consumers. Decent employment and economic growth, especially for women and youth in the chocolate value chain, will be provided and contribute to the eradication of extreme poverty.

DR MAJIYA HUSSAINI, NIGERIA

Photodynamic inactivation of fresh produce spoilage/pathogenic microorganisms: Harnessing the abundant sunlight to irradiate photosensitisers for prolonging the shelf-life and prevention of foodborne diseases in Nigeria

Sunlight-driven fresh produce sanitation methods could help reduce fruit and vegetable wastage and disease transmission in Nigeria, where microbial contamination of fresh produce is a major public health and socioeconomic problem and bright sun is available for free. Photosensitisers, when irradiated with visible light and in the presence of oxygen, can generate reactive oxygen species in aqueous solution which can efficiently inactivate food spoilage and pathogenic organisms including those resistant to chlorine. This research will produce the food grade photosensitisers from colouring plants (calyxes of *Hibiscus sabdarifa* and leaves of *Sorghum bicolor* and *Lawsonia inermis*) which are available abundantly in Nigeria. This research can lead to a low-tech sunlight-driven fresh produce sanitation system that is cheap, efficient, sustainable and environmentally friendly. Ultimately, more money will go into the purses of fresh produce farmers and wholesalers while consumers can buy more that is safe for less money.

MS JOLLY AKULLO, UGANDA

Preserving quality of insects consumed in Uganda using plant extracts

Insects are a vital and preferred food among many cultures throughout the world, as sources of protein, fat, minerals and vitamins. However, the major limitation in utilizing insects as food is seasonality, perishability and high post-harvest losses due to rancidity. Use of plant extracts in food preservation is safe and meets the current consumer demand for minimum use of chemical preservatives in food. This project aims

Ms Jolly Akullo, Uganda, assessing quality of insect flour preserved with spice extracts.

Dr Franklin Kenechukwu, Nigeria. Extraction of keratin from grinded pre-processed poultry feathers.

to preserve the quality of commonly consumed insects in Uganda using spice extracts, and specifically to assess the effect of different extraction solvents on antioxidant activity of spice extracts, evaluate the microbiological quality and safety of insect foods treated with spice extracts, determine the shelf life of insect food products preserved with spice extracts, and evaluate the sensory quality and acceptability of insect food products treated with spice extracts.

MRS THI THANH MAI HA, VIETNAM

Improving food security for ethnic minority households: Evidence from Son La Province, Vietnam

Son La, the largest northeastern province of Vietnam, is home to about 6.5 million ethnic minorities, whose poverty remains a persistent challenge. Thai and Hmong, the two biggest ethnic minorities in Son La, differ in culture, social norms, and values but face a similar problem of food poverty. This project aims to estimate the prevalence of household food insecurity among Thai and Hmong in Son La Province; identify and compare factors affecting their food insecurity; and investigate the relationship between their food insecurity and coping strategies. The research will answer the question of how to improve food security for upland households and contribute to the existing literature on this topic.

MS ADAEZE ECHEZONA, NIGERIA

Co-loaded liposomal artemether and doxycycline for effective management of resistant P. falciparum *malaria*

Malaria is a health burden in Sub-Saharan Africa, with Nigeria as one of the ten highest countries in Africa reported to have increased cases of malaria. The country accounted for 19% out of the 80% of global malaria deaths in 2017 that was concentrated in 17 countries in the WHO African Region and India. Children aged less than five years are the most vulnerable group affected by malaria and accounted for 61% of all global malaria deaths. Current therapy recommended by WHO for management of malaria is associated with poor solubility and erratic absorption as well as the emergence of drug resistance. In this research, a co-formulation of artemether and doxycycline will be developed to harness the possible synergistic effect of using the two drugs to improve the clinical outcome. This study is expected to establish a scientific basis for the use of doxycycline in combination with artemether to improve its therapeutic effect in severe and cerebral malaria. In addition, it will help prevent the emergence of resistance to artemether in the treatment of malaria.

DR FRANKLIN KENECHUKWU, NIGERIA

Harnessing keratin from poultry feathers as potential cheap nano-formulation raw material for transdermal delivery of anti-malarial combo-therapeutics: A proof-of-concept investigation

This research will design an innovative and versatile transdermal nanotool capable of overcoming non-compliance and enhancing treatment efficacy in cerebral malaria (CM), a key public health concern with an urgent need for more efficient and selective therapies, using keratin generated from chicken feather as a cheap readily-available biodegradable pharmaceutical excipient. The nano-system is conceived to carry multiple drugs to optimize systemic pharmacological responses of artemisinin antimalarials. The primary goal is to develop a transdermal nanocarrier encapsulating clotrimazole and miconazole nitrate each with artesunate to potentiate antimalarial activity and improve patient compliance in CM. Results will expand the arsenal to fight malaria and provide a novel nanotool that can be extended to other applications where co-delivery of small-molecule drugs is needed.

Advanced Grants given in 2021

We implemented the new Advanced Grant scheme in 2021 in collaboration with Philippines-based SEARCA[3] with a Call for Research on Accelerating Transformation through Agricultural Innovation in Southeast Asia. The theme was selected in response to the COVID pandemic. We received 52 Advanced Grant applications for pre-screening, with 32 then sent out for external review and to SAC members. Twenty-seven (27) applications were recommended for continued consideration, with ten grants eventually awarded, as below.

DR BUI THI LAM, VIETNAM

Moving toward a healthier diet: Consumer intention to eat more vegetables and less meat in Vietnam

Since the 90s, the dietary pattern in Vietnam has remarkably shifted towards unhealthy diets high in animal protein but insufficient in fiber. While malnutrition is prevalent among a proportion of the rural population, cities are facing an increased rate of overweightness and obesity. Unbalanced diets that favour meat have been linked to large greenhouse gas emissions, therefore posing a considerable risk to the environment, as compared to plant-based diets. A healthier diet with less meat and more vegetables is the key solution for such a health and environmental crisis. This project will analyse the characteristics of distinct consumer segments across different stages of behaviour changes in meat and vegetable consumption in Vietnam; and investigate the intention to eat more vegetables and less meat, along with the association between the two practices. This project will contribute to the existing literature and provide comprehensive evidence-based recommendations to facilitate a shift toward more plant-based diets in Vietnam.

DR OANH NGUYEN CONG, VIETNAM

Potential for using some indigenous medicinal plants as feed additives relating to animal health, growth performance and meat quality of pigs in Northern Vietnam

Overuse of antibiotics for growth promotion and disease prevention in animals can contribute to the emergence of antibiotic resistance and to increased human health risks. Phytogenics have been studied and used in animal feeds as replacements for antibiotics. Some indigenous medicinal plants in pig diets can improve digestive health and growth performance while others can enhance carcass characteristics, sensory quality and fatty acid compositions of pork. However, little is known about the effect of locally phytogenic additives in pig diets on growth performance, carcass characteristics and meat quality of pork. Thus, this project will survey availability and use of indigenous medicinal plants as feed additives in pig production in Northern Vietnam, and analyze their chemical constituents, bio-active compounds and antioxidant capacities. It is expected that the results of this project will be a good basis for scientists to develop feed production strategies for animals based on local resources of indigenous plants in Vietnam.

MS MILDRED GUIRINDOLA, PHILIPPINES

Food environment and socio-ecological attributes as drivers of food security before and during enhanced and general COVID-19 quarantines in Cavite, Philippines

The Philippines is noted to have a stricter and longer duration of quarantines than in other parts of the world. The imposed quarantine, depending on its level of restrictions, heavily affected the mobility of people that resulted in decreased availability and affordability of food and loss of jobs and livelihoods. Currently, there is a gap in how the quarantine restrictions affect households' food behaviour and food choices and their food security based on the way they obtain and or buy, prepare, store, cook, and consume their food with their inherent socio-ecological factors. There is also a gap on how the changes in food supply and demand in the community brought about by the quarantine affect food retailers and the foods they sell, and how they evolve to keep their food retail market in operation despite the pandemic. There is also a need to know if the safety net programs of the government were able to ameliorate poor people's access to nutritious food based on the timing of quarantine restrictions imposed by the government. This study aims to provide holistic information on how the COVID-19 quarantine restrictions affect the households' consumer behaviour and food security based on the changes in their food environment. This study is critical in developing post-pandemic policy recommendations towards improving the food environment and food security of the most vulnerable sectors of the population living in a peri-urban and varying landscape environment.

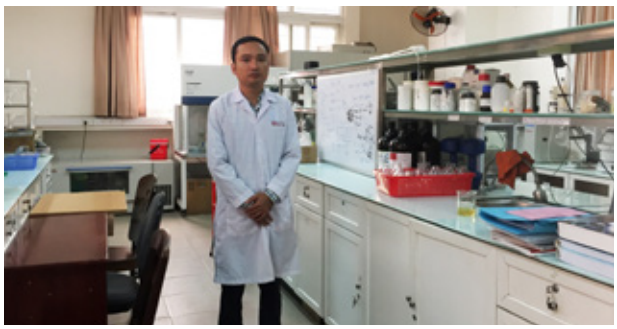
DR TRAN NGUYEN DUY KHOA, VIETNAM

Application of light-emitting diodes (LEDs) in larviculture of mud crab (Scylla paramamosain)

Light, including its rhythms, quality and intensity, is a key environmental factor influencing the growth, culture and survival of aquatic organisms. Throughout development and evolution, organisms gradually adapt to different lighting conditions through changes in their physiology, morphology and behaviour. Based on the various physical and chemical properties of light, artificial conditions should therefore aim to simulate natural lighting characteristics to encourage the growth and development of aquatic organisms and promote a healthy and sustainable aquaculture industry. Mud crab *(Scylla paramamosain)* is a valuable aquatic species to the aquaculture indu-

Dr Bui Thi Lam conducting a face-to-face interview on how to change unhealthy food habits.

Mastering the operation of a UV-Vis spectrophotometer. Left: Dr An Quoc Trieu, at the computer his undergraduate student, Khang Duy Hoang.



Thien Nguyen in the biotechnology lab of Duy Tan University.

stry. However, the current technology for mud crab larviculture is facing mass mortality during larval metamorphosis. Importantly, the light quality is considered as one of the critical factors to improve the rearing technology of mud crab due to light quality effects on behaviour activity or moulting rates, feeding rhythms, food intake, and innate immune responses. This study aims to provide more comprehensive insights into the optimal spectral environment of mud crab larvae. Through evaluation of biometric performance (e.g., growth, metamorphosis, survival), digestive capacity, stress and innate immune response) of mud crab larvae under different LED light spectra, intensities and rhythms, this study can suggest appropriate LED lighting in the mud crab hatchery, which can bring more profit for farmers as well as contribute to the sustainable development of mud crab culture.

