Uganda National Council for Science and Technology

Uganda Millennium Science Initiative Project: Book of Abstracts

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CONTENTS

ACKNOWLEDGEMENT ..... **II**

ACRONYMS ..... **VII**

FOREWORD ..... **VIII**

INTRODUCTION **1**

WINDOW A1: SENIOR RESEARCH TEAMS **5**

1.1 Malaria Vaccine Studies in Uganda: Site Preparation, Infrastructure Development, and Capacity Building for Clinical Trials 6

1.2 Unlocking the Potential of Maize as New Food, Feed and Industrial Raw Material 8

1.3 Development of Culture Technologies for Increased and Sustainable Production of the Nile Perch (*Latesniloticus*) (Linnaeus, 1758) 9

1.4 Long-term Surveillance for Carcinogenic Genital Human Papilloma Virus Infections and Sexual Behaviours among Girls Who Receive an HPV Vaccine to Prevent Cervical Cancer in Nakasongola and Ibanda districts 11

1.5 Development and Application of Pozzolanic Materials in Uganda 13

1.6 Towards Understanding and Developing Varieties Resistant to Cassava Brown Steak Diseases in Uganda 15

1.7 Use of Molecular Diagnostic Methods in the Study of *Trypanosome* Infections in Post–Conflict Districts of Adjumani, Amuru and Moyo in Northern Uganda 16

1.8 Establishment of Appropriate Diagnostic Technologies for Increased Animal Production in Uganda 17

1.9 Rural Electrification in Uganda – Increasing Access to Modern Energy Types 18

WINDOW A2: EMERGING RESEARCH TEAMS **20**

2.1 Influence of Climate Change and Human-Induced Environmental Degradation on Lake Level Dynamics of Lake Victoria 21

2.2 Targeting Gene-based Markers Associated with Drought Tolerance Mechanism for Cassava (*Manihotesculenta* Crantz) Breeding.....22

2.3 Enhancing Banana Production through Biotechnology Applications: Scaling up the Production of Disease-free Tissue Culture Banana Plantlets in Uganda....23

2.4 Assessment of Antimalarial Drug Use in Mulago Referal Hospital by Febrile Patients with Negative Blood Smears.....24

2.5 Adaptive Band Width Management in Cooperative Wireless Network: Affordable and Equitable Access to Internet.....25

2.6 Increasing Access to Safe Drinking Water by Disinfection Using Solar and UV Radiation: Towards reducing Incidence of Debilitating Diarrhoeal Diseases.....26

2.7 Contributing to Basic Understanding and Management of Napier Stunt Disease in Uganda.....27

2.8 Functional Genomics of Type III Type III Secretion System (TTSS) of *Xanthomonasvasicolap.v. musacearum* 28

2.9 Development of Market-Class Beans with Durable Resistance to Multiple Pathogens.....30

2.10 Isolation and Evaluation of Local Newcastle Disease Thermostable Virus Strains for Vaccine Development 31

2.11 Benzathine penicillin Adherence for Secondary Prophylaxis among Patients affected with Rheumatic Heart Disease attending Mulago Hospital.....32

2.12 Untangling the Biology of Groundnut Rosette Virus Complex and Mechanism of Resistance to the Disease.....33

2.13 Gaining Insight into Physical, Ecological and Biological Factors Influencing Mango Fruit Fly Infestation in Uganda 34

2.14 Development of Biological Tools for Enhancing Production and Utilisation of High Quality Seed Potato 36

WINDOW B1: NEW UNDERGRADUATE SCIENCE AND ENGINEERING DEGREE PROGRAMMES 38

3.1 Enhancing Curricular Connectedness in Mathematics, Science and Technology: An In-Service Gender-Sensitive Secondary Teacher's Program 39

3.2 Creation of the Bachelor of Science in Biosystems Engineering at Gulu University....40
3.3 Establishment of a New Undergraduate Degree Programme in Textile ngineering at Busitema University....41
3.4 Creation of Bachelor of Science in Biotechnology....42

WINDOW B2: UPGRADED EXISTING UNDERGRADUATE SCIENCE AND ENGINEERING DEGREE PROGRAMMES....43

4.1 Upgrading the B.Sc Physics Program and Modernization of Physics Laboratories at Makerere University....44
4.2 Strengthening Curriculum Innovations (PBL/COBES) of the Faculty of Medicine in Makerere University....45
4.3 Strengthening and Upgrading Undergraduate Degree Programmes in Quantity Surveying, Land Economics and Construction Management....46
4.4 A Methodological Information and Communication Technologies (ICTs) Approach for Demystifying the Perception that Teaching of Mathematics and Science in Lower Secondary Education is Hard....48
4.5 Strengthening and Upgrading the Undergraduate Degree Program in Pharmacy and Pharmaceutical Sciences at Mbarara University of Science and Technology....49
4.6 Upgrading B.Sc Surveying Curriculum at Makerere University....50

WINDOW C: PRIVATE SECTOR COOPERATION....51

5.1 Participatory Research for Rural Dairy Development Using Public Private Partnership Approach....52
5.2 Status and Opportunities for Improving Rice Processing Industry in Uganda....54
5.3 High Density Culture of African Catfish, Product Development & Value Addition Technologies....55
5.4 Evaluation of Industrial and Edible Salt Processing Technology at Lake Katwe....56
5.5 Automated Cargo Route and Vehicle Management (ACRAV) Investment in Computer-Based Management for Improved Productivity and Profitability in the Transport Sector....57

5.6 Strengthening of Practical Training in Teaching in Diploma Granting Vocational and Technical Training Institutions 58

INSTITUTIONAL STRENGTHENING OF UGANDA INDUSTRIAL RESEARCH INSTITUTE (UIRI) 59

7.0 ANNEXES 61

Annex 1: The Uganda MSI Technical Committee members 61

Annex 2: Summary of MSI Projects: 2007-2010 63

ACRONYMS

ACRAV	Automated Cargo Route and Vehicle Management
AGT	Agro- Genetic Technologies Limited
ASTI	Agricultural Science and Technology Innovation
DDA	Dairy Development Authority
FAO	Food and Agricultural Organisation
IPR	Intellectual Property Rights
KORD	Kakira Out-growers Rural Development Fund
MSI	Millennium Science Initiative
MUST	Mbarara University of Science and Technology
NaCRRI	National Crops Resources Research Institute
NaFIRRI	National Fisheries Resources Research Institute
NARL	National Agricultural Research Laboratories
NARO	National Agricultural Research Organisation
NaSARRI	National Semi-Arid Resources Research Institute
NSW	National Science Week
PPP	Public Private Sector Partnerships
RHD	Rheumatic Heart Disease
SMT	Science, Mathematics and Technology
STI	Science, Technology and Innovation
TDC	Technology Development Centre
TC	Technical Committee
UIRI	Uganda Industrial Research Institute
UNCHE	Uganda National Council for Higher Education
UNCST	Uganda National Council for Science and Technology

FOREWORD

Uganda National Council for Science and Technology (UNCST) is a Government of Uganda Agency, established by Act of Parliament (Cap 209). Its parent Ministry is Ministry of Finance Planning and Economic Development. UNCST is mandated to facilitate and coordinate development and implementation of policies and strategies for integrating science, technology and innovation (STI) into the national development process.

UNCST implemented the Uganda Millennium Science Initiative (MSI) Project. It was a USD 33.35 million project co-financed by Government of Uganda and World Bank. Its aim was to support Ugandan universities and research organizations to produce more and better qualified science and engineering graduates, and undertake high quality and relevant scientific research. Private sector/industry would utilize the research results and innovations to improve productivity and enhance science and technology led growth. The MSI supported a total of 39 competitive grants in three categories: Window A, B and C. UNCST and partners demonstrated through the Uganda MSI project that it is possible to run a competitive research funding scheme in Uganda. It also demonstrated that academia-industry collaboration can be enhanced through innovative financing involving students, lecturers and industry partners. Furthermore, it showed that productivity of local scientists can be enhanced through well-structured science and research funding programs. The key challenge is to carry forward these lessons, successes and achievements of the project into the future.

This book of abstracts presents the summaries of the research projects and other programmes that benefited from the MSI. Countries, which invest in human resources, science, technology and innovation, do better in achieving prosperity and enhancing their citizens' livelihoods. Therefore, building Uganda's capabilities in science and technology is essential for moving the country towards a knowledge based society. Uganda MSI project was a catalyst for building a vibrant national system of innovation in the country and region.

We are grateful for the support of Government of Uganda and World Bank, which enabled Ugandan scientists exploit opportunities in research, training and private sector cooperation for sustainable national socio-economic development.

Dr. Peter Ndemere,
Executive Secretary
Uganda National Council for Science and Technology

INTRODUCTION

The Uganda Millennium Science Initiative (MSI) was a USD 33.35 million project co-financed by the World Bank (USD 30 m) and Government of Uganda (USD 3.35 m) between 2006 and 2013. The project's overall development objective was to support Ugandan universities and research organizations to produce more and better qualified science and engineering graduates, and to undertake high quality and relevant research. Private sector/industry would utilize the outputs to improve productivity and profitability. All of this is for the sake of enhancing a science and technology-led economic growth. The project had two major components, each with various subcomponents and activities.

Component 1 was the MSI Funding Facility, which provided competitive grants in three Windows. Window A funded research groups led by senior researchers or emerging investigators. These groups conducted relevant, high-quality scientific and technological research projects, and also trained postgraduate students at MSc and PhD levels. Window B funded the creation of new undergraduate programmes in basic science and engineering in public and licensed private universities as well as review and upgrading of existing degree programmes in basic science and engineering. Window C supported private sector cooperation through: (i) "Technology Platforms" where firms and researchers defined collaborative agenda for solving problems of direct interest to industry, and then pursue solutions collaboratively, and (ii) internships where students were attached to firms for three to nine months to enhance skills and practical experience as well as contribute to the firms' growth and competitiveness.

The MSI project supported over 250 Ugandan scientists and innovators. It trained 31 PhDs and 57 MSc in diverse disciplines in science and engineering. The project also established and/or upgraded seven undergraduate courses in science and engineering in six Ugandan universities viz: Makerere University, Busitema University, Gulu University, Mbarara University of Science and Technology, Kyambogo University and Kabale University. All together, these new or upgraded programmes would produce

over 1,000 highly qualified undergraduate science and engineering graduates in the next four years. A number of innovative research products also emerged from the projects. These included, for example, cattle feed for milk enhancement, value added cereals products, new leads in malaria vaccine development, models for monitoring climate change, banana rapid multiplication protocols, novel diagnostics tools for domestic animals and poultry, new high value construction materials, new models for scaling up access to wireless services, and crop improvement technologies. Most of these products (and intellectual assets) are ready to be incubated and scaled up for commercialization. Institutional capacities of Uganda National Council for Science and Technology and Uganda Industrial Research Institute (UIRI) were greatly enhanced to execute their respective mandates in guiding the STI agenda in Uganda. In all, 39 grants were awarded: 12 in round one (2007), 15 in round two (2008) and 12 in round three (2009).

Component 2 was institutional strengthening of UNCST and UIRI. UNCST had the overall responsibility for MSI coordination and implementation. UIRI was strengthened to facilitate partnerships with industry through rehabilitation of pilot plants and upgrading of analytical laboratory facilities. Component 2 also supported an outreach program to improve public understanding and appreciation of science and technology. The main activities were school visits that comprised: (i) a series of structured school visits by model scientists, technologists, engineers, and S&T-related entrepreneurs and (ii) annual National Science Week (NSW) programme during which various kinds of social marketing and awareness rising on science and technology issues took place. Winners of the MSI grants were announced at the end of the NSW.

