GOVERNMENT OF UGANDA

MAKERERE UNIVERSITY

Makerere University Research and Innovations Fund; Contribution to the Sustainable Development Goals

November 2022

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1.0. INTRODUCTION

We are halfway to the deadline set by the 2030 Agenda of ensuring that we have the world better than we found it. Although we have made significant progress in a number of areas that improve health and wellbeing, we can't underestimate the impact of the COVID-19

pandemic and quite a number of regional shocks (both Natural and man-made) that have caused some setbacks. The war in Ukraine has halted food supplies to many countries around the world, the high cost of fuel has had living standards rise up to unprecedented levels.

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. The 17 SDGs are integrated and recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability. All over the world, countries have committed to prioritize progress for those who are furthest behind. The SDGs are designed to end poverty, hunger, HIV/AIDS, and discrimination against women and girls. Creativity, know-how, technology and financial resources from all of society are necessary to achieve the SDGs in every context. These goals are compressed into the 5Ps of People, Planet, Peace, Prosperity and Partnerships. The creativity, knowhow, technology and financial resources from all of society is necessary to achieve the SDGs in every context. We highlight the progress made from research and innovations in Makerere University Kampala which is receiving funding from the Government of Uganda to contribute to National Development Priorities which are aligned and derived from the Sustainable Development Goals

1.1. Government of Uganda's commitments to advance Research for development

Research universities in low- and middle-income countries have crucial roles to play in developing differentiated and effective academic systems, and in making it possible for their countries to join the global knowledge society and compete in sophisticated knowledge economies. Makerere University is on the path to becoming a research-led university. Makerere University created a Research and Innovations Fund (Mak-RIF) in 2019 to support

high-impact Research and Innovations that inform National development priorities with funding from the Government of Uganda. The fund illustrates the increasing importance that the Government attaches to Research and Innovation as catalysts to Uganda's march towards Middle Income Status and attainment of the National Development Plan, the Vision 2040 and Sustainable Development Goals of 2030. The objective of this fund is to increase the local generation of translatable research and scalable innovations that address key gaps required to drive Uganda's development agenda, especially the un-funded priorities. We highlight the contribution of Makerere University towards achievement of the 17 Sustainable Development Goals through the various projects funded by the Government of Uganda.

2.0. MAK-RIF Funded Projects and The Sustainable Development Goals

2.1 Sustainable Development Goal 1; Zero Poverty

This goal targets to reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions by 2030. Progress has also been limited in sub-Saharan Africa and Asia, which account for 80 percent of those living in extreme poverty. Most of the projects included in this report indirectly contribute to this Sustainable Development Goal.

It is worthy to note that all the projects highlighted in this report contribute to the attainment of the sustainable development goal through economic empowerment, equal opportunity, skills development among others.

Skills Matching, Wages and Productivity gains: Creating a Competitive Advantage for Ugandan Youth in the Labour Market; Dr Joweria Teera

The increased investment in education has led to a constant increase in the average level of education of the Ugandan labour force. However, despite the increase of resources devoted to education, Uganda has still failed to get full return on investment in education. This can partly be attributed to the inadequate technical skills possessed by the students from the

education and training systems that do not match those demanded in Uganda's labour market which is commonly referred to as skills-mismatch.

Objective: To explain the relevance of skills matching in bridging wages differentials and enhancing productivity, with particular attention paid to the youthful labour force in Uganda.

Contribution to SDG: Employers have continuously raised the challenge of the increasing skills mismatches. This hampers productivity growth and economic growth at both firm level and the economy at large. Dr Joweria Teera from the College of Business and Management Sciences provided evidence that Policies to alleviate skills mismatch are critical for bridging wage differentials and productivity differences while ensuring increased and gainful employability of youth.

2.2. Sustainable Development Goal 2; Zero hunger

Extreme hunger and malnutrition remain a huge barrier to development in many countries. The SDGs aim to end all forms of hunger and malnutrition by 2030, making sure all people–especially children–have sufficient and nutritious food all year.

Enhancing Value addition on Potato-Sorghum enterprises for Improved Livelihoods in Uganda; Johnny Mugisha

Target addressed; 2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers.

Prof Johnny Mugisha from the College of Agriculture and Environmental Studies pioneered a project focused on enhancing physical, economic and nutrition value of potato (*Solanum tuberlosum*) and sorghum (Sorghum bicolor) in Uganda with interest in South-western region. Potatoes and sorghum are the region's main enterprises. However, they compete for

farm resources, and in terms of household food, they are neither substitutes or complements.

Objective; The overall objective of the project was to improve the economic value of potato and sorghum enterprises for improved livelihoods of the value chain actors. Specifically, the project developed, tested and validated innovative potato-sorghum based value-added products with potential for commercialization; and finally determined the economic viability and market potential of the validated products in a competitive food market.

Outputs; The project was able to develop a range of high-quality potato-sorghum based products including cookies, biscuits and waffles. By providing another alternative to the potato (especially the tiny tubers) and sorghum, farmers in the potato growing regions were motivated to pursue growing potatoes. In addition, farmers were investing as entrepreneurs in value addition and commercialisation of the developed products in order to enhance their incomes and diversify their activities.

Developing dry season feeding technologies for different cattle production systems: Team lead: Dr Justine Nambi

Scarcity, high cost and fluctuating quality of feeds are major constraints to sustainable cattle production in Uganda, particularly during the dry seasons. Use of crop residues plays an important role in reducing feed stress. However, most crop residues are bulky and low in nutrient content hence unable to support maintenance and production requirements of cattle. A team from the College of Agriculture and Environmental Sciences has therefore developed crop residue-based multi-nutrient blocks (MNB) and pellets to improve feed value of crop residues using sustainable, cost-effective, and acceptable techniques. Two types of MNB & pellets based on dried and milled maize stover (MS) (MNB-MS) & Banana peelings (BP) (MNB-BP) are formulated to supplement cows on natural pastures. The blocks contain milled Rhodes grass hay, urea, molasses, salt, *Gliricidia* leaf meal, maize bran, and cassava

flour porridge (as the binder). An on-station trial was used to test the MS & BP based blocks against a Control diet (grazing pastures alone) for milk yield & composition. Supplementation with the 2 multi-nutrient blocks resulted in increased ($P < 0.05$) average milk yield (by 7.4 and 8.4% from 6.67 l/cow/day (control) to 7.19 (MNB-MS) and 7.23 l/cow/day (MNB-BP), and improved milk protein content. The banana peels-based multi-nutrient block showed superior chemical composition quality attributes (i.e. high crude protein and low fibre content) compared to the maize stover-based block. Maize stover and BP-based MNB & pellets are a promising option for supporting dry season smallholder dairy production in Uganda.

Contribution to SDG; This contributes to Enhancing agricultural production and enhancing food security in the population. This leads to good health, less hunger and improved income for people.

<u>On-farm comparative evaluation of hermetic and conventional storage technologies on post-harvest quality of stored common beans: Francis Okori</u>

Objective: To evaluate the technical performance, profitability, and constraints to the adoption of four hermetic storage technologies against the conventional woven polypropylene (PP) bags for the storage of common beans on grain quality.

Output: Bean cultivar: A local bean cultivar commonly grown in Northern Uganda and susceptible to bruchids was used. Naturally infested beans without any synthetic or local pesticides were bought from a local grain trader in Awindiri market, Adjumani town.

Treatments: Four hermetic storage technologies (HSTs) were investigated for the storage of dry common beans for six months. These were: 1) Purdue Improved Crop Storage (PICSTM) bag (100kg); 2) SuperGrain bag (100kg); 3) Metal silo (100kg); and 4) Plastic silo (100kg).

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These were compared against the conventional woven polypropylene bag as a control. Each of these five treatments was used for bean storage under two circumstances: 1) Naturally infested, and 2) Artificially infested beans

Contribution to SDG: There is/will be reduced post-harvest storage losses in the study area hence improved food security and household income. Besides, the project has provided a trajectory towards Vision 2040 and SDGs of zero Hunger and No Poverty for the Community of Adjumani district and West Nile in general.