MR THANH DIEN LE, VIETNAM

Isolation and characterization of bacteriophages for biocontrol of multidrug-resistant Campylobacter jejuni *in broilers*

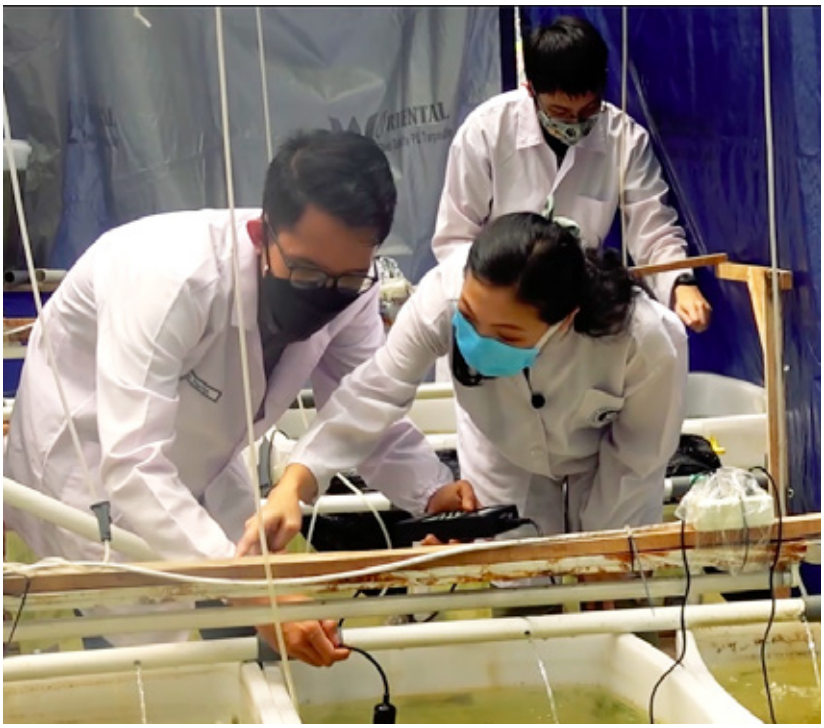
Vietnam was often considered a hotspot for emerging infectious diseases. *Campylobacter jejuni* is responsible for the majority of cases of Campylobacteriosis in humans (one of the most frequently reported foodborne illnesses). A previous study in Hanoi (Vietnam's capital) showed that approximately 30% of raw chicken in school and hospital canteens and at retail markets contain *Campylobacter spp*. Moreover, thermophilic campylobacters from 35.1% of chicken carcasses in large and small abattoirs of Ho Chi Minh City (the biggest city of Vietnam) were isolated and 67.9% of the isolates belonged to the species *C. jejuni*. The contamination with *C. jejuni* during broiler slaughter and processing represents a high risk of Campylobacteriosis transmission. The reduction of *C. jejuni* in broilers can contribute to decreasing human Campylobacteriosis significantly towards food safety. Bacteriophages are one of the potential approaches to reduce *C. jejuni* counts in broilers. Nonetheless, the diversity and evolution of *C. jejuni* in nature are the main reasons to pave the efforts to find novel lytic bacteriophages against multidrug-resistant and phage-resistant *C. jejuni*. This project will isolate, identify, and characterize lytic bacteriophages specific for multidrug-resistant *C. jejuni* in broiler fecal matter and fresh chicken meat in Tien Giang Province, Vietnam. The isolated lytic bacteriophages and their suitable characterizations will be critically potential material for further promising projects to apply bacteriophages in broilers and the poultry industry and to reduce the risk of Campylobacteriosis in humans in Vietnam and other vulnerable countries.

MR HUU TIEN NGUYEN, VIETNAM

Study on damaging potential and diversity of plant-parasitic nematodes associated with vegetables in Vietnam and development of biological control strategies using endophytic bacteria

Nematodes are one of the most numerous metazoans on our planet. They can be animal parasites, plant parasites, insect parasites, or free-living nematodes. Among them, plant-parasitic nematodes (PPNs) are one of the most damaging pests to plants, affecting directly the food security and economy of humans. PPNs are capable of causing damage to all parts of plants such as stems, leaves, flowers, fruits, or roots. Each PPN group causes different levels of damage, and the total damages caused by PPNs are estimated at 157 billion USD per year worldwide. Although studies on plant-parasitic nematodes in Vietnam have been carried out since 1970, they are still quite scattered and limited, only at the level of symptoms recognition, without damage assessments and nematode management. Therefore, this project will investigate and evaluate the damage and

Dr Tran Nguyen Duy Khoa, Vietnam, with daily work in crab hatchery.



Dr Magdalena Lenny Situmorang, Indonesia. Water quality measurement in closed hybrid ZWD-RAS system for shrimp growout.

host range of PPNs associated with vegetables in Vietnam; identify and study the diversity and phylogeny of PPNs associated with vegetables in Vietnam, to provide morphological data and DNA barcodes for future research; evaluate the potential of endophytic bacteria in controlling selected PPN (*Meloidogyne spp.*); and build an online database from the achieved results to facilitate the prevention of PPNs as well as to create a basis for sustainable agricultural development.

DR THIEN NGUYEN, VIETNAM

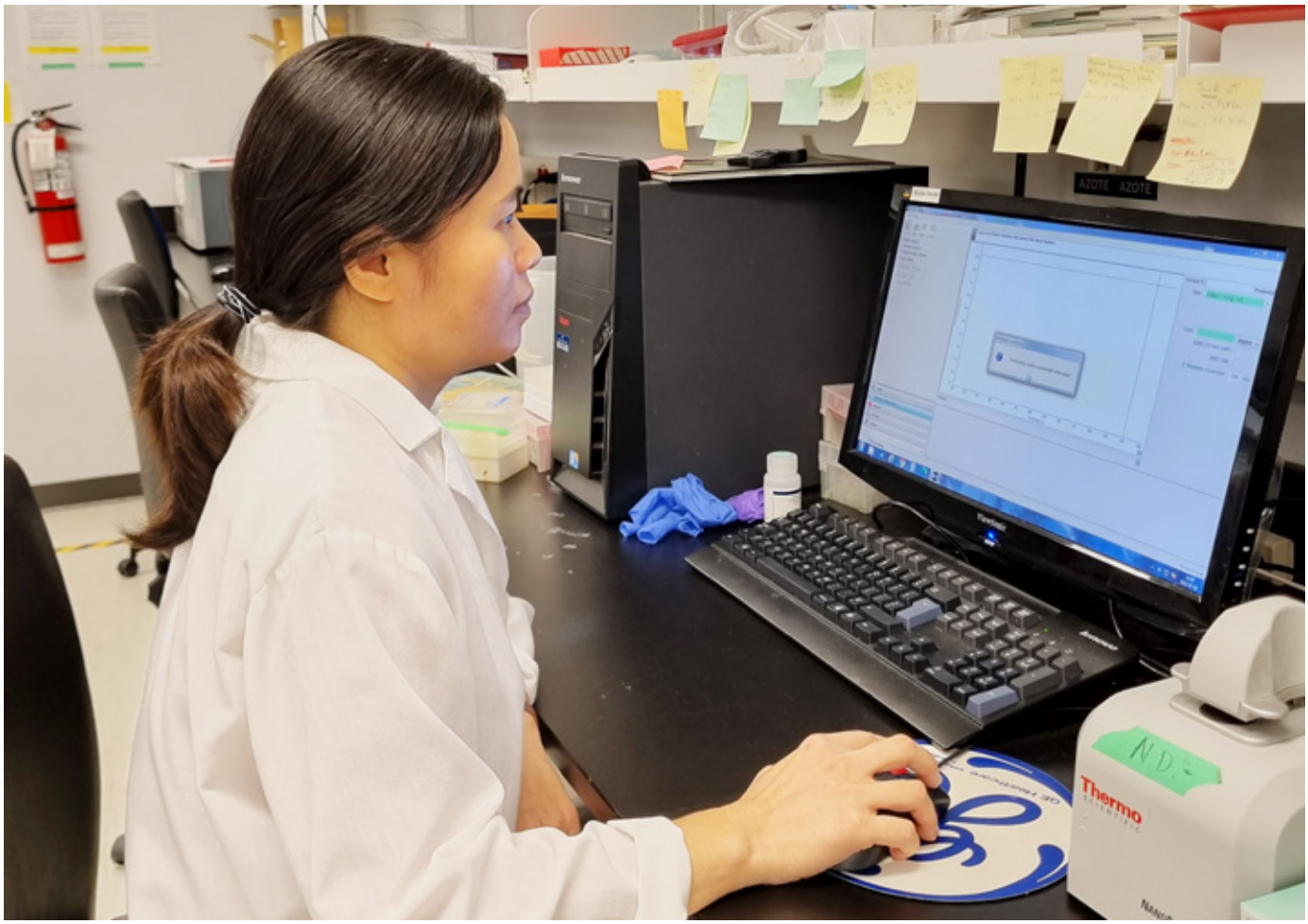
Experimental and computational NMR in detection, structure elucidation, and kinetic analysis of lipid oxidation products in fried foods in Vietnam

Cytotoxic and genotoxic lipid oxidation products (LOPs), such as peroxides, aldehydes, ketones, and alcohols, generated in culinary frying oils during high-temperature frying practices, may pass into fried foods, causing high risks of non-communicable diseases, including cardiovascular diseases and prostate cancer, for regular consumers. Therefore, the method developments for detecting and identifying LOPs in fried foods are of interest to both producers and customers. Nuclear magnetic resonance (NMR) has been an invaluable tool for food compositional analysis, structure elucidation, and formation mechanism due to its ability to provide important structural information without the need for sample purification. In addition, the advancements of computational NMR have tremendously supported the difficult assignments of complex structures. The support of computational NMR would be significantly useful for solving difficult assignments and unstable peroxides. By unravelling the composition, the structures, and formation mechanism of LOPs in fried food, the proposed research will provide solid evidence about the presence of LOPs in fried foods, to raise the awareness of LOPs, and to contribute to the establishment of a fair market.

DR MAGDALENA LENNY SITUMORANG, INDONESIA

Application of closed hybrid Zero Water Discharge–Recirculating Aquaculture System technology along with synbiotic functional feed as alternative to antibiotics for disease biocontrol strategy in whiteleg shrimp (Litopenaeus vannamei) *culture: An approach to reduce antimicrobial resistance towards sustainable shrimp industry through the One Health lens*

The Asian continent is of great significance to international shrimp supply, but as shrimp aquaculture intensifies to meet global demand, so does the disease burden affecting the shrimp culture. The emergence of bacterial diseases, including the ones caused by Vibrio sp., had resulted in heavy losses in global shrimp production. Antibiotics are extensively used as prophylactics against bacterial pathogens, which carries important disadvantages including the residues in shrimp products that can lead to antimicrobial resistance. Therefore, sustainable solutions to replace antibiotics usage and increase system resilience in the shrimp industry are significantly and urgently needed. Best farming practices through improved farming systems and use of better feed are likely to reduce antibiotics resistance. A closed hybrid Zero Water Discharge-Recirculating Aquaculture System (ZWD-RAS) offers the simplicity and the high level of microbial control of the ZWD system, and the high water quality controlling capacity of the RAS system with less operational (electricity) cost. Overall, this project aims to evaluate the application of the closed hybrid ZWD-RAS system along with synbiotic functional feed as alternative to antibiotics for disease biocontrol strategy in whiteleg shrimp farming, with emphasis on reducing antibiotics usage as an approach to reduce antimicrobial resistance towards sustainable shrimp industry in Indonesia that prioritizes not only the animal and the environment



Dr Nguyen Thi Tam Thu, Vietnam, measuring protein concentration on nanodrop.

but also human health, as in the "One Health" notion.