The NSW targeted policy makers, S&T entrepreneurs, scientists, researchers, educationists, school children, artisans, and technology entrepreneurs, S&T professional bodies, politicians, civil society and visiting international S&T experts. The School Visits Programme (SVP) comprised structured visits by science and engineering professionals - role models (medical doctors, teachers, technologists, researchers, engineers, nutritionists and S&T entrepreneurs) to schools to share experiences, interact and inspire secondary school students to pursue careers in science, technology and engineering. School visits helped to demystify S&T by demonstrating its relevance to students' lives and well-being, raising the professional profile of local science teachers, and providing information on career opportunities in science and engineering at national, regional and international levels.

By the end of 2012, 86 secondary schools across the country had participated in the SVP, with an audience of over 70,000 secondary school students. Thirty four (34) percent of the schools were in northern Uganda, 27% in central Uganda while western and eastern regions constituted 20% and 19%, respectively. In terms of gender, the majority (58%) of the schools were mixed boys and girls, 26% were girl only schools and 16% were boys only schools. Fifty five (55) percent of the schools visited were public schools, 36% were private while the rest were community schools. Over 30 scientists and engineers who served as role models were given orientation through seminars and thereby facilitated to visit the schools. They were accompanied by UNCST staff. Role models were drawn from public and private universities, research organizations, and public agencies such as Parliament of Uganda, universities (Islamic University in Uganda, Mbarara University of Science and Technology, Makerere University, Gulu University, Nkumba University), National Crop Resources Research Institute, Ministry of Education and Sports, Uganda National Commission for UNESCO, School Net Project, Uganda National Bureau of Standards, Uganda Virus Research Institute, Civil Aviation Authority and National Animal Genetics Research Institute. Other role models were selected from private sector institutions such as Uganda Clays Limited and Uganda Cargo Handling Services.

Monitoring and evaluation of both the MSI's specific goals, and overall progress in the S&T within country was undertaken in Component 2. The MSI project has been acclaimed as very successful in terms of relevance, effectiveness, efficiency and impact as revealed by the World Bank supervision missions, country portfolio review reports and independent review of the project. The Technical Committee (TC) and peer reviewers rated highly the scientific results of the research projects funded under MSI. Positive feedbacks were received from stakeholders during dissemination workshops, scientific conferences, policy dialogues and project meetings. MSI increased the profile of S&T in Uganda, arguably leading to inclusion of science, technology and innovation as a separate chapter in Uganda's National Development Plan 2010-2015.

Furthermore, MSI supported policy studies on the STI system. It also provided a platform for regular engagement between scientists, researchers and policy makers through policy dialogues. It also facilitated formulation of the national STI policy (2009). Other related sector policies have been formulated and adopted with the support of MSI and using data generated by the project. In many respects, MSI has been a trailblazer and catalyst for future efforts towards STI financing especially with

regard to the competitive research grants. The project has generated world-class scientific breakthroughs with potential for progression into industrial products and applications that will improve Uganda's STI capability and economic outcomes in the medium and long term. However, sustained efforts are needed to ensure that the MSI project outputs 'roll out' of the universities and research institutes into the market place.

This book of abstracts presents the summaries of the research projects and other programmes that benefited from the MSI. Its purpose is to share key results and achievements so far of the Uganda MSI project.

WINDOW A1: SENIOR RESEARCH TEAMS

1.1 Malaria Vaccine Studies in Uganda: Site Preparation, Infrastructure Development, and Capacity Building for Clinical Trials

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The major goal of the project was four-fold: (a) to upgrade the field laboratory in Apac District (b) to gather baseline data on malaria in preparation for future malaria vaccine clinical trials (c) to design and test novel malaria vaccine constructs in animals and (d) to build human capacity in malaria vaccine studies. Field laboratory in Apac district was ill-equipped and only served as a collection centre for field samples which were transported to Kampala. Under the MSI support, various types of laboratory equipment were procured, a generator (back-up power) and VSAT (internet). This upgrade effectively transformed the laboratory into a fully functional unit capable of supporting world-class malaria research and clinical trials. In order to establish baseline malaria transmission data in Apac District, over 700 homes were mapped using GPS, four cross-sectional studies were carried out, and over 500 study subjects aged one to 65 years old followed up for malaria episodes in a longitudinal study. The study provided vital information about malaria prevalence, incidence, and clinical definition, and confirmed the high intensity of malaria transmission in the district. Current malaria sub-unit vaccines have two major limitations: poor immunogenicity and short-lived immunity. With a view to overcome these shortcomings, the following were designed: malaria plasmid DNA vaccines which encoded T cell epitopes from Bacillus Calmette–Guérin (BCG) and tetanus toxoid (TT), 39 amino acids from Plasmodium falciparum SERA5 vaccine candidate, and a human chemokine (RANTES or CCL20). Mice immunized with the SERA5/RANTES plasmid showed increased T cell responses and controlled parasitemias after challenge infections while mice immunized with the SERA5/CCL20 plasmid survived longer after challenge infections. Baboons immunized with the plasmids had three-fold lower peak parasitemias when challenged. These data show that the vaccine constructs are promising and should be

developed further. Finally, with regard to capacity building, five students training in various aspects of malaria immunology and vaccinology were registered at Makerere University (Betty Mawagali, Sylvia Kiconco, Connie Agwang) and Nairobi Universities (Ruth Mumo, Wycliffe Onkoba) resulting in five MSc degree awards. In conclusion, this project achieved all four goals and has demonstrated that with some support a home-grown Ugandan malaria vaccine can be developed.

1.2 Unlocking the Potential of Maize as New Food, Feed and Industrial Raw Material

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Maize and sorghum are staple cereals in Uganda but are consumed predominantly as primary commodities with little value addition. Consequently, these crops yield low remunerability in the economy of Uganda. In the developed and emerging economies, a wide array of foods, feeds and industrial products are obtained from these two crops. The value of maize and sorghum can also be increased in Uganda if key technical and socio-economic debilitating factors are addressed. This would have a multiplier effect of not only improving food security but also incomes and overall livelihoods of the population. This project was designed to undertake pluralistic value-chain based research for development (R4D) to generate novel sorghum and maize based products and innovations. The overall goal was to contribute to strengthening capacity ofUganda's Agricultural Science and Technology Innovation (ASTI) systems to develop novel technologies and processes that strengthen livelihood strategies of Ugandans. Specialised sorghum and maize-based technologies were developed with a view to expanding market opportunities, reducing food and nutrition insecurity and sustainably using natural resources for production.The project also developed genetic resources which are being used to breed sorghum and maize. New varieties of sorghum are under release process as a result. The project also trained 2 PhDs, and five MSC all of whom have defended their thesis. These young scientists along with the infrastructure developed at MUARIK are contributing to Uganda's ASTI.

1.3 Development of Culture Technologies for Increased and Sustainable Production of the Nile Perch (Latesniloticus) (Linnaeus, 1758)

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Nile perch (*Latesniloticus*) is a large freshwater fish and a major contributor to the national fish catch in Uganda. The demand for the fish to meet the local, regional and international needs surpasses the supply from the wild due to increasing human population. The declining trend in the population of Nile perch if not reversed is likely to result in severe socio-economic hardships. The aim of this project was to generate information for culture of Nile perch. Data were collected using various methods including review of documents, field observations, molecular genetics, morphometry, histology, histochemistry, Enzyme Linked Immunosorbent Assay (ELISA), gas chromatography/mass spectrometry, scanning and transmission microscopy to study various aspects of the genetics, reproduction, digestive and nutrition systems of Nile perch. Nile perch populations were found to have high genetic diversity with two morphs. The species, though found in freshwater environment, resembled marine fishes in physiology as exhibited by the pelagic eggs with long hatching period and high levels of Polyunsaturated Fatty Acids (PUFA). Further investigations of the relationship between Nile perch and other teleosts, through cloning of the gonadotrophin sub units (GTH –α, FSH-β and LH-β) indicated that the species is phylogenetically related to the Epinephelus species at all the gonadotrophin sub units. No sex change previously hypothesized was observed through histological examination of the gonads. From histological observation and profiles of Estradiol coupled with capture of the running females, it was deduced that Nile perch is a protracted batch spawner, with a unimodal spawning peak in contracts to the bimodal rainfall pattern in Uganda. Although

ovulated eggs did not hatch, they exhibited embryo development similar to that reported in marine species. Intestinal brush border enzyme activities showed specific enzyme activity of leucine amino peptidase (LAP) and maltase that was significantly higher ($P< 0.05$) in the upper intestine. Furthermore, there was a significantly higher activity ($P< 0.05$) of γ-glutamyltransferase (γ-GT) in the lower intestine indicating respective roles in protein and carbohydrate degradation and assimilation. Embryonic development observed was an indication that the eggs can hatch followed by development of appropriate feed.

1.4 Long-term Surveillance for Carcinogenic Genital Human Papilloma Virus Infections and Sexual Behaviours among Girls Who Receive an HPV Vaccine to Prevent Cervical Cancer in Nakasongola and Ibanda districts

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Vaccines to prevent certain types of human Papilloma virus (HPV) and associated cancers are recommended for routine use among young women. Nationally, representative reports of vaccine uptake have not explored the relationship between HPV vaccine initiation and various sexual behaviors. Reduction of cervical cancer morbidity/mortality relies on prevention and early detection of human Papilloma virus (HPV). This study examined sexual behavior of vaccinated girls against HPV, fears related to sexual life among vaccinated girls against HPV vaccination, and the relationship between knowledge of HPV vaccine and girls' sexual behaviors. Theory of Reasoned Action (TRA) was used as the theoretical framework for this study. The theory proposes that attitudes about protective action, perceptions of what others would think about this (subjective norms), and behavioral control would be important predictors of sexual behavior. A cross-sectional survey of a random sample (n=768) was used to study sexual behaviours of both vaccinated and non-vaccinated girls (12-18 years) against HPV in Ibanda and Mbarara district (Rwampara county), Uganda. Multistage sampling was used to select schools and within each school random sampling was used to identify girls. Results showed that there was no difference in sexual behaviours of vaccinated girls and non-vaccinated girls. In the sample, 25 girls were already sexually active and not using condom. Vaccinated girls indicated that they would recommend the vaccine to colleagues while the non-vaccinated girls said they were willing to take the vaccine if offered without a cost. The girls in both groups reported that HPV vaccine cannot make someone sexually active or promote sexual activity but a significant proportion of non-vaccinated girls did not know if it did or did not perhaps because they had no knowledge of HPV vaccine.The findings suggest that there is no difference in sexual behaviours of vaccinated and non-vaccinated girls against HPV infection. Knowledge about HPV vaccine was not related to girls' sexual behaviours. These findings should be used to carry out future health care education and

implementation of HPV vaccine in Uganda. Furthermore, there is a need to educate girls about sexual and reproductive health issues to help them understand the dangers of sexually transmitted infections especially HPV. Programmes to improve adolescent sexual and reproductive health should include dimensions of parental involvement that would strengthen the programme's specific behavior change goals.