2.3 Sustainable Development Goal 3; Good Health and wellbeing

This goal was developed to ensure healthy lives and promote wellbeing for all at all ages. Mak-RIF has funded research and innovations to test possible solutions to eradicate a wide range of diseases and address many different persistent and emerging health issues as detailed below;

The Early Preeclampsia Detection (EPED) Strip: Prof. Paul Kiondo

The EPED Strip is a rapid diagnostic test strip for testing pre-eclampsia among women. For women in the rural and low resource areas, who have no regular access to prenatal care, the low-cost, point-of-care diagnostic test for preeclampsia provides a home-based method for women to self-diagnose preeclampsia. This diagnostic test reduces the Maternal Mortality due to Pre-eclampsia through early detection thus driving the country towards achieving sustainable development goal 3 sections 1 and 2 that focus on maternal and neonatal health.

Designed a Smart Postpartum Haemorrhage (PPH) Volumetric Drape: Dr Ononge Samuel

Postpartum haemorrhage is one of the leading causes of maternal mortality in Uganda. There has been no specific technique to measure PPH. This research team designed a smart postpartum haemorrhage Volumetric Drape which is used for measuring the amount of

blood lost by a mother during delivery and postpartum. This will guide the health workers on the effective management of PPH hence reducing maternal mortalities attributed to PPH.

Development of an Artificial Intelligence (AI) Model for Rapid and Robust Screening of Tuberculosis (TB) from Chest X-ray Images.

This innovation will facilitate the quick and fast diagnosis of tuberculosis and thus resulting in early case management and prevention which in turn will lower the morbidity and mortality rates as well as the financial burden of TB on the health system. Furthermore, it will make diagnosis for TB in resource constrained areas much easier and feasible since with AI, diagnosis can be conducted without the human resources for health.

Fabricated Solar Autoclave by Engineer Gerald Kiseka

The solar autoclave is a machine used to disinfect reusable medical tools and medical waste before disposal. Rural health centres use charcoal or firewood to boil water that is used in an attempt to sterilise reusable medical equipment which is not effective as the quality of boiled water and sterilisation process do not meet the World Health Organization (WHO) recommended temperature requirement of at least 121 degrees Celsius. This study developed a prototype and was deemed effective upon testing in our local context. This solar autoclave will ensure effective sterilisation processes hence elimination of health facility transmitted infections. This innovation is very timely and can be scaled to rural areas of the country where electricity is still a huge challenge yet there is a need to improve health outcomes.

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Advancing Tissue and Organ bio-banking in Uganda; Prof. Joloba Moses

Target addressed: 3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.

Prof. Moses Joloba from the College of Health Sciences built capacity for organ and tissue biobanking. The team has pioneered bio banking in Uganda by establishing the first well-annotated, quality assured biorepository for nucleic acids, blood, and its derivatives with over 100,000 samples in storage over the last 10 years. Basing on this success, the multidisciplinary team expanded the scope to tissue and organ bio banking, starting with sperm, ovum, and umbilical cord blood.

Effect of COVID-19 pandemic on access to community Health care services for common childhood diseases among children under five years in Wakiso District, Uganda; Dr Piloya Theresa

Access and utilisation of health services for children including immunisation and management of common childhood illnesses were affected by movement restrictions during the COVID-19 pandemic in 2020. This study hypothesised that there was more utilisation of the community health services by children under the age of 5. However, study findings show that the total number of children seen by Village Health Teams (VHTs) during the 2020 COVID-19 lockdown period reduced by 8% and those visiting for acute respiratory infections or pneumonia (ARI) reduced by 46%. Children who had cough or flu were often rushed to the VHT or hospital to rule out COVID-19. VHTs reported a limited role in the management of children during the COVID-19 lockdown because of stock out of drugs and other supplies due to challenges related to travel restrictions. They also had fear of contracting COVID-19 infection, lacked training on COVID-19 recognition and management, personal protection equipment and limited workforce. These study findings have been shared with the Ministry

of Health task force on Continuity of Essential Health Services committee, the Integrated community childhood management (ICCM) Technical Working Group meeting and Uganda Paediatrics Association.

Contributions to SGD3; the study shows that Village health teams who are part of Community Health workers contribute significantly to improved health in the community

Testing a Community-based Ultrasound Scan system during early and late antenatal care to facilitate gestation age dating, referral and preterm care in low resource districts in Eastern Uganda by Prof. Peter Waiswa

This project contributes to target 3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births by testing the effectiveness of use of ultrasound during early and late antenatal care or labour to facilitate gestation age dating, referral and preterm care in Luuka, a rural Ugandan district.

Outputs: A pre-post evaluation study was designed to extend ultra sound scan services through routine outreach programs and community health workers volunteer systems to reach low resource areas. Clinical assessment and decision-making was done after obstetric scan and focusing on detection of high-risk obstetric conditions such multiple gestation, mal-presentation, oligohydramnios, placenta previa, gestational age<37 weeks, and foetal heart rate abnormalities. Study participants received the first scan between 24 and 28 weeks and a follow-up scan was planned after 37 weeks. Mothers with these complications were referred for appropriate management and followed up until delivery. Additionally, we trained 55 Village health teams members to identify, register and refer pregnant women for scanning, Refurbished un-utilized rooms into Ultrasound scan rooms with equipment, furniture and accessories, Operationalized ultrasound scan services at the Health Centres of Kiyunga and Bukoova.

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Contributions to SGD3: The project demonstrated that it is possible to run Ultrasound scan services at lower level health centres and early detection of pregnancy complications is possible in low-resource health facilities.

Scale-up of the electronic partograph (e-partograph) to improve skilled delivery and emergency referral among refugees and host communities in the West Nile region of Uganda by Dr. Justine Bukenya.

According to the Uganda Demographic and Health Survey 2016, the current levels of maternal and neonatal mortality stand at a staggering rate of 368 deaths per 100,000 live births while neonatal mortality rate is 27 deaths per 1000 live births. Accountability and commitment to lowering maternal and neonatal mortality should be emphasised. Therefore the World Health Organisation promotes interventions at labour and childbirth as this bears the highest dividend since it has got a triple effect: reduces maternal mortality, reduces neonatal mortality and prevents stillbirths. Therefore, this project has successfully trained 13 trained health workers in 2 health facilities in Adjumani district on how to monitor labour using electronic and paper based partographs. This has ensured timely checkups on expectant mothers thereby improving the quality of intrapartum care and improving maternal and newborn survival.

Leveraging on technology to reduce cardiovascular-metabolic risk among patients with diabetes mellitus in a resource limited setting, Mulago Hospital: A randomised controlled trial: Edrisa Ibrahim Mutebi

Goal 3 Target addressed: 3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being by evaluating the caloric values of selected locally available foods, assessing

their glycaemic indices for selected locally available foods and determining the cardiovascular-metabolic benefits of a closely monitored pre-set exercise plan and dietary regimen. Outputs: The study came up with the caloric content of different carbohydrate-based foods. These were ranked in the following order of caloric content: Chapati, bread, cassava, sweet potatoes, rice posho, millet, Irish potatoes, matooke. Matooke and Irish potatoes will give the lowest glycaemic response while chapati and cassava will give the highest response among the foods. The higher the caloric content, the greater the glucose rise after ingestion of the food.

Caloric reduction of 35% with 10,000 steps per day or exercises for 150 minutes per week by patients living with Diabetes Mellitus led to a significant change in the mean (SD) BMI 2.33 (1.39) and mean (SD) HBA1C 2.48 (1.41). These, in the long run, lead to control of the DM and reduction in the complications.

<u>A Mobile Health Individualised Dietary Plan and Behavioural lifestyle tracker for Diabetics in Uganda; Alice Mugisha Nandawula</u>

Objective; To develop a mobile health (mHealth) individualised dietary plan and behavioural lifestyle tracker for addressing nutrition challenges and improving behavioural lifestyles for diabetics in Uganda

Outputs; The application development framework which incorporates the three principles; Behavioral Change Theories, User Centred Design (UCD) and Social Marketing, guided the development of this mobile application. Behavioral Change Theory based on the health belief model was used to evaluate personal factors that may be influencing health behaviors.The App has been deployed on the android Google play store for free download and installation but also can be accessible through an internet web browser from an ordinary computer. The release name in play store is mDiabetesUG

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Contributions to SDG3: The project will affect the way the health care system manages patients with Diabetes mellitus. It will provide the patients with all the knowledge about the different local carbohydrate-based foods. This will enable them to control their DM better through diet. The clinicians who are involved in the treatment of patients with DM will have adequate data about the foods and their caloric contents; they will therefore be in a position to advise their patients better about diet and control of DM. The ministry of health will be in a position to use the data in the development of policies about exercises and caloric reduction in the management of DM. These will in the long run reduce morbidity and mortality attributable to DM.