DR NGUYEN THI TAM THU, VIETNAM

Production and characterization of polyhydroxyalkanoate (PHA) by halophilic microorganisms isolated from Truong Sa island in Vietnam

Polyhydroxyalkanoate (PHA) is a bioplastic that can be degraded in a marine environment. It is a group of polymers formed from hydroxyalkanoate monomers that are linked together by ester bonds. PHA can be biosynthesised by bacteria and Achaea, both normal and halophilic bacteria. Many authors studied bacterial groups that can produce PHA such as Burkholderia, Candidatus, Caulobacter, Comamonas, Halomonas, Halococcus, Rhodobacter, Roseobacter, Paracoccus and Sphingomonas. Among them, Halomonas and Halococcus are halophilic bacteria that can produce PHA with high efficiency. These halophilic bacteria are also present in Truong Sa island and are capable of producing pyruvate and PHB. However, there is no study about PHA producing halophilic bacteria and PHA structure in this sea.

DR QUOC AN TRIEU, VIETNAM

Recovery of phosphate from eutrophic water bodies by nano-biocomposite adsorbents: Application as smart fertilizers

Global food production relies mostly on the use of fertilizers and P-containing pesticides for the treatment and protection of crops. Lately, it has been realized within the scientific community that the current practices in the P supply chain are not sustainable in the long term. Common practices of applying P-based fertilizers and their gradual enrichment in water reservoirs lead to eutrophication, which causes the overgrowth of harmful algal blooms and degradation of water quality. Therefore, the aforementioned issues could be resolved simultaneously if a water treatment process that could take into account this double-faceted issue is researched and developed. The aims of this project include fabricating nano-biocomposites adsorbents based on the concept of integrating hydrated nano-oxides into the natural polymeric network including chitosan and agricultural waste such as spent coffee grounds; extensively studying the phosphorus adsorption of the as-synthesized bio-sorbents; and preliminarily assessing the applicability of as-synthesized P-load nano-biocomposites as smart fertilizers. In addition, the philosophy of the circular economy could be satisfied in this project in which reusing, refurbishing, remanufacturing, and recycling processes are promoted. The principles of green chemistry will be addressed in the synthesis of materials such as the use of renewable feedstock, mild conditions, and the reduced use of hazardous chemicals.

Collaborative Grants

Since Collaborative Grants were introduced in the IFS Strategy 2011–2020, IFS has joined with a variety of strategic partners to conceive, develop, implement, manage, monitor, evaluate, audit and report on three multidisciplinary collaborative research pilot projects. These projects have involved 112 individual grants to 57 women and 55 men, 31 team grants, 17 countries, five implementing partners and four funding partners.

Beginning in 2012, the Pilot 1 countries were Ghana, Nigeria, South Africa, Tanzania and Uganda, with financing from the Carnegie Corporation of New York, on the topic of **neglected and underutilized species.** The Pilot 2 countries were Benin, Burkina Faso, Cote d'Ivoire, Ghana, Nigeria, South Africa, Tanzania and Uganda, financed by Carnegie and the Belgian Science Policy Office (BELSPO), on the topic of **biodiversity**. From 2015, IFS and Philippines-based SEARCA (Southeast Asian Regional Center for Graduate Study and Research in Agriculture) piloted collaborative research in a number of Southeast Asian countries where the two organizations are both active. Pilot 3 was financed by the Carolina MacGillavry Fund and SEARCA. It covered Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, Timor-Leste, and Vietnam, on the topic of **climate change adaptation and mitigation**.

In mid-2017, an online survey was conducted with the 73 scientists who received collaborative research grants in Pilots 1 and 2. The study was conducted to follow up with the participants and to learn about their experiences as individual researchers and working in collaboration with others. By the end of 2017, the Pilot 3 teams were about halfway through their projects on climate change adaptation and mitigation. All 43 participating researchers completed a mid-term survey to follow up on their progress and to identify any challenges they were facing. Additionally, they were asked about their experience of the collaboration and to report on their budgets. As reported in the IFS Annual Report 2017, findings from the two surveys of the three collaborative research pilots' participants touched on benefits, challenges, solutions and IFS actions. The 12 mixed-country teams (3-4 members each) from Pilot 3 recently concluded the reporting of their projects. Below are some highlights of how their research results are being used.

Six of the 12 Pilot 3 teams focused on the impact of climate change on farming communities. In one, research results suggested climate change impacts are being experienced by upland farming communities in the Philippines, Timor-Leste and Vietnam, with an urgent need to enhance local adaptive capacity. In another, a model was created where livelihoods can be assessed and vulnerability measured using the circumstances of upland farming communities in the Philippines and Vietnam. In Cambodia, Myanmar and Vietnam, recommendations were provided by the team to increase uptake of climate change adaptation measures at farm level and reduce the negative effects of climate change on farm households.

The direct interactions with community, village leaders and agricultural staff helped another team understand and value indigenous knowledge in climate change adaptation, while the sharing of the research results also informed companies working with indigenous products to understand more about their environmental and social value, in addition to their economic worth. Their results were also used to teach students at Thai Nguyen University of Agriculture and Forestry about climate change. Another team organised a training course to raise awareness on the use of indigenous knowledge in responding to climate change in Vietnam, with 25 young people from the Institute of Strategy and Policy on Natural Resources and the Environment and the NGO network NorthNet. The research results of one team provided evidence for local planning of agriculture strategy and policy in response to climate change at province level, and also found their way to the Institute of Policy and Strategy for Agriculture and Rural Development of the Vietnam Ministry of Agriculture and Rural Development.

Other collaborative research projects were more technically oriented, such as one whose innovative data advanced the understanding of carbon dynamics in secondary tropical forests, and their response to climate change and variability under tropical conditions. Three projects looked at climate change issues in aquaculture, with one proposing mathematical models for tilapia aquaculture at hatchery and grow-out levels, another finding that ex-situ biofloc technology in shrimp culture systems has high potential for climate change adaptation and mitigation, and for enhancing food security with high quality shrimp, and another reporting how the impact of climate change on the pathogenicity of *Vibrio parahaemolyticus* – the cause of acute hepatopancreatic necrosis disease in shrimp – was used to identify practical culture conditions for solving the disease's outbreak at laboratory scale.

Three of the projects involved collaborations with industry and government colleagues, one with small and medium enterprises in Indonesia to prepare granule organic fertilizer as a raw material, using chitosan as a binder composted with manure, organic compost and limestone. A master's degree student also used their results to enhance fertilizer efficiency at the national fertilizer company where they work. In Malaysia, simulation results were used for construction of greenhouses in the field by local collaborators, and there was the unexpected result of the research outcome also being put to use by industry. In another case, research results helped government technicians and farmers in rural areas to manage solid waste using the rice husk biodigester developed by the collaborative research team.

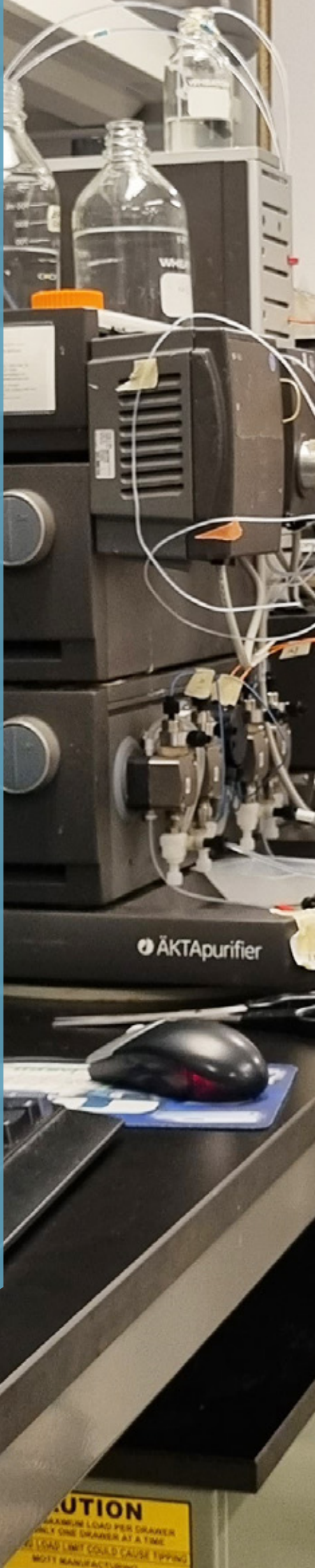
The two pilot projects in Africa and the one in Asia have now concluded and all the grantees have submitted their final individual and team reports to IFS. The grantees from all three pilots have thus far have published 32 articles in peer-reviewed journals from 2016-2021, with others also expected to be published. A policy brief on collaborative research has been produced and disseminated, as has an evolving document on mentorship guidelines.