1.5 Development and Application of Pozzolanic Materials in Uganda

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Within the foreseeable future, rapid growth in construction activity is expected to increase in the region. This is due to the convergence of four major factors, namely: rapid human population increase, high rural-urban migration, rising and changing standards of living, high economic and industrial growth rates. However, these trends are expected to impact significantly on the natural resource base of the country. While Uganda is endowed with large deposits of pozzolanic materials of volcanic origin found in eastern, western and southwestern parts of the country, their exploitation and use remain limited. A pozzolan is a natural or artificial material that predominantly contains amorphous silica. Natural pozzolans in the form of tuffs, rocks and solidified volcanic ash occur naturally in some parts of Uganda. Its principal use is to replace a *proportion* of cement and/or lime. It can also be used directly with certain carbonate bearing soils for soil stabilization. The research focused on high level scientific and technological approach in the identification, sustainable exploitation, efficient small-scale manufacture, and economic use of pozzolanic materials. Findings confirm the location and new mapping of major deposits. In addition, it has been established that deposits contain high quantities of amorphous silica, indicating high reactivity. Laboratory tests such as the determination of mineralogical, petrological, pozzolanicity, chemical and physical properties were successfully conducted in specialized laboratories in the region. Findings confirm significant deposits of high grade pozzolans being abundant in the south, west and eastern regions of Uganda. Furthermore, mass production sites for exploitation of pozzolanic materials can be cheap to establish, as they rely mainly on the use of local resources found on site. It was experimentally established through mix trials that as little as 5-10% replacement of cement with a pozzolan resulted in significant improvement in chemical stabilization. At the other extreme, amounts in excess of 30% had the opposite effect. Proportions with lime reached up to 40%. The use of pozzolanic materials increased the strength of concrete fourfold. As well

as durability. Direct mixing with selected soils could also result in soil stabilization. We found that existing production units were owned communally, individually, or by loose groupings of local people. Current practice and production methods were found to be inefficient in terms of utilization of labour, raw materials and transportation. Lack of literature and knowledge about the extraction and use of pozzolanic materials in the country which hitherto had been a major drawback, has now been redressed largely through literature sourced and contributed by training of PhD and M.Sc. students. The overall conclusion is that the pozzolanna research was successful, and will make a significant contribution to the economic development and environmental conservation goals of the country.

1.6 Towards Understanding and Developing Varieties Resistant to Cassava Brown Steak Diseases in Uganda

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The aim of the project was to increase understanding of CBSD and devise appropriate control and management strategies for the disease. The aim was achieved through collaboration between NaCRRI, DDPSC and UoH made up of a functional team of scientists and graduate students. Makerere University trained the students. The key technical outputs from the project included (i) confirmation and mapping of the distribution of the two viruses, UCBSV and CBSV in Uganda (ii) identification of new sources of resistance to CBSD (CR-20A-1, NASE1, MM96/4271, TZ/06/130, TZ/06/140, N3/58/1, N3/363/15) (iii) development of a novel heterogeneous base population for further mainstream breeding and (iv) first evidence that RNAi approach can confer resistance to CBSD in *N. benthamiana*and cassava (Cv. 60444). This was the first major attempt to carry out a systematic investigation on CBSD in the 21st Century. Beyond the technical elements, the project supported the construction of a biosafety level II screen house and procuredvarious laboratory equipment and supplies. The project has strengthened biosciences at NaCRRI that has become one of the national reference laboratories for agricultural biotechnology research in Uganda and beyond. Three junior scientists were trained at PhD and two at MSc levels. Three papers from the students theses were published in peer review journals and 10 articles were expected to be published by 2012. In summary, the project broadened NaCRRI's partnership horizon and increased the institute's competence in CBSD research and its competitiveness for other research grants.

1.7 Use of Molecular Diagnostic Methods in the Study of Trypanosome Infections in Post–Conflict Districts of Adjumani, Amuru and Moyo in Northern Uganda

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Tsetse flies and the trypanosomes they transmit continue to contribute enormously to the economic and social backwardness in tropical Africa. Over 60 million people are at risk of contracting sleeping sickness and hundreds of thousands of livestock are lost annually. The control of trypanosomaisis in both animals and humans is difficult, partly because of low sensitivity of the routine parasitological techniques used to diagnose the disease. *Trypanosome* parasites of *brucei* sub-species are morphologically indistinguishable but vary in pathological and clinical outcome, thus complicating the transmission dynamics and anthropo-zoononic potential of these trypanosomes. The objectives of this research were to (1) establish the epidemiology of animal and human trypanomaisis in northern districts of Uganda using molecular tools (2) characterize socio-economic and livelihood patterns of internally displaced returnees and (3) establish a diagnostic laboratory and develop appropriate human capacity to support research. A laboratory was refurbished at Gulu University to the level suitable for undertaking molecular diagnostics. Four PhD and three MSc students were registered with Gulu University under the project. A total of 3,565 people were screened and the mean prevalence for all ages combined was 1.54% by CATT test. Out of 2,752 animals screened the prevalence ranged between 7.8% and 8.7% with *T. vivax* predominating. The overall infection rate in tsetse was 19.11% with *T. vivax* also predominating. The socio-economic status of the returning communities appeared to be improving in regards to food availability, but not the provision of other non-food necessities of life. Therefore, socio-economic support to the local communities by various stakeholders is recommended. Tsetse and trypanosomaisis is prevalent in the area and strategies for control should be developed. Further analysis of samples is on-going.

1.8 Establishment of Appropriate Diagnostic Technologies for Increased Animal Production in Uganda

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The aim of the project was to develop diagnostic technologies that would enable accurate and quick diagnosis of African Swine Fever (ASF) and paratuberculosis (PTB) in Uganda with a view to aiding the control of the diseases and thus contributing to improvement of livestock production in the country. The proposed diagnostic technologies were based on antigen-antibody detection system for ASF and loop mediated isothermal amplification for ASF and PTB. This research was in line with the Millennium Science Initiative (MSI) goal of enhancing human resource and infrastructural capacity to address problems of the country. African swine fever is a devastating disease of pigs and is highly prevalent in Uganda. The only method of control is early detection and institution of various biosafety measures such as quarantine. Unfortunately, there is limited infrastructural and technical capacity for diagnosis. Paratuberculosis is an emerging disease in Ugandan cattle. Because of the insidious nature of the disease and the way it is spread, establishment of a quick and reliable method of diagnosis which could enable timely intervention and control is needed. The objectives of the study were to (i) isolate and characterize the strains of ASF occurring and produce antibodies and antigens from local strains of ASF and use it to develop card agglutination test, immuno strips, and ELISA (ii) develop and establish LAMP as a diagnostic technology for effective diagnosis of ASF and Paratuberculosis (iii) train human resource at the district level in sample collection and basic diagnostic technologies.Data were collected using field sample collection, ASF virus isolation, culture of *M. paratuberculosis*, PCR on blood and tissue samples, isolation of specific antigens and production of antibodies, ELISA, histopathology, immunohistochemistry and Loop mediated isothermal amplification on ASFV. ASF virus strains from different parts of Uganda were isolated and characterized. Additional work focused on LAMP procedures on ASF and PTB and evaluation of putative peptides, antigens, antibodies of ASFV. The outputs and outcomes of this project included (1) four papers being considered for publication (2) two PhD and three M.Sc. students trained under this project (3) refurbishment of one laboratory and (4) an animal house. The diagnostic technologies developed from this shall be for diagnosis of other livestock diseases.

1.9 Rural Electrification in Uganda – Increasing Access to Modern Energy Types

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This research examined four technologies related to renewable energy namely: biogas, small hydropower, gasification of solid biomass and solar energy. The technologies offered great potential to supply electricity to rural areas in Uganda and thus unlock the untapped potential of business in these areas currently plagued with poverty. **Biogas:** In rural areas of Uganda, households keep one to three cows normally to provide milk for domestic consumption. Wastes from the cows are usually not utilized. Inexpensive bio-digesters can be constructed to transform the cow dung into biogas which can be used for cooking and lighting purposes thus reducing the costs and reliance on firewood, charcoal and paraffin as sources of energy. We examined various types of feed for the bio-digester for electricity production at a field laboratory site in Mpigi district. An economic analysis was also carried out.

Small hydropower: Uganda is endowed with many small rivers and streams which flow all year round. The rivers and streams, no matter how small can provide electricity via the installation of small hydropower stations which costs no more than a few thousand of dollars. The stations can provide hydro power for 50 to 100 households. The technology for designing, fabricating and installing these small engines is not yet available in Uganda though it is quite common in countries such as Vietnam, China, Bangladesh and others. A study of control techniques for induction generators with 3kW Pico hydro site in western Uganda has been undertaken. Features such as control techniques, voltage, frequency, dynamic load performance, transients time for load changes, excitation and reactive power reductions of these small power stations are under consideration. As it was done with the biogas, the economic aspect of this applied research for boosting a tourism business was also taken into consideration.

Gasification: The conversion of solid biomass into syn-gas through incomplete combustion is commonly known as gasification. It takes advantage of a number of agricultural residues available in many up-country trading centres such as coffee

husks, saw dust, rice husks and others that can be converted into gas which in turn can be used to power gas turbines to produce electricity and heat. There are no companies in Uganda involved in commercialization of gasifiers thus, this research entered into a partnership with a company called Pamoja to install three small gasification units, one in a laboratory environment in Makerere University and two in a rural set up where the energy harnessed can be used to power income generating activities and serving the community. Finally, the research dealt with Solar Energy in two aspects: the provision of a energy kiosk set up in a village called Kabanga in Mukono district and the provision of a small grid connecting ten households in another village called Nakasengere in Kiboga district.

WINDOW A2: EMERGING RESEARCH TEAMS

2.1 Influence of Climate Change and Human-Induced Environmental Degradation on Lake Level Dynamics of Lake Victoria

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This project established the relationship between climate variability, human-induced environmental degradation and the dynamics of water levels of Lake Victoria and the implication of these changes on human health and socio-economic status of the riparian populations. A multi disciplinary and multi-proxy approach was applied to provide baseline information on the dynamics of the lake and the implications on livelihoods and future management of the ecosystem. Documentary, historical and sedimentary records were obtained from key study sites located at Kagera, Katonga and the outlet of River Nile at Jinja. Results indicate significant changes in sedimentary composition of organic and inorganic materials, suggesting that environmental and anthropogenic factors have influenced the deposition process in the Lake Victoria basin. The onset of sediment accumulation appears to have been driven by erosion processes, as it largely comprises inorganic material, mainly clay particles from the surrounding catchments, suggesting a period of increased runoff from the lake catchments. Pollen and phytolith records indicate a period of relatively humid climatic conditions during the last ca. 10,000 yr. BP, during which vegetation in the lake catchments was characterized by mixed medium altitude evergreen and semi-deciduous forest. However, abrupt decline in forested vegetation occurred around ca. 4000 yr. BP and ca. 3500 yr. BP as a result of reduced moisture conditions experienced in most parts of the region, followed by a return to moist and humid environmental conditions in the lake region after ca. 3500 yr. BP, reaching a climax at ca. 1200 yr. BP. The early part of the second millennium AD (cal 975-1155 AD) has been marked by significant decline in forest vegetation, which commenced around ca. 1000 yr. BP. Meanwhile, there has been fluctuation in rainfall in the region since 1896 and drastic decline in Lake Victoria water level from 2004 to 2005.This coincided with high out flow from the lake during this period, suggesting that more water was lost probably due to generation of hydro power from Kiira and Nalubaale power stations. Therefore, there is a need for appropriate management of the lake ecosystem as a result of its sensitivity

2.2 Targeting Gene-based Markers Associated with Drought Tolerance Mechanism for Cassava (ManihotesculentaCrantz) Breeding

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The ability of cassava (*Manihotesculenta*Crantz) to withstand drought stress has been recognized for decades. Breeding for drought tolerance in cassava is currently difficult due to high genotype by environment (GXE) interaction, the heterozygous nature of the crop, its long growth cycle, poor knowledge of the crop's diversity and the complexity of the control mechanisms of the trait. As such, little has been achieved through conventional breeding methods but advances in plant biotechnology provide new opportunities for efficient breeding. The development of gene-based markers relating to drought tolerance will enhance the improvement of cassava for production in semi-arid areas. This project characterized local cassava germplasm for drought tolerance, consolidated all publicly available Expressed Sequence Tags (ESTs) and developed Single Nucleotide Polymorphisms (SNPs) linked to drought tolerance in cassava. It also contributed to both human and infrastructural capacity building.