Developing Monitoring System for Quantifying and Mapping antibacterials used in Livestock Farming Systems in Uganda; Prof. Lawrence Mugisha

Antimicrobial Resistance (AMR) is one of the top three challenges faced by mankind today after Climate change and terrorism. The consumption of antimicrobials is a leading cause of antimicrobial resistance (AMR).

Objective; To develop an Information Technology (IT) System for reporting antimicrobial quantities imported, distributed and used in livestock production systems in Uganda to inform surveillance and management of Antimicrobial Resistance (AMR)

Output; The team conducted a study to establish the national consumption data of antimicrobials used in livestock production systems and to develop an information technology (IT) monitoring system for reporting antimicrobial quantities imported, distributed and consumed. The system is able to display antimicrobial data for animal use from import data to an IT dashboard visualised by regulators and policymakers in simplified formats. The data is extremely important to monitor antimicrobials imported and eventually used in different livestock. The data can be used to predict the antimicrobials being overused and likely to contribute to the development of resistance.

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Sustainable Development Goal 4; Quality Education

Since 2000, there has been enormous progress in achieving the target of universal primary education. The total enrolment rate in developing regions reached 91 percent in 2015, and the worldwide number of children out of school has dropped by almost half. There has also been a dramatic increase in literacy rates, and many more girls are in school than ever before. These are all remarkable successes.

Exploring children's understanding of COVID-19 and its preventive strategies in Uganda; Dr Nalwadda Christine

Globally, COVID-19 continued to scourge irrespective of age between 2020 and 2022. Evidence showed that children were less affected by the disease itself but were agents of its spread. In the absence of a cure and small-scale vaccination being rolled out, COVID-19 control has largely been dependent upon pragmatic preventive measures such as restriction of movements, closure of schools and risk communication. However, such immensely limited socio-economic productivity and could not be sustainable preventive measures. Therefore, there was a need for more emphasis on flexible preventive measures like continuous risk communication, hand washing, use of facemasks and vaccines, which can be practised amidst the happening of socio-economic activities. This study sought to explore the children's understanding of COVID-19 and its preventive strategies in Uganda to contribute to efforts of the ongoing COVID-19 risk-communication among children. The study recommended that efforts for risk communication for this age group should focus more on how to perform the recommended practices. This could be achieved through simplified step by step communication of the procedures or through more visual communication media. These findings were used by the Ministry of Health Technical Advisory Group to inform School re-opening

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Contribution to the SDGs; These contributed to the Health and education goals by reducing closure of school time and improved health of school going children amidst a pandemic

Improving Point-of-Care Learning for Prostate and Breast Cancer Imaging using Machine Learning

In Uganda, 25.1% and 12.5% of cancer deaths are from prostate and breast cancer respectively, and early diagnosis and treatment facilitated by efficient radiology services can address this. Radiology skills are acquired through apprenticeship at the Point-of-care (PoC) but these are currently, PoC-learning is ad hoc, using unstructured curriculum, interruptive and not seamless with workflow. The team developed and implemented a structured radiology curriculum initially for prostate and breast imaging driven by Machine Learning to improve PoC-learning. The curriculum is codified into a Machine learning driven game and integrated with Picture Archiving Systems (PACs) to run on handheld learner electronic tablets. Live streaming of radiology procedures, learning tasks and assessments will be processed through this gamified learner-tutor tablet interface at the PoC. This innovation was designed and implemented at Ernest Cook Ultrasound Research and Education Institute in collaboration with Makerere University School of Computing and Informatics Technology. This can be scaled to the various regional cancer care centres in the country

Resilient Communities for Quality Primary Education in Uganda (ReCoPE)

The Uganda Government's commitment to achieve SDG-4 on Quality Education has been tremendous through investment in Universal Primary Education (UPE). However, out of the 2,159,850 who enrolled in P1 in 1997, approximately 22% reached P7 in 2003 and 29% in 2004. The completion rate in 2011 was 67% but dropped to 62% by 2017 (NPC 2018). The fluctuation was partly attributed to the dismal participation of parents in their children's education.

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Objective; to improve the quality of primary education in Uganda through the development of a community-led support system that enhances the resilience of both male and female parents and the wider community to effectively participate in children's learning. Through discussions, the project has raised the consciousness of parents, teachers, community members, and identified gaps in parental involvement and how to act to fill them using the key messages developed through dialogue with the community. The project trained/capacitated 150 change agents in Mayuge and Nakaseke district with skills and knowledge on how to engage communities/parents in their children's learning.

PeerLearn: Peer-to-Peer Offline e-Learning Content Distribution Platform by Alex Mwotil.

Unreliable and high cost of Internet services remain major barriers to the adoption of e-learning thereby affecting thousands of learners in higher institutions of learning in Uganda. Despite the wide adoption of smartphone devices among students and teachers, the current e-learning tools are dominated by traditional platforms that require access via standard personal computing (PC) devices and assume consistent Internet connectivity throughout learning activities. This project developed PeerLearn, a novel mobile learning platform optimised to work online or offline and provides support for peer-to-peer learning resource distribution and sharing amongst learners.

Way forward; This can be rolled out to other Institutions of Higher Learning

Optimising surgical training: Live video recording to remotely relay surgical procedures to large groups of trainees using smart glasses and storage of video operative manuals by Cathy Kilyewala

Uganda is short of medical officers with 1 doctor per 12,000 population and 1 surgeon per 100,000 persons compared to the WHO recommended Physician to population ratio of 1:1,000. This team introduced smart glasses, a non-conventional yet feasible approach to

surgical training and skills transfer. Smart glasses are a pair of wearable eyeglasses with an optical head mounted display, that allows for relaying information onto a screen device like phones, projectors, or televisions via internet connection. They are handy for augmented imaging, video simulation, and as a technology to improve medical training, aid skills transfer, and assessment.

Way forward; This teaching method can be adopted in other teaching units beyond surgery and other education institutions

Digitization of Land Archival Documents in Makerere University Library (1830-1995): Rhoda Nalubega

Objective: To preserve and promote access to land archival records of Makerere University which were at a risk of deterioration/eminent danger

Output: This research project digitised land archives that are part of the 238 boxes of archival materials embedded in Buganda government archives 1831-1977 and Uganda protectorate government archives 1880-1992 accommodated at Makerere University Library. The land archives in question comprise titles, Lukiiko minutes and correspondences, treaties and testamentary practices at Makerere University Library, Africana section. The Africana section doubles as the host for special collections and the national reference library. It hosts collections on/by/about Uganda, Africa, UN depository, music archive, audio-visual collections, newspapers, microfilms, and paper archives. This project focused on the land archives which are a portion of the paper archives.

Contribution to SDGs (4 and 9): The project enhanced the availability and access of land archival documents for the period 1830-1995. The project also has played the role of sensitising stakeholders about the availability and access of land archival documents in Makerere University

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The Transactional Law Clinic: Phiona Muhwezi Mpanga

Objective: The overall objective of the intervention is to enhance the appropriateness and relevance of legal education and practice in addressing the legal needs of indigent persons, low income earners, and not-for-profit business ventures through the use of clinical methods of teaching and setting up a legal aid clinic to support these communities.

Output: The project in this initial year targeted 12 law students drawn from the third and fourth year of study to learn various aspects of commercial law using clinical methods and journal their learning experience; 47 academic staff at the School of Law to receive training in using clinical methods of teaching. Three clients willing to partner with the Clinic included two social innovation enterprises, the Social Innovation Academy and United Social Ventures; and one community of informal traders under Platform for Vendors in Uganda (PLAVU) all of which provided practical learning experiences for the students under close supervision. The experiences of the pilot have been documented through students' reflective journals, activity reports, client satisfaction surveys and later a manual developed to advise on how best to establish and run such a clinic in a university setting.

Contribution to SDGs (4): Under the pilot, law academics teaching commercial subjects were introduced and interested in changing the way they instruct learners. They were made to appreciate the use of clinical methods in the teaching and learning of the commercial law subjects under the LLB programme. The pilot also provoked debate on pedagogical issues especially for law academics who generally do not have a background in pedagogy. The pilot also initiated collaborations and networking between law schools on matters of pedagogy and innovations. A case for revolutionising the teaching of commercial subjects has been made and advocacy on the same in the different universities kick-started.