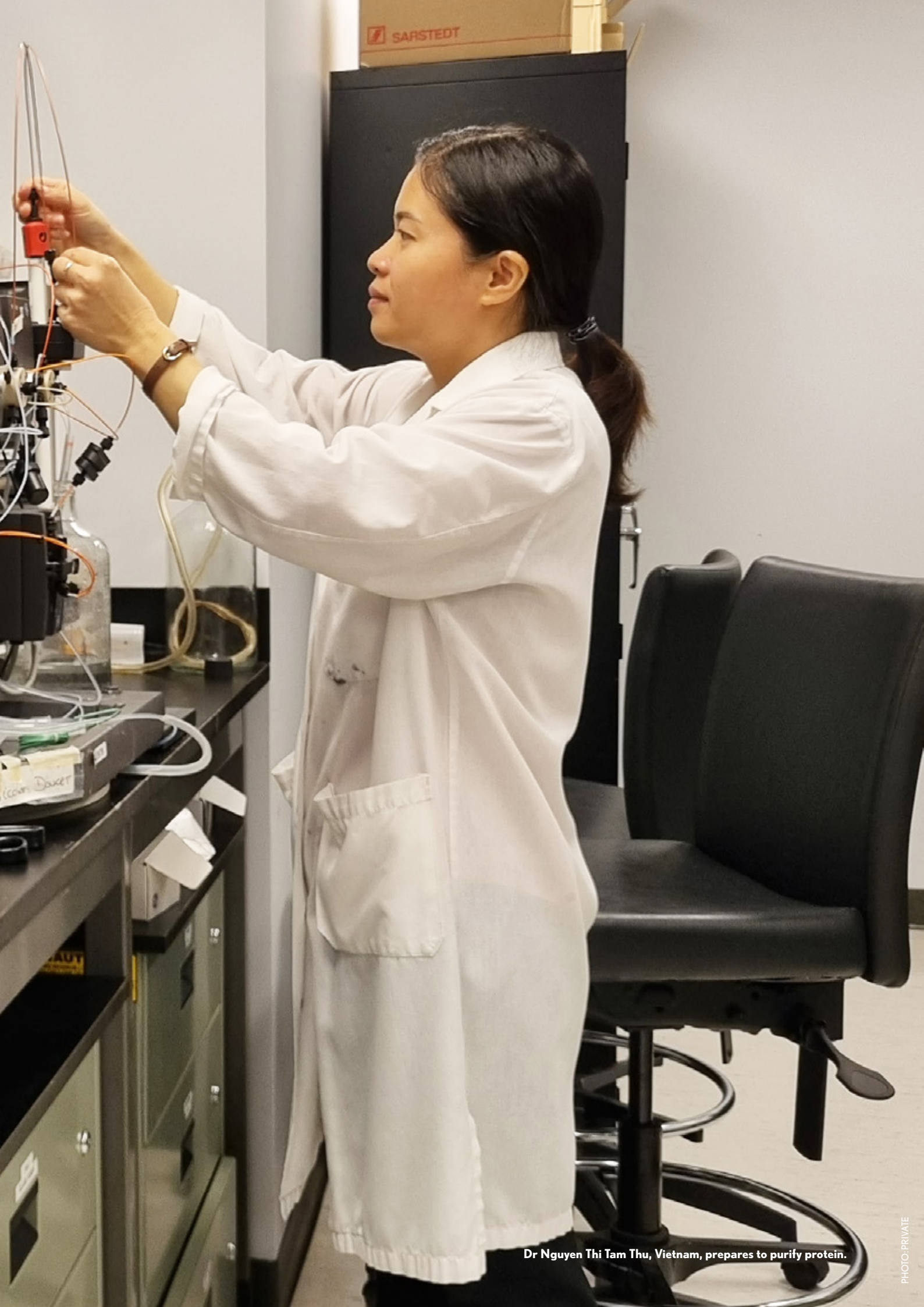
IFS's experience with and learning from the three collaborative research projects has informed the pilot project of IFS's new Advanced Grant scheme in collaboration with SEARCA (from 2020-2023), involving a similar process to the three previous pilots (see previous sub-section). The two organisations are currently funding the research projects (on **food security in the context of the COVID pandemic**) of ten grantees in Indonesia, Philippines and Vietnam.

CAPACITY-ENHANCING SUPPORT

IFS supports promising early career scientists through a flexible but structured process, centred around securing funding to conduct research in the researchers' home countries, complemented by the provision of capacity-enhancing activities, coordinated by the IFS Secretariat, and in collaboration with strategic partners.

The development of national cadres of research scientists in Low- and Lower-Middle-Income Countries (LLMICs) helps identify and address pressing societal problems and build shared values, including an appreciation of science and its role in society. Scientists acquire their skills by conducting research in an enabling environment that includes access to resources and mentorship, both of which are in short supply in LLMICs. As scientists gain experience over time in planning, conducting and publishing their research, they establish a reputation in their field. This helps improve their abilities to identify and prioritise research, collaborate with others, develop and lead successful research groups and influence policy. Scientists who acquire such skills also help empower the institutions in which they work and build science literacy in their home countries.





Dr Nguyen Thi Tam Thu, Vietnam, prepares to purify protein.

PHOTO: PRIVATE

IFS as a Valuable Scientific Partner

In 2021, IFS was jointly engaged in nine virtual events with a variety of strategic partners or alumni associations across a spectrum of topics. Most of these virtual workshops were in response to requests from grantees and partners. The development of IFS's virtual meeting tools that started in 2020 also continued throughout 2021.

The overall objectives of these workshops were to:

- Strengthen early career researchers' scientific skills to develop a scientific proposal, publish in scientific journals, and communicate their results to the public at large (including scientists, politicians and policy-makers, donors and private interest groups)
- Enhance capacity to conduct original research that relates to genuine problems and that generates fundamental and/or applicable scientific knowledge that can be put into use
- Contribute to science literacy
- Influence science priority setting
- Network and collaborate with the global research community to shape research agendas, both local and global, and
- Position participants in international research, to carry out regional projects or to develop their own networks.

The workshops conducted in 2021 included (descriptions below):

- Online Course on Statistical Computing with R
- Online Training Course and Competition for International Livestock Research Institute (ILRI) Cap Dev Grand Challenge
- ILRI and the International Veterinary Vaccinology Network (IVVN) Online Workshop on Integrating Gender into Livestock Research
- ILRI Online Workshop on Science Communication for Non-technical Audiences
- IFS Online Workshop on Designing Online Training Events and Preparing a Research Budget
- ILRI Online Workshop on Blogging for Impact
- International Science Programme Online Workshop on Gender, Diversities and Unconscious Bias: How to master the playground rules in Academia
- Food Systems for New Realities - Agri4D 2021
- African Women in Agricultural Research and Development (AWARD) Webinar on Scientific Publishing/Proposal Development and Funding

Online Course on Statistical Computing with R (February-March 2021)

Organised by IFS SAC Member Prof Eugenio Parente (Università degli Studi della Basilicata), 44 IFS grantees registered and enrolled in this course, including 17 women. Given that one of the weaknesses in almost all applications that IFS receives is statistical design and analysis, and while it is true that there is plenty of material on R available on the web, there is no systematic course for food science, agriculture and applied biology. The purpose of this course was to fill this gap. More than 60% of participants attended the online lectures and/or watched the online recorded lectures, which is relatively high compared to the average rate for attendants expected at free online events such as webinars (40–50%). Almost all the participants benefitted from receiving the course material, with 3/4 of them using more than 80 percent of materials for their wider studies and research. Participants reported an increase in their proficiency in all aspects covered in the course, especially in the fundamentals of working in R, including data visualisation, data wrangling, and programming, as well as in using statistical tests such as ANOVA, DOE, and Linear Regressions. Those who attended either all of the online lectures or viewed all of the recorded lectures reported higher levels of proficiency scores across the board.

Online Training Course and Competition for International Livestock Research Institute (ILRI) Cap Dev Grand Challenge (March 2021)

IFS nominated 11 participants (including six women) to participate in the Capacity Development Grand Challenge (ILRI CapDev Grand Challenge) where a total of 46 participants attended. The Challenge is a 10-month process designed to equip young researchers with the requisite people and leadership skills as they transition from graduate training mode into actors in national research and extension systems. The CapDev Grand Challenge process aims to equip these next-generation livestock sector professionals with the leadership and interpersonal skills they need to be effective leaders, science communicators and influencers after their academic/technical training. The 11 IFS grantees participated in the three-minute research pitching contest where they presented their research projects and findings to a panel of judges comprising at least one donor, communications expert, journalist, development policy expert, M&E expert and researcher, all of whom are well-informed of ILRI's mission and scope of research. The judges selected 22 participants with the most successful pitches, including four IFS grantees, two of whom were women.

ILRI and the International Veterinary Vaccinology Network (IVVN) Online Workshop on Integrating Gender into Livestock Research (May 2021)
The goal of this training course was for researchers of all disciplines to become more comfortable with the basic vocabulary of gender research and to encourage participants to continue thinking about how to integrate gender into their research. The course focused on "why do gender research" and discussed the differences between biological gender and social gender as well as how gender norms affect our lives. A session on "how to do gender research" introduced best practice methods and case studies. Nine IFS grantees participated in this course.

ILRI Online Workshop on Science Communication for Non-technical Audiences (July 2021)
Fifteen IFS grantees from 2021 and women grantees of 2020 were invited to participate. The goal of the training was to equip participants with communication skills that will enable them to effectively communicate scientific processes and findings to non-scientific audiences and the public at large. Participants were familiarized with principles of effective science communication, skills in message development in response to anticipated stakeholder questions and/or concerns about their research projects, effective media relations skills, including social media, and strategies and tools for engaging policy-makers to secure supportive policy environments for their research.

IFS Online Workshop on Designing Online Training Events and Preparing a Research Budget (August 2021)
Thirty-four early career scientists and six workshop facilitators from 17 countries in Africa, Asia and Europe met virtually on Microsoft Teams. Workshop participants were post-doctoral researchers who were IFS and IRD grantees. The workshop coordination team included IFS staff, as well as Dr Beth Ndunda and Dr Ruth Odhiambo from the University of Nairobi, Kenya, and Dr Valère Kolawolé. The workshop was delivered by IFS within the framework of the Partnership Agreement between IFS and the French National Research Institute for Sustainable Development (IRD) for Capacity Building Activities in 2021. Participants included nine IFS grantees and 3 IRD grantees who were women. The workshop employed an inclusive design, using a pre-workshop survey to identify and minimise any barriers to women, and keeping the timing of the workshop within working hours to minimise barriers to those who cannot attend out-of-hours, for example, due to caring responsibilities.

ILRI Online Workshop on Blogging for Impact (September 2021)
This opportunity was shared widely on the IFS Community with IFS grantees and with the IFS women grantees of 2020. The course covered reasons to blog, tips and tricks for blogging, writing press releases and where/how to place them, and alternative blogging channels, and taking advantage of social media to promote, disseminate and create conversations.

International Science Programme Online Workshop on Gender, Diversities and Unconscious Bias: How to master the playground rules in academia (September 2021)
IFS staff and grantees joined this workshop as part of the ISP's 60th anniversary celebration. The workshop focused on unconscious bias and gender issues in STEM disciplines in different parts of the world and in different cultural environments. The aim was to increase awareness about aspects and methods for improving gender balance and to get new tools to find their own ways for reaching gender equality.

Food Systems for New Realities – Agri4D 2021 (September 2021)
Agri4D brought together researchers, policy-makers and practitioners to engage actively with the challenges of food systems with a focus on low-income contexts in a globalised world. The conference aimed to take stock of the current knowledge frontier, connect science to policymaking and practice, and spark new collaborations. IFS were part of a digital exhibition at the Agri4D conference, including information on the IFS mission and scientific program, important links, pictures/videos of grantees, and an invitation for interested parties to contact IFS for potential partnerships. Conference participants were able to visit and interact with the digital exhibition booth throughout the conference, which included 30-minute live video sessions where participants could drop in and interact with IFS staff. A three-minute pitch on IFS was delivered.

African Women in Agricultural Research and Development (AWARD) Webinar on Scientific Publishing/Proposal Development and Funding (October 2021)
Fifteen IFS grantees (among them 11 women) from the 2021 cohort attended the training course. IFS presented its program and talked about "Finding the right funders: Are you deliberate and selective about which grant opportunity you pursue and which you forgo?". In addition, IFS staff participated as resources persons on successful publishing of research.

Gender Equality in Capacity Enhancement

IFS has continued to offer additional support to women in the IFS program, through capacity-enhancing workshops or webinars, and supporting their career development towards senior or leadership positions. Among the workshops and webinars listed above, several were on the communication of science, which in turn increases the visibility of women in science.

The Partnership Agreement between IFS and IRD for Capacity Building Activities in 2021 included opportunities for IFS grantees to join IRD workshops. One female IFS grantee based in Paraguay was selected to attend a workshop in Mexico City in November. The workshop covered writing articles for scientific journals and image processing.

