



RESEARCH FOCUS AREAS



INSPIRING GREATNESS





UNIVERSITY OF
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FOREWORD



Research focus areas not only characterise institutional research direction, but are also critical to how the institution is perceived in its engagement in multi-disciplinary partnerships to address scientific and societal agendas.

The University has identified nine research focus areas that are aligned to the national priorities and institutional strategic objectives and capacity and which, it believes, are critical to supporting its vision of being a notable centre of African scholarship. The research conducted in the different focus areas contributes towards making UKZN an integral player in the global partnership embodied in the United Nations Millennium Development Goals, which seeks to restore a sense of meaningful and sustainable development in particular research that benefits and uplifts the poor in our society. The research focus areas were identified after an extensive consultative process with the researchers to ensure ownership. The focus areas on Race, Gender and Identity Studies, Indigenous African Knowledge Systems and Maritime Studies were recognised for their strategic importance in the context of the national imperatives and geographical location of UKZN, and it was agreed to adopt them as institutional signature projects to accelerate their development.

The objective of this publication is to provide a brief but concise presentation of the research focus areas and the notable findings emanating from the different projects. Work in Agriculture and Food Security has resulted in the development of high yield and disease resistant crops as well as improved farming methods of indigenous crops. Research in Biotechnology is truly multi-disciplinary

covering areas from chemistry to drug development and stem cell research. Research in Energy and Technology is conducted in collaboration with industry to develop environmentally sustainable products and systems. The focus area on HIV/AIDS, TB and Health Promotion is the most extensive, engaged in research covering clinical, epidemiological and socio-economic aspects of TB and HIV. It has produced globally notable results that have led to the development of better prevention and intervention protocols. Through research in Social Development and Economic Studies, UKZN has made major contributions towards the understanding of the dynamics in the society on the labour markets, informal economy and urban-rural divides. Research in Water, Environment and Biodiversity has led to understanding of the ecosystems, improved sanitation and waste disposal systems, more efficient utilisation of water resources as well as better methods for plant development and seed preservation.

Work in the focus areas is also enhanced by research activities of the eleven prestigious Chairs awarded to UKZN through the South African Research Chairs Initiative (SARChI) as well as the six National Research Foundation (NRF) A-rated researchers linked to UKZN.

Professor Nelson Ijumba
Deputy Vice-Chancellor – Research

GLOBALLY RELEVANT YET LOCALLY RESPONSIVE

RESEARCH FOCUS AREAS



The University of KwaZulu-Natal (UKZN) has identified a number of research focus areas which it believes are critical to supporting its vision, not only as a notable centre of African scholarship in South Africa, but as an integral player in the global partnership embodied in the Millennium Development Goals, which seek to restore a sense of meaningful development to some of the world's poorest countries.

OVERVIEW

Through sustained research involving multi-disciplinary and cross-border collaborations, the University's efforts are pushing research boundaries, impacting international research trends, and drawing South Africa and Africa into a global network of knowledge production and academic excellence.

Thus our areas of research focus are globally relevant, yet locally responsive and include:

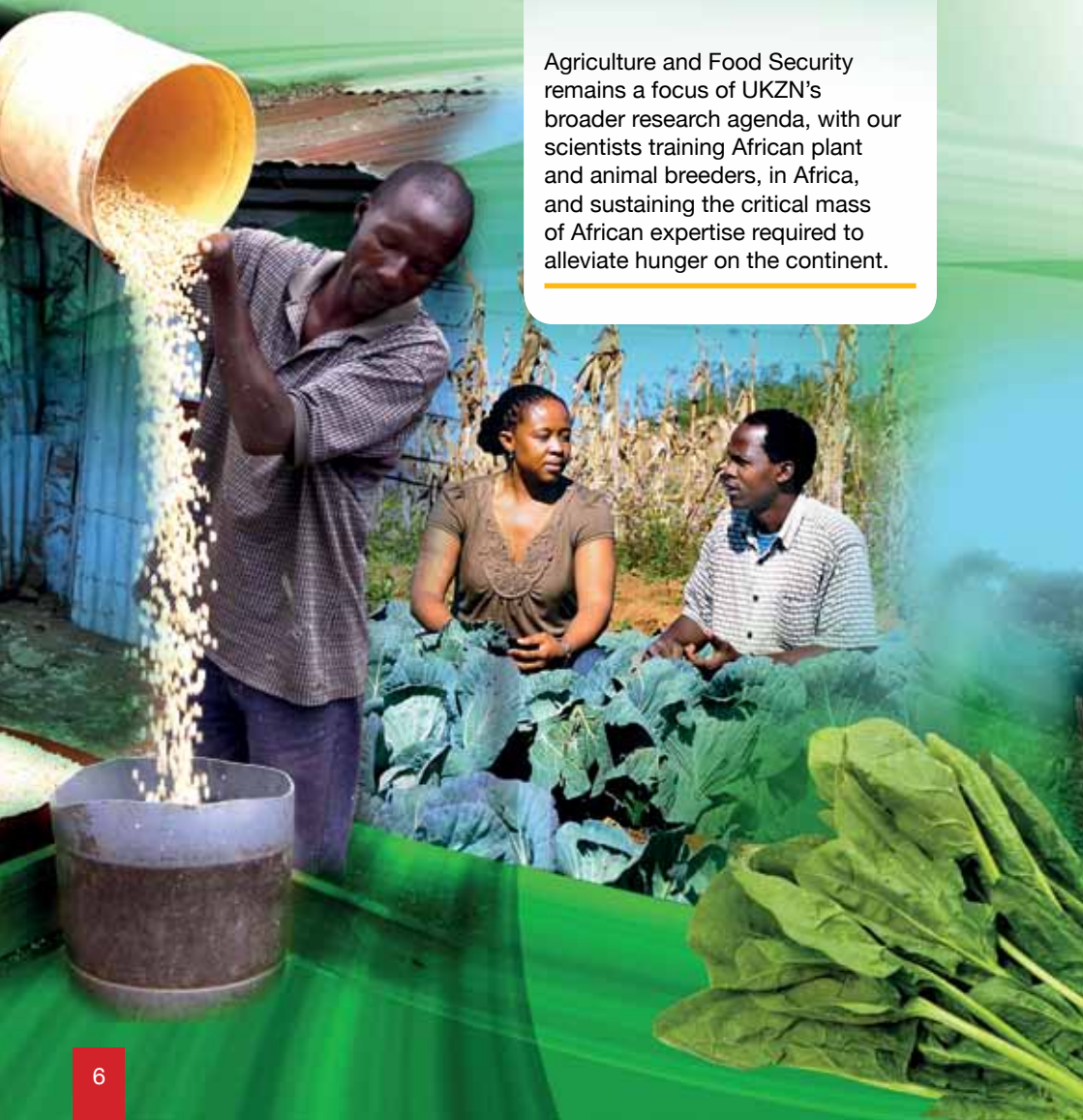
- **HIV/AIDS, Tuberculosis and Health Promotion;**
- **Biotechnology;**
- **Water, Environment and Biodiversity;**
- **Social Development and Economic Studies;**
- **Agriculture and Food Security;**
- **Energy and Technology for Sustainable Development;**
- **Gender, Race and Identity Studies;**
- **Indigenous African Knowledge Systems;**
- **and Maritime Studies.**

In addition, the full spectrum of research – from curiosity-driven to application-based and participatory action research – is undertaken at UKZN, where there is a strong emphasis on team work. Senior academics take pride in the mentorship they provide to postgraduate students, postdoctoral scholars and other emerging researchers.



AGRICULTURE AND FOOD SECURITY

Agriculture and Food Security remains a focus of UKZN's broader research agenda, with our scientists training African plant and animal breeders, in Africa, and sustaining the critical mass of African expertise required to alleviate hunger on the continent.



This research area is a home to several research institutes concerned with eradicating food deprivation and enhancing sustainable livelihoods among the people and nations of Africa, namely the African Centre for Crop Improvement (ACCI), African Centre for Food Security (ACFS), and Poultry Research. The research in these institutes has led to extensive publications, which in turn resulted in a paradigm shift in the way plants and animals are handled throughout the world.

The African Centre for Crop Improvement (ACCI), located within the School of Agricultural, Earth and Environmental Science was established in 2001 to train African plant breeders, in Africa, in the area of African food security crops. Its vision: African scientists solving Africa's food problems.

The ACCI was initially funded solely by the Rockefeller Foundation but in 2007 the Bill & Melinda Gates Foundation came on board through a consortium known as the Alliance for a Green

Revolution in Africa (AGRA) which is funding a second round of five cohorts of 10 students. This brings to more than 80 the number of PhDs in plant breeding that the ACCI aims to train. The focus of the PhD theses is on the applied breeding of key food crops such as sorghum, cassava and cowpeas for increased disease and drought tolerance, and improved yields and quality, with the aim of improving food security in 12 African countries including Ethiopia, Kenya, Mozambique, Zambia and Malawi.

A key feature of the project is that AGRA has committed itself to ongoing funding of ACCI graduates who continue to breed their chosen food crop, aiming to deliver registered cultivars to farmers. Graduates have started to register a range of new crop cultivars in their home countries.

The staff of the ACCI each has their own plant breeding projects including mutagenesis of sorghum and wheat, development of low phytic and maize using molecular markers, breeding for high beta-carotene maize and the



development of biofuel crops. Aware of the growing food security crisis in Africa, the School of Agricultural, Earth and Environmental Science established the African Centre for Food Security (ACFS) in 2006 to contribute to building and sustaining the critical mass of African expertise required to alleviate hunger on the continent.