2.3 Enhancing Banana Production through Biotechnology Applications: Scaling up the Production of Disease-free Tissue Culture Banana Plantlets in Uganda

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Bananas are a very important crop in Uganda for food and income security. However, in the last decade the country has witnessed a declining trend in banana production and increasing demand for healthy planting material. The common farmer practice of using suckers from gardens infected with the various pests and diseases has also played a big role in their spread from one plantation to another and thus a decline in banana productivity. The MSI Banana Tissue Culture Project was launched at Makerere University in 2008 with the aim of contributing to food security, income generation and livelihood improvement through scaling up the production of disease free tissue culture (TC) banana planting material in Uganda. The project was implemented as a research for development project involving graduate student research and training, and adaptive research with a private company, Agro-Genetic Technologies Ltd (AGT). The key output areas included to i) an elite banana mother garden was established at Makerere University Plant Tissue Culture Laboratory (MAKTC LAB, Kabanyolo, ii) optimised protocols for rapid *in vitro* multiplication of farmer-preferred banana cultivars, iii) protocol for enhanced somatic embryogenesis in recalcitrant East African Highland Bananas, iv) optimized molecular protocol for indexing banana plants for viruses and status of banana viruses in Uganda, and v) enhanced human capacity through training graduate students (2 MSc and 1 PhD) in modern biotechnology, and infrastructural capacity for plant disease diagnostics and in vitro micropropagation. MAKTC LAB also acquired equipment and repaired some existing ones. Human capacity at AGT was enhanced through hands-on training of technicians and sharing of virus indexing skills and knowledge. Knowledge in production management of TC banana was disseminated to farmers through demonstration gardens in collaboration with AGT. Production capacity at MAKTC LAB improved from 6,000 (in 2009) to 120,000 TC plantlets per year. Six scientific papers have been generated from this project, and this is expected to guide future biotechnology driven banana industry in Uganda.

2.4 Assessment of Antimalarial Drug Use in Mulago Referal Hospital by Febrile Patients with Negative Blood Smears

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Although World Health Organisation recommends confirmatory diagnosis of all suspected malaria cases prior to treatment, in some areas of moderate/high malaria transmission, children under five years of age with suspected malaria continue to receive antimalarial treatment. Adherence of health workers to microscopy results has been poor in Uganda, due to insufficient evidence to recommend withholding treatment on the basis of negative parasitological results hence the perceived risks of a missed diagnosis outweighing all other risks. The aim of the study was to assess the risks of withholding antimalarials in children who have a negative blood smear result and to provide evidence for the safety of withholding antimalarials in these children. The specific objectives were to (1) investigate the costs, risks and benefits of giving antimalarial treatment only when confirmed by microscopy in patients presenting to Mulago Hospital (2) assess the quality of microscopy and (3) compare the sensitivity and specificity of RDTs to that of microscopy. Prospective cohort study was undertaken to assess the health outcomes of children that were managed according to microscopy results. Eligible children that were aged from one to 10 years were enrolled and followed up for two weeks. In addition, the sensitivity and specificity of RDT results was determined using expert microscopy as the gold standard. Overall 880 patients were screened. We excluded 150 patients who did not meet the inclusion criteria and recruited 730 patients. Five patients were lost during the follow up (three withdrew their consents due to difficulty in coming for follow-up, one developed infective diarrhoea (dysentery) on day 7 and on receiving treatment requested to be released from study follow up visits, one patient was assaulted on day 7 and developed severe head injury and died. No patient developed complicated/severe malaria and four patients developed uncomplicated malaria (diagnosed with uncomplicated malaria before day 14). The HRP2 based RDTs had a 91.2% sensitivity and 77.4% specificity of RDT. A negative predictive value of 95.3% and a positive predictive value of 70% were observed. In order to confirm whether febrile illnesses were possibly due to missed parasitemia, the risk of being diagnosed with malaria was assessed over the subsequent 14 days. There were no deaths during thestudy and no episodes of severe malaria based on standardized WHO criteria.

2.5 Adaptive Band Width Management in Cooperative Wireless Network: Affordable and Equitable Access to Internet

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Given the limited fixed line telecommunication infrastructure, wireless technologies have emerged as the boon to addressing Uganda's connectivity needs. However, worldwide, it is found that current licensing regimes for managing scarce bandwidth are not optimal. One solution to improve the utilisation of the radio spectrum is the concept of cognitive radios (CR). Cognitive radios are defined by the basic idea to periodically monitor the radio spectrum, intelligently detect occupancy in the spectrum, and opportunistically communicate in "free spaces" with minimal interference to the active licensed users. The MSI-supported research was designed to address the issue of affordable and equitable access to the Internet through developing adaptive bandwidth management techniques to enable efficient use of bandwidth at each of the telecentre-based wireless networks associated with CWRC (e.g. among telecentre and partners in and through investigating use of cognitive radio techniques to obtain the best available spectrum to meet user communication requirements in order to support the development of sustainable cooperative/community wireless networks – which are a last mile solution to facilitate access to accurate and timely information. Over three years, adaptive bandwidth management and cognitive radio techniques were reviewed, simulated and tested by fifteen undergraduate and three graduate students. Testing included lab simulations and testing with spectrum and network analyzer equipment sourced under the MSI project. Two of the graduate students also conducted research under well-established programs at the Broadband and Wireless Multimedia Communications (BWMC) Lab at the University of Pretoria, South Africa, and the Meraka Institute – the African Advanced Institute for Information and Communications Technology based at the Council for Scientific and Industrial Research (CSIR) in Pretoria, South Africa. In summary, the research project built capacity in wireless technologies through supervision, mentoring and training of both graduate and undergraduate students. The next steps is for field testing of the techniques developed in order to gain a further understanding of how to leverage the technologies for sustainable community wireless networks in Uganda.

2.6 Increasing Access to Safe Drinking Water by Disinfection Using Solar and UV Radiation: Towards reducing Incidence of Debilitating Diarrhoeal Diseases

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Solar radiation disinfection (SODIS) water treatment process involves filling transparent polyethylene terephthalate (PET) plastic bottles with water for drinking, and exposing the bottles to full sunlight for at least five hours for bacterial cell inactivation, and at least 10 hours to inactivate cysts. SODIS relies on the germicidal ultraviolet radiation of sunlight, and the thermal infrared radiation of the solar energy to heat the water. Studies have shown that SODIS achieves >99% reduction of the inoculated faecal contamination indicator organisms (thermotolerant coliforms) within six hours of exposure to sunlight in transparent PET plastic bottles. The technology was well received by participating households after sensitization and demonstration during the study. The importance of maintaining a safe water chain within the household to avoid contamination after disinfection was observed. Preliminary findings agree with those reported from other countries and suggest that wider use of solar disinfection in rural and peri-urban communities in Uganda merits further exploration and promotion. Further research will build on this work and provide the scientific elaborations for sustainable and affordable safe drinking water supply at household level in rural and peri-urban Ugandan communities using solar disinfection.

2.7 Contributing to Basic Understanding and Management of Napier Stunt Disease in Uganda

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Napier grass (*Pennisetumpurpureum*), also known as elephant grass, is threatened by the recent emergence of an epidemic of Napier grass stunt disease (NSD) in Uganda, caused by a phytoplasma. The disease was first reported in Uganda in Masaka district in 2001, and rapidly spread to 15 districts by 2007. It causes severe stunting and reduction of fodder yield and availability. This constituted direct threat to smallholder dairy industry in Uganda, which greatly relied on elephant grass as a source of feed. The biology of the phytoplasma(s), nature if its transmission and spread of NSD, and effects on productivity of Napier grass in Uganda are not yet well understood. The aim of the project was to provide knowledge on NSD and options for its management. Field experiments were conducted to determine the (i) epidemiology, resistance/ tolerance of Napier grass cultivars to NSD and alternative hosts and (ii) effects of NSD on growth and productivity of Napier in Uganda. Experiments were conducted in NaCRRI (Namulonge), NaLIRRI (Tororo), BugiZARDI (Sironko) and Kamenyamigo DATIC (Masaka). Studies were also carried out on the vector(s) and transmission of Napier stunt phytoplasma in the screenhouse at Namulonge. Laboratory experiments were conducted at NaCRRI and Aarhus University in Denmark to chracaterize and determine the genetic diversity of the NSD phytoplasma. Experiments have also been carried out on the effect of NSD on the nutritive value of Napier grass. One PhD and 2 M.Sc. students were trained in the project.

2.8 Functional Genomics of Type III Type III Secretion System (TTSS) of *Xanthomonasvasicolap.v. musacearum*

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Banana xanthomonas wilt (BXW) disease is currently the most damaging disease of bananas causing severe yield losses in East and Central African region. The disease is caused by *Xanthomonasvasicolapv.musacearum* (Xvm) leading to characteristic symptoms of wilting and death of infected plants. The pathogen also induces a hypersensitive response on non-host maize plants. Efforts to understand the pathogen are underway in order to come up with management strategies. There is evidence that genome of the pathogen was sequenced and revealed several virulence factors including the type III secretion system effectors (T3SEs), the major pathogenicity factors in *Xanthomonas spp*. The objective of the project was to identify and characterize putative genes and their promoters that are responsible for induction pathogenicity in banana and hypersensitivity in maize. Genomewide analysis of *Xanthomonascampestris*pv. *Musacearum*(Xcm), *Xanthomonasvasicolapv. Vasculorum*(Xvv) and *Xanthomonas*sp strains was carried out and the distribution of selected virulence factors among strains of Xcm, Xsp. and Xvv (T3SS effectors, lipopolysaccharides and type four pili) established. Using the Illumina GA2x sequencing platform we generated genome-wide sequence data for 13 isolates of *Xcm* available from the National Collection of Plant Pathogenic Bacteria (NCPPB). All raw sequence data were submitted to the Sequence Read Archive. Up to the time of carrying out this project, little was known about sequence diversity among isolates. A set of genes that were conserved in the sequenced isolates of Xcmwas identified and these were absent in the sequenced isolates of Xvv. Efforts were made to differentiate between Xcm and Xvv on the basis of which a candidate for use in an *Xcm*-specific PCR assay was obtained. By aligning

sequence reads against the previously published NCPPB4381 genome assembly and systematically comparing gene-coverage in each of the alignments, a genomic region (GenBank: GG699410.1) that showed differential coverage among isolates of Xcm was identified.This information was instrumental in understanding the pathosystem of *Xanthomonas* and banana and formed the basis for developing resistance against the disease.

2.9 Development of Market-Class Beans with Durable Resistance to Multiple Pathogens

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Bean anthracnose and root rot are the two most constraining diseases to bean production in Uganda and the only economic way to overcome this, is to breed for resistance to these two diseases simultaneously. The aim of the project was to generate knowledge on bean anthracnose and bean root rot diseases and to develop market-class bean genotypes with dual resistance to both diseases so as to improve food security and decrease the economic impact of the diseases on bean production in Uganda. Field surveys were carried out in the main bean agro-ecologies of Uganda. The causal pathogens of bean anthracnose and root rot were collected, isolated and characterized both genotypically and pathogenically. Two parents with different anthracnose resistance genes and one parent with root rot resistance genes were used in a gene pyramiding scheme to generate candidate genotypes with dual resistance to both diseases. We found that 27 races of *Colletotrichumlindemuthianum* were causal pathogens of bean anthracnose disease in the surveyed districts. Two races 4095 and 2479 not previously reported in Uganda were the most diverse. These two races broke down the resistance in cultivar G2333 (one of the most resistant). This raised a serious concern to the bean breeding community in Uganda. It has also been found that pathogen *Pythiumvexan* is responsible for bean root rot disease in central Uganda. The project's outputs included (i) a map of Uganda showing the prevalence of bean anthracnose and bean root rot (ii) 206 new candidate bean lines pyramided with either two or three anthracnose resistant genes and one root rot resistant gene.These were forwarded to the bean breeding programme for further evaluation and eventual release as new varieties (iii) gene sequences of the Internal Transcribed Spacer (ITS) region of the collected pythium isolates (iv) an update report on the pathogenic and virulence diversity of *Colletotrichumlindemuthianum* in Uganda (v) One PhD and two M.Sc. students were trained in this project and (vii) Four manuscripts were prepared and two have been published in journals.