IFS held a workshop in November 2021 for new women grantees. The annual event provides an opportunity for women grantees to learn about the IFS gender strategy and network

with other women. During the workshop, grantees also identified initiatives that they could themselves carry out within the IFS Women in Science Community such as online language cafés and support groups. Grantees were invited to join the IFS Women in Science Community and sign up to the IFS Women in Science Public Contact List, which was created to increase the visibility of women in science, facilitate opportunities, and encourage peer-to-peer mentoring in the cohorts from 2020 and 2021. The IFS Women in Science Public Contact List currently has 20 grantees and was adapted from the mentoring network which was launched with the 2020 cohort in March 2021.

Mentorship

Cutting across all of IFS's capacity-enhancing support is a learning approach which includes mentoring. In 2021, IFS staff and external specialists mentored the grantees carrying out ongoing research projects. We also supported our alumni to associate and support other potential grantees through training and coaching. As they conduct their research, grantees inform IFS about the support they need, which may include:

- Technical concerns related to the specific project topic or research problem
- Research design
- Research methods and techniques
- Data collection and analysis
- Research findings and conclusions
- Research project administration and/or budget management
- Research report, journal article and/or policy brief writing and language
- Communicating research results
- Intellectual ownership / property rights
- Team and/or administration relations
- Conversations with funders, and
- Other or future funding opportunities.

Mentorship through the IFS Advanced Grant

IFS and Philippines-based SEARCA (Southeast Asian Regional Center for Graduate Study and Research in Agriculture), conducted a virtual Mentoring Workshop for Advanced Grants from 15-21 June 2021. The workshop aimed to improve the quality and effectiveness of research on agriculture and food systems by enhancing the capacity of early career scientists. Workshop participants were 24 selected researchers from Indonesia, the Philippines, and Vietnam. They submitted applications for the grants, passed the pre-screening, and were recommended for further consideration for funding.

In general, the first two days of the workshop presentations and sessions focused on helping the participants to refine their proposals by relating current issues in agriculture, food systems, and climate change to their respective research proposals and becoming more aware of research concepts, approaches, designs, methods, and data analysis. The expectations and skills associated with advanced research were also discussed to prepare them for future engagement in the global mission to fight food insecurity, reduce poverty, and support sustainable development.

The workshop presentations were capped off with interactive discussions wherein the participants were divided into groups. The discussions included their reflections from the presentations of the resource persons and how these affected the revisions they intended to make to their proposals. The subsequent sessions of the Mentoring Workshop focused on presentations of the participants, featuring the lessons they learned and how they planned to reflect these in their proposal revisions.

The support of IFS through donors, strategic partners and individuals

We are deeply thankful for the support of the long-time donors and strategic partners who have continued their relationships with IFS as we embark on our new IFS Strategy 2021–2030, *Investing in Future Scientists*. They are:

- Sida, the Swedish International Development Cooperation Agency
- SNSF, the Swiss National Science Foundation
- OPCW, the Organisation for the Prohibition of Chemical Weapons, and
- COMSTECH, the Ministerial Standing Committee on Scientific and Technological Cooperation of the OIC (Organization of Islamic Cooperation).

We would also like to highlight and thank the Carnegie Corporation and the Belgian Science Policy Office (Belspo), as donors, the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), as a strategic partner, and Carolina MacGillavry, as an individual. Through their support, IFS has been able to successfully pilot three collaborative research projects in Africa and Asia, involving 112 individual grants to 57 women and 55 men, 31 team grants, 17 countries, five implementing partners and the above four funding partners. In addition, the pilot projects resulted in:

- Three research themes of neglected and underutilized species, biodiversity, and climate change adaptation and mitigation being addressed
- A facilitated social networking platform and a web-based application review system being built
- The three pilot iterations each attracting around 500 eligible scientists who expressed interest in joining, and
- Collaborative research capacity-enhancing activities and peer-to-peer learning being designed and implemented.

Donors, strategic partners and individuals like Carnegie, Belspo, SEARCA and Carolina MacGillavry are the reasons we can continuously support early career researchers and we truly cannot thank them enough.

Carolina MacGillavry

Impact of IFS on my life – Dr Florencia Montagnini

Planting seeds for a successful and meaningful career in science and education

I first heard about IFS in the late 1980s when I was working as Academic Coordinator for the Organization for Tropical Studies (OTS) in Costa Rica. I was designing and conducting courses in tropical ecology and agroecology, and wanted to do research at OTS's La Selva Biological Station on native trees that could be used for plantations and agroforestry and could help recover nutrients and other soil properties in degraded pastures. My first IFS grant and its renewal was for a project entitled "Impacts of native trees on soil nutrients in the Atlantic lowlands of Costa Rica, Central America". The total funding of $22,000 spurred my career, for which I am thankful.

Not only was I awarded the grants, but at the time IFS also encouraged me to publish my research in *Ambio*, the prestigious scientific journal published by the Royal Swedish Academy of Science (Montagnini, F and Sancho, F 1990 Impacts of native trees on tropical soils: A study in the Atlantic lowlands of Costa Rica. *Ambio* 19(8): 386 390.) I later published other articles in *Ambio* in 1996 and 2011, and both times these articles also served to further my career.

While I was one of its grantees, IFS invited me to a 1990 workshop that it organized for grantees in the Philippines, on multipurpose tree research in Asia. There I presented my research advances, and IFS also took us all on a visit of the International Rice Research Institute headquarters in Los Baños (irri.org), and to see several agroforestry projects conducted by the International Institute for Rural Reconstruction (iirr.org). Today I still use pictures and information from that visit to the Philippines in my agroforestry courses.

The experience I gained as a researcher with my IFS grants led to my first position in 1989 as a Professor in Tropical Ecology with Yale University School of Forestry and Environmental Studies. I was enjoying my life and career in Costa Rica, but my motivation to join Yale was driven by the need to take greater action to contribute to halting the degradation of nature and fostering the restoration of natural landscapes and their biodiversity. I was especially concerned about the devastation of the Amazon forest and thought that my efforts in research and education in Latin America would be greatly enhanced by joining a prestigious academic institution such as Yale, a world leader in forestry and environmental science.

Once I joined Yale, I was able to get other funding from the AW Mellon Foundation and the National Science Foundation in the USA to expand the work in Costa Rica to include more native tree species, and could also expand the whole project to contribute to science and education in Argentina and Brazil. I am proud to say that the initial grant from IFS and the results of that research resulted in this larger funding that lasted until 2010, helping to fund the work of many masters and doctoral students, and other research that has continued until the present with other independent funding. In my current position as Senior Research Scientist, I teach and advise individual project courses in agroforestry, landscape restoration, and soil conservation and management. I am also engaged in activities organized by Yale's Environmental Leadership and Training Initiative (elti.org), designing courses and teaching subjects such as Tropical Forest Restoration in Human-Dominated Landscapes and Sustainable Agricultural Landscapes, in English and Spanish.


Dr Florencia Montagnini.

Through these activities I have been interacting as a leader and professor with a large audience from around the world from academic, government and non-government institutions. I hold honorary professorships at universities in Latin America and participate in scientific and technical meetings in English and Spanish. I also have ample experience communicating my research in local and international media (such as in CNN in Español), radio, newspapers and magazines. Therefore, although based at Yale, I continue to contribute to science and education in Latin America.

I have written eleven books on agroforestry systems, ecological restoration, and biodiversity conservation, and over 250 scientific articles, of which 80% have been published in international refereed journals, in English and Spanish. I have published extensively on natural resource management, climate change, and conservation science, in both refereed scientific journals and in scientific books. I have also written articles intended for the general public.

I feel that it is great that the International Foundation for Science continues to support scientists from developing countries to improve and develop successful careers, such as my case when I first started as an IFS grantee.

IFS Alumni Network

Recognising the importance of its alumni network, IFS provides support for individual alumni, associations of alumni which have been founded in several countries in Africa, and informal initiatives launched by alumni in Asia, and Latin America and the Caribbean. Our past grantees represent a source of mentoring, networking and collaboration in their respective countries, offering a range of services that benefit members, aspiring researchers, grant applicants and IFS. Examples include support for new applicants, advice to prospective grantees through seminars and talks, publicising IFS grant calls, collaborating with other alumni associations, and informing IFS of relevant local and national activities. IFS always tries to find ways to mobilise our existing resources to activate, support and strengthen our alumni.

Kenya

A project co-funded by IFS and the Global Biodiversity Information Facility (GBIF) is being led by IFS alumnus Dr David Chiawo of Strathmore University. Entitled "Capacity Development for Mobilization and Use of Biodiversity Information Development (BID) Data on Endangered Bird Species in Kenya", the project runs from April 2021 to March 2023, with IFS funding of €5,116 and funding from GBIF at €39,960. The project focus areas are:

1. Capacity development of young researchers in science writing to advance biodiversity information sharing on endangered birds in Kenya, largely lacking information for conservation planning
2. Training on writing policy briefs from research findings to bridge the science-policy interface to promote uptake of biodiversity research into conservation policy
3. Training on promoting data sharing among early career researchers and conservation managers
4. Enhancing use of biodiversity data accessible on free access database of GBIF
5. Publishing peer review articles, and
6. Contributing towards biodiversity data sharing on endangered bird species in Kenya.

The project is expected to have an impact on the capacity development of early career researchers and conservation managers and in the engagement of IFS alumni for research co-supervision and co-publishing for career advancement. Manuscripts under preparation for peer review publishing with acknowledgement of IFS and GBIF include:

- Nesting site selection and breeding success of Ruppell's vulture *(Gyps Rueppellii)* in Hell's Gate National Park, Kenya
- Species distribution modelling and threat analysis of grey-crowned crane *(Balearica Regulorus)* in the niche hotspots of Nairobi Metropolitan Area
- Niche distribution and predictive modelling of the effect of overhead powerlines on raptors in Maasai Mara Game Reserve, Kenya
- Modelling the spatial-temporal niche distribution of the grey-crowned cranes in Kenya
- Global Raptor Impact Network (GRIN) data on raptor observations in Kenya for the period 2013-2021 (gbif.org); 11,669 occurrence data records published

The Kenya project has also produced a video by our grantee, the chair of the Kenya alumni association, where he is acknowledging IFS, at: https://drive.google.com/file/d/1Rmq_r8PR2VXlgBiXvRT9MceZB2Ex7vNa/view?ts=615f5c2b

Other IFS Kenya Alumni Association activities include:

- IFS alumni collaborating with RUFORUM alumni and ACTS for science debate on decolonizing research methods in Africa, for a virtual conference that explored collective imaginations in decolonization of research in Africa; dominant narratives associated with research in Africa to be decolonized; and development of indicators for practice and policy in research decolonization
- Dr Enos W Wambu, Head, Department of Chemistry & Biochemistry, School of Science, University of Eldoret: Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI), focused on development of superior rice varieties using Korean elite germplasm and Kenyan plus other African lines through double haploid system
- Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI) focused on agricultural extension, with a thrust to produce certified rice seeds for farmers' access and thus accelerate adoption of elite breed lines for improved on-farm productivity and help reduce imports, and
- IFS alumni are collaborating across Africa to transform youth employability and sustainability in tourism through innovation and entrepreneurship. This is being led by Dr. David Chiawo in a British Council project in partnership with partners from South Africa, West Africa and the UK.