The ACFS, one of very few institutions internationally providing accredited capacity development for food security

research and policy analysis, aims to contribute towards eradicating food deprivation and enhance sustainable livelihoods among people and nations of sub-Saharan Africa. Its achievements have been remarkable and include: endorsement by the New Partnership for Africa's Development (NEPAD) as the lead agency in the food security activities of the Comprehensive African Agricultural Development Programme (CAADP) and formal recognition as the Southern African Development Community (SADC) Regional Centre of Excellence for Vulnerability Assessment and Analysis (VAA), including VAA training

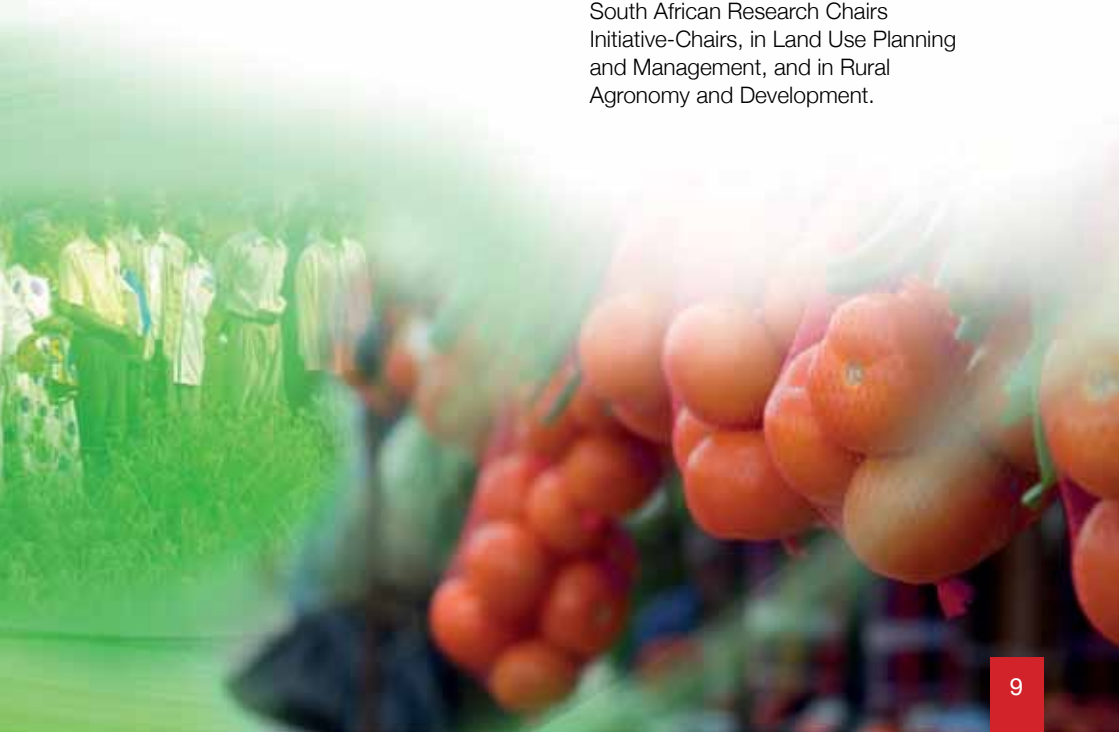


and co-ordination. It is one of the few established Food Security Centres in the world to offer trans-disciplinary training, and through UKZN, named degrees in food security. Through its representatives, the Centre played a leading role in the development of the Framework for Agricultural Food Security (FAFS).

UKZN has developed a model that has been taken up by poultry scientists and producers around the world. Research over the past two decades has involved the development of simulation models that predict food intake and growth of broilers and pigs, and reproductive activity in broiler breeders and laying hens. These simulation models have optimised the way in which broilers and pigs should be fed so as to maximise any one of a number of objective functions, such as margin over feed cost or feed conversion efficiency.

The research has led to extensive publications on the lighting management of broiler breeders and has resulted in a paradigm shift in the way that these birds are managed throughout the world. As part of its engagement with the community, the Poultry Institute is involved in training prospective poultry managers by providing them with the skills needed to manage people, finances, poultry operations and even themselves.

The Institute has impressive training facilities, including accommodation, lecture rooms, computers and a wide range of ongoing poultry operations, and these are housed on the University's research and training farm, Ukulinga. This Institute has been, and continues to be, highly successful in training students and preparing them for life. This focus area is home to an A-rated National Research Foundation researcher and two recently awarded South African Research Chairs Initiative-Chairs, in Land Use Planning and Management, and in Rural Agronomy and Development.



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BIOTECHNOLOGY

Biotechnology is a broad multi-disciplinary area which is defined by the United Nations Convention on Biological Diversity as “any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use”. Biotechnology has a range of applications in medicine, industry, agriculture, and the environment.



UKZN provides a common link to various biotechnology research projects and has a wide curriculum geared to train students in areas of biotechnology ranging from the bio-engineering of industrial yeast for controlled flocculation to biofuel production, mitochondrial enzyme regulation, the development of biomarkers of water pollution in aquatic organisms and an examination of the microbial response to climate changes in soils, and the implications on carbon-cycle feedbacks.

Chemistry: Research areas include organic synthesis, asymmetric catalysis, peptide drug design and computational chemistry. Collaborative research is conducted around the testing of tuberculosis and anti-fungal drugs, the identification and diagnosis of tuberculosis and radio-labelled imaging agents. Researchers have access to an extensive collection of modern instrumentation – among the best on the African continent – which

includes four NMR spectrometers (including 600 MHz with solids probe), and a wide range of chromatographic equipment (including GC-MS, LC-MS and MALDI TOF).

Medical Biochemistry: A mini drug discovery platform setup facilitates the conducting of assays for various natural and synthetic compounds to test for cytotoxicity. An evaluation of immunotoxicity using apoptosis assays is also conducted.

HIV/AIDS and TB: A collaborative link with Virology at Inkosi Albert Luthuli Hospital has been established to screen compounds for anti-HIV activity. Currently, the research focus is on using micro RNA species to type serum in patients infected with TB. This has therapeutic potential in infected patients.

Cancer: Novel drug development and screening.



Diabetes: Development of a novel non-genetic animal model for Type-2 diabetes is under way using rats. This research also focuses on the analysis of the chemical composition of several functional foods and medicinal plants and extracts as well as their effects on non-communicable chronic diseases.

Malaria: To combat the scourge of malaria in Africa, a research team is focused on malaria-related biochemistry, diagnostics, vaccines, metabolism, sequestration, immune-modulation, anti-malarial drug action and potential drug targets. The team is looking at developing new ways to diagnose malaria with a simple and cost-effective dipstick assay. To understand how the disease affects cells of the immune system during a malaria infection and under the influence of anti-malarial drug therapy, an X-Ray microanalysis is used which

enables the measurement of minute changes in the concentrations of elements within individual cells. The expression, location and structure of the protein are being studied.

Sleeping Sickness: Research is conducted into Trypanosomiasis which looks at poultry pathogens and trypanosomes of importance in South Africa and the rest of Africa in order to develop diagnostic assays, therapeutic strategies and, ultimately, vaccines against the diseases caused by these infectious agents. The research focuses on the molecules involved in the binding of the pathogens to their host tissues, antigenic differences between different strains of pathogens and between those of field strains and vaccine strains. Techniques in protein purification and characterisation, immunochemistry and molecular biology are employed.



Stem cell research: Research is conducted involving the regulation of skeletal muscle formation from mouse and human stem cells. The effect of extracellular and growth factors as well as anti-retrovirals (ARVs) on this process is being investigated. In addition, the generation of in vitro three dimensional, functional, skeletal muscle is under development.

Techniques used include tissue culture, primary cell isolation, fluorescence and confocal microscopy (including live cell imaging), wound healing assays and standard protein determination methods.

Nano-therapeutics: Research is conducted into the use of nanotechnology in foreign gene delivery (classical and mitochondrial gene therapy), expression and gene silencing mediated by RNA interference. UKZN has a dedicated

cell/tissue culture facility which is also actively involved in assays looking at the in vitro cytotoxic effects of natural products.

Genetics: Quantitative, population and molecular genetics technologies are employed in unveiling the contribution that genes make to important traits in animals. Molecular techniques are used to examine genetic factors underpinning biological diversity in the field of evolutionary biology. In the field of redox systems biology, the focus is on elucidating how the components in biological systems are integrated to give functional properties.

Microbiology: Research is conducted into the role and function of micro-organisms in a wide range of environmental and biotechnological processes. These include screening for biocatalysts from



environmental samples, optimisation of biotechnological processes by artificial intelligence tools, isolation and characterisation of micro-organisms and their secondary metabolites with potential to tackle pathogens, improving beer quality by profiling flavour-active ester compounds in beer under different fermentation and nutritional conditions, and the study of diesel degradation mechanisms by several isolates using real time PCR and proteomic techniques. Screening is performed to isolate micro-organisms with potential for biotechnological applications.

Studies currently under way also include:

Biofuels: Research in this area focuses on the impact of microbial population dynamics on the stability and performance of biotechnological processes employed to generate biogas or bio-hydrogen and an assessment of the potential of organic waste materials for microbiological energy generation. It also includes bio-mining for novel, thermophilic enzymes for lignocelluloses metabolism, cloning in heterologous hosts and enzyme characterisation, construction of lignocellulosesmetabolising and ethanol fermenting strains, construction of consortia for lignocelluloses bioconversion to ethanol, and the application of crude enzyme extracts in conjunction with recombinant yeast strains expressing cellulose and xylanasedegrading enzymes in order to develop enzyme cocktails to be used in biofuel production from lignocellulosic biomass in consolidated bio-processing fermentations.

Biopulping: An assessment of seasonal microflora variation and their physical and chemical effects on wood chips for the pulping industry is under way. The aim is the development of strategies to manage chip piles in order to avoid chip deterioration which leads to reduced pulp yields or inferior pulp quality.

Water quality: These entail examining the biochemical and molecular characterisation of bacteria isolated from wastewater treatment plant for chlorophenol degradation. Research focuses on the genomic evolution and adaptation of phenol-degrading bacteria to lethal phenol concentrations. Phenol-degrading isolate increased the phenol tolerance level from 400 mg/l to 800 mg/l and 2.5 fold in degradation rate within a 10-day adaptation period. Studies in a virus evaluation programme of the Umgeni River in Durban showed varying viral abundance along the Umgeni River and many enteropathogenic viruses have been detected.

Other studies demonstrate that bio-competitive exclusion can be used to slow down metal corrosion by supplementing additional nitrogen sources. Studies into the generation and on-site treatment of synthetic grey water for non-potable application are also carried out by the Discipline. Other water-related studies include: The impact of irrigation water quality on the safety of fresh fruits and vegetables, a six-year collaborative research project with the University of Pretoria. Bioremediation of water co-contaminated with chlorinated organic compound and heavy metals and profiling the microbial population and

diversity involved in the degradation processes, as well as the contribution of heterotrophic micro-organisms to eliminate metal from groundwater.