2.10 Isolation and Evaluation of Local Newcastle Disease Thermostable Virus Strains for Vaccine Development

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Newcastle disease (ND) is the principal disease limiting rural poultry production in low-income food-deficit countries where poultry has a great potential to reduce poverty in line with national development agenda. The objectives of this project was to (i) isolate and evaluate thermostable Newcastle Disease Virus (NDV) strains for selection of vaccine candidates and (ii) create capacity for seed vaccine production for local industrial production that can serve the smallholder poultry farmer. A total of 2,070 samples were collected (1,223 from domestic poultry and 847 from waterfowl) across the country. All the samples were inoculated into 9-day embryonated chicken eggs for isolation of NDV. In total, 186 ND viruses confirmed by heamgglutination inhibition (HI) were isolated and several isolates characterised through a number of methods for selection of non-virulent thermostable vaccine candidates. The cleavage site of the fusion protein of 112 isolates (78 from domestic poultry and 34 from waterfowl) were sequenced to determine their virulence. The thermostability, MDT and ICPI data for 87, 131, 32 respectively were obtained. Data on F protein cleavage site sequences, thermostability, MDT and ICPI are available for 32 isolates. From the data 4 isolates were confirmed as non-virulent by all the three methods and confirmed to be thermostable and meet the criteria for further assessment in immunological and immunoprotection studies. More isolates shall be characterized. Should the selected strains generate protective antibodies capable of protecting against virulent challenge, then the overall goal of identifying potential vaccine candidates will have been achieved. Three students (1PhD and two Master students) were trained by the project.

2.11 *Benzathine penicillin* Adherence for Secondary Prophylaxis among Patients affected with Rheumatic Heart Disease attending Mulago Hospital

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Rheumatic Heart Disease (RHD) frequently occurs following recurrent episodes of acute rheumatic fever (ARF). *Benzathine penicillin* (Benzapen) is the most efficacious method for secondary prophylaxis against ARF whose efficacy largely depends on adherence to treatment. Various factors determine adherence to therapy yet there are no data on current use of Benzapen in patients with RHD attending Mulago Hospital. The objectives of the study were to (1) determine the levels of adherence with Benzapen prophylaxis among Rheumatic Heart Disease patients and (2) identify patient factors associated with adherence or non-adherence with Benzapen prophylaxis among RHD patients. A longitudinal observational study was undertaken in Mulago Hospital cardiac clinics over a period of 10 months. Ninety five consecutive patients who met the inclusion criteria were recruited over a period of 4 months, and followed up for six months. Data on demographic characteristics and disease status were collected using a questionnaire and a card to document the Benzapen injections received. Most participants were females (78.9%). The age range was five to 55years, with a mean of 28.1 years (SD±12.2) and median of 28 years. The highest education level was primary school for most patients (46.3%) while 8.4% were illiterate. Most of the patients (41.1%) were either NYHA classification II or III (33.7%). Fifty four percent of the patients adhered to the monthly Benzapen prophylaxis with adherence rates ≥ 80% while 46% were classified as non-adherent to the monthly Benzapen with rates less than 80%. The mean adherence level was 70.12% (SD±29.25; median= 83.30%; range= 0-100%). Thirrty three percent of the patients had extremely poor adherence levels of ≤ 60%. Higher education status and residence near health facility favored high adherence while painful injection was a major reason among poor performers. The level of non-adherence was significantly high (46%). Residence in a town/city and attainment of secondary education was associated with better adherence while the painful nature of the Benzapen injections and lack of transport money to travel to the health center were the main reasons for non-adherence among RHD patients in Mulago Hospital.

2.12 Untangling the Biology of Groundnut Rosette Virus Complex and Mechanism ofResistance to the Disease

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The goal of the project was to contribute towards increased groundnut production in Uganda by generating knowledge on the groundnut rosette disease and development of appropriate sustainable disease management strategies. The project was collaborative and implemented in partnership with Makerere University and University of Georgia in USA. The key outputs included (i) mapping the distribution of both yellow and green rosette in Uganda (ii) identification and verification of the critical cultural practices in rosette management (iii) identification of new sources of resistance to disease and the aphid vector (iv) influence of ambient ecological factors, particularly rainfall and wind speed on the disease epidemiology (v) optimization of the regeneration protocols for different groundnuts botanicals (Valencia, Spanish and Virginia) (v) enhanced human capacity through training of graduate students (2 M.Sc. and 1 PhD) in modern biotechnology. So far four manuscripts have been drafted from the students' theses with three more expected. A greenhouse has been constructed and enhanced NaSARRI's capacity to conduct research under controlled conditions. Project has generated knowledge and new information on groundnut rosette virus epidemiology, rosette-vector relations, and developed regeneration protocols besides identifying different forms of resistances among the released varieties of which some of them were being integrated in the breeding programmes to mitigate rosette epidemics.

2.13 Gaining Insight into Physical, Ecological and Biological Factors Influencing Mango Fruit Fly Infestation in Uganda

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Fruit flies (Diptera: Tephtritidae) are one of the economically most important groups of insects causing heavy fruits and vegetable losses word wide. A team of scientists from National Agricultural Research Laboratories (NARL), Makerere University and the Natural Resource Institute (UK) assessed the magnitude of the fruit fly problem and generated baseline information for guiding fruit fly control strategies in Uganda. The key findings were: (1) 9 fruit fly species from 4 fruit fly genera (*Bactorecera, Ceratitis, Dacus, Tririthium*) were found in 11 agro-ecological zones in Uganda and *Bactrocerainvadens* was the most prevalent (2) *Ceratitis and Dacus* although exhibited species diversity, had a low representation in traps and reared fruits thus demonstrating displacement of indigenous species by the exotic *B. invadens* (3) frequency of fruit fly infected fruits ranged from 30% to 80% depending on management level at the mango orchard (4) over 20 host plants were found infested by fruit flies implying that alternative hosts should be considered while developing fruit fly management practices for mangoes (5) dult fruit flies occurred in the field throughout the year and fruit fly infestation occurred as early as fruit set implying that fruit fly management should be continuous but intensified as the fruiting season progresses (7) local and exotic mango varieties were all attacked by fruit flies and this finding is contrary to the previous perception that local varieties such as Kagogwa were not infected by fruit flies. Fruit fly management should be addressed in local and exotic varieties since they are infested (8) for the first time this project showed evidence that variation in fruit fly susceptibility in mangoes in Uganda has a physical and biochemical basis which could be harnessed in designing fruit fly management strategies. One PhD and 2 M.Sc. students were trained and three publications in peer reviewed journals and another 5

articles shall be published from the theses. Fruit fly rearing facility has been established at NARL, fruit fly specimens were collected and will be used in taxonomic reference and as a provisional package for management of fruit flies in the country. This project positioned NARL as an institute with fruit fly expertise and fruit farmers continue to receive guidance on fruit fly management. NARL's partnership horizon has been widened, the institute's competence on fruit fly research increased and opportunities for future research funding opened up.

2.14 Development of Biological Tools for Enhancing Production and Utilisation of High Quality Seed Potato

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Potato (*Solanumtuberosum L.*) grown by 300,000 smallholder households that produce a total of 650,000 tons on 93,000 hectares (FAOSTAT, 2007) translates into farm gate incomes of Shs. 180 billion per annum in Uganda. On farm yields have stagnated at an average of 7 t ha^{-1} yet the demonstrated potential is above 25 t ha^{-1}. This yield gap is attributed mainly to utilization of degenerated "home-saved seed" by majority of the farmers. Seed degeneration is caused by prevalence of key diseases, bacterial wilt (*Ralstioniasolanacearum)* and potato viruses (PLRV, PVY, PVX, PVS, PVA and PVM). This study sought to enhance quality seed potato availability through validating and institutionalizing technological tools for enhancing timely availability of affordable quality seed of the farmer preferred varieties Rutuku, Victoria, Kachpot1, Kinigi and Rwangume. For elimination of viruses, thermotherapy and meristem-tip culture were tested under varying temperatures and combinations using the different potato varieties. *In-vitro* thermotherapy combined with meristem-tip culture resulted in the recovery of virus free potato plantlets with cultivar Victoria showing the highest elimination rate for potato virus S (67.6 %) while cultivar Rwangume had the highest virus elimination rate for *potato virus X* (52.3 %). Thus, by using these tools, virus-free starter seed can be produced. Testing of different hormonal combinations, formulations and tissue culture plantlets stem cuttings and tuber sprouts for mini-tuber production using aeroponics, GA_3 and NAA hormonal combination were the best for development of complete plantlets. Tuber sprouts as well as tissue culture plantlets were better than stem cuttings in generating minitubers. Using *Agrobacterium*-mediated transformation protocol, transgenic lines were generated with *NPR1A*

gene Victoria (8), Kachpot1 (6), with *1NPR1B gene* Victoria (4), Kachpot1 (22) and with *PFLP gene* Victoria (4), Kachpot 1 (5), and Rutuku (5). Confirmation of these "transgenic lines" being BW resistant was expected to be a great breakthrough in the struggle for use of genetic resistance to control BW. Two students have been trained up to M.Sc. level in biotechnological tools. With the equipping of the tissue culture laboratory at Kachwekano ZARDI, production of quality seed potato for enhanced potato productivity in Uganda was expected to increase.

WINDOW B1: NEW UNDERGRADUATE SCIENCE AND ENGINEERING DEGREE PROGRAMMES

3.1 Enhancing CurricularConnectedness in Mathematics, Science and Technology: An In-Service Gender-Sensitive Secondary Teacher's Program

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The core activity of this project was to upgrade Grade V Diploma Teachers of Science and Mathematics in Uganda secondary schools to graduate teachers of the academic subjects, in the environment of computer applications and gender inclusiveness. Moreover, the connectedness methodology was key in the teaching and learning, under this program, to generate learner interest and meaningfulness in the subject matter studied. The subject cluster Biology, Chemistry, Computer Applications, Mathematics and Physics are, by their epistemic nature, connected and any attempt to teach them disjointedly will lose appreciation by the learners. Gender inclusiveness was a necessary aspect of this project because, in Uganda, female learner participants are much fewer than their male counterparts. This gender imbalance in Science, Mathematics and Technology (SMT) is evident in many countries of the world, besides Uganda. The project also reduced the participation gap between male and female students by affirmative action in recruitment processes. In order to attract applicants to the program, it was deemed necessary to waive tuition fees for the selected students, since Grade V teachers earn low salaries and would not afford to pay tuition fees. The selection of 40 students per intake was meant to permit individual attention by teachers to learners under limited teaching facilities. Recruitment was spread to all geographical regions of Uganda to give the program a national representation. A total of 120 students were enrolled for the three intakes, representing 48 districts of Uganda, 31 of these students were female. Staff members who were employed by the Kabale MSI Project gradually joined the Kabale University regular employment, thus increasing employment opportunities for the Uganda academic workforce. The thesis that strong national economies are driven by a population skilled in Science and Technology was the major impetus for contributing to the study of SMT in Uganda.

3.2 Creation of the Bachelor of Science in Biosystems Engineering at Gulu University

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Faculty of Agriculture and Environment in Gulu University is based on four pillars of education namely: social conscience, environmental commitment, a business mentality and formation of human values. The teaching methodology of participatory (hands-on) learning promotes the development of creative, critical, innovative and disciplined professionals who able to work as part of a team and pose a strategic vision for development. The faculty received funds from the MSI to create a Bachelor of Science in Biosystems Engineering whose goal was to produce graduates with both engineering and entrepreneurial skills to harness the interactions of biological systems to produce goods and services and recycle the waste products in an environmentally sustainable manner. An internationally acceptable curriculum was developed by a committee of experts and the Uganda National Council for Higher Education (UNCHE) accredited it in March 2009. The first batch of students was admitted and started training in the first semester of 2008/09 academic year. The project sponsored seventy seven students in the programme.