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Sustainable Development Goal 5; Gender Equality

Ending all discrimination against women and girls is not only a basic human right, it's crucial for a sustainable future; it's proven that empowering women and girls helps economic growth and development. Currently, there are more girls in school now compared to 15 years ago.

Enhancing Capacities of Women to Leadership Positions in Universities in Uganda (WOLEP); Florence Nakamanya

Objective; To identify the capacity needs and what works for women to occupy leadership positions in universities in Uganda

Output; Through the initiative, there are more women willing to occupy and aspire for leadership positions in Ugandan universities. A document on women's experiences with the existing leadership programmes and how they influence their aspirations and progression to leadership in Ugandan Universities. With such evidence availed, we believe more women will aspire and progress to leadership. From our findings, we also developed a Post Graduate Certificate in Gender and Leadership in Higher Education.

This contributes to Target 5.1 and 5.5 of the SDG 5 that seeks to End all forms of discrimination against all women and girls everywhere and Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision making in political, economic and public life.

Sustainable Development Goal 6; Clean Water and Sanitation

More and more countries are experiencing water stress, and increasing drought and desertification is already worsening these trends. By 2050, it is projected that at least one in four people will suffer recurring water shortages. Safe and affordable drinking water for all by 2030 requires we invest in adequate infrastructure, provide sanitation facilities, and encourage hygiene. Protecting and restoring water-related ecosystems is essential.

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Building Stewardship and Resilient Ecosystems through Participatory Integrated Planning Approaches. The Case of Manafwa Watershed, Eastern Uganda

This project led by Dr. Frank Mugagga focused on the Manafwa watershed in Eastern Uganda, which covers part of the Mount Elgon National Park, and is impacted by increasingly frequent landslides, loss of forest reserves, soil degradation and droughts. The urgency to conserve and restore the watershed's ecosystem services to a stable state of land degradation neutrality is huge given the recurrent landslide devastation. To tackle this challenge, mobilizing the local population is key, from farmers to policy-makers, at all institutional levels. This requires a bottom-up participatory approach, in which generating intrinsic motivation, commitment and collaboration to invest in the watershed are crucial using the Participatory integrated planning approach. The project approach pursued a proactive and meaningful engagement of authorities and stakeholder groups from various sectors of the watershed, counting on the participation of public/governmental institutions, NGOs, and the private sector. By employing a watershed-based approach, the project was strategically designed to contribute to the actualization of some key sector policies.

Sustainable Development Goal 7; Clean and affordable Energy

As the population continues to grow, so will the demand for cheap energy, and an economy reliant on fossil fuels is creating drastic changes to our climate. Investing in solar, wind and thermal power, improving energy productivity, and ensuring energy for all is vital if we are to achieve SDG 7 by 2030. Expanding infrastructure and upgrading technology to provide clean and more efficient energy in all countries will encourage growth and help the environment.

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Developing a community-based model for integrating bioenergy and poultry production using rice agro-waste: Prof John Kabasa

Objective: This project aimed at developing and deploying among rice-growing communities, novel technology innovations useful for integrated production of commercial bioenergy (Bio-energy combo) and poultry products using rice agro-waste. This was attained through a "One Health approach" to realise the optimal wellbeing for humans, animals and the environment.

Outputs: A series of sessions in an action learning fashion, experimentation trials and polishing of innovation products was carried out. For briquette making from agro-waste, modifications to suit rice agro-waste briquette processing were carried out. Both laboratory and field-based studies were undertaken to characterise the bio-briquettes. Low cost pyrolysis equipment was developed for carbonization of rice husk, its yield detailed at various operating conditions, and by-products extensively characterised and classified for purposive application. The project examined different combinations of substrates for producing cheap, safer and healthier prototypes of One Health rice agro-waste briquettes that have low levels of carcinogenic smoke particles, high calorific value and long burning time.

The briquettes developed will be used as an enabler for synchronised hatching and brooding of indigenous chicken, a process essential for efficient commercial indigenous poultry hatchery. This project established the knowledge of the technology and its applicability and produced a manual. This was conducted with the goal of deriving appropriate housing and husbandry conditions for indigenous chicken hatcheries suitable for small and medium scale rural poultry farmers.

This is made possible with funding from the Government of the Republic of Uganda through Makerere University Research and Innovations Fund (Mak-RIF)

Contribution to SDGs: 9,7,13, Integration of bioenergy into the existing household activities like poultry farming is a huge opportunity as some of the farmers who keep livestock, chicken in particular reported to do synchronised hatching which uses energy with this technology, this can be handy.

Sustainable Development Goal 8; Decent Work and Economic Growth

As the global economy continues to recover we are seeing slower growth, widening inequalities, and not enough jobs to keep up with a growing labour force. According to the International Labour Organization, more than 204 million people were unemployed in 2015. The SDGs promote sustained economic growth, higher levels of productivity and technological innovation. With these targets in mind, the goal is to achieve full and productive employment, and decent work, for all women and men by 2030.

Pedagogical Leadership for Academic Staff in Higher Education Institutions to Enhance Graduate Work Readiness and Transition to Work; Prof. Ronald Bisaso

Universities across the globe are increasingly required to produce highly skilled graduates who are able to respond to the ever changing and complex needs of a dynamic labour market and workforce. There is a notable gap in linking graduate aspirations and employer expectations to the content and pedagogy in higher education institutions (HEIs) to enhance graduate work readiness and transition to work. Unfortunately, sixty- three per cent (63%) of Uganda graduates are unemployable according to the employers, and the existing pre labour market education or training is inadequate.

Objective; To build capacity for Higher education institution staff to implement university curricula using pedagogy that facilitates graduate work readiness and transition to work. However, they have disciplinary and research expertise.

Output; There is evolution of a National Innovation System where Higher Education Institutions (HEIs) work closely with National Council for Higher Education (NCHE), The

National Planning Authority (NPA) and professional bodies among other stakeholders to integrate graduate work readiness and transition to work standards/guidelines into institutional policies and practices. Thus contributes to both SDG 8 and 9

Sustainable Development Goal 9; Industry, Innovation and Infrastructure

Investment in infrastructure and innovation are crucial drivers of economic growth and development. Technological progress is also key to finding lasting solutions to both economic and environmental challenges, such as providing new jobs and promoting energy efficiency. Promoting sustainable industries, and investing in scientific research and innovation, are all important ways to facilitate sustainable development. More than 4 billion people still do not have access to the Internet, and 90 percent are from the developing world. Bridging this digital divide is crucial to ensure equal access to information and knowledge, as well as foster innovation and entrepreneurship.

Crane Cloud: an open source multi-cloud service layer for highly available cloud-based services in Africa: Engineer Bainomugisha

Objective: To design and develop an open source multi-cloud service layer for highly available cloud-based services in Africa.

Output: Developed a Crane Cloud Prototype (MVP) and organised training to introduce University students to Cloud Computing from different perspectives.

Contribution to SDGs (4 and 9): Capacity building: Over 147 developers and students were trained on cloud computing and cloud-native application development. Additionally, 4 student developers and 3 interns were part of the development team for Crane Cloud. Additionally, the student developers obtained hands-on skills in managing a local cloud infrastructure. The development of Crane Cloud demonstrated ability and possibilities for institutional clouds and cloud-native in resource constrained environments. Cloud-Native

applications should be adopted if users are to benefit from application reliability in an environment with limited and failure susceptible infrastructure.

A Speech-to-text model for Ugandan Bantu Languages to aid analysis and Inform Policy

In rural areas, where almost 90% of the population lives, radio serves as a vital platform for public discussion, information sharing and news. The team developed a speech to text prototype that makes it possible to conduct analysis of public discussions on radio. For the first time, automatic speech-to-text technology will be developed for Ugandan bantu languages (Starting with Luganda, Runyaktara) from radio in combination with data mining. For the first time also people's voices from public radio broadcasts will be accessible to advance the Global Goals. The main objective is to develop a tool that can convert what people say in local languages into text and analyse radio content for predetermined topics of interest such as 'malaria', 'flood' or 'domestic violence' that are automatically found by the tool. And test if this tool can be used as an early warning tool to signal issues ongoing at local level.