The study of bacterial diseases associated with aquaculture and the ability of the pathogenic bacteria to form biofilms, identifying their antimicrobial resistance phenotypes, identifying alternative strategies to eliminate these micro-organisms, including the use of phytochemicals,

identifying the role of quorum sensing in biofilm formation and attempting to inhibit quorum sensing and thus the associated pathogenicity. Additionally, genotyping of these bacterial pathogens is being undertaken, as is a study on the genes associated with antimicrobial resistance which hamper effective therapy. Aerobic catabolism of aromatic priority pollutants by freshwater and marine micro-organisms.





ENERGY AND TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT

The Energy and Technology for Sustainable Development focus area is providing leading research for the needs of South Africa, in keeping with the mission of UKZN as the Premier University of African Scholarship. The energy sector is by far the largest contributor to global GDP and is the engine that drives the world's economy. Humankind's insatiable appetite for energy has meant that this sector influences all aspects of the economy and has direct and indirect bearing on the socio-economic development of a country and its people.

Research that is currently undertaken at UKZN in the area of technologies for sustainable development is finely woven into the research being undertaken in the energy sector. The development of technologies for renewable energy, which include fuel production from renewable sources, is a perfect example of this. Research in sustainable technologies also includes environmental sustainability studies which aim to ensure that current industrial processes lead to minimal damage to the environment. In the National System of Innovation, energy security has been identified as one of the “grand challenges”. Research in the energy sector is not limited to production and distribution of electricity, but also to efficient energy usage, as well as the limitation of the negative environmental effects which are caused by the production and use of energy sources. In this regard there has been a rapidly-growing research interest in improving and developing new technologies for the reduction of carbon dioxide and other greenhouse, and flue gases emitted from coal power plants and fuel burning plants.

The University has a number of Institutes and Centres in this focus area which are conducting research in various aspects of energy production and utilisation as well as technology application for sustainable development. Research work on renewable and alternative energy systems and technologies such as solar and wind as well as biofuels and conversion of municipal waste to natural gas for electricity production is being conducted by multi-disciplinary teams in the College of Agriculture, Engineering and Science. One of the pillars of this initiative is the Integrated Renewal Energy Advancement Programme (IREAP) which is a partnership between UKZN, engineering company Karebo Systems, the Department of Trade and Industry, the Industrial Development Corporation of South Africa (IDC), the Technology and Human Resources for Industry Programme (THRIP), and other relevant partners for the development of a strategy for fundamental research into renewal energy.



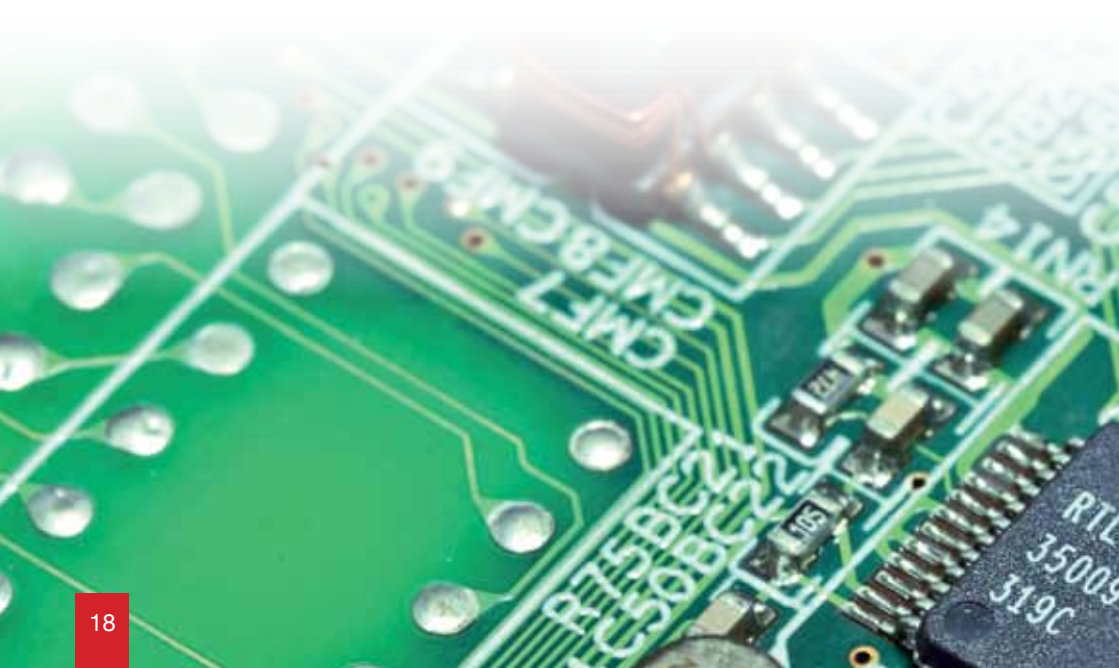
This research focus area is also the home base for three South African Research Chairs Initiative (SARChI) – Chairs which are technology based, namely, the Quantum Information Processing and Communication Chair, which is at the frontier of applying quantum mechanics to develop new technologies in the areas of quantum cryptography and quantum computing; the Fluorine Process Engineering and Separation Technology Chair, which supports the South African Fluorochemical Expansion Initiative (FEI) and will aid in the development of a substantial fluorochemical industry in the country; and the recently awarded Chair in Intelligent Real Time Power Systems which will focus on optimised utilisation of energy sources in an integrated power system.

At UKZN there are a number of Units and Centres in this focus area which are conducting research in various aspects of energy

production and utilisation as well as technology application for sustainable development. Some of the Units have been established through close research collaborations with major industries such as ESKOM and SASOL.

The partnership with ESKOM has resulted in massive investment in research and the establishment of state-of-the-art facilities such as the High Voltage Direct Current (HVDC) Centre and the Vibrational Research and Test Centre (VRTC). The facilities are for research on improved equipment and system performance of electricity transmission and distribution networks.

Sustainable manufacturing and chemical production is an area of strength in the School of Engineering with large research groupings in Mechanical and Chemical Engineering respectively. The Thermodynamics Research Unit which resides in the

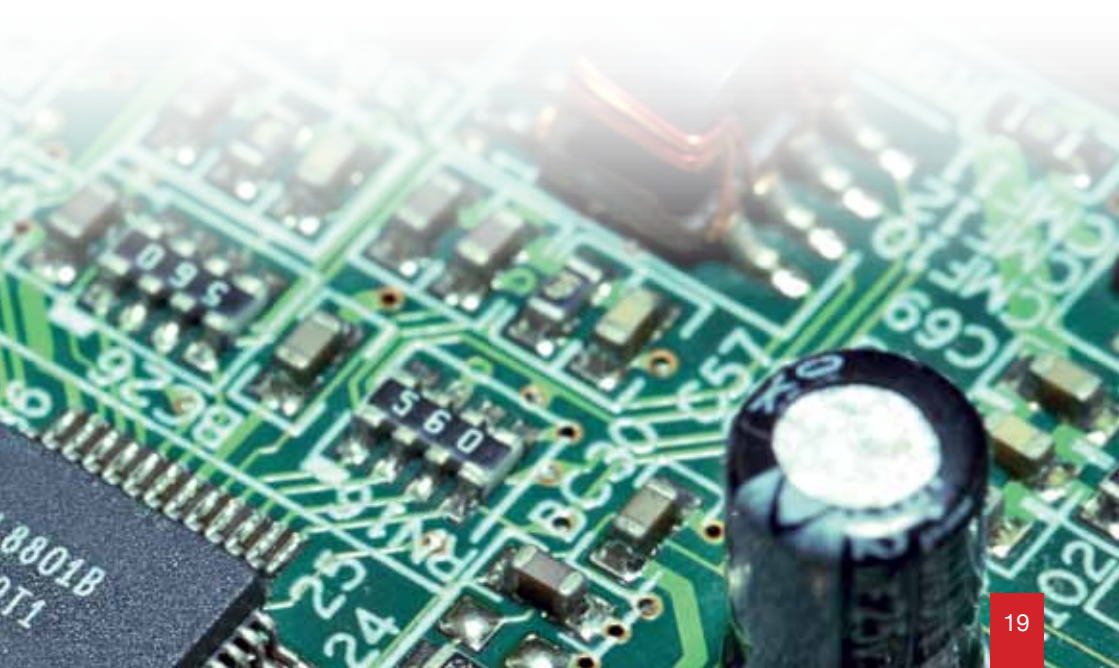


Discipline of Chemical Engineering is a SASOL Centre of Excellence in Chemical Thermodynamics and undertakes research into the improvement and optimisation of chemical and separation processes for SASOL.

Partnerships also exist with major players in the telecommunications industry with a centre of excellence in this area in partnership with Telkom and Alcatel-Lucent in the Discipline of Electrical, Electronic and Computer Engineering.

Research in Mechatronics and Robotics for Advanced Manufacturing Systems at UKZN has focused on Reconfigurable Manufacturing Systems (RMS), autonomous mobile robots and quality control systems for Advanced Manufacturing environments. The research uses the concept of 'system integration' to achieve the desired outputs and results.

Reconfigurable Manufacturing Systems research has included topics such as reconfigurable machine design and materials handling for mass produced custom products. Research in autonomous mobile robots has focused on navigation, guidance, mobile robot co-operation, differential drive operational dynamics and optimised material handling routing. Research in quality control for Advanced Manufacturing systems has produced designs, assemblies and results that validate research objectives for part inspection and recognition. Research and development has also produced a human transporter robot platform, autonomous robot bird, low cost Mechatronic vehicle simulator, an amphibious robot for search and rescue operations as well as in overhead transmission lines maintenance.



4

GENDER, RACE AND IDENTITY STUDIES

The focus area draws on multiple disciplines within the University, to examine the ways in which identities are constructed, created and consolidated. These disciplines draw on several frameworks for engaging with issues of race, and gender, among other social categories – like age, sexualities and class.

In the context of health inequalities, AIDS, gender and sexual violence, the focus areas of Gender, Race and Identity provides important conceptual tools to address how social structures that arise in history are reproduced but are also open to change. The research is strongly influenced by contemporary critical theories which question the framing of power inequalities. Gender, Race and Identity focus on the dynamism and intersections of social inequalities and the vulnerabilities and anxieties of those belonging to groups usually constructed as powerful, as well the agency of those belonging to groups usually seen as lacking power.

