UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

School of Engineering

Discipline of Agricultural Engineering

Energy, Food and Water Engineering Research Group (EFWERG)

Post-Graduate Research Opportunities

(MSc Eng, MSc Bioresources Systems and PhD)



The Energy, Food and Water Engineering Research Group at the University of KwaZulu-Natal in South Africa is the largest and most influential group of its kind on the continent. The group forms part of the School of Engineering at the University of KwaZulu-Natal in Pietermaritzburg, South Africa. The group of Professors, Lecturers, Post-Doctoral, PhD and Master's degree students contribute to the development of Engineering and Applied Science research in three main areas of research:

- Energy and Supply Chains in Biomass Production and Processing Systems,
- Irrigation, Soil & Water Engineering, and
- Food Process and Postharvest Engineering.

The group comprises, among others, specialists in various fields of Agricultural Engineering, including irrigation engineering, soil and water engineering, water resources and engineering hydrology, supply chains in agricultural production systems, food process engineering and technology.
For more information, visit http://efwe.ukzn.ac.za

Research Opportunities for 2027

The following is a list of potentially funded research opportunities that will be available in 2027

Development and Performance Evaluation of a Lithium Bromide-Based Liquid Desiccant Cooling System Incorporating Evaporatively Cooled Water Circulation in the Heat Exchanger Section

PhD or MSc Engineering