A Pedal-Operated Seed Cleaner (PoS-Cleaner) To Boost Post Harvest Grain & Legume Quality, Increase School-Study time & Create Financial Freedom in Rural-Uganda: Peter Tumutegyereize

Objectives: To develop a pedal-operated seed cleaner (PoS-Cleaner) to boost post-harvest grain & legume quality

Output: Five pedal operated seed cleaners were developed and distributed to five farmer groups which are active in grain crop production in Butansi and Namasagali sub counties in Kamuli District. The cleaner consists of a bicycle-like pedalling system, hopper, a centrifugal fan and three cleaning sieves which include two inside interlocking sieves and one fixed; whose meshes can be adjusted to be larger than the size of the unclean seeds by simply

translating the second sieve to achieve the appropriate seed size. This allows trapping of foreign impurities larger than the seeds. Host farmers for the machines among the five groups were selected based on their potential to provide space and security for the machine as well as potential to train other farmers on the use and operation of the machine. For monitoring and evaluation of the use of the cleaners, a data collection sheet was also provided so that whoever uses the machine, registers his or her subcounty, parish, village, type of seed brought for cleaning, quantity cleaned, time taken, approximate distance from their homes to the host farmer and remarks for feedback. This provided important information for example, the effect of distance on machine use, the clean rate and user acceptance.

Contribution to SDGs (9): The five seed cleaning machines this project piloted proved necessary to the communities where they are located. At least 450 farmers have had access to these machines and used them since they were piloted.

Optimised and intelligent classroom environments for new generation learners: Fildah Ayaa

Objective: The main objective was to design an intelligent and optimized classroom model for university students

Output: An optimization software, "OPTISPACE' was designed to optimize classroom spaces. A social distancing feature was added during the COVID-19 pandemic and a user is able to determine the room capacity sufficiently. OPTISPACE can also be used to optimize space use in offices, warehouses, hospitals, and any other public spaces or places of business. A virtual reality feature in the software enables the client to experience the space before it is built or re-modeled so that changes in the design are made before construction. A three-seater, two-seater and one-seater chairs comfortable for university students was designed

and the prototype successfully tested. For room 160, a three-seater was recommended because of the large student number that has to fit in a limited space. It was estimated that 50 seats were required to fit the space from OPTISPACE and the chairs were fabricated in the CEDAT workshop. The chair features a central worktop, book case, bag hanger and leather covered seat for the comfort of the student following International design criteria.

Contribution to SGDs (9): Room 160 in CEDAT fully furnished with brand new furniture made in the University.

Sustainable Development Goal 10; Reduced Inequalities

Income inequality is on the rise and in developing countries, inequality has increased by 11 percent. Income inequality has increased nearly everywhere in recent decades, but at different speeds. It's lowest in Europe and highest in the Middle East. These widening disparities require sound policies to empower lower income earners, and promote economic inclusion of all regardless of sex, race or ethnicity. Income inequality requires global solutions. This involves improving the regulation and monitoring of financial markets and institutions, encouraging development assistance and foreign direct investment to regions where the need is greatest. Facilitating the safe migration and mobility of people is also key to bridging the widening divide.

Perspectives on Land Capping in Uganda (PLCU) Research Project: Zahara Nampewo

Objective: To elucidate on the challenges of unlimited private land ownership to development programming in Uganda. It interrogated whether it is possible to enforce a land ceiling and whether this would provide a solution to unregulated private land accumulation and under-utilisation of land in Uganda.

Output: This study interrogated whether it is possible to enforce a land ceiling and whether this would provide a solution to unregulated private land accumulation and under-utilisation of land in Uganda. It clarified the role of key players and actors regarding the aspect of land capping in Uganda but also capturing key voices – the voices of Ugandans on this critical issue. The recommendations of the research report are a resource for the government, the private sector, and civil society to generate discussion and consent on this very sensitive and yet critical aspect of Uganda's development agenda. Relatedly, the study touched on other key factors central to land conflicts and with an effect on development;

- The land tenure system in Uganda – should it be reformed?
- How to improve land access for the poor and vulnerable – including women, youth and the new IDPs in Uganda (those who have lost their land due to land evictions);
- How to increase efficiency and transparency in land administration services and which institutions should be mandated for this.
- What is needed in developing / enhancing capacity in land administration.

Contribution to SGDs (10 and 16): The study established that there is considerable support for land capping which has the potential to facilitate the guaranteeing of a minimum amount of land for every person's livelihood including the poor and marginalised, while addressing current challenges of idle, unutilised land, speculative accumulation of land and the unregulated accumulation by the rich and powerful.

Re-imagining Real Estate Education in Uganda: The Ministry of Lands, Housing and Urban Development has taken up this project's findings in the development of its strategic plan and the Real Estate Bill. This project has helped the public, real estate industry and academia to learn more about the state of the brokerage industry.

This is made possible with funding from the Government of the Republic of Uganda through Makerere University Research and Innovations Fund (Mak-RIF)

Recommendations from this project will lead to a real estate law that improves regulation of brokers and agents in Uganda, and an ethical code of conduct. Development of this industry will ultimately lead to economic growth through the investor confidence that comes from a more organised real estate industry.

Sustainable Development Goal 11; Sustainable Cities and Communities

More than half of us live in cities at the moment. By 2050, two-thirds of all humanity—6.5 billion people—will be urban. Sustainable development cannot be achieved without significantly transforming the way we build and manage our urban spaces. The rapid growth of cities—a result of rising populations and increasing migration—has led to a boom in mega-cities, especially in the developing world, and slums are becoming a more significant feature of urban life. Making cities sustainable means creating career and business opportunities, safe and affordable housing, and building resilient societies and economies. It involves investment in public transport, creating green public spaces, and improving urban planning and management in participatory and inclusive ways as highlighted in selected Mak-RIF projects:

Improving the prediction of Storms and flood forecasting over Kampala City; Alex Nimusiima

Weather and climate issues have become increasingly recognised world challenges especially in the era of climate change. Kampala has faced a number of flooding events resulting from heavy storms in the past that have led to serious damages in many low-lying areas of the city. Theteam led by Dr. Alex Nimusiima from the College of Agriculture and Environmental Sciences aimed at addressing this challenge by improving the forecasting skills of such flood-causing magnitudes that affect the city through issuing early warning alerts and working with the relevant authorities. There was limited information on the influence of storm kinematics on the occurrence and generation of major floods in Kampala

City. The team provided additional indicators that guide in the forecasting of heavy rainfall events that normally cause flooding in the city to the Uganda National Meteorological Authority (UNMA). This contributes to Goal 13 on Climate Action.

Sustainable Development Goal 12; Responsible Consumption and Production

Achieving economic growth and sustainable development requires that we urgently reduce our ecological footprint by changing the way we produce and consume goods and resources. Agriculture is the biggest user of water worldwide, and irrigation now claims close to 70 percent of all freshwater for human use. Encouraging industries, businesses and consumers to recycle and reduce waste is equally important, as is supporting developing countries to move towards more sustainable patterns of consumption by 2030. This can help with food security, and shift us towards a more resource efficient economy:

Developing Monitoring System for Quantifying and Mapping antibacterials used in Livestock Farming Systems in Uganda: Lawrence Mugisha

Objective: To develop an Information Technology (IT) System for reporting antimicrobial quantities imported, distributed and used in livestock production systems in Uganda to inform surveillance and management of Antimicrobial Resistance (AMR)

Output: The project developed a web-based Information Technology System in collaboration with National Drug Authority (NDA) and Ministry of Agriculture, Animal Industry & Fisheries (MAAIF) that captures the importation data, sales data and purchase data of antimicrobial medicine in real-time and display it on IT dashboard in different usage formats accessible to regulators, policymakers, researchers, Veterinary drug importers and distributors and end-users (farmers). The system has in-built access levels for data protection and controlled access.

This is made possible with funding from the Government of the Republic of Uganda through Makerere University Research and Innovations Fund (Mak-RIF)

Contribution to SDGs (2,3,9,17): This Project was able to display antimicrobial data for animal use from import data to an IT dashboard visualised by regulators and policymakers in simplified formats. The data is extremely important to monitor antimicrobials imported and eventually used in different livestock. The data can be used to predict the antimicrobials being overused and likely to contribute to the development of resistance.