The focus area thus locates itself by initiating serious and difficult debate, and by researching alternative routes to creating a society that is non-racial and that is simultaneously and measurably moving towards greater equality than that which is currently experienced by all South Africans. The focus area is a home to the Centre for Critical Research on Race and Identity (ccrri) which is dedicated to facilitating the study of race thinking and changing identities so as to improve understanding of, and stimulate public dialogue about, the epistemological, moral, cultural and other bases for perceptions of human diversity and difference.

Many of the initiatives in this focus area are housed in the College of Humanities. The following are some of the key programmes:

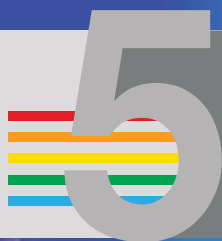
Postgraduate and Research Programme in Gender and Education

Making schools safer, more peaceful and more egalitarian, the Gender and Education programme examines how educators and learners interact, how they construct their gender identities and how schools operate. This post-graduate programme has trained many Masters and PhD students to address ongoing challenges (including violence in schools), and approaches to achieving Gender Equity (in e.g. the curriculum).

Postgraduate and Research Programme in Gender and Religion

South Africa, like many other parts of Africa, claims to be 85% religious, yet patriarchy and sexism still persists within a web of other oppressions such as racism and poverty. These oppressions often find overt and covert justification from within religion and culture. At the same time, it is acknowledged that religion and culture can also provide plausible structures as a means with which to overcome oppression. This seemingly dialectic tension is explored through research and the sharing of knowledge from such research within the Gender and Religion programme which has not only produced many Masters and PhD graduates but has also produced research that has gained national and international prominence as the only formalised programme in Gender and Religion offered in Africa.





HIV/AIDS, TUBERCULOSIS AND HEALTH PROMOTION

As the pre-eminent academic institution at the epicentre of the HIV epidemic in South Africa, UKZN has taken up the challenge of providing leadership in response to HIV and AIDS and Tuberculosis, and is undertaking ongoing research to enhance scientific capacity in these critical areas and strengthen the biomedical and broader societal response to the epidemic.

UKZN's focus on HIV/AIDS, Tuberculosis and Health Promotion is a multi-faceted and multi-disciplinary initiative, involving a number of established research groups and projects which recognise the importance of rigorous scientific inquiry aimed at, for example, an understanding, of the pathogenesis, virology, immunology and epidemiology as it relates to HIV/AIDS, or the role of breastfeeding in mother-to-child HIV transmission and the facilitation of clinical trials for treatment of HIV and TB in both children and adults. The focus area is a home to an A-Rated NRF Researcher and SARCH Chairs in Indigenous Health Care Systems, and Systems Biology of HIV/AIDS.

UKZN continues to attract international recognition for its groundbreaking research in both HIV and TB prevention and treatment. At a global level, UKZN strives to nurture international institutional partnerships such as its long-standing relationship with the universities of Columbia and Harvard, both in the United States.

In recognition of its standing as a world-class research centre in HIV/AIDS and Tuberculosis, the University has successfully attracted significant funding from influential international organisations such as the Howard Hughes Medical Institute (HHMI), the Wellcome Trust, the US National Institutes for Health (NIH), the US Agency for International Development (USAID), and the European Union (EU).

Major research centres and institutes include: The Africa Centre for Health and Population Studies; the Centre for the AIDS Programme of Research

in South Africa (CAPRISA); the KwaZulu-Natal Research Institute for Tuberculosis and HIV (K-RITH); the Enhancing Care Initiative; HIVAN, the HIV Pathogenesis Programme (HPP) and the Health Economics and HIV/AIDS Research Division (HEARD). CAPRISA is a designated UNAIDS collaborating centre for HIV prevention research.

Through the Columbia University-Southern African Fogarty AIDS Training and Research Programme, the institution is committed to building scientific capacity in HIV/AIDS and tuberculosis research in several countries in Southern Africa to enhance continuing efforts to counter the HIV/AIDS and TB epidemics. Over the years the programme has trained many of South Africa's young AIDS and TB researchers.

At the same time, however, this research cluster does not neglect the socio-economic implications and impact of diseases such as HIV/AIDS and TB. Thus, there is significant emphasis on research into the ethics, law and human rights issues as they relate to the administering of AIDS vaccines through the ELH (Ethics, Law, Human Rights) programme, and the HIV/AIDS Vaccine Ethics Group (HAVEG). The broad socio-economic impacts of AIDS are examined through the Health Economics and HIV/AIDS Research Division (HEARD), and the research around the role of indigenous health care systems in addressing the epidemic is conducted under the leadership of a Chair in Indigenous Health Care Systems.



6

INDIGENOUS AFRICAN KNOWLEDGE SYSTEMS



A Review conducted in 2009 by a team of external and internal experts on Indigenous African Knowledge Systems (IAKS) capacity at UKZN, revealed that the University has great capacity and potential in terms of active researchers and publications on IAKS in its various units. In-line with the institutional vision “to be a Premier University of African Scholarship” and promoting Africa-led globalisation, UKZN has identified IAKS as a strategic focus area for research, teaching and community engagement. Taking into consideration the holistic and multi-disciplinary nature of IAKS, the scope of research undertaken in the field is quite comprehensive.

Researchers are engaged in collaborative research work locally, nationally and internationally in areas of:

(i) **Indigenous African Agriculture and Food Security**

including use of Wild food resources and Postharvest Technologies in the context of natural resource and disaster management systems for climate change adaptation and mitigation. Researchers in these areas investigate the behaviours of living organisms as early warning systems, taboos and totemic systems as indigenous environmental protection mechanisms;

(ii) **Traditional African Medicine**

involving working with traditional healers in the identification and screening of medicinal plants for the treatment of various community ailments; smoke research for conservation, cultivation and improving chemical constituents of indigenous medicinal plants;

The scope of research in this area is wide – there are more than 3 000 medicinal plants presently traded and used in African traditional medicine

The scope of research in this area is wide – there are more than 3 000 medicinal plants presently traded and used in African traditional medicine – and ranges from the pharmacological screening of coniferous plants such as the *African Podocarpaceae* and the pharmacological potential of plants from the *Orchidaceae* family, to investigations of the effect of storage on the phytochemical composition and biological



activities of certain Southern African medicinal species. Other areas of research include the study of medicinal plants traditionally used for the treatment of stomach ailments; the isolation of the antibacterial compounds from *Erythrina caffra*; the study of medicinal plants used by the Venda communities to treat venereal disease and plants used to treat diarrhoea; the efficacy, safety and pharmacological properties of commercial herbal mixtures which are an increasingly popular form of African traditional medicine. Studies are also being undertaken to compare the anti-microbial activity of bulb versus

leaf extracts of certain plants so as to reduce the threat to species that comes with the increasing harvesting of bulbs. Work has also started on the phytochemical makeup of *Cyrtanthus contractus*, a member of the family Amaryllidaceae, from which the commercial Alzheimer drug Galanthamine has been produced.

- (iii) **Indigenous African Approaches** to conflict management and transformation. This includes investigation into actors, principles, mechanisms and their applicability in modern times within the context of culture, gender and human rights;

(iv) **Traditional African Leadership** and governance systems.

Researchers investigate the nature and characteristics of Traditional African institutions; issues of legitimacy, democracy and accountability; traditional African institutions and modernity (challenges and prospects);

(v) **Indigenous Knowledge Systems** and Creative/cultural Industries, especially with regard to promoting indigenous community enterprises for employment creation and income generation among vulnerable social groups (women, youth and people living with disability);

(vi) **Indigenous African Languages**

where researchers investigate issues on the diversity of indigenous African languages and its impact on development policy, language demographics, linguistic features of indigenous African languages, etc.

The issue of gender and language is crucial in all these IAKS research areas at UKZN due to the centrality of African women and language in sustainable community livelihood in African communities.





MARITIME STUDIES

The primary research focus in this area is Marine Science and Coastal Engineering, the secondary being Climate change – prediction models, adaption strategies, Air quality analysis and modelling in urban areas, Analysis and design of renewable energy systems – wave, wind, currents; Analysis and mitigation of natural hazards – floods, droughts, dispersion of toxic gases; Catchment management – erosion/sediment yield, soil moisture mapping, remote sensing, modeling; Management of urban water reticulation networks and storm water systems.

The aim is to achieve significant scientific advances in the analysis and modelling of human impacts on productive aquatic ecosystems, including threatened estuarine systems – addressing issues of sustainability, increasing pollution, flow reductions, and widespread degeneration of the functioning of these critical ecosystems. The main innovation targeted in the research is the effective integration of physical dynamics with ecosystem responses in a way

that is appropriate for encapsulating understanding of their functioning into predictive models for application to sustainable management.

Overall, the scientific importance of the activities of the research groups within this area is embedded in its focus on developing new insights and understanding of the structure, functioning and sustainable management of critical productive hydro-ecosystems, using theoretical, computational and field-based research techniques to develop insight and understanding of flows in the natural environment. This work is done through multidisciplinary teams using an integrated approach to understanding and modelling physical and biological systems.

MARINE SCIENCE AND COASTAL ENGINEERING

UKZN research in Coastal Engineering is led by the eThekweni Municipality Chair in Civil Engineering and Professor of Hydraulics and Environmental Fluid Mechanics at the School of Engineering. The Metro, UKZN and TU Delft (TUD) in Holland, one of the top 20 universities in the world, are collaborating on research in Coastal Engineering.

TUD are partners in the University's SANPAD-funded research projects at St Lucia estuarine lake. One of the most significant aspects of this research initiative, and that of the postgraduate students, is the unique and innovative collaboration with Biological and Conservation Sciences. This partnership sees engineers working hand-in-hand with biologists on the ecosystem functioning of Lake

St Lucia, one of the world's critically important estuarine systems which is part of the iSimangaliso world heritage site. Since 2004, academics have worked on developing an integrated biophysical model for the entire estuarine system. The primary research focus aims to achieve significant scientific advances in the analysis and modelling of human impacts on productive aquatic ecosystems, including threatened estuarine systems – addressing issues of sustainability, increasing pollution, flow reductions, and widespread degeneration of the functioning of these critical ecosystems. The main innovation targeted in the research is the effective integration of physical dynamics with ecosystem responses in a way that is appropriate for encapsulating understanding of their functioning into predictive models for application to sustainable management.