3.3 Establishment of a New Undergraduate Degree Programme in Textile Engineering at Busitema University

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Uganda has a potential for producing 1.0-1.2 million bales of cotton unit annually though it currently produces only a ¼ of this amount due to lack of trained personnel among others, the country's textile industries currently operate well below optimum, resulting in over 97% of the country's cotton and over 88% of the leather being exported row. In light of the above challenges, Busitema University initiated a Textile Engineering Programme to train human resources to revitalize the textile industry for the development of Uganda. This effort was expected to stimulate investment through value addition processes in textile raw materials and fashion designs, hence creating markets and employment in the textile sector.The aim of the project was to train the required human resource for the textile industry in Uganda.Project outcomes were realized at different stages of project implementation as follows: Textile Engineering programme was established, internationally accepted curriculum for Textile Engineering, improved laboratories and workshops, improved capacity of Busitema University to teach, Textile Engineering in an effective and efficient manner, developed and implemented remedial activities such as Chemistry as some students lacked "Advanced " Level High School Chemistry background, blacksmith course in production technology, increased enrolment of female students in the Textile Engineering programme, establishment of partnerships between Busitema University, the private sector and local communities.

3.4 Creation of Bachelor of Science in Biotechnology

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Department of Biological Sciences in Makerere University developed a curriculum for Bachelor of Science in Biotechnology (B.Sc. Biotech) with financial support from MSI project. The creation of the new programme was motivated by the need to spearhead the training and production of graduates with appropriate training, knowledge and skills in biotechnology in partnership with the public and private sectors. Graduates of the programme are expected to contribute to the production of a critical mass of human resources with appropriate knowledge and skills in biotechnologies desired to catalyze science-led economic growth in Uganda in tandem with achievement of the Millennium Development Goals. The objectives of the project were to (i) recruit and train students into graduates with sufficient competences in biotechnology applicable in such fields as agricultural and industrial production, biodiversity and environmental conservation (ii) upgrade and equip teaching and research facilities to foster state-of-the-art research and instruction (iii) enhance collaboration between the Department of Biological Sciences and other academic units in Makerere University as well as other research institutions in Uganda. The following have been achieved: a new B.Sc. Biotechnology curriculum has been approved and accredited by the National Council for Higher Education (NCHE); two cohorts of biotechnology students have been admitted (30 students for the 2011/2012 academic year and 57 students for the 2012/2013 academic year); laboratories/lecture rooms and staff offices have been renovated and refurbished; a stand-by generator has been installed; laboratory equipment have been ordered and collaborations with other research institutions such as Uganda Industrial Research Institute (UIRI), National Agricultural Research Organization (NARO), National Crop Resources Research Institute (NaCCRI) have been strengthened. The programme will contribute to continued training of competent biotechnologists to address the ever increasing demand of this cadre of scientists to spearhead a science-led economic growth

WINDOW B2: UPGRADED EXISTING UNDERGRADUATE SCIENCE AND ENGINEERING DEGREE PROGRAMMES

4.1 Upgrading the B.Sc Physics Program and Modernization of Physics Laboratories at Makerere University

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The Department of Physics at Makerere University is one of the best science departments in the region. Over the years it has produced some of the best scientists in Africa. However a number of factors have affected the quality of the products of the Department. The Department of Physics recognized that its current B.Sc. Physics graduates were not adequately equipped with integrated theoretical and practical skills. This resulted in low innovativeness and limited contribution to the nation's economic development. The inadequacy in the training is attributed to ill equipped laboratories and deficiencies in the physics curriculum, in which theory and experimental work were not sufficiently correlated. The new curriculum has experimental manuals for Year 1, Year 2 and Year 3. The implementation of this new curriculum started during the 2010/2011 academic year. The laboratories were modified to fit the new and modern equipment acquired by the project. The University recruited five academic members of staff comprising two females. The greatest achievements of the project were the acquisition of renovated and modernized laboratories, an upgraded curriculum and increase in the number of academic staff.

4.2 Strengthening Curriculum Innovations (PBL/COBES) of the Faculty of Medicine in Makerere University

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Makerere University College of Health Sciences received support from Millennium Science Initiative (MSI) project to further roll out its new and innovative student centered curricula, in response to the challenges of health care in Uganda. The challenges include low human resource for delivery of health care services, geographical accessibility, poor infrastructure and inadequate empowerment of end users. The aim of the new curriculum was to address the above challenges with a view to enhancing access, quantity, and quality of health workers utilizing working better infrastructure for better health in the community. The funds helped to renovate infrastructure at the College of Health Sciences and community-based learning sites, purchase laboratory equipment and support use of ICT in teaching and learning. The curriculum was enhanced by redesigning key modules. In addition, 382 faculty staff were trained, faculty needs assessment undertaken and student welfare improved through support for supervisory visits to students activities and exposure of 450 students to various project interventions. These were conducted annually for the duration of the project. By the end of the project, infrastructure at all the health professional training Universities in Uganda had been improved. Key lessons were learnt about setting up university-community-local government partnerships, engagement of faculty in community-based health professional education and collaboration among local health professional training intuitions. The project helped to align university education with national and Millennium Development Goals (MDGs) while generating information for policy development. The long-term nature of investment in education and the need for key stakeholder engagement has been demonstrated in this project.

4.3 Strengthening and Upgrading Undergraduate Degree Programmes in Quantity Surveying, Land Economics and Construction Management

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The Department of Construction Economics and Management, created in 2005 anchors Bachelor of Science in Quantity Surveying (4 years), Bachelor of Science in Land Economics (4 years), and Bachelor of Science in Construction Management (3 years). It was realized through consultations with stakeholders, that demand for extensive changes in the curriculum were necessary and urgent to incorporate modern methods of teaching, construction, measurement, management, valuation and communication technology. The objectives the project were to create indigenous capacity at Makerere University for training of quantity surveyors, land economists and construction project managers; reduce the human resource gap in these professions; incorporate modern methods of teaching, management, measurement, computerized billing, and alternative construction, and improve the gender and generational imbalances in the profession. The updated and diversified courses have brought together departments in the College of Engineering, Design, Art and Technology. The project was expected to make significant contributions to the economy through training of cost management, control and valuation professionals for better and more rational use of resources within the construction industry in Uganda. Laboratory, computer training and field attachment in the curriculum provide hands-on opportunities to apply knowledge to practical problem-solving in the construction industry. The enhanced practical training components in the curriculum introduce students to actual field practice, thus preparing them early enough to begin appreciating the need for setting up their own firms after graduation. The grant also provided reference books, computers and professional software, recruited staff, and provided presentation aides. The pilot changes took effect during the 2010/11 academic year, while the fully revised programmes were expected to come into effect during the 2014/2015 academic year. The degree programmes have become more focused and profession specific. The concept of examining academic programmes through vertical and horizontal matrices

of courses, developed through the project, has now been adopted by the University Senate. Current student numbers have risen to 698 from 215 when the project started. The department has so far graduated over 400 professionals who were expected to make a significant contribution to the human resource and economic development goals of the country. The project has been successful as all the objectives have been fully met.

4.4 A Methodological Information and Communication Technologies (ICTs) Approach for Demystifying the Perception that Teaching of Mathematics and Science in Lower Secondary Education is Hard

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The aim of the project was to improve the quality of training and producing a critical mass of competent secondary school Mathematics and Science (Biology, Chemistry, Physics, Sports Science and Information and Communications Technology, ICT) teachers by expanding access to training through the Open, Distance and e-Learning (ODeL) mode supported by Information and Communication Technologies (ICTs). A Methodological Information and Communication Technologies (ICTs) Teaching Approach (MICTTA)was developed to help demystify the perception that teaching Mathematics and Science subjects is hard. This approach involved several stakeholders who had been tasked to undertake several activities. It involved four main activities: infrastructure establishment, content development and review, content delivery and community outreach. The project established that the methodological approach proposed was feasible and effective.

4.5 Strengthening and Upgrading the Undergraduate Degree Program in Pharmacy and Pharmaceutical Sciences at Mbarara University of Science and Technology

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Mbarara University of Science and Technology (MUST) won a grant in September 2009 for curriculum and infrastructure development in Pharmacy and Pharmaceutical sciences. The grant helped to address inadequate teaching facilities at MUST and low human resource capacity in the pharmaceutical sector in Uganda. The main objectives of the project were to (1) improve the quality of training and increase output of Pharmacy and Pharmaceutical sciences graduates who were expected to be well-acquainted with the challenges and development needs of the Pharmaceutical sector in Uganda (2) development of a new curriculum for Bachelor Science in Pharmaceutical Sciences (BSPS) and review the existing Bachelor of Pharmacy (B.Pharm) curriculum using a competence-based approach (3) increase student enrolment (4) improve the capacity of domestic academic and research staff (5) upgrade teaching and research facilities (6) enhance collaboration and establish close partnerships with stakeholders. The outputs and outcomes of the project were: (i) A new BSPS program was started with 20 pioneer students (ii) Bachelor of Pharmacy students admitted annually increased from 20 to 60 (iii) new faculty were recruited and put on University payroll (iv) teaching and research facilities (laboratories, lecture rooms and offices) were refurbished and an ICT facility and library set up and (v) collaboration with other Universities and relevant institutions has been strengthened. The project facilities have provided a suitable environment for both undergraduate and postgraduate student research projects and research by academic staff. The project is premised on the fact that increase in number of adequately-trained Pharmacy and Pharmaceutical Sciences graduates will contribute towards improvement in pharmacy practice, and growth of local pharmaceutical industry as one of the pillars in a Science and Technology led economy in Uganda.

4.6 Upgrading B.Sc Surveying Curriculum at Makerere University

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The aim of the project was to develop a modern curriculum in Geomatics at Makerere University BY upgrading the B.Sc Surveying undergraduate degree programme. Previously, majority of the students admitted to the programme did not select B.Sc. Surveying as a 1st choice, but as 2nd or 3rd choice. Most of the students who did not pass well-enough to be admitted to the Engineering programmes settled for Surveying as a last resort. This affected their perfomance at the university and in the field as professionals because they were not motivated to pursue the programme. The purpose of reviewing and upgrading the programme was to produce highly skilled, practically grounded and motivated surveyors to deal with the rampant land related issues in Uganda. The review process included needs assessment among key stakeholders, training of staff in curriculum review as well as pedagogical skills, curriculum over haul and re-drafting, benchmarking, career guidance and accreditation of the new programme by National Council for Higher Education (NCHE). The curriculum was benchmarked and harmonized with international curricular in UK, South Africa, Tanzania, Kenya, Malaysia and Hongkong. The name of the Department was changed from Surveying to Geomatics& Land Management while the name of the degree programme changed to B.Sc Land Surveying and Geomatics. Teaching methods have begun to change gradually towards learner centered approaches and ICT-based instruction. The Department is now a full member of the International Federation of Surveyors (FIG). Our experience in the curriculum review process has led us to innovative ways of delivering a modern Geomatics curriculum. In order to produce motivated and industry-ready graduates to extend the frontiers of Geomatics technology, it wass necessary to first and foremost attract students from high school through career guidance. As a result, the B.Sc Land Surveying Programme now competes with other Engineering Programmes in the College terms of admission points attained at **A** level. Secondly, it was equally important to train teachers in pedagogical skills and modern techniques for delivering knowledge. Finally, the project has helped to maintain a functional link between the university and professional bodies as well as benchmarking the curriculum regionally and internationally as a strategy for ensuring that the curriculum remains relevant to meet stakeholders' needs.