Harnessing microbial probiotics for improving pig health and productivity: Samuel Majalija

Objective: To unravel Lactic Acid bacillus strains with potential to improve pig health and productivity in Uganda

Output: The project isolated candidate probiotic organisms that have shown good results of promoting pig growth and reducing smell in piggery units. initial packaging of these organisms has been done and available to farmers.

Contribution to SDGs (1,2): The feeding costs of pigs will be reduced for farmers, A formulation of pig probiotics from indigenous organisms will be available on the Uganda market, There will be reduced use and reliance on antibiotics as a feed additive for pigs.

Agrochemical residues in meat and milk of cattle in the acaricide-tick-resistant infested areas: a case study of Gomba District: Peter Waiswa

Objective:To determine the level of agrochemical residues of Acelomectin and lava in meat and milk and the knowledge, attitudes, and practices that influence the application of agrochemicals on cattle in Gomba district.

Output: Socio-demographic and economic drivers for pesticide use in tick control were investigated by assessing knowledge, attitudes, and practices of farmers towards the use of pesticides to control ticks. In addition, beef samples (i.e. muscle tissue, liver and kidney)

from butcheries and milk from selected farms were analysed for the presence and concentration of pesticide residues in the laboratory using HPLC.

Contribution to SDGs (3 and 2): This project has documented the use of agrochemicals to control ticks alongside conventional acaricides in Gomba district. Although the farmers know the effects of agrochemical residues on public health, they continue to use agrochemicals given the prevalent tick resistance. Policymakers should come up with measures to stop the use of agrochemicals on cattle to control ticks by giving farmers viable alternatives. There is evidence of contamination of meat and milk by agrochemical residues although to a small extent but this is likely to escalate if the use of agrochemicals against ticks continues unabated.

Profiling the role of Escherichia coli in the aetiology of piglet diarrhoea in selected pig producing districts of Central Uganda: Towards adoption or development of vaccines for prevention: Joseph Erume

Objective: To determine the role that E. coli plays in the aetiology of piglet diarrhoea in the smallholder pig farms in selected pig producing districts of Central Uganda.

Outputs: Faecal samples were collected from 2 piglets in each litter for E. coli isolation. Antimicrobial susceptibility testing of isolates was performed against WHO recommended antibiotics using standard protocols as described by the Clinical and Laboratory Standards Institute.

Contribution to SDGs (2): This study has revealed a high prevalence of enterotoxin gene markers among E. coli tested in piglets and highlights the potential role of these diarrheagenic bacteria in the aetiology of piglet mortalities in Uganda. Additionally, this study has identified risk factors that can be observed to control infection and relevant drugs that can be used for treatment.

This is made possible with funding from the Government of the Republic of Uganda through Makerere University Research and Innovations Fund (Mak-RIF)

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Enhancing mango production and productivity for sustainable livelihoods in Uganda: Grace Nakabonge

Objective: 1. To assess the performance and production practices of mango varieties in selected districts of Uganda. To Investigate the level of pest and disease prevalence in mangoes orchards and the corresponding management practices in selected districts of Uganda and evaluate the influence of soil nutrient availability on mango fruiting in selected districts of Uganda

Outputs: Plots were established in farmer fields and susceptibility of different varieties to pests and diseases was evaluated. Finally, soil profiles at visited mango farms were characterized focusing on Nitrogen, Phosphorous, Potassium, Organic matter and soil acidity (PH) levels. Interviews were administered in farmers' mango orchards in order to crosscheck farmers' responses regarding the pest and disease status with field observations.

Contribution to SDGs (12): The information generated will inform policy (NAADS, Operation wealth creation) in their initiative towards promoting Mango production and productivity.

Goal 13; Climate Action

There is no country that is not experiencing the drastic effects of climate change. Greenhouse gas emissions are more than 50 percent higher than in 1990. Global warming is causing long-lasting changes to our climate system, which threatens irreversible consequences if we do not act. The annual average economic losses from climate-related disasters are in the hundreds of billions of dollars:

An innovative e-community governance model for monitoring implementation of catchment restoration and management interventions in River Rwizi sub catchment. By Dr Patrick Musinguzi:

This is made possible with funding from the Government of the Republic of Uganda through Makerere University Research and Innovations Fund (Mak-RIF)

To address the threat of climate change and improve water management in Uganda, scalable models for mitigation and adaptation are needed, along with studies to quantify future water demand. Conservation technologies, behavior change, and leadership models can drive their uptake. Community-driven approaches such as tree-planting and carbon sink development are necessary for catchment restoration. An e-based innovation using smart phone applications is being developed to monitor the community response to restoration interventions in River Rwizi catchment. The project aims to supplement the existing Integrated Water Resources Management (IWRM) efforts to enhance water management in line with the Sustainable Development Goal (SDG) 6 and the Uganda National Development Plans III. Elite community members are engaged in the restoration efforts. The app can so far capture images, detect degradation, and provide accuracy, location, and time data. A web-based center will be established for policy-making and database management. The project will provide insights into community perceptions of technological innovations in catchment-based water management and inform implementation of similar strategies in other Ugandan catchments.

Automation of communal hand water pumps to eliminate COVID-19 transmission: Maknai. By Dr. Kiggundu Nicholas:

The Maknai project aims to automate hand-cranked water pumps in rural Uganda to limit the spread of COVID-19 through surface contact. These pumps supply water to an estimated 18.5 million people, and the traditional cranking process is a potential hotspot for transmission. Maknai v1.0, powered by solar or AC power, demonstrates that automation is feasible and has additional advantages of reducing drudgery and saving time. Field tests showed power drawn averaged 1 hp and the average time to fill a 20-liter container was 50 seconds. The touchless machine eliminates the need for hand washing or sanitizer use. The next step, Maknai v1.1, will optimize the system's main units to reduce costs for wider affordability and use, bringing it to about 40% the cost of installing submersible systems.

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Maknai will greatly boost the Ministry of Water and Environment initiative to replace hand-pumped boreholes with submersible pumps.

Development and optimisation of a biodegradable packaging solution for liquid based cosmetics using response surface methodology: Ronald Kayiwa

Objective: To develop and evaluate the performance of liquid based cosmetic packaging material from lignocellulosic waste.

Output: Tested for suitability of selected lignocellulosic waste for cosmetic packaging, developed an aesthetically acceptable packaging from lignocellulosic agricultural waste and evaluated the performance of the developed material versus the prevalent plastic packaging. Documented the Process of manufacturing containers from agricultural waste pulp without moulding

Contribution to SDGs: Use of agricultural waste has potential to improve livelihoods of farmers once a value chain for biodegradable cosmetic packaging is established (SGD 1,9). A better perspective environment with less plastic cosmetic packaging (SGD 13)

Up-cycling plastic wastes by incorporation of agricultural residues for the development of environmentally friendly packaging products: Engineer Michael Lubwama

Objective: To develop up-cycled plastic packaging products using agricultural residues as filler materials

Output: Agricultural residues were used as reinforcing material in the production of egg-trays from plastic wastes in Uganda. Physical and thermal properties of both plastic wastes and agricultural residues were obtained by proximate analysis, ultimate analysis and TGA. Van Soest method was used to determine lignin, cellulose and hemicellulose compositions. Moisture absorption testing was carried out to obtain the rate of increase in weight when

raw materials are soaked in water. These properties had an impact on the resulting up-cycled plastic packaging materials and products developed. Agricultural residues were dried to a moisture content of less than 1% using standard laboratory ovens.

Contribution to SGDs (9,13,1): The project creates a means of utilizing plastic wastes and agricultural residues to produce novel up-cycled plastic packaging products. This impacts on waste management including collection, sorting, re-use, recycling and up-cycling so as to achieve a circular plastics economy that is environmentally sustainable. This project built the capacity of local farmers on how they can use the wastes from their produce to develop upcycled products so as to reap extra income from agriculture. Jobs can be created in aspects of collecting agricultural residues and plastic wastes.

Yo-Waste: a mobile and cloud-based garbage collection service (uber for garbage)

Deploying the app in communities impacted 200+ households who use the app to schedule and request waste pickups. Over 120 tons of garbage that would have ended up in streets or water channels was collected using the platform, including 10 tons of plastic. The project created over 5 direct and over 10 indirect jobs just in the pilot area. The project is projected to have a positive impact on more communities once scaled, promoting zero-waste, recycling, and reduced dependence on landfills.