Maritime Initiative

The Maritime Initiative has been identified as a potential Research Focus Area for UKZN, based on historical activities in this area as well as the University's strategic location on the Eastern Seaboard. Research and studies are geared towards the utilisation of the resources of the ports and the sea for socio-economic benefits. The Unit for Maritime Studies focuses on the following academic areas:- International Business Transactions and Supply Chain Logistics, International Trade Economics, Maritime Economics, International Taxation, Customs and Excise Taxation, Maritime Law and Commerce, Ship and Marine Environment Management.



SOCIAL DEVELOPMENT AND ECONOMIC STUDIES

The primary objective of this area of research is to strengthen and enhance applied and policy-relevant research in the fields of Economic Development, Finance, Sociology, Development Studies, Economic History, Agri-Business, Cultural and Heritage Tourism, and Health Economics.

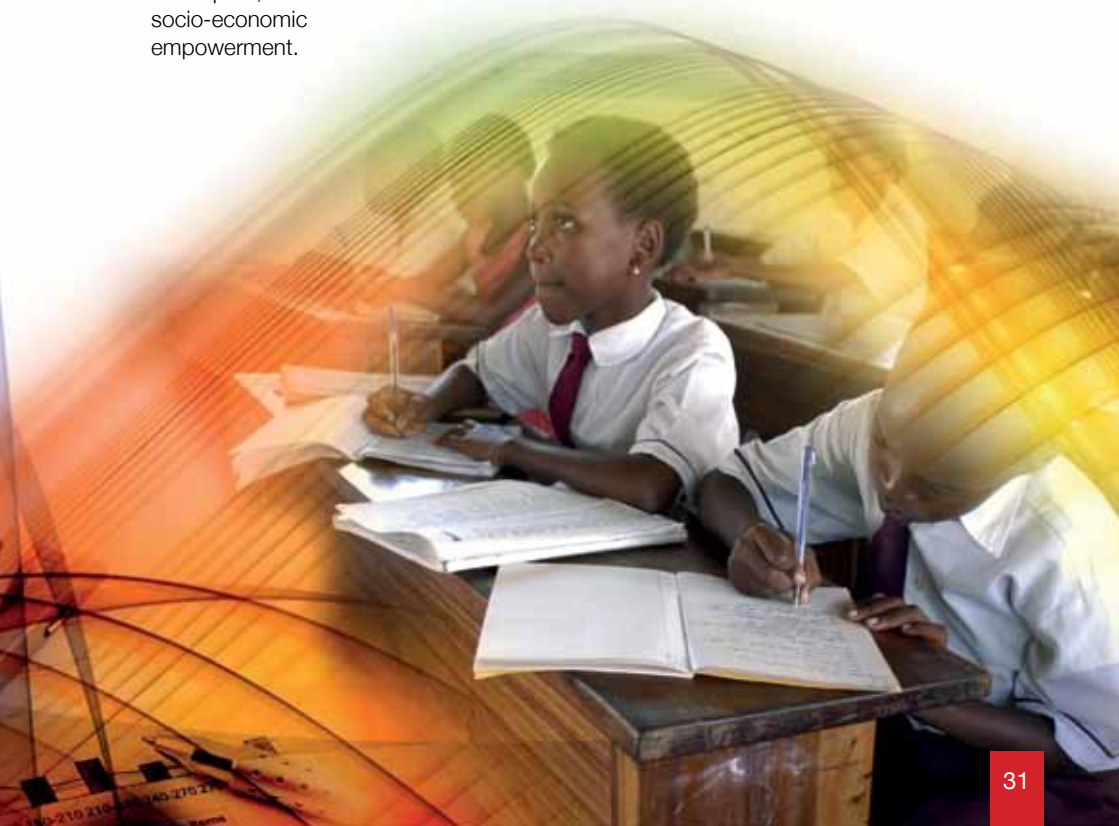


Some of the leading research undertaken in this focus area delves into urban-rural economic and livelihood inequalities in South Africa and continues to ask what the relationship is between the growth and spatial distribution of the public and private economic sectors, and explores the interface between households and labour markets in South Africa, advancing knowledge across a range of socio-economic areas, including those relating to marriage, migration, child care, household survival strategies and resource sharing, and labour force participation and employment.

The research encompasses the formal and informal economy, the nature of poverty, the characteristics of the poor, areas and socio-economic empowerment.

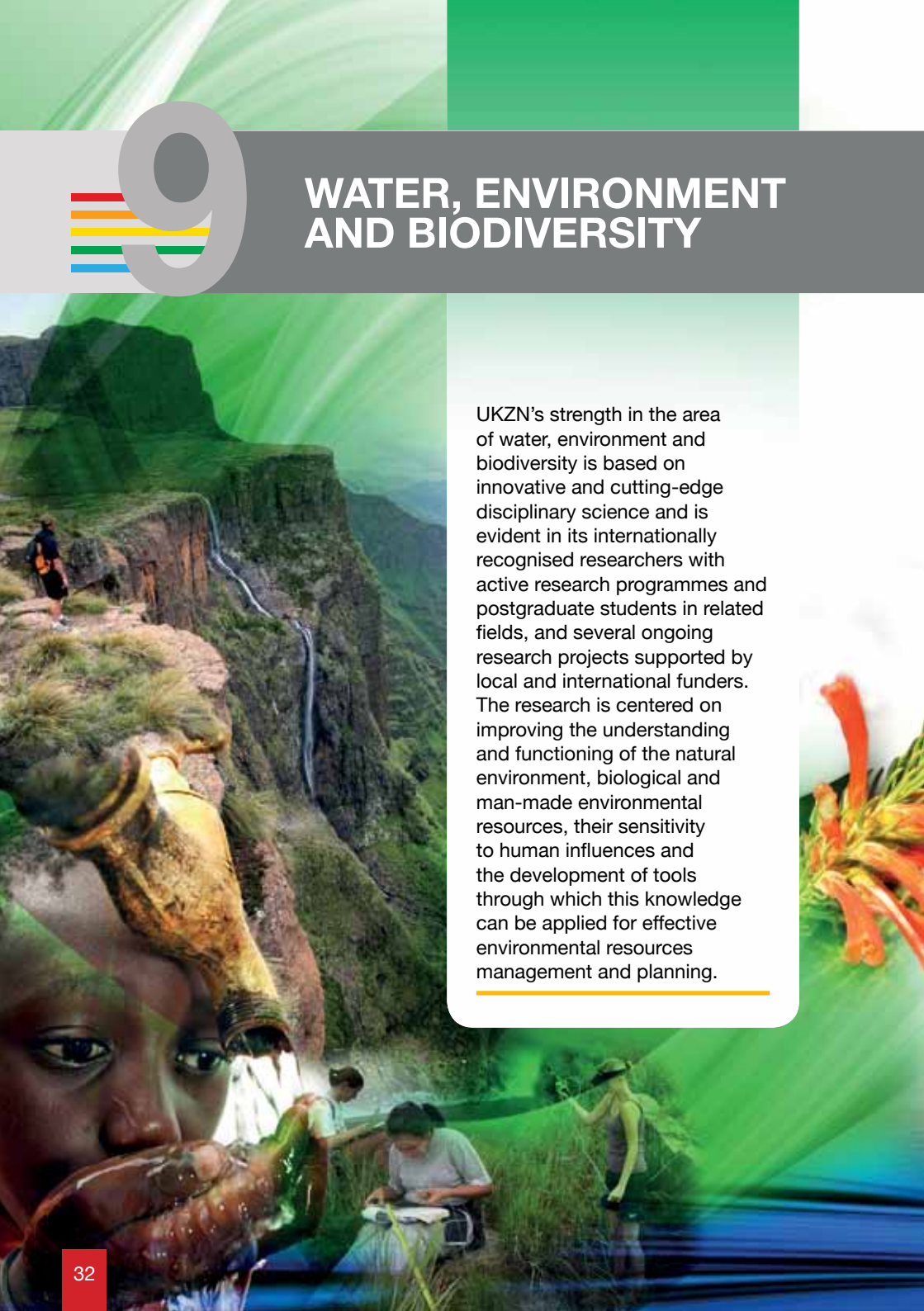
This research is integral to evaluating the experiences of economic development among individual South Africans and to assessing economic and social policy that seeks to reduce poverty and increase well-being.

The focus area is a home to SARCHI Chairs in Economic Development, and Applied Poverty Reduction Assessment. The Centre for Civil Society (CCS) deals with issues falling into this focus area. Its main objective is to advance socio-economic and environmental justice by developing critical knowledge about, for and in dialogue with civil society through teaching, research and publishing. The research focus area covers social issues on education and it houses the J.L. Dube Chair in Rural Education.



A large, stylized number '9' in a light grey color. To its left are five horizontal stripes in red, yellow, green, and blue, stacked vertically.

WATER, ENVIRONMENT AND BIODIVERSITY

The background of the page is a collage of environmental images. At the top left, there's a green abstract shape. Below it, a hiker is seen on a rocky trail overlooking a deep canyon with a waterfall. In the bottom left, a close-up of a person's face is shown drinking from a large, rusted metal pipe. In the bottom center, a person is kneeling in a field, possibly conducting research. On the right side, there's a close-up of a red, branching plant structure. The overall color palette is dominated by greens and blues, with some earthy tones from the landscape and the person's face.

UKZN's strength in the area of water, environment and biodiversity is based on innovative and cutting-edge disciplinary science and is evident in its internationally recognised researchers with active research programmes and postgraduate students in related fields, and several ongoing research projects supported by local and international funders. The research is centered on improving the understanding and functioning of the natural environment, biological and man-made environmental resources, their sensitivity to human influences and the development of tools through which this knowledge can be applied for effective environmental resources management and planning.

The activities in this area form the focus of a multi-disciplinary team of engineers, biologists, political scientists and community medical professionals, and have included participation in international research projects. In addition to large research groups in this area, there are several other multi-disciplinary initiatives, notably working on wetlands, soil erosion, community interactions and sanitation, estuary-related research, and water and public health, working closely with other stakeholders, including local communities.

UKZN has wide and varied expertise and experience in water-related teaching, research and outreach activities throughout South Africa and in many parts of Africa and beyond. The research focus area draws in a range of academics and students from all the University's Colleges and most of its Schools.

UKZN's strength in the field of water is evident in its nationally and internationally recognised researchers with active research programmes and postgraduate students in water-related fields, and several ongoing research projects supported by local and international funders. These projects and the contribution of the University's graduates have resulted in UKZN being recognised as one of the leading institutions in water-related research and training in South Africa and internationally.