Nigeria
The IFS Nigeria Alumni Association (IFS-NAA) reported these individual and group activities in 2021:

- Organized tree planting activities in secondary schools in Kwara State, Nigeria
- Beneficial scientific research grant and fellowship information sharing and publication using WhatsApp
- 2nd Nigerian Academy of Science (NAS) Conference on Applied and Translational Research in National Development (January 2021)
- Virtual Workshop of Ibadan Branch of Organization for Women in Science in the Developing World (OWSD) on New Perspective in the Covid-19 Era (January 2021)
- Virtual Workshop of Mountain Top University and Lagos Branch of Organization for Women in Science in the Developing World (OWSD) on Challenges & Opportunities in Winning Grants for Women in Science (May 2021)
- Symposium of the Research & Development Unit of Bells University of Technology on Driving Excellence in Academic Research: Exploring Credible Outlets (June 2021)
- Physical & Virtual Workshop of Ibadan Branch of Organization for Women in Science in the Developing World (OWSD) on Time Management & Research Ethics in the Post-Covid-19 Era (August 2021)
- At the Annual General Meeting in November 2021 these IFS grantees will be highlighted in the annual report: Dr Afolayan Adedotun Onoyinka promoted to Assistant Director, National Center for Genetic Resources and Biotechnology and became President of Nigerian Chapter of Society for Conservation Biology; Dr Folaranmi Babalola collaborated with colleagues and published a book entitled Building a Successful Forestry Career in Africa.

IFS BOARD OF TRUSTEES

Dr Patrick Van Damme (Chair), Professor, Faculty of BioScience Engineering, University of Ghent, Belgium

Dr Thammarat Koottatep (Vice-Chair), Associate Professor , School of Environment, Resources and Development, Asian Institute of Technology, Pathumthani, Thailand

Dr Malcolm Beveridge, Fisheries and Aquaculture Department, FAO, Rome, Italy

Dr Assogbadjo Achille Ephrem, Professor , Faculty of Agronomic Sciences , University of Abomey-Calavi, Cotonou, Benin

Dr Nighisty Ghezae (ex-officio), IFS Director

Dr Kjell Havnevik, Professor , Department of Global Development and Planning, University of Agder, Kristiansand, Norway

Dr Anders Malmer, International coordinator /Adjunct Professor (SLU Tropical Forestry), Swedish Forest Agency, Jönköping, Sweden

Dr Mónica Moraes R. , Professor, Institute of Ecology – Unidad de Botánica (Herbario National de Bolivia – LPB), Carrera de Biología, Universidad Mayor of San Andrés, La Paz, Bolivia

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Dr Bishnu Raj Upreti, Executive Director, Nepal Center for Contemporary Research , Kathmandu, Nepal

IFS STAFF

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Dr Nighisty Ghezae, Director

Dr Ingrid Leemans, Scientific Programme Coordinator, Animal Production, Aquatic Resources and Water Resources

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Ms Sirilak Pongpatipat, Accounting Administrator

Dr Jennifer Sjölund, Scientific Programme Coordinator Crop Science and Forestry/Agroforestry

Ms Jill Wallin, Office Manager, Purchasing Manager and Adminstrator

STATEMENT OF INCOME AND EXPENSE (in thousands SEK)

	1 January–31 December 2021	1 January–31 December 2020
Programme Revenue		
Core and Restricted Contributions	23 073	25 772
Grants Withdrawn	881	1168
Other Programme Revenue	21	10
Total Programme Revenue	**23 974**	**26 951**
Programme Expense		
Programme Services	19 466	23 529
Fundraising and Partnership Building	1499	1506
Management and General	1907	1805
Total Programme Expense	**22 872**	**26 840**
Programme Income less Expense	**1 103**	**111**
Result from financial assets		
Income from other investments held as fixed assets	1151	884
Interest Income	28	19
Exchange gain / loss	-28	-344
Asset Income less Expense	**1 152**	**559**
Net Income less Expense	**2 254**	**670**

BALANCE SHEET (in thousands SEK)

	31 December 2021	31 December 2020
Assets		
Fixed Assets		
Tangible Assets		
Equipment, Furniture and Fixtures	77	81
Financial Assets		
Other long-term investments	17 959	16 808
Long-term Donor Receivables	92	84
Total Fixed Assets	18 128	16 973
Current Assets		
Current Receivables		
Donor Receivables	1 081	1 870
Other Current Receivables	848	797
Prepaid Expense and Accrued Income	733	701
Total Current Receivables	2 662	3 368
Cash and Bank Balances	31 473	11 229
Total Current Assets	34 135	14 597
Total Assets	**52 263**	**31 569**
Equity and Liabilities		
Designated funds		
Board Designated Fund for Contingencies	13 347	11 711
Carolina MacGillavry Fund	19 914	16 410
Total Designated Funds	33 261	28 122
Balanced capital		
Balance, 1 January	-9 390	-4 921
Net Income less Expense for the Year	2 254	670
Total Balanced Capital	-7 136	-4 251
Total Equity	26 125	23 871
Current Liabilities		
Research Grants Payable	3 803	5 412
Deferred Restricted Contributions	634	573
Accounts Payable	0	0
Other Current Liabilities	584	633
Accrued Expense and Prepaid Income	21 117	1 081
Total Current Liabilities	26 138	7 699
Total Net Assets and Liabilities	**52 263**	**31 569**

AFFILIATED ORGANISATIONS

NATIONAL ORGANISATIONS

ARGENTINA
Academia Nacional de Ciencias Exactas, Físicas y Naturales (ANCEFN)
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

AUSTRALIA
Australian Academy of Science (AAS)

AUSTRIA
Fonds zur Förderung der Wissenschaftlichen Forschung (FWF)
Österreichische Akademie der Wissenschaften (ÖAW)

BANGLADESH
Bangladesh Council of Scientific and Industrial Research (BCSIR)

BELGIUM
Académie Royale des Sciences d'Outre Mer (ARSOM)
Académie Royale des Sciences des Lettres et des Beaux Arts de Belgique
Koninklijke Academie voor Wetenschappen, Letteren en Schone Kunsten van België (KVAB)

BOLIVIA
Academia Nacional de Ciencias de Bolivia (ANCB)

BRAZIL
Academia Brasileira de Ciencias (ABC)
Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPQ)
Fundaçao Oswaldo Cruz (FIOCRUZ)

BURKINA FASO
Ministère des Enseignements Secondaire, Supérieur et de la Recherche Scientifique (MESSER)

CAMEROON
Ministry of Scientific and Technical Research

CENTRAL AFRICAN REPUBLIC
l'Enseignement Supérieur et de la Recherche Scientifique

CHAD
Direction de la Recherche Scientifique et Technique, MESRS

CHILE
Academia Chilena de Ciencias
Comisión Nacional de Investigación Científica y Tecnológica (CONICYT)

CHINA
Chinese Academy of Sciences (CAS)

COLOMBIA
Academia Colombiana de Ciencias Exactas, Físicas y Naturales (ACCEFYN)
Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria (CIPAV)
Instituto Colombiano para el Desarrollo de la Ciencia y Tecnología (COLCIENCIAS)

CONGO (BRAZZAVILLE)
Direction Générale de la Recherche Scientifique et Technique, MENRST

COSTA RICA
Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT)

CÔTE D'IVOIRE
Académie des Sciences, des Arts, des Cultures d´Afrique et des Diaporas Africaines

CUBA
Academia de Ciencias de Cuba (ACC)
Ministry for Foreign Investment and Economic Cooperation

DENMARK
Akademiet for de Tekniske Videnskaber (ATV)
Det Kongelige Danske Videnskabernes Selskab (RDVS)

ECUADOR
Fundación para la Ciencia y la Tecnología (FUNDACYT)

EGYPT
Academy of Scientific Research and Technology (ASRT)

EL SALVADOR
Consejo Nacional de Ciencia y Tecnología (CONACYT)

ETHIOPIA
Ethiopian Science and Technology Commission (ESTC)

FINLAND
Delegation of the Finnish Academies of Science and Letters

FRANCE
Académie des Sciences
Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)
Institut National de la Recherche Agronomique (INRA)
Institut de Recherche pour le Développement (IRD)

GERMANY
Deutsche Forschungsgemeinschaft (DFG)

GHANA
Council for Scientific and Industrial Research (CSIR)

GUINEA
Direction Nationale de la Recherche Scientifique et Technique

GUINEA BISSAU
Instituto Nacional de Estudos e Pesquisa (INEP)

GUYANA
Institute of Applied Science and Technology

HONDURAS
Consejo Hondureño de Ciencia y Tecnología (COHCIT)

INDIA
Indian National Science Academy (INSA)

INDONESIA
Lembaga Ilmu Pengetahuan Indonesia (LIPI)

ISRAEL
The Israel Academy of Sciences and Humanities

JAMAICA
Scientific Research Council (SRC)

JORDAN
Royal Scientific Society (RSS)

KENYA
Kenya Agricultural Research Institute (KARI)
Kenya National Academy of Sciences (KNAS)

KOREA DPR (NORTH)
Academy of Sciences of DPR Korea

KOREA R (SOUTH)
National Academy of Sciences (NAS)

KUWAIT
Kuwait Institute for Scientific Research (KISR)

LATVIA
Latvian Academy of Sciences (LAS)

LESOTHO
The National University of Lesotho (NUL)

LIBERIA
University of Liberia (UL)

MADAGASCAR
Académie National Malgache

MALAWI
National Research Council of Malawi (NRCM)

MALAYSIA
Malaysian Scientific Association (MSA)
Ministry of Science, Technology and Innovation

MALI
Centre National de la Recherche Scientifique et Technologique (CNRST)
Comité National de la Recherche Agricole (CNRA)

MEXICO
Consejo Nacional de Ciencia y Tecnología (CONACYT)

MONGOLIA
Mongolian Academy of Sciences

MOROCCO
Centre National de Coordination et de Planification de la Recherche Scientifique et Technique (CNR)
Institut Agronomique et Vétérinaire Hassan II

MOZAMBIQUE
Universidade Eduardo Mondlane (UEM)
The Scientific Research Association of Mozambique (AICIMO)

NEPAL
Royal Nepal Academy of Science and Technology (RONAST)

NETHERLANDS
Koninklijke Nederlandse Akademie van Wetenschappen (KNAW)

NIGER
Université Abdou Moumouni

NIGERIA
Federal Ministry of Science and Technology (FMST)
The Nigerian Academy of Science (NAS)

NORWAY
Det Norske Videnskaps Akademi (DNVA)

PAKISTAN
Pakistan Council for Science and Technology (PCST)

PANAMA
Secretaria Nacional de Ciencia y Tecnologia e Innovación (SENACYT)
Universidad de Panamá

PAPUA NEW GUINEA
The University of Papua New Guinea

PERU
Consejo Nacional de Ciencia y Tecnología (CONCYTEC)

PHILIPPINES
National Research Council of the Philippines (NRCP)

POLAND
Polish Academy of Sciences (PAS)

SAUDI ARABIA
King Abdulaziz City for Science and Technology (KACST)