Building Stewardship and Resilient Ecosystems through Participatory Integrated Planning Approaches. The Case of Manafwa Watershed, Eastern Uganda

The project aimed at not only strengthening competitiveness for sustainable wealth creation, but it has also led to employment creation particularly for the youth and spurred inclusive growth through landscape restoration, led by intrinsically motivated farmers.

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Up-cycling plastic wastes by incorporation of agricultural residues for the development of environmentally friendly packaging products

The project enables utilisation of plastic wastes and agricultural residues to produce novel up-cycled plastic packaging products. This impacts waste management to achieve a circular plastics economy that is environmentally sustainable. Local farmers can earn extra income from the up-cycling value chain. Jobs can be created in aspects of collecting agricultural residues and plastic wastes. The up-cycled packaging products have enhanced mechanical, thermal, biodegradability and bio-chemical properties.

Valorisation Of Waste Chicken Feathers For Water Purification: Designing and Constructing Low-Cost Keratin Based Nanofilters As Adsorbents Of Heavy Metals and Nanosized Contaminants. By Dr. Alice Nabatanzi

Access to safe water in homes is crucial, and new technologies and cost-effective approaches are needed to increase availability. This project designed, constructed, and demonstrated a drinking water purification system that combines sand filtration with keratin, a natural protein from waste chicken feathers, to remove heavy metals and nanosized contaminants from water. The poultry industry generates a large amount of feather waste that is often improperly disposed of, and industrial effluents are contaminating fresh water sources with heavy metals. The use of keratin-based nanofilters is a low-cost, eco-friendly solution that can improve water quality, reduce waterborne illnesses in humans and animals, and reduce environmental pollution. The study found that the water quality met the limits by the World Health Organization. The project team recommends the adoption of keratin-based nanofilters due to the abundance of waste chicken feathers.

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Nylon Based Litter Management Trap for Drainage Systems. By Dr. Andrew Ayor Ssemakula

Storm water and running water carry garbage and debris from two major towns, Kampala and Jinja, into Lake Victoria, Uganda's largest freshwater source, causing pollution and clogging. To address this problem, a flexible nylon mesh sock was designed to capture floating litter and debris in drainage channels. The trapped waste can be easily removed by untying the base of the sock and dumping the collected material into garbage trucks. The nylon-based litter trap has a diameter of 1200mm, length of 1.2m, and strand size of 3mm, with a diamond-shaped opening. It has an average retention capacity of 55.03 kgs per hour and can hold up to 152 kgs of waste without breaking. The team plans to engage with the Kampala Capital City Authority on the commercialization/buying of the product.

Monitoring and Enforcement for Sustainable Forest wood Extraction. By Dr. Julius Opiso:

Africa experiences the highest annual net forest loss, and Uganda's national aggregate wood stock has declined by 45% from 1990 to 2015. To address this issue, the study developed a modified model using resource allocation and regulation to deter excessive forest wood extraction by use of penalty and sanctions and analysed the current policies for improvement. The model integrates policy makers, regulators, and forest wood users to establish an optimal extraction path for sustainable forest management. The study recommends the use of drone technology to monitor forest wood extraction, an increase in staff, private sector participation, and clear land allocation terms to promote forest conservation. The research delivered policy briefs to inform policy review and planning.

Dr. Paul Kutyabami studied Pharmaceuticals in the Environment: The emerging pollutants for surface water and foodstuffs grown in Kampala District.

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Pharmaceuticals, though critical in healthcare, have harmful environmental effects such as bacterial resistance and ecosystem disruption. They are widely consumed, excreted, and disposed of, becoming environmental pollutants. Different pharmaceuticals together with personal care products cause additive or synergistic effects that aggravate environmental toxicity. Human inefficiencies during the pharmaceutical lifecycle cause pollution. Pharmaceuticals enter the environment mostly through excretion and inappropriate disposal of waste. The study aimed to prove the concept of Pharmaceuticals in the Environment (PiE) in Kampala and create awareness to develop preventive strategies. The study used interviews, laboratory analysis, and semi-structured questionnaires, and found that respiratory infections and malaria were the most common household conditions, while chronic conditions included hypertension, HIV, diabetes, and mental illness. About half of the food samples and nearly three-quarters of water samples contained at least one pharmaceutical. The study recommends routine environmental surveillance of pharmaceutical pollution around different point sources and interagency efforts to address it.

An innovative e-community governance model for monitoring implementation of catchment restoration and management interventions in River Rwizi sub catchment. By Dr Patrick Musinguzi: To address the threat of climate change and improve water management in Uganda, scalable models for mitigation and adaptation are needed, along with studies to quantify future water demand. Conservation technologies, behaviour change, and leadership models can drive their uptake. Community-driven approaches such as tree-planting and carbon sink development are necessary for catchment restoration. An e-based innovation using smart phone applications is being developed to monitor the community response to restoration interventions in River Rwizi catchment. The project aims to supplement the existing Integrated Water Resources Management (IWRM) efforts to enhance water management in line with the Sustainable Development Goal (SDG) 6 and the

Uganda National Development Plans III. Elite community members are engaged in the restoration efforts. The app can so far capture images, detect degradation, and provide accuracy, location, and time data. A web-based center will be established for policy-making and database management. The project will provide insights into community perceptions of technological innovations in catchment-based water management and inform implementation of similar strategies in other Ugandan catchments.

Automation of communal hand water pumps to eliminate COVID-19 transmission: Maknai. By Dr. Kiggundu Nicholas

The Maknai project aims to automate hand-cranked water pumps in rural Uganda to limit the spread of COVID-19 through surface contact. These pumps supply water to an estimated 18.5 million people, and the traditional cranking process is a potential hotspot for transmission. Maknai v1.0, powered by solar or AC power, demonstrates that automation is feasible and has additional advantages of reducing drudgery and saving time. Field tests showed power drawn averaged 1 hp and the average time to fill a 20-litre container was 50 seconds. The touchless machine eliminates the need for hand washing or sanitizer use. The next step, Maknai v1.1, will optimise the system's main units to reduce costs

Design and development of mobile irrigation technology systems for small to medium commercial farmers and pastoralists in the rain constrained areas of Uganda by Dr. Kivumbi Balimunsi Hussein:

Agriculture in Uganda is predominantly rain-fed and is increasingly suffering adverse effects due to climate change and variability manifested in erratic rainfall patterns, prolonged dry spells, and floods. As a result, farm-level productivity is far below the attainable potential for most crops. Under these conditions, irrigation is critical in aiding farmers in climate change adaptation and plays an integral role in transitions from subsistence to commercial farming

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by ensuring year-round production coupled with farm employment. There is unreliability of food security in Uganda caused by over-reliance on rain-fed agriculture by the biggest percentage (97%) of households in Uganda. This is further exacerbated by prolonged droughts, which lead to food scarcity in the country. Introduction of Irrigation systems as per the National Irrigation Master Plan (NIMP) provides a solution to this problem. This project has developed a mobile irrigation system that will help farmers who suffer with unpredictable rainfalls and those in areas which experience long drought seasons to have an all-year-round harvest of produce.

Sustainable Development Goal 14; Life Below Water

The world's oceans – their temperature, chemistry, currents and life – drive global systems that make the Earth habitable for humankind. How we manage this vital resource is essential for humanity as a whole, and to counterbalance the effects of climate change. Over three billion people depend on marine and coastal biodiversity for their livelihoods. However, today we are seeing 30 percent of the world's fish stocks overexploited, reaching below the level at which they can produce sustainable yields:

Strengthening the capacity of small holder fish farmers and fisheries extension officers to mitigate the risk of fish diseases in fish farms in Uganda: Samuel Posiano Wamala

Objective: To improve fish health care in Uganda by increasing the knowledge of fish farmers and extension staff in detection, prevention and control of fish diseases

Output: An illustrated farmers' manual of fish diseases was developed. This is useful to fish farmers, fish health care workers/veterinarians, students and institutions concerned with fish health care. The manual demonstrates that fish diseases are actually a challenge in fish production in the country. Fish farmers and fisheries officers increased their awareness about fish diseases through the field training.