Hydrology: Research is centered on improving our understanding of the functioning of the hydrological cycle, its sensitivity to human influences and the development of tools through which this knowledge can be applied for effective water resources management and planning. Within this context, hydrology research is conducted within the following areas: Agricultural water use and innovation in irrigation practices; Water related aspects of land use change; Hydrology process studies; Hydrological aspects of climate change and forecasting; and the Hydrological model and database design and development.

Development of tools and practices to assist in the implementation of South Africa's National Water Act and the management of the country's water resources is an outcome of these studies, but the Research Group is also active in regional, continental and global initiatives. One of the more notable outputs from this group is the Agricultural Catchments Research Unit's Agro-hydrological Modelling System, a software system that is being used as a research and management tool for water resources planning and operations in South Africa and provides a foundation for several ongoing research projects. Projects completed recently include a revised Agrohydrological Atlas for South Africa, and tools to estimate the water use of commercial afforestation in South Africa, both of which are now used by the Department of Water Affairs and Forestry in water licensing and regulation.

Waste, Water and Sanitation

Management: As a result of a Memorandum of Agreement signed between the eThekweni Municipality's Water and Sanitation Department and UKZN, the University's Pollution Research Group (PRG) has expanded its activities into municipal water and wastewater management. These activities form the focus of a multi-disciplinary team of engineers, biologists, political scientists and community medical professionals, and have included participation in two European Union research projects related to membrane bioreactors and the identification and dissemination of best practice of water and sanitation supply to un-served communities. Sanitation projects are being undertaken on pit latrines and urine diversion toilets.

Collaborative research on the anaerobic baffled reactor process includes internationally recognised projects being undertaken by the non-governmental organisation Borda, which is working in South-East Asia and Africa. Research for the Water Research Commission and SASOL is ongoing. The Pollution Research Group recently received a R 2.8 million grant from the Bill & Melinda Gates Foundation to fund its toilet technology and sanitation research, the aim of which is to design a toilet system that will lead to the safe disposal of waste water in poor communities. UKZN was one of eight institutions – and the only one in Africa – chosen out of 22 to take part in the “Reinvent the Toilet” challenge. UKZN's revolutionary system placed sixth at the Reinvent the Toilet Fair held in the United States. UKZN's toilet was designed to burn waste solids while re-routing urine to a storage tank where it would be decontaminated, purified and repurposed for flushing and hand-washing.

Micrometeorology and

Agrometeorology: Investigations are conducted into the energy and water balances between the soil, plants and atmosphere through the Soil-Plant-Atmosphere Continuum Research Unit (SACRU) which specialises in micrometeorology and agrometeorology. This internationally recognised Research Unit has a major research thrust in the investigation of energy and water balances and emphasises the use of and development of methods for the measurement of evaporation, sensible heat and, more recently, carbon dioxide fluxes above land surfaces. Most of this research is funded by the Water Research Commission.

Hydrological Engineering: The way in which engineering interacts with the natural environment and can be used to promote sustainable practices is consolidated in research conducted by the Centre for Research in Environmental, Coastal, and Hydrological Engineering (CRECHE). Projects include the management of landfill emissions, the dispersion of pollutants in the atmosphere and coastal waters, spatial rainfall modelling and estuary bio-hydrodynamics.

The Centre also conducts leading national research into radar-rainfall relationships and flood forecasting through its Satellite Applications and Hydrology Group (SAHG).

Limnology: Biological limnology research, with particular focus on man-made lakes and integrated catchment management, is concentrated in the School of Biological and Conservation Studies. Members of the Grassland Science Group collaborate with communities in the Upper-Thukela on a pilot “Payment for Environmental Services” project funded by the Department of Water Affairs and Forestry. Here, indicators for the payment of water services are developed and tested.

Applied research into and management of water resources, decision support tools for estuaries, fresh water management and water conservation is conducted by the Institute of Natural Resources, an associate institute of UKZN. In addition to these larger water research groups there are several other initiatives, notably working on wetlands, soil erosion, community interactions and sanitation, estuary-related research, and water and public health. The research work has received substantial funding from the Water Research Commission,

research grants in the Ford Foundation, the European Union and Dutch and Swedish Development Agencies.

THE SMALLHOLDER SYSTEM INNOVATIONS (SSI) RESEARCH PROJECT

This flagship research project cuts across and involves all UKZN groups. An applied and development-oriented research programme, it aims at advancing knowledge on how to balance water for food and the environment with a particular focus on upgrading smallholder rain-fed agriculture in water-stressed catchments. The multi-disciplinary research programme encompasses biophysical and social research themes, Grassland Science and the University's Farmers' Support Group, with the researchers working closely with other stakeholders, including local communities at two pilot catchments (Potshini and Makanya) in two river basins (Thukela and Pangani) in South Africa and Tanzania respectively.

The project is being implemented jointly by five research institutions: Sokoine University of Agriculture (Tanzania); Stockholm University (Sweden); the UNESCO-IHE Institute for Water Education (The Netherlands); the University of KwaZulu-Natal; and the International Water Management Institute. Funded by the Dutch and Swedish governments, the programme – notwithstanding its development orientation – is based on innovative and cutting-edge disciplinary science.

Biodiversity: Research in this area is conducted in a number of research institutes and units such as The Research Centre for Plant Growth and Development which does research on plants concentrating on 5 main

focus areas – Ethnobotany and Traditional African Medicines; Plant Biotechnology where we try to increase plant production and the synthesis of secondary products of medicinal value; Plant Hormone Physiology and their regulation and control of growth processes to increase plant production; Smoke Technology where we study the regulation of plant growth by fires and their products; and Microalgae and their effect on higher plant growth and potential use as biofuels; the Plant Germplasm Conservation Research on cryopreservation and seed storage; the Centre for African Parrot Conservation; and the Unit on Plant Pollination Biology which is devoted to research on evolutionary diversification of plants. This study area is a home to two NRF A-rated researchers and a SARCHI Chair in Evolutionary Biology.

Plant germplasm conservation research focuses on recalcitrant seeds, which are enduringly desiccation-sensitive, short-lived and representative of many over-exploited plant species, a large proportion of which are threatened.

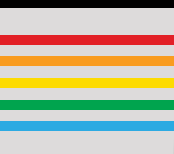
Work carried out which first established the high international profile of this research group, firmly established the basis of recalcitrant seed behaviour, as being a consequence of unabated active metabolism, the fine details of which are presently the subject of on-going projects. Parameters facilitating short-to medium-term storage of recalcitrant seeds have been optimised

on a species-basis, and presently research is directed on means to eliminate seed-associated fungi which seriously curtail storage life spans.

Long-term conservation of the germplasm of recalcitrant-seeded species is achievable only by cryopreservation, usually in liquid nitrogen (-196°C). This is impossible for intact seeds, thus the use of excised embryonic axes is a major research focus. The procedures, however, have been identified to be accompanied by oxidative stress, which seriously compromises successful production of plants from cryopreserved material.

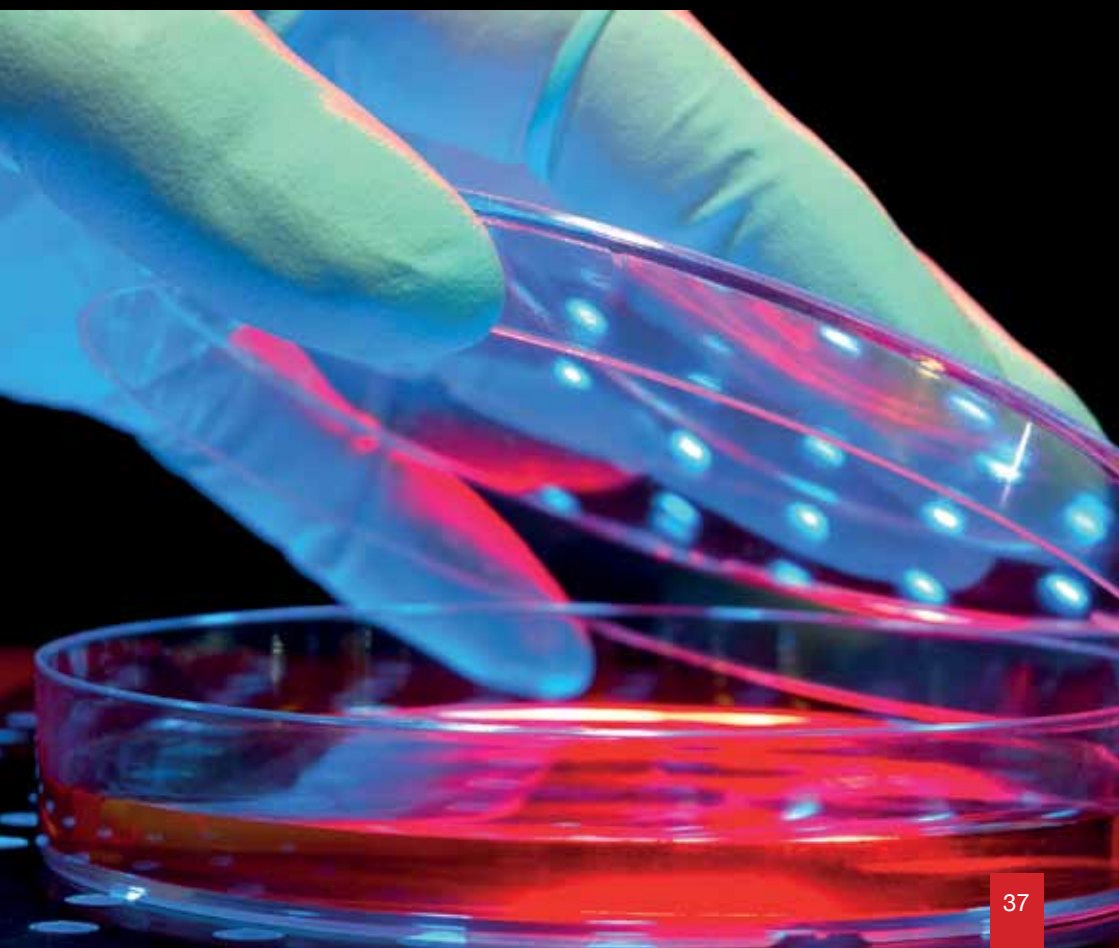
A major break-through from current research aimed at ameliorating oxidative damage, is the innovative application of the reducing power of the cathodic fraction of electrolysed water, which has afforded not only success, but avoids the use of chemical anti-oxidants, which themselves are potentially toxic. The Centre has recently completed a basic document commissioned by the FAO, setting the standards for conservation of the germplasm of recalcitrant-seeded species.