WINDOW C: PRIVATE SECTOR COOPERATION

5.1 Participatory Research for Rural Dairy Development Using Public Private Partnership Approach

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Complementary synergies between private sector endowed with agro-industrial sugar cane molasses and university scientists equipped with scientific knowledge and skills were used to convert the sugarcane molasses into a commercial dairy feed supplement. Scientists from Makerere University in partnership with Kakira Sugar Works Limited, Kakira Out-growers Rural Development Fund (KORD) and Dairy Development Authority (DDA) in a participatory manner tested the effect of molasses urea supplement (MUS) on dairy cattle productivity among zero grazing farmers. One hundred Friesian dairy cows were used to evaluate the effect of graded levels of MUS on milk productivity using four treatments (1) control, representing farmers' dairy management practice without the MUS supplement intervention (2) control + 0.5 kg/animal /day MUS (3) control + 1 kg/animal/day MUS (4) control + 2 kg/animal/day MUS. Data were analysed using polynomial contrasts with linear and quadratic functions. Adoption of the intervention was tested among zero grazing farmers to establish how farmers embraced the innovation. Milk yield increased linearly with a quadratic trend. Increasing response in milk production at a decreasing rate suggested that MUS supplementation was optimal at 1 kg/animal/day. The dairy supplement has now been commercialized as "milk booster". Adoptability analysis of the innovation indicated existence of variations in milk yields across different farms even when farms were supplied with similar levels of supplementation of MUS. It was concluded that complementary synergies between the private sector endowed with physical resources such as equipment and feed resources can work together with public research institutions with knowledge and skills to transform industrial molasses into a commercial molasses urea supplement needed by dairy farmers as a solution for

improving dairy cattle productivity. Even with good innovations in animal nutrition, improvement in milk productivity is only possible if routine farm management practices such as adequate basal feed supply, adequate watering, the right animal breeds and overall animal health are adhered to. In practical terms, this implies that even with excellent livestock innovations, extension services that that build good stockman ship at the farm level is indispensible. Despite success in producing a commercial dairy feed supplement (MUS) in a PPP, the challenge of intellectual property rights (IPR) still exists between private sector and researchers due to different incentive structures and weak legal support to scientists in universities. It is concluded that despite its shortcomings, complementary synergies between public and private sector is crucial in translating science into tangible sellable products. This is necessary in eliminating barriers that have hitherto prevented smallholder dairy farmers from gaining access to agricultural research innovations that are vital to boosting milk production during the dry season.

5.2 Status and Opportunities for Improving Rice Processing Industry in Uganda

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Rice is the second most important cereal crop in Uganda. Despite the sharp increase in local production in recent times, the country still imports rice worth US $ 35 million. Low market value of the locally grown and processed rice is one of the major reasons for high quantities of rice imports. The aim of the project was to identify critical points of entry for improvement of rice processing industry through evaluation of methodologies and technologies in the post-harvest rice value chain from harvesting to milling that are currently used by farmers and cottage rice milling factories in Uganda. Findings have shown that 98.9% of farmers use obsolete and inefficient traditional practices and technologies for post-harvest rice processing operations. The most common types of rice mills found in Uganda are the rudimentary and poor performing englebergs (77.5%) and mill-tops (20.8%). There were 13 medium sized rice milling factories and Tilda is the only big rice factory in Uganda having modern rice processing equipment. Continued use of these obsolete technologies has negative effects on the quality of locally processed rice and causes high levels of grain loss. The national average aflatoxin contamination in milled rice was 12.6ppb. This is below the allowable limit of 20ppb set by the Food and Agricultural Organisation (FAO) in human food and animal feeds but failed to meet European Union standards of 4ppb in adult and 0ppb in baby foods. The average physical grain loss in the entire post-harvest value chain excluding storage was 23.4% which translates to annual financial loss of US$ 33.4 million. The study also showed that the average drop in market value of milled rice was about 12.5% (US$ 15.4 million). Therefore, there was a need to address the low quality of milled rice and the high post-harvest losses through research, direct development initiatives and policy. Research needs to focus on improving postharvest processing technologies, increasing the utilization of rice mill products and by-products, developing rice varieties which take into account consumer preference, low shattering properties and improvement of cottage rice milling technologies.

5.3 High Density Culture of African Catfish, Product Development & Value Addition Technologies

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The project investigated the viability of applying alternative production technologies for artificial African catfish propagation to enhance sustainable fisheries for Uganda's competitiveness in global commodity value chains. The project was premised on the fact that Uganda's bio-diversity was under severe pressure, attributed among others to the harvesting of juvenile catfish from the wild habitats, to service baits for the thriving Nile Perch export market. The study involved two fish farms: M/s Sun Fish Farms and M/s Umoja Fish Farms that produce catfish fingerlings for seed and bait market. Nigerian catfish farms were visited to learn appropriate technologies in the value chain management that could be adopted by local fish farms in Uganda. Findings revealed that farmed baits (compared to wild) were preferred by fishers in thriving Nile Perch industry because of their attractive colour on the hooks that result in high catches; the farms were able to break-even but did not produce efficiently and effectively; Nigerian farms had perfected production techniques resulting in low mortality rates. In addition, they had innovative marketing strategies such selling live fish for roasting using the 'shoot and kill' approach. The study also identified the following deficiencies in the two participating farms: high mortality rates, high cost of larval feeds, scarcity of quality larval feeds, lack of skilled staff in hatcheries management, high power tariffs coupled with persistent power failures. Major recommendations include: setting up mini-diagnostic laboratories at the farms for disease outbreak controls; training of catfish out-growers in efficient feed and feeding management; installing water conservation and reuse systems; value addition for table catfish by setting up smoker chimneys; installing efficient energy saving equipment and solar power, and establishment of a vibrant fish farmers association to assist in creating a reliable catfish market.

5.4 Evaluation of Industrial and Edible Salt Processing Technology at Lake Katwe

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Lake Katwe is a saline lake endowed with raw salt which is harvested for human and animal consumption. Local technologies have been used to harvest salt from the brine. A study was carried out to determine the quantity and quality of the saline reserves using advanced laboratory procedures and GPS technology. Modern technology and machinery for salt processing was identified and studied in terms of cost, input/output, capacity to process the impurities among others. A market study was carried out to establish the demand and supply of salt and related products in Uganda and the great lakes region. Results indicated that saline reserves of above 20 million tons of rock salt and at a purity of 82.7% sodium chloride with pH above 10 were available. Sulfur is the major impurity in the salt deposits. This reduces the salt quality and constrains the purification process of table salt for human consumption. However, the project is financially profitable, economically viable and socially desirable if modern technologies for harvesting, purifying and iodizing salt can be applied. Use of such technologies will create jobs, , improve livelihoods, generate other products in addition to salt, promote related industries, improve market for Lake Katwe salt and reduce importation of salt thus saving valuable foreign exchange.

5.5 Automated Cargo Route and Vehicle Management (ACRAV) Investment in Computer-Based Management for Improved Productivity and Profitability in the Transport Sector

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The aim of the project was to design an information system that would make transportation of heavy goods, using road transport, more effective by eliminating communication barriers between transport companies/agents and their clients. For example, resources are not wasted on transporting empty trucks to an area where another empty truck is within the vicinity which reduces fuel cost. Results have revealed that transporters in Uganda would benefit more from the ACRAV information system if it provided a collaborative portal that brings transit companies and agents together (by removing middlemen), thereby presenting increased visibility and greater control of freight. The project developed a fleet management system which will enable tracking of vehicles cheaply and keep a computerized update of the company's assets and liabilities. We found that it will be possible to use the ubiquitous telecommunications infrastructure (80% national coverage) as a means of communication between the ACRAV information system, transit companies and the agents, using SMS messages and data via the internet. It is recommended that, for efficient growth of the economy of a land locked country, it is necessary to have an efficient transport system that enables quick and cost effective delivery of goods from the ports of entry to their destinations. Such a system requires efficient and on time access to information, as it is received, by the various stakeholders so that they perform their duties as timely as possible.

5.6 Strengthening of Practical Training in Teaching in Diploma Granting Vocational and Technical Training Institutions

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There is evidence in Uganda that the industrial sector of the economy is expanding rapidly and hence an increasing demand for qualified technical human resource suitable to work in the industrial sector. There is a need to promote industry-academia linkages which is a component of Public Private Sector Partnerships (PPP). This helps to promote growth of firms and to accelerate the country's transition to a more science and technology driven economy. The greatest support which industry can provide to tertiary institutions is real-life experiences and advice on how to take advantage of rapid change. There is an increasing emphasis on cross-disciplinary teams, computer and communication technologies, and greater relationships with customers and suppliers. BM Technical Services Ltd (BMTS) and Uganda Technical College (UTC) in Bushenyi worked closely and collaborated in the strengthening of practical training in the teaching of Diploma awarding vocational and technical training programs by offering students industrial training opportunities. BM Technical Services Ltd played a crucial role in promoting and facilitating practical training by giving interns opportunity to gain exposure to "real life industrial technical problems". This collaboration was an innovative means of achieving the goal and vision to produce industrial technicians with integrated skills attuned to contemporary industrial problem-solving, comfortable with ill-defined problems, able and eager to work in teams, and cognizant of product realization and commercialization. It is also an innovative initiative that will help the college review their curricula and aligning it to industry requirements.

INSTITUTIONAL STRENGTHENING OF UGANDA INDUSTRIAL RESEARCH INSTITUTE (UIRI)

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Uganda Industrial Research Institute (UIRI) has the official mandate to be the focal point for technological development of the industrial sector in Uganda. Convergence of the mandate of UIRI and the objectives of MSI project led the institution to serve better Uganda's Industrial sector. UIRI's Capacity for Research and Development was enhanced through acquisition of new scientific equipment and machinery, specialized staff training and international collaborations. UIRI has thus been designated as a Regional Center of Excellence in Applied Research for Industrial Development in the East African Community. Through the MSI Project, UIRI setup a National Industry Resource Center whose long-term goal was to collect comprehensive information on the state and current needs of Uganda's industrial sector, and conducted a national industry needs assessment. A state-of-the-art Business Development Center was setup and facilitated training of over 1000 entrepreneurs from all over the country in ICT and entrepreneurship. The UIRI Technology Development Centre (TDC) was remodeled and its physical infrastructure upgraded to suit its status as a Government Science Unit. New precision machines and equipment capable of manufacturing custom machinery from concept through design to delivery and with capacity to reverse engineer existing industrial equipment and machinery were acquired. Five-year Strategic Plan for TDC, and an ESMF with Compliance Plan was developed. The analytical laboratories at UIRI were strengthened; the microbiology laboratory was renovated and equipped and new specialized equipment procured for the chemistry laboratory. The microbiology laboratory has established a Biotechnology Centre of Excellence and the Chemistry laboratory has become a Center of Excellence for food fortification for Eastern, Central and Southern Africa (ECSA). The pilot plants were augmented with modern equipment and machinery to strengthen operations and

to support the incubation programme. A multimedia production unit was set up to create capacity for in-house product labeling and branding. UIRI was a focal point in the promotion of the MSI Window C Project by creating awareness through private sector visits and organizing meetings and workshops both in Kampala and upcountry to promote Private Sector Cooperation.