This is made possible with funding from the Government of the Republic of Uganda through Makerere University Research and Innovations Fund (Mak-RIF)

Contribution to SDGs (14 and12): The project increased the knowledge of fish farmers and fisheries extension officers from Mukono, Mpigi, Buikwe and Wakiso through field training. This is expected to improve fish diseases detection, prevention and control and thereby improving fish production

Enhancing Marketing of Fish and Fish Products through an Innovative Mobile and Web-based Platform (eFish Marketing)

Uganda is endowed with vast fishery resources that contribute significantly to food and nutritional security, livelihoods, employment, foreign exchange earnings. However, poor infrastructure, inadequate technological capacity, disconnect between fishers and consumers due to lack of marketing information impedes the translation of fish into improved incomes, enhanced livelihoods and food and nutritional security. This project developed an innovative mobile and web-based platform called “eFish Marketing”. The goal of the innovation is to empower fish supply chain actors with market information that will improve their bargaining position and increase incomes from fish trade, and enhance food and nutrition security. The expected benefits include transparent pricing, improved fish prices, improved access to fish products, increased and timely availability of quality fish to consumers, and reduced marketing costs.

Sustainable Development Goal 15; Life on Land

Human life depends on the earth as much as the ocean for our sustenance and livelihoods. Plant life provides 80 percent of the human diet, and we rely on agriculture as an important economic resource. Wildlife trafficking not only erodes biodiversity, but creates insecurity, fuels conflict, and feeds corruption. Urgent action must be taken to reduce the loss of natural habitats and biodiversity which are part of our common heritage and support global food and water security, climate change mitigation and adaptation, and peace and security:

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Product formulation and evaluation of a herbal acaricide containing bioactive extracts of Albizia coriaria on acaricide resistant Rhipicephalus ticks: Bush Herbert Aguma

Objective: Product formulation and evaluation of herbal acaricide containing bioactive extracts of Albizia coriaria on larvae of acaricide resistant Rhipicephalus ticks.

Output: Herbal extract and herbal product were formulated using the stem bark powder of Albizia coriaria. Ticks larvae from 3 farms where resistance has been reported in Kiruhura District were exposed to the duplicates of the serial dilutions of 200mg/ml;100mg/ml/50mg/ml and 25mg/ml for both the extract and the herbal product using Larval Packet Test method. Tween 80 and Amitraz were used as the negative and positive controls respectively. The mortality was then determined after 24 hours and the average mortality for the duplicates per concentration was recorded. The results indicate that both the ethanolic extract and herbal acaricide of Albizia coriaria have slightly a higher mortality effect against the tick larvae compared to Amitraz. Therefore, the herbal acaricide formulated can be produced on a large scale and be used as a substitute to the failing synthetic acaricide in addressing the tick challenge in Uganda.

Contribution to SGDs (12,15): The findings show that a herbal acaricide can be produced on large scale to provide an alternative to synthetic acaricides

Integrating assisted reproductive technologies and elite pig genetics to transform the pig value chain in Uganda. Team lead: Dr. Donald Kugonza

Poor access to good quality pig genetics by smallholder (SH) farmers, is a major constraint to most pig farmers in Uganda. A recent study found that 52% of SH farmers in central Uganda, especially women, do not keep a boar. Such SH farmers who keep just a couple of sows make over 75% of all pig farms and they rely on communally-used boars. Few overworked boars ultimately sire small litters. Smallholder farmers cannot afford boars due

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to cost, but are willing to pay for a credible artificial insemination (AI) service. Makerere University Agricultural Research Institute (MUARIK) has a boar stud and a mini-laboratory for processing boar semen to meet expected demand for AI. This project developed and piloted a new long term semen extender, packaged semen for sale to small holder farmers in Kamuli, Luweero and Wakiso districts, developed a community-based AI distribution model, trained a team of 21 pig artificial inseminators and developed one boar-based sow stimulant. In the near future, the project seeks to produce & package a product from the pheromones of Boars that is able to make sows get on heat (synchronisation) so as to fasten the reproduction process.

This will enhance food production in the country contributing to zero hunger.

Sustainable Development Goal 16; Peace, Justice and Strong Institutions

Transforming presumptive age estimation in Uganda: methods, certainty and the law by Dr. Annet Kuteesa

Justice Law and Order Sector (JLOS) is a government body with the goal of promoting the rule of law, through improved safety of the person, security of property, and access to justice for inclusive growth. However; there is an urgent need of strengthening, safe-guarding procedures, forensic standards locally available and improving the age estimation procedures that are in line with effective and efficient age assessment processes used at international levels. Together this will promote human rights and justice in the country. While international laws and guidelines promote the importance of a multi-disciplinary approach to age assessments, Uganda has no guidance, and no scientifically proven methods specific for age determination policy. Although the third molar eruption is popularly used to estimate age in this population it has not been standardised. Hence this project has developed standards for age estimation using third molar development specific to the Ugandan adolescent and young adult population. Sex

specific tables for mean ages at the various stages of third molar development have been established; interestingly, females were found to develop third molar stages earlier compared to males. This project addresses key issues that are useful for the Ugandan population in strengthening the age estimation practice within the judiciary system.

Framework for integration of refugees into the national health system: Prof. Garimoi Orach

Uganda hosts over 1.5 million refugees and asylum seekers. Several partners and the Government of Uganda contribute to the delivery of health care services for refugees. This framework therefore will enhance the integration of refugees into the national health system. This will enable host communities to benefit from the health services provided for refugees therefore saving on the costs of operation and enhancing improved health service delivery. It will also provide an implementation plan for District Local Governments to manage the health facilities constructed for refugees.

Sustainable Development Goal 17; Partnerships for the Goals

The SDGs can only be realized with strong global partnerships and cooperation. The world is more interconnected than ever. Improving access to technology and knowledge is an important way to share ideas and foster innovation. Coordinating policies to help developing countries manage their debt, as well as promoting investment for the least developed, is vital for sustainable growth and development. The goals aim to enhance North-South and South-South cooperation by supporting national plans to achieve all the targets. Promoting international trade, and helping developing countries increase their exports is all part of achieving a universal rules-based and equitable trading system that is fair and open and benefits all.

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GOVERNMENT OF UGANDA

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ICT Innovations Marketplace (InnoMak) Dr. Mary Nsabagwa

Objective: To develop an innovation marketplace, which would help to promote Makerere University ICT projects, to ensure that they gain commercial value

Output: Developed a web-based innovations marketplace with a payment service to enable innovations teams to raise funds for use in developing more usable and advanced features. The innovations have social media pages on Facebook and Twitter accounts that will be used in promoting, marketing and branding the innovations to worldwide audiences. The portal is directly accessible to Makerere University and accounts can be created for other public and private universities for their innovators to use. The marketplace provides

Contribution to SDG17: The innovative marketplace provides an aggregated portal through which the promising innovations conceptualised and proof-of-concepts developed as early-stage prototypes by students in CoCIS every year can be found by the public and thus makes it easier to reach their intended users in Uganda and beyond.

Mainstreaming Kiswahili in Uganda's National Agenda for Regional Integration and Sustainable Development: Caroline Asiimwe

Objective: It was intended to critically discuss the ways and means of mainstreaming Kiswahili in Uganda's national agenda as an approach for promoting the development and use of the language. It aimed at demonstrating the efficacy of Kiswahili in strategically positioning the country for active participation in regional integration and sustainable development.

Output: The study adopted a multi-layered process of critical and contextual interpretation of the Kiswahili Language Question in Uganda from the colonial era to the present times, pointing out landmark decisions and actions that impacted the language in the country, as

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well as trends in policy fields in response to emerging development and integration imperatives. The study provided a comprehensive assessment of data collected from field participants using robust methodology, and synthesizes key findings and implications of main policy lessons.

Taking use and development domains as key analytic categories, the study deployed approaches that account for historical and contemporary shifts in the Kiswahili Language Question in Uganda. It gathered a set of data from participants for systematic and sustained analysis of mainstreaming Kiswahili in Uganda's national agenda. In pursuit of the relationship between Kiswahili and development and regional integration, attention was paid to mainstreaming as a conceptual term and national agenda as a critical issue.

Contribution to SDGs (17): Appreciation of Kiswahili as a second official language, Sustainable partnerships and networking relationship among the line ministries and other stakeholders involved in the development of Kiswahili. Mind set change out of the sensitization and creation of awareness activities.

Conclusion

Makerere University continues to take the lead in driving research and innovations that foster development and provide solutions to day to day challenges in the community and the Nation. Through teaching, research and innovation. The contribution through research and innovation is significant in creating new knowledge and improving the status quo for people. We believe that together, we can achieve peace, prosperity, and partnerships for all.

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