SOUTH AFRICAN

RESEARCH CHAIRS INITIATIVE (SARChI)



Economic Development

Professor Dori Posel

posel@ukzn.ac.za



Professor Dori Posel is an economist who specialises in the micro-econometric analysis of

household survey data. Her Research Chair in Economic Development is located in Development Studies in the School of Built Environment and Development Studies.

Professor Posel obtained her PhD in Economics from the University of Massachusetts in the United States in 1999. She has been the recipient of numerous awards for her research and has published widely on questions of migration, marriage, labour markets and socio-economic indicators of well-being.

The overall research objective of the Research Chair in Economic Development is to explore the interface between households and labour markets in South Africa, advancing knowledge across a range of socio-economic areas, including those relating to union formation, mobility, child care, household survival strategies and resource sharing, labour force participation and employment.

The research is integral to evaluating the experiences of economic development among individual South Africans and to assessing economic

and social policy that seeks to reduce poverty and increase well-being.

Professor Posel is also using the opportunities afforded by the Research Chair both to strengthen quantitative research skills in the analysis of South African micro datasets, and to foster inter-institutional research on socio-economic issues.

During 2011, she introduced the MASA conference. MASA - the Micro-Econometric Analysis of South African data - brings together national and international researchers who work with South African micro data.

The conference provides a forum for the presentation of new and on-going micro-econometric research in various areas, including education, labour, welfare and poverty, demographic economics, health and social capital. Given the success of MASA 2011, the conference will be held regularly, and plans for MASA 2012 are well underway.

Professor Posel's recent research investigates specific characteristics of the post-apartheid period in South Africa, including: the temporary nature of labour migration; marriage and cohabitation in the context of bride wealth payments; the determinants of subjective well-being or happiness, and relations of trust among South Africans.

A key project undertaken during 2011 investigated the economics of language. Although the majority of South Africans are African mother-tongue speakers, English and to a lesser extent Afrikaans, are the main languages of business.

Professor Posel's research used recently released micro data to explore measures of adult literacy, the relationship between home language and English language proficiency, the returns to these language abilities in the South African labour market, and the implications for language policy.

Her research finds that among Africans, English language proficiency is highly rewarded (more so than home language proficiency) in the South African labour market, a finding which helps explain why English is viewed as the language of success and why parents want their children to study in English. However, her research also shows that South Africans are more likely to be proficient in English if they are also able to read and write very well in their home language.

This finding is consistent with a large body of literature which argues that the acquisition of second-language skills is best supported through the acquisition first of home language skills during schooling.

Evolutionary Biology

Professor Steve Johnson

johnsonsd@ukzn.ac.za



Prominent academic and researcher Professor Steve Johnson of the School of Biological and

Conservation Sciences was awarded the Research Chair in Evolutionary Biology for a five-year period.

His research in the field of evolutionary biology focuses on plant pollinator interactions. The interactions between flowers and their pollinators are not only important for seed production of wild plants and crops but have also been instrumental in the evolution of the spectacular diversity of the world's flowering plants.

Professor Johnson has contributed significantly to the understanding of the evolutionary diversification of plants in southern Africa and also the ecological requirements that plants have for their reproduction.

Fluorine Process Engineering and Separation Technology

Professor Deresh Ramjugernath

ramjuger@ukzn.ac.za



Professor Deresh Ramjugernath is the DST/NRF South African Research Chair for Fluorine Process Engineering and

Separation Technology and also Director of the Thermodynamics Research Unit at UKZN.

Ramjugernath leads a large team of post graduate students and researchers - arguably one of the leading research groups in its field globally - which undertakes cutting-edge research contributing towards chemical process development and optimization in South Africa and abroad.

The group actively contributes to the Government's Fluorochemical Expansion Initiative (FEI) by researching and developing South Africa's fluorinated products with its activities being integral to the development of a fluorochemicals industry in the country and directly linked to the South African Nuclear Energy Corporation (NECSA) and SASOL.

Although South Africa possesses the second largest reserves of fluorspar (the starting material for all fluorochemicals), it currently imports almost all of its fluorinated products. There is very little beneficiation of the fluorspar reserves in the country and the activities under the Chair assist in addressing the problem by developing technology and human capacity to drive the development and expansion of a fluorochemical cluster.

The research activities under the Chair are not limited to fluorochemicals but also cover the areas of chemical thermodynamics and separation technology. In this regard the Research Unit has one of the best equipped laboratories in the Southern Hemisphere and is one of the largest groups working in this field.

Ramjugernath is passionate about human capacity development and is a strong believer in a collaborative approach to research capacity development. In this regard he has had a number of research bi-lateral agreements for the exchange and training of students and researchers with research groups based in countries such as Germany, the United States of America, Canada, Sweden, the United Kingdom, Poland, France, and Czech Republic.

Quantum Information Processing and Communication

Professor Francesco Petruccione

Petruccione@ukzn.ac.za



Francesco Petruccione, Professor of Theoretical Physics at the University of KwaZulu-Natal,

was awarded an Innovation Fund grant in 2005 to set up a Centre for Quantum Technology and in 2007 was granted the South African Research Chair for Quantum Information Processing and Communication.

Professor Petruccione has been working on the theory of open quantum systems, which is at the basis of many recent quantum technological applications. The miniaturization of technological devices necessitates manipulation of objects at the nanoscale level at which coherent quantum mechanical processes start to dominate the physical properties.

The unavoidable interaction of these systems with their environment gives rise to dissipative mechanisms and a strong loss of quantum coherence, i.e. decoherence. Since perfect isolation of quantum systems is not possible, it is of central importance to incorporate the methods and tools of the theory of quantum systems in the exploration of quantum technologies. Among the basic tools of the new

quantum technologies are quantum metrology, quantum control, quantum, communication and quantum computation.

In 2011 the Research Chair started to apply the theoretical methods of open quantum systems and quantum information processing to quantum biology. As the name suggests, quantum biology is the application of quantum mechanics to aspects of the biological sciences.

Recently, developments in experimental spectroscopy have for the first time revealed quantum effects in biological systems, including in the photosynthetic light-harvesting complexes of certain bacteria and marine algae. The energy transfer in photosynthetic complexes is achieved with an efficiency of 95%.

To understand how living systems, which are highly complex, warm and in constant interaction with the environment can sustain and exploit quantum coherence, has huge implications for quantum engineering of technological devices.

Members of the Group, together with Professor A. Ekert of the University of Oxford and the National University of Singapore, have suggested a mechanism that can help explain some of the experimental observations [I. Sinayskiy, A. Marais, F. Petruccione, A. Ekert, Phys. Rev. Lett. 108, 020602 (2012)].

The Research Chair has been renewed for a further five years.

Systems Biology of HIV and AIDS

Professor Thumbi Ndung'u

ndungu@ukzn.ac.za



Professor Thumbi Ndung'u holds the position of Associate Professor in HIV/AIDS Research at UKZN and is

Director of the HIV Pathogenesis Programme (HPP), a collaborative initiative between the University, Harvard Medical School and the University of Oxford in England. HPP is dedicated to understanding host-pathogens interactions in HIV and tuberculosis infections, particularly immune responses and to the training of globally competitive African scientists.

Professor Ndung'u, his team and their collaborators are currently studying how certain individuals are able to resist HIV-1 infection despite evidence of persistent exposure and how certain HIV-1 infected people are able to achieve relative control of HIV-1 replication. The knowledge gained from studies of people able to resist or control HIV-1 may eventually be used to develop novel vaccines or therapies against HIV and AIDS.

He and his team have recently shown that during the early phases of HIV-1 infection, before full seroconversion has been achieved, the body is unable to mount detectable cellular immune responses to some viral epitopes despite the presence of wild-type virus

sequences that should induce such an immune response, based on patterns of responses seen in chronically infected persons. They also demonstrated that genetic polymorphisms in the immunoregulatory cytokine interleukin 10 (IL-10) may affect the quality of immune responses, providing mechanistic evidence of earlier observations that IL-10 genetic variation can influence HIV infection outcome.

Further they have explored the consequences of immune-driven sequence variation for the virus and clinical disease outcome. Using a population of over 400 chronically infected people, they showed that recombinant viruses constructed using patient-derived Gag-protease proteins can differ widely in their replicative fitness. Viral fitness varied significantly across different immune genes called HLA-B class I alleles and viral fitness differences correlated with disease outcome. These studies have shed new light on how a vaccine may be designed to attenuate the virus.

In other studies, they have described emerging patterns of drug resistance among children and adults in KwaZulu-Natal.

A graduate of the University of Nairobi and Harvard University, Professor Ndung'u is a molecular virologist by training based at the Doris Duke Medical Research Institute at UKZN's Nelson R Mandela School of Medicine. In 2007 he was awarded the prestigious Vice-Chancellor's award for exceptional research and research-related scholarly activities. He was previously awarded the Edgar Haber Award (Harvard University) for outstanding doctoral thesis research.

Professor Ndungu's previous significant accomplishments include the development of the first full-length infectious clone of HIV-1C from Africa, an important reagent for detailed genetic studies of this strain. This genetic tool allows for various studies on drug sensitivity and vaccine design to be conducted. He is also credited with the generation of the subtype C simian human immunodeficiency virus (SHIV), a genetic chimera between HIV and SIV vaccine tests.

Professor Ndung'u's main research interests are in the host-virus interactions underlying HIV and AIDS pathogenesis and antiviral immune responses. He is also interested in the development of biomedical interventions that can be used in resource-limited settings to stop the spread of HIV and AIDS.

He has a special interest in the training and development of young scientists.

Gravitating Systems

Professor Sunil Maharaj

maharaj@ukzn.ac.za



Professor Sunil Maharaj is the holder of the prestigious South African Research Chair in Gravitating

Systems. He was made a Fellow of UKZN in 2009 for his research contributions.

Professor Maharaj, who is the Director of the Astrophysics and Cosmology Research Unit in the School of Mathematical Sciences, focuses his

primary research on the modeling of astrophysical processes in relativistic stars and the mathematics of large scale dynamics in cosmology.