ANNEXES

Annex 1: The Uganda MSI Technical Committee members

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7. **Prof. Luiz Antonio Barreto de Castro**
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8. **Prof. Michael. T. Clegg**
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Annex 2: Summary of MSI Projects: 2007-2010
Round 1

No	PI	Organization	Title	Contact Address	Grant amount USD
A1 – Senior Teams					
1	Thomas Egwang	Med-Biotech Laboratories	Malaria vaccine Studies in Uganda	Med-Biotech Laboratories P.O. Box 9364 Kampala **Tel:** 0414-510-245 **Mob:** 0785-605-620 +254-712-504-010 **Fax:** 041-510-408 **Email:** tgegwang@gmail.com	800,000
2	Justus Rutaisire	National Fisheries Resources Research Institute	Culture technologies for increased and sustainable production of the Nile perch	National Fisheries Resources Research Institute (NaFIRRI) P.O. Box 530, Kampala **Tel:** 0414-200-745 **Mob:** 0772-501-227 **Email:** jusruta@gmail.com	799,806
3	Patrick Okori	Makerere University	Unlocking the potential of maize and sorghum as new food	Department of Crop Science Makerere University P.O. Box 7062 Kampala **Tel:** 256-414- 534766 **Mob:** 256-772-683623 **Fax:** 256-414-531641 **Email:** pokori@agric.mak.ac.ug	799.970

A2– Emerging Teams					
4	Julius Bunny Lejju	Mbarara University	Influence of climate change on Lake Victoria	Department of Biology, Mbarara University of Science and Technology P. O. Box 1410, Mbarara **Mob:** 256-782-809814 **Fax:** 256-485-20782 **E-mail:** lejju2002@yahoo.co.uk	246,131
5	David Osiru	Makerere University	Drought tolerance mechanisms for cassava breeding	Department of Crop Science Faculty of Agriculture, Makerere University, P.O. Box 7062, Kampala **Mob:** 256 -772-311-560, **E-mail:** dsoosiru@agric.mak.ac.ug	249,165
6	Settumba Mukasa	Makerere University	Banana production through application of biotechnology	Department of Crop Science Makerere University P.O. Box 7062 Kampala, Uganda **Tel:** 256-414-533580 **Mob:** 256-782-670041 **Fax:** 256-414-531641 **Email:** sbmukasa@agric.mak.ac.ug	250,000
7	Denise Meya-Njama	School of Health Sciences -Mulago	Assessment of antimalarial drug use at Mulago National referral hospital	Uganda Clinical Epidemiology and Biostatistics Unit, Department of Medicine, P.O. Box 7072, Kampala **Mob:** 256-772-448-850 **Fax:** 256-41-540-524 **Email:**denise.meya@gmail.com	241,400

B1- New Courses					
8	Callistus Baliddawa	Gulu University	Creation of Bachelor of Science in Engineering	Faculty of Agriculture and Environment P.O. Box 166, Gulu **Tel:** 0471-432-518 **Mob:** 0774-757-830 **Email:** cbaliddawa@gmail.com	1,249,998
9	Allen Babugura	Kabale University	Enhancing curricular connectedness in Mathematics, Science and Technology	Kabale University, Kabale **Tel:** 0777-131608 **Email:** babugura_allan@yahoo.com	1,085,647
B2 –Upgrading					
10	Florence Mutonyi	Makerere University	Upgrading the Physics laboratories at Makerere University	Dept of Physical Makerere University P.O. Box 7072, Kampala **Tel:** 0772-478-333 **Email:**fdujanga@physics. mak.ac.ug	1,191,203
11	Nelson Sewankambo	School of Health Sciences -Mulago	Strengthening Curriculum Innovations-Faculty of Medicine	School of Health Sciences Makerere University P.O. Box 7062, Kampala **Tel:** 0414-530-020 **Fax:** 0414-541-036 **Email:** sewankam@infocom.co.ug	1,245,898
Window C					
12	Fred Kabi	Makerere University	Participatory research on use of molasses urea blocks	Makerere University P.O. Box 7062, Kampala **Mob:** 0772- 657-155 **Email:** fredkabi@agric.mak.ac.ug or caec@agric.mak.ac.ug	49,844
Total					**7,409,892**

Round 2					
A1 – Senior Teams					
13	Florence Mirembe	School of Health Sciences -Mulago	Long-term surveillance for carcinogenic genital human Papillomavirus infections and sexual behaviors among girls	School of Health Sciences Kampala **Tel**: 256-414- 534361 **Mob**: 0772-467655 **Fax:** 256-414- 531 511 **Email:** flomir2002@yahoo.com	743,789
14	Kerali Anthony Geoffrey	Makerere University	Development and Use of Pozzolanic Materials	Makerere University Faculty of Technology Email: agkerali@tech.mak.ac.ug **Tel:** 256-414- 662-878 **Mob:** 0772-534-972 **Fax:** +256-414-531-048	798,600
15	Yona Baguma	National Crops Resources Research Institute	developing varieties resistant to cassava brown streak virus disease in Uganda	National Crops Resources Research Institute, (NaCRRI) Namulonge P.O. Box 70841 Kampala **Tel:** 0752-726554/ 0772-930185 **Email:** baguma1234@yahoo.com	799,890
A2– Emerging Teams					
16	Dorothy Okello	Makerere University	Adaptive bandwidth management in cooperative wireless networks	Faculty of Technology Makerere University P.O. Box 7062 Kampala **Tel:** 0414-531-046/533-163 **Mob**: 0772-957-550 **Email**: dkokello@tech.mak.ac.ug	250,000
17	Eleanor Wozei	Makerere University	Increasing Access to Safe Drinking Water	Faculty of Technology Makerere University P.O. Box 7062 Kampala **Tel:** 0714-262994 **Email:** ewozei@yahoo.com	249,992

18	Titus Alicai	National Crops Resources Research Institute (NaCRRI)	Management of Napier Stunt Disease in Uganda	National Crops Resources Research Institute (NaCRRI), Namulonge P.O. Box 70841 Kampala **Tel:** 0772-970-585 **Email:** talicai@naro-ug.org talicai@hotmail.com	250,000
19	JoremKurabira	National Crops Resources Research Institute (NaCRRI)	Functional genomics of Type III Secretion System (TTSS)	National Crops Resources Research Institute (NaCRRI), Namulonge P.O. Box 70841 Kampala **Email**: jkubiriba@kari.go.ug **Tel:** 0773-155760	249,952
20	Stanley Nkalubo	National Crops Resources Research Institute (NaCRRI)	Market-Class Bean Varieties with Durable Resistance	National Crops Resources Research Institute (NaCRRI), Namulonge P.O. Box 70841 Kampala **Tel:** 0702-412-752 **Email:** tamusange@yahoo.com; tamusange@naro-ug.org	249,955
B1- New Courses					
21	Johnnie Wandera	Busitema University	Bachelor of Science in Textile Engineering	Busitema University **Tel:** 0712-865-391/0702/776 **Email:** wanderajohnnie@yahoo.com	1,250,000

B2 –Upgrading					
22	Kerali Anthony Geoffrey	Makerere University	Bachelor of Science in Quantity Surveying, Land Economics, and Construction Management	Faculty of Technology Makerere University Email: agkerali@tech.mak.ac.ug **Tel:** 256-414-662-878 **Fax**: 256 -414-531-048 **Mob:** 0772-534-972	1,250,000
23	Sam Obwoya	Kyambogo University	Training of Mathematics and Science Teachers by Incorporating ICTs Through Open Distance and E-Learning	Physics Department Kyambogo University **Email:** ksobwoya@yahoo.co.uk **Tel**: 0782-471-604	1,249,999
Window C					
24	Alphonse Candia	Agricultural Engineering and Appropriate Technology Research Center (AEATREC)	Opportunities for Improving rice Processing Industry In Uganda	Agricultural Engineering and Appropriate Technology Research Center(AEATREC) P. O. Box 7144, Kampala **Tel:** 0772-328519 **Email:**hugoscand@yahoo.com aeatri@starcom.co.ug; aeatrec@yahoo.com	49,990
25	EisahMayanja	New Wave Technologies	Automated Cargo Route and Vehicle Management	New wave Technologies Plot 30, Jinja Road Kampala P.O. Box 24159 **Tel:** 0414 389 220 **Mob:** 0772-712899 **Email**: emayanja@newwavetech.co.ug	49,190
26	Michael Mugabira	Uganda Management Institute (UIA)	Artificial Catfish Propagation and Sustainable Capture Fisheries:	Uganda Investment Authority (UIA) **Tel:** 0712-534781 **Email:** mmugabira@yahoo.com	50,000
27	Daniel Musitwa	JDG Africa Limited	A preliminary evaluation of industrial and edible salt	JDG Africa Limited **Tel:** 0772- 417-743 **Email:** ssubidan@yahoo.co.uk	50,000
Total					**7,541,357**

Round 3					
A1 – Senior Teams					
28	Pen-Mogi Nyeko	Gulu University	Molecular diagnostic methods in the study of trypanosome infections in post-conflict districts of Northern Uganda	Gulu University, P. O. Box, 166, Gulu **Tel:** 256-471-320-93 **Mob:** 256-772-586-008 **E-mail:**pnyeko@gmail.com	800,000
29	OjokLonzy	Makerere University	Diagnostic technologies for increased animal production in Uganda	Department of Veterinary Pathology, Makerere University P.O. Box 7062, Kampala **Tel:** 0712- 410-577 **E-mail:** Lonzy@vetmed.mak.ac.ug	800,000
30	Izreal Da-Silva	Makerere University	Rural Electrification in Uganda – Increasing Access to Modern Types of Energy	Centre for Research in Energy and Energy Conservation. Makerere University **Tel:** +256-772-505-792 **Email:** idasilva@tech.mak.ac.ug	800,000

A2– Emerging Teams					
31	Denis Byarugaba	Makerere University	Isolation and evaluation of local Newcastle Disease Thermo-stable Virus Strains for vaccine development	Faculty of Veterinary Medicine Makerere University P.O. Box 7062, Kampala **Tel:** 0414-531-169 **Mob:** 0712-881-464 **Email:** dkb@vetmed.mak.ac.ug	250,000
32	Charles Mondo	School of Health Sciences -Mulago	The Uganda Rheumatic Heart Disease National Registry	Uganda Heart Institute, Mulago Hospital P. O. 7051,Kampala **Tel:** 0772-462-370/0774-460-496 **Email:** charlesmondo2011@gmail.com	250,000
33	Beatrice Akello	National Semi-Arid Resources Research Institute (NaSARRI)	Untangling the biology of groundnut rosette virus complex and mechanisms of resistance to the disease	National Semi-Arid Resources Research Institute (NaSARRI), Soroti **Mob:** 256-772 -480-482 **E-mail:** lbakello@yahoo.com	250,000
34	Caroline Nankinga	National Agricultural Research Laboratories (NARL)	Gaining Insight into Physical and Biochemical Factors Influencing Mango Fruit Fly Infestation in Uganda	Senior Entomologist National Agricultural Research Laboratories, Kawanda P. O. Box 7065, Kampala **Tel:** 256-772-524-642 **E-mail:** cnankinga@kari.go.ug	250,000
35	William WagoireWamala	Buginyanya Zonal Agricultural Research and Development Institute (BUZARDI)	Development of biotechnological tools for enhancing production and utilization of high quality seed potato	Buginyanya Zonal Agricultural Research and Development Institute (BUZARDI) **Tel:** 0414-531169 **Mob**: 0782 892480 **E-mail:** wagoire1@yahoo.co.uk	250,000

B1- New Courses					
36	Sylvester Nyakaana	Makerere University	B.Sc. in Biotechnology	Department of Botany Makerere University P.O. BOX 7062, Kampala **Tel:** 256-0392 -947-428 **Email:**snyakaana@botany.mak.ac.ug	1,250,000
B2 –Upgrading					
37	AmonAgaba	Mbarara University of Science and Technology	Bsc. in Pharmaceutical Sciences	Mbarara University of Science &Technology (MUST) P.O. Box 1410 Mbarara, Uganda. **Tel:** 0712-482-845 **Email:** amonagaba@yahoo.com	1,250,000
38	Moses Musinguzi	Makerere University	B.Sc. in Surveying	Faculty of Technology Makerere University P.O. Box 7062, Kampala, Uganda **Tel:** 256 414 -531-047 **Mob:** 256 772- 511-119 **E-mail:**musinguzim@tech.mak.ac.ug	1,250,000
39	Theodara Mondo	BM Technical Services Ltd (BTM) &Mbarara University of Science and Technology	Training in teaching in Diploma Granting Vocational and Technical Training Institutions	BM Technical Services Ltd Plots 7-25 Jetha Ismail Road, Kakoba, Mbarara P.O. Box 956, Mbarara, Uganda **Tel:** 0772-821335 **E-mail:**mwebasa200@yahoo.com	50,000
Total					**7,450,000**