SENEGAL
Délégation aux Affaires Scientifiques et Techniques, MRST

SEYCHELLES
Seychelles Bureau of Standards (SBS)

SIERRA LEONE
Institute of Agricultural Research (IAR)

SOUTH AFRICA
National Research Foundation (NRF)

SRI LANKA
National Science Foundation (NSF)

SUDAN
National Centre for Research (NCR)

SWEDEN
Ingenjörsvetenskapsakademien (IVA)
Kungliga Skogs och Lantbruksakademien (KSLA)
Kungliga Vetenskapsakademien (KVA)

SWITZERLAND
Council of the Swiss Scientific Academies (CASS)
Swiss National Science Foundation (SNSF)

TANZANIA
Tanzania Commission for Science and Technology (COSTECH)

THAILAND
National Research Council of Thailand (NRC)
Thailand Research Fund (TRF)

TUNISIA
Direction Générale de la Recherche Scientifique et Technique, MES

UGANDA
National Agricultural Research Organisation (NARO)
Uganda National Council for Science and Technology (UNCST)

UNITED KINGDOM
The Royal Society
Natural Resources Institute (NRI)

URUGUAY
Programa de Desarrollo de las Ciencias Basicas (PEDECIBA)

USA
American Academy of Arts and Sciences (AAAS)
National Academy of Sciences (NAS)
New York Academy of Sciences (NYAS)

VENEZUELA
The Ministry of Popular Power for Science and Technology

VIET NAM
Ministry of Science and Technology (MOST)

ZAMBIA
National Institute for Scientific and Industrial Research (NISIR)

ZIMBABWE
Scientific and Industrial Research and Development Centre (SIRDC)
University of Zimbabwe

REGIONAL ORGANISATIONS

AFRICA
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
Association of African Universities (AAU)
Centre Regional pour l'Eau Potable et l'Assainissement à faible coût (CREPA)
Institut du Sahel (INSAH)
The African Academy of Sciences (AAS)
West and Central African Council for Agricultural Research and Development (WECARD/CORAF)
Western Indian Ocean Marine Science Association (WIOMSA)

LATIN AMERICA AND THE CARIBBEAN
Centro Agronónomico Tropical de Investigación y Enseñanza (CATIE)
The Caribbean Academy of Sciences (CAS)
Caribbean Agricultural Research and Development Institute (CARDI)

INTERNATIONAL ORGANISATIONS

BioNET (The Global Network for Taxonomy)
International Organisation for Chemical Sciences in Development (IOCD)
International Union of Forest Research Organisations (IUFRO)
The Academy of Sciences for the Developing World (TWAS)
Consultative Group on International Agricultural Research (CGIAR): CGIAR Secretariat
Bioversity International
Centro Internacional de Agricultura Tropical (CIAT)
Centre for International Forestry Research (CIFOR)
International Centre for Agricultural Research in the Dry Areas (ICARDA)
International Centre for Research in Agroforestry (ICRAF)
International Water Management Institute (IWMI)
World Fish Center

* 1 applicant selected for grant award has not fulfilled the conditions yet and 1 did not fulfil the conditions.

BASIC GRANTS AWARDED IN 2021

BANGLADESH

ISLAM M M Majedul
Monitoring and quantifying health risks of antibiotic resistant bacteria in urban surface water

PARVIN Fahmida
Appraisal of microplastic abundance in different trophic zones of urban lake and translocation to freshwater fishes in Bangladesh

BENIN

AFLOUKOU Fabrice Marina
Citrus tristeza disease in southern Benin Republic

ALABI Adégbéïga Cham Donald
Morphobiometric, phaneroptic, molecular characterization and zootechnical performance of populations of local turkeys (*Meleagris gallopavo*) populations reared in Benin

AZALOU Maximilien
Perceptions of farmers and genetic parameters of endangered Pabli cattle breed: Implication for communitybased conservation of the species in Benin

BIAO Eliézer
Assessing the impacts of climate change on water resources and sustainable adaptation strategies in two climate regions in Benin (West Africa)

DJIMENOU David
Phenotypic and molecular diversity of African local pigs in central and northern Benin

AZONGNIDE Gbèdotchitché Gwladys
Morphological characterization and early growth improvement of *Vitellaria paradoxa C. F. Gaertn* in Benin

HOUNGBEDJI Marcel
Developing stabilized multifunctional backslop starter using cost-effective drying technic for sustainable fermentation of selected cereal-based foods in West Africa

MENSAH Sylvanus
Assessing the effects of abiotic and biotic factors on the early recruitment of the threatened Afzelia africana Sm. ex Pers. (*Fabaceae-Ceasalpinoideae*) in Benin (West Africa)

TCHOKPONHOUÉ Dèdéou Apocalypse
Elite genotypes selection and development of vegetative propagation techniques for enhanced production and fruit quality attributes in the miracle plant *Synsepalum dulcificum (Schumach & Thonn.) Daniell*

TOGBEVI HONFIN Quentin Fiacre
Hydro-climatic modelling of a tropical West African catchment under land use and climate changes (Tiélé, Benin)

BHUTAN

TSHERING Sangay
Diversity and distribution of bat communities along an elevational gradient in the districts of Haa and Gasa, Western Bhutan

BURKINA FASO

DIMOBE Kangbéni
Multiple abiotic and biotic drivers of seedling survival and growth of the endangered Pterocarpus erinaceus Poir. *(Fabaceae-Faboideae)* in Burkina Faso: Implications for sustainable management

HEMA Mewoéami Delphine
Evaluation of the essential oils' efficacy in the control of poultry ticks in Burkina Faso

CAMEROON

ANOUMEDEM MOUAFO Elodie Gisele
Search for antibacterial secondary metabolites from endophytic fungi associated with the Cameroonian medicinal plant *Garcinia lucida*

HIPPOLYTE Mouafo Tene
Assessment of the presence of biofilms in recovered plastic bottles used as traditional food packaging in Cameroon and the sanitary risks associated

YAYA GBAWENG Abel Joël
Phytochemical investigation of *Phragmanthera capitata S. Balle (Loranthaceae)* and *Commiphora kerstingii Engl (Burseraceae)* for their anti-proliferative constituents

CONGO, THE DEMOCRATIC REPUBLIC OF THE

KISEKELWA Tchalondawa
Assemblage and trophic ecology of *Labeobarbus spp. (Teleostei: Cyprinidae)* from the Luhoho basin in relation to environmental variables

MANGAZA Lisette
Monitoring and scaling up carbon stocks in the tropical forest landscape of the Tshopo province, Democratic Republic of the Congo

COTE D'IVOIRE

ASSO Asso Armel
Poaching, trade and role of critically endangered vulture species in traditional medicine in Côte d'Ivoire (West Africa)

ETHIOPIA

ASTATKIE Higemengist
Development of fluoride filter: An electro-sorption approach

DIBABA Abyot
Ethnobotanical study of medicinal plants used by local people around Gerba Dima forest: Implication for sustainable natural resource management and traditional health care system

GEBREYESUS Kirubel Mekonnen
Integrating satellite rainfall estimates and daily rain gauge observations to improve flood simulations in poorly gauged Upper Awash Basin, Ethiopia

METEKIA TAMIRU Tasew
Evaluation of neem leaf meal to combat heat stress and improve performance of layer and broiler chicken

WASEYEHON ASSEN ABATE
Exploring the potential of locally grown amaranth crop seed as poultry feed in southwest part of Ethiopia

WOLDEKIROS Tamirat Hailegebriel
Distribution, genetic diversity and population structure of intermediate hosts of schistosomiasis (*Biomphalaria spp.*) of Lake Tana and its tributary rivers, Ethiopia

GHANA

ABDALLAH Abdul-Hanan
Understanding the implication of domestic land grabbing on livelihoods: Evidence from mixed method study of farm households in northern Ghana

AKONOR Paa Toah
Performance of yellow cassava in food application: Development of instant flakes, carotenoid stability during processing and storage, and product shelf stability estimation

KONGOR John Edem
Process development and product characteristics of beetroot dark chocolate using the melanger in an alternative chocolate production technique

KORESE Joseph Kudadam
Unravelling the links between processing conditions and product quality for improved food and nutrition security in northern Ghana – the case of shea (*Vitellaria paradoxa*) fruit pulp

OFORI Jennifer Afua
Identification and characterization of carbapenem-resistant enterobacteriaceae and associated resistance genes in poultry in Ghana

OFOSU-BAMFO Bismark
Liana community structure in relation to climatic and edaphic factors across five forest ecosystem types in Ghana

KENYA

KARISA Juliet
Spatial pattern in the resilience of coral reefs from climatic disturbances in Kenya

KIMANI James
Anti-rheumatoid arthritis potential and mechanism of action of methanol extract of *Boscia angustifolia* and *Rhamnus Prinoides* in wistar rats

KIMANI Mark
Search for antiprotozoal agents from *Flueggea virosa* and *Teclea nobilis*

MIBEI Elias
Identification and modulation of heavy metal transport-related genes in cowpea (*Vigna unguiculata L. Walp.*)

MULI Joshua
Evaluation of phosphorous scavenging genes in cultivated and wild crotalaria species

NGENO Emily
Investigating the concentration levels of selected endocrine disrupting chemicals in wastewater and their removal through phytoremediation using *Eicchornia crassipes* in constructed wetlands

ORINDA Mary
Analysis of growth performance and nutritional profiles of common house (*Acheta domesticus*) and field (*Gryllus bimaculatus*) crickets fed on plant-based feed rations

ORONDO Pauline
Determination of biotic and abiotic factors in the larval habitats affecting mosquito larval development and vector competency

MADAGASCAR

ANDRIARIMALALA Herilalao Jose
Estimation of the diet quality and intake by grazing ruminants in the highlands of Madagascar

MOZAMBIQUE

MBANZE Aires
Dambos wetlands over-exploitation and its implications for biodiversity conservation and local people livelihoods in Niassa Province, Northern Mozambique

NEPAL

BASNET Buddha
Bioprospecting, extraction, screening, isolation and characterization of novel antibiotics from endolichenic fungi isolated from lichen of Butwal-Basantapur trekking trail area of Nepal

NIGERIA

AGBAJE Michael
Investigating the causes of variations in strains of *Dermatophilus congolensis* and their possible association with infectivity of specific animal host

AKINBULUMA Mobolade
Semiochemical-based strategy in the sustainable management of the invasive pest *Spodopterafrugiperda (Lepidoptera: Noctuidae)* in Nigeria

AKOLADE Jubril
Development of antimalarial formulation from citrus essential oils

COKER Oluwakayode
Genetic diversities and structures of two edible frog species (*Hoplobatrachus occipitalis* and *Xenopus muelleri*) in southwestern Nigeria

ECHEZONA Adaeze
Co-loaded liposomal artemether and doxycycline for effective management of resistant *P. falciparum* malaria

KENECHUKWU Franklin
Harnessing keratin from poultry feathers as potential cheap nano-formulation raw material for transdermal delivery of antimalarial combotherapeutics: A proof-of-concept investigation

MAJIYA Hussaini
Photodynamic inactivation of fresh produce spoilage/pathogenic microorganisms: Harnessing the abundant sunlight to irradiate photosensitisers for prolonging the shelf-life and prevention of foodborne diseases in Nigeria

OHEMU Temitayo
Bioactivity guided isolation of bioactive principles with male fertility activity from the whole plant of *Loudetia phragmitoides (Poaceae)*

OLAGUNJU Titilope
Development of a smart low loss solar dryer for drying local varieties of ginger and black pepper cultivated in Osun State, Nigeria

OKE Philip
Epidemiology, species identification and pathogen detection in culicoides from Nigeria

PAKISTAN

FATIMA Humaira
Isolation of antileishmanial compounds from *Datura innoxia*

HAMEED Amir
Investigations of the toxic glycoalkaloids in commercially grown potatoes across Pakistan and their dietary exposure among the urban adults (20–24 years old)

QADEER Saima
Assessment of ram sperm DNA integrity in relation to cryopreservation and in vivo fertility rate

SHABBIR Muhammad Abu Bakr
Molecular characterization and potential transmission of colistin resistant genes in *Escherichia coli* from commercial poultry to humans

ZAFEER Noureen
Feed-grade nano-additives to control and prevent dissemination of zoonotic diseases from poultry

TOGO

PALANGA Koffi Kibalou
Genetic diversity and agro-morphological characteristics of cultivated pigeon pea (*Cajanus cajan L.*) in Togo

TUNISIA

KHOULOUD Krichen
Impact of human activity on degradation of North African *Stipa tenacissima L.* ecosystems: Case of Tunisia

UGANDA

AKULLO Jolly
Preserving the quality of insects consumed in Uganda using plant extracts

RUTARO Karlmax
Value chain hygiene practices and microbial contamination of street and market vended ready-to-eat edible grasshopper *Ruspolia differens* in Uganda

WANGI Godfrey
Development of zeolite-based nanocomposite water filters for removal of heavy metals and *Escherichia coli* from drinking water

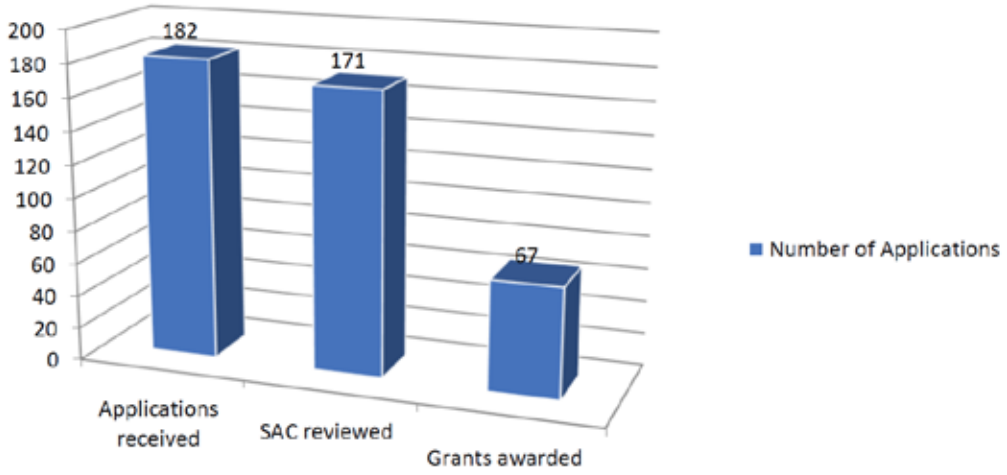
VIETNAM

BUI Vinh
Farmers' perception of land degradation in marginal lands of Van Yen district, Yen Bai province of Vietnam's northern mountain region

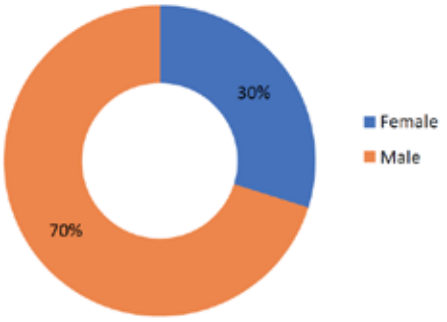
HA Mai
Improving food security for ethnic minority households: Evidence from Son La province, Vietnam

TONG THI Anh Ngoc
Food nutrition and safety evaluation of cooked and ready to eat food products from online platform in Vietnam

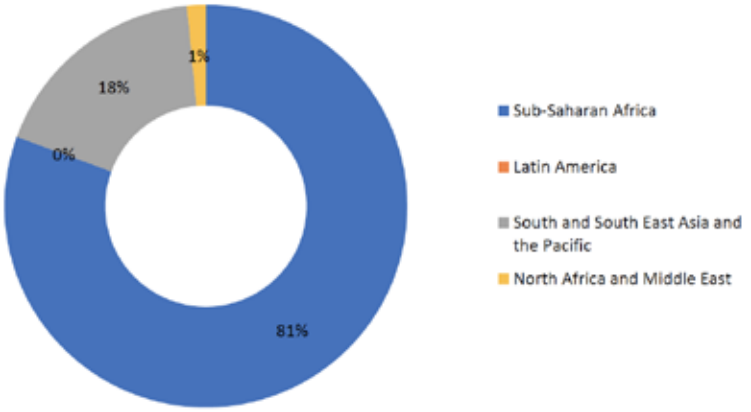
Basic Grant Applications Processed by IFS 2021



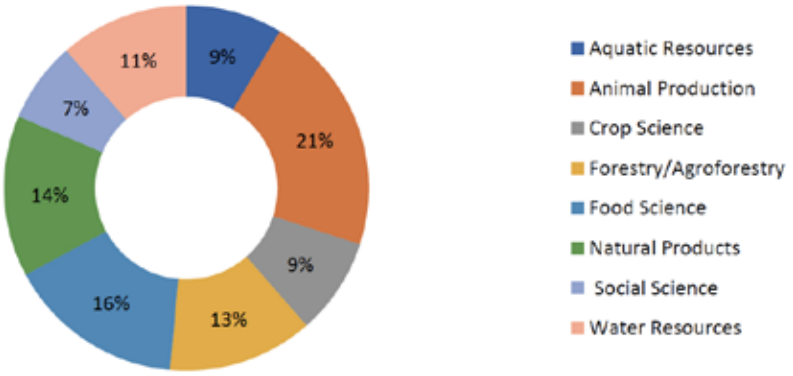
Basic Grants Awarded by Gender 2021



Basic Grants Awarded by Region 2021



Basic Grants Awarded by IFS Research Areas 2021



ADVANCED GRANTS AWARDED IN 2021

INDONESIA

SITUMORANG Magdalena Lenny
Application of closed hybrid zero water discharge–recirculating aquaculture system technology along with synbiotic functional feed as alternative to antibiotics for disease biocontrol strategy in whiteleg shrimp *Litopenaeus vannamei* culture

PHILIPPINES

GUIRINDOLA Mildred
Food environment and socio-ecological attributes as drivers of food security before and during enhanced and general COVID-19 quarantines in Cavite, Philippines

VIETNAM

BUI Thi Lam
Moving toward a healthier diet: Consumer intention to eat more vegetables and less meat in Vietnam

DUY KHOA Tran Nguyen
Application of light-emitting diodes (LEDs) in larviculture of mud crab *(Scylla paramamosain)*

LE Thanh Dien
Isolation and characterization of bacteriophages for biocontrol of multidrug-resistant *Campylobacter jejuni* in broilers

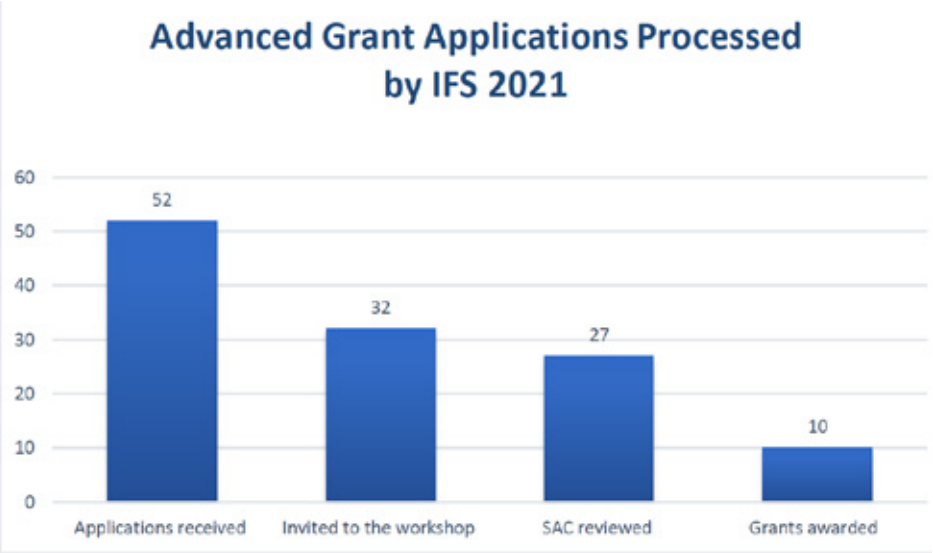
NGUYEN Huu Tien
Study on damaging potential and diversity of plant-parasitic nematodes associated with vegetables in Vietnam and develop biological control strategies using endophytic bacteria

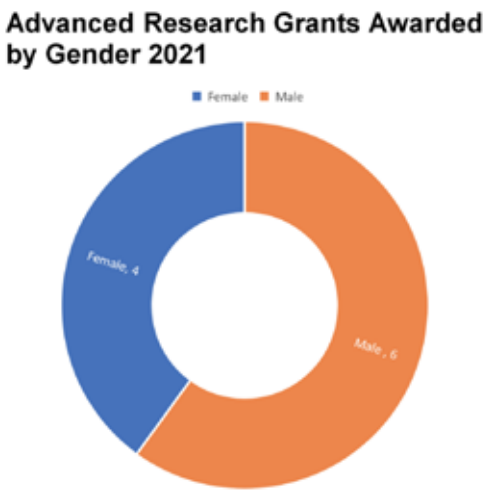
NGUYEN Thien
Experimental and computational NMR in detection, structure elucidation, and kinetic analysis of lipid oxidation products in fried foods in Vietnam

NGUYEN Cong Oanh
Potential for using some indigenous medicinal plants as feed additives relating to animal health, growth performance and meat quality of pigs in Northern Vietnam

THU Nguyen Thi Tam
Production and characterization of polyhydroxyalkanoate (PHA) by halophilic microorganisms isolated from Truong Sa island in Vietnam

TRIEU Quoc An
Recovery of phosphate from eutrophic water bodies by nano-biocomposite adsorbents: application as smart fertilizers





SUPPORTING YOUNG RESEARCHERS

The International Foundation for Science (IFS) supports early career scientists in Low- and Lower-Middle-Income Countries through grants and capacity-enhancing activities. IFS was established as a non-governmental organisation in 1972, is funded by the academic, development and private sectors and has provided more than 8000 grants to researchers in 105 countries for a half-century.

IFS INTERNATIONAL FOUNDATION FOR SCIENCE

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