His contribution, in collaboration with many MSc and PhD students, to science and technology is manifested in his work on gravitational forces within the context provided by Einstein's theory of general relativity. These works include: exact solutions of the Einstein Field equations, the structure of ultra compact stars and the thermodynamics of radiating matter.

Inhomogeneous cosmological models are important in describing realistic processes such as the formation of voids and particle creation in the universe. With colleague, Professor Kesh Govinder, and a doctoral student, Mr Mandla Kweyama, Professor Maharaj has been analysing the dynamics of these processes. Together they have found several new solutions to the Einstein equations in this context by using a variety of advanced mathematical techniques including Lie point and contact transformations.

In particular they studied the evolution of shear-free spherically symmetric charged fluids in strong gravitational fields. This required the detailed analysis of the coupled Einstein-Maxwell system of equations, which couple gravity and charge in a nonlinear way. Few models to this long-standing and difficult problem are known. By using advanced group theoretical techniques involving Noether and Lie conserved quantities, they generated new classes of charged gravitational models which are the most general known.

This is a significant achievement as it completes an initiative that arose in the pioneering work of Kustaanheimo and Qvist in the 1950s. The results have been published in the international journal *Classical and Quantum Gravity*.

These new models will help to obtain a deeper insight into the behaviour of gravity in the presence of charge.

The University of KwaZulu-Natal was awarded three new South African Research Chairs in 2011 in the College of Agriculture, Engineering and Science. The College has identified the need to increase the relevance of research and training and engaged with municipal, provincial and national government as well as research councils, conservation agencies, and private entities to build research and training targeted towards the needs and outcomes of the broader South African Research Chairs Initiative.

In addition, the College has identified a strategy of moving beyond traditional disciplinary work, and creating new areas of investigation and training shaped by the emerging needs of a complex environment. The College has thus identified SARChI Chairs and Research Professorships as a key element to achieving this strategy. These are being positioned as interior trans-disciplinary catalysts that will do science in a new way, and draw together a range of disciplines that each contribute to solving a problem.

The three new Chairs are:

- Land Use Planning and Management;
- Intelligent Real Time Power Systems; and
- Rural Agronomy and Development.

Chair in Applied Poverty Reduction Impact Assessment

The aims of the Chair are in three interrelated areas of applied poverty reduction assessment: the on-going improvement of the indicators that are used to reflect change; the analysis of the impact of poverty reducing interventions; and investigating wider dynamics that offset or contribute towards desired policy goals.

During 2011 assistance was provided to Statistics South Africa (Stats SA) in the development, implementation and analysis of a new national data series, the Living Conditions Survey (LCS) that was undertaken in 2009. This survey collects information on a wide range of poverty indicators including anthropometric status of children, subjective measures of poverty as well as conventional money metric measures.

As a part of this activity, the SDS hosted a six-month visit by Dr Louis Manyukazi, the former Statistician-General of Rwanda. With the support of the African Development Bank and International Comparisons Project (ICP) based in Washington DC, USA, a new instrument is being developed for the collection of data on the impact of construction sector on poverty reduction. At the present most international data exclude the construction of informal and traditional housing. Specialist quantity surveyors will be involved in this project which will have global significance for the

calculation and comparison of Gross Domestic Product and poverty indicators if accepted.

Working with four telecentres in poor communities in KwaZulu-Natal, Community-based Learning, ICT and Quality-of-life (CLIQ) trained 100 participants in the use of computers and the internet. The impact of this training and their use of ICT have been monitored using participatory research methods.

In Uganda, Tanzania, Rwanda and Kenya a project using panel data from 1600 households interviewed in 2008 and again in 2010 has developed new methods of depicting multi-dimensional poverty and has estimated the causal association between ICT access and poverty reduction. This was presented to the international ICT4D2010 conference held in London in 2010.

The third assessment is an impact assessment of the KwaZulu-Natal Gijima programme for Local Economic Development (LED) which involves targeted grants to promote poverty reduction through enterprise. A multi-disciplinary team of economists, planners and impact specialists is working on this project.

Finally using a competitive grant awarded by the European Union (EU) via the Programme to Support Pro-Poor Policy Development (PSPPD), a collaborative project with the London School of Hygiene and Tropical Medicine and the University of Cape Town is examining factors influencing inequities in child outcomes.

Chair in Indigenous Health Care Systems

The prime focus of the Research Chair in Indigenous Health Care Systems Research, is to provide a platform for research and development in the field of traditional medicine providing an essential academic link between national policy and implementation.

The Chair will – through research – contribute to developing scientifically proven African traditional medicines and also to the institutionalisation of the African traditional health care system. Various projects currently exist and include the United States government-funded Biomedical and Traditional Healing Collaboration on HIV/Aids; the NIH/NCCAM-funded traditional medicine clinical trial at Edendale Hospital in Pietermaritzburg, and the Department of Science and Technology IKS Bioprospecting Programme.

This platform promotes bidirectional referrals between THPs and public health centres, document ethnomedical evidence, bioprospecting and other mechanism to evaluate plant-based and herbal mixtures for biological activity with therapeutic efficacy in the areas of cancer, TB, and HIV/AIDS. It also conducts clinical trials and equips THPs to conduct their own clinical research on traditional medicine. Above all, the indigenous health care systems research, enhances scientific knowledge on traditional medicine and attracts young scientists to this field.

Land Use Planning and Management

Land Use Planning and Management falls under the Water, Environment and Biodiversity Research Focus Area.

The work of the Chair will directly address the following prioritised outcomes in order of contribution:

- Protection and enhancement of environmental assets and natural resources;
- Vibrant, equitable, sustainable rural communities and food security for all; and
- Sustainable human settlements and improved quality of households.

The Chair fits into the landuse planning, land management and sustainable development strategic thrust which is a key area for drawing the Life Sciences disciplines together in a new way that will unlock a stepchange in research and human capital development capacity.

The Chair also forms a hub for interaction across private and public research institutions. Synergy between government, councils, industry and UKZN will be enhanced through improving productivity as well as making the research knowledge base applicable to conservation and economic development.

Envisaged outcomes of the work of the Chair include:

1. An understanding of the factors influencing resilience of natural systems, particularly the savanna, grassland, forest, thicket mosaic of eastern and northern South Africa. This will be in the context of different land-use options, including natural systems, agricultural systems, and urbanising systems, all of which occur adjacent to each other, creating an integrated matrix. The focus will be on the savanna and grassland habitats; on sugarcane and forestry, and large-scale commercial agriculture in eastern South Africa; and for the urban context, especially in the eThekweni Municipal Region.
2. An understanding of threats to resilience of systems and to the ecosystem services they offer, and how to monitor and assess these on an ongoing basis.
3. A local/regional model of conservation planning in the context of hyper-biodiversity and biome mosaics at the local scale.
4. An environmental management plan for eThekweni Municipality that incorporates ecosystem services and natural system resilience into a sustainable development plan incorporating trajectories of global (climate) change.
5. A decision-making system for sustainable economic development within eThekweni Municipality, which is transferable and scalable to other systems, and incorporates the value of, and risks to, natural systems.

6. A planning framework for commercial agricultural development (sugarcane and forestry; including potential bioenergy production), consumptive and non-consumptive use of natural systems, and small-scale community farming using a matrix approach.
7. Development of human capital and institutional capacity across a range of education, research and advisory bodies, which are mandated with responsibilities incorporated within the domain of this work. This includes development of staff, and training of a large number of postgraduate students through the programme.

Intelligent Real Time Power Systems

Intelligent Real Time Power Systems (IRTPS) falls under the Energy and Technology for Sustainable Research Focus Area.

The Chair, with its focus on energy security, is well aligned with UKZN's energy and technology for sustainable development research thrust.

IRTPS considers the utilisation of computational intelligence techniques for use on power systems in a smart grid utilising wireless networked systems for monitoring and control.

The Chair will consider utilisation of intelligence embedded in the grid to perform dynamic optimisation of power grid resources to ensure grid stability, energy efficiency, among other issues.

IRTPS is essential for the control and intelligence (and learning) needed for the electricity grid to become 'smart'.

South Africa is facing considerable challenges in terms of energy and there are significant market opportunities which can be exploited by developing a core capability in IRTPS and a linked capability in advanced sensor networks (ASN). Examples include: smart grid and the green economy.

Solutions in this area will require multidisciplinary research and development. IRTPS is a critical field since it focuses the disciplines of computational intelligence, pattern recognition, power systems, and wireless communications to operate within resource constrained environments which are very sensitive to computational and energy requirements needed for security, communications and co-operative processing. IRTPS is therefore a priority area to build significant competence and excellence.

South African capability to respond to smart grid opportunities is currently fragmented and sub-critical (not only for IRTPS, but also for the linked ASN environment). The IRTPS Research Chair is thus part of a significant government intervention to stimulate use and development of indigenous applications. The IRTPS Research Chair is one part of the strategy to co-ordinate the fragmented national capability and build critical mass in IRTPS.

This will be complemented with a significant Eskom partnership in the smart grid niche area for research and development and product development along with schemes to leverage

government procurement power to build local industrial and service capability.

The intention with this IRTPS Research Chair is to build up core R&D capability in IRTPS at UKZN and link this to sensor networks research at the University of Pretoria and the CSIR and other capacity programmes nationally to create critical R&D mass with the ability to solve hard R&D challenges and develop products for niche areas through joint product development with industry.

Rural Agronomy and Development

The Research Chair in Rural Agronomy and Development - in the Energy and Technology for Sustainable Development Research Focus Area - enjoys high priority in terms of the strategic planning of the College of Agriculture, Engineering and Science.

Its focus and thematic areas are aligned with the key strategic areas and thrusts of the SA National Agriculture and Development Strategy (DoA 2008), particularly human capital development; innovation and transfer of technology; and collaboration and partnerships.

The work of the Chair will involve contributing to community development through research, agricultural innovation and agricultural extension. The work will be done in partnership with public institutions and other agriculture-supporting bodies.

It is aligned with the Government's priorities of employment creation, food security, support for smallholder farmers and sustainable livelihoods, rural wealth creation and skills development.

The Chair will contribute to the development of new technology to support smallholder farmers in agriculture, and the agricultural industry in general. It will also contribute towards human capital development through training of post graduate students at MSc and PhD levels.

The Chair will have strong links with the existing centres of excellence such as the African Centre for Crop Improvement (ACCI) and African Centre for Food Security (ACFS) at UKZN.







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Email

corporaterelations@ukzn.ac.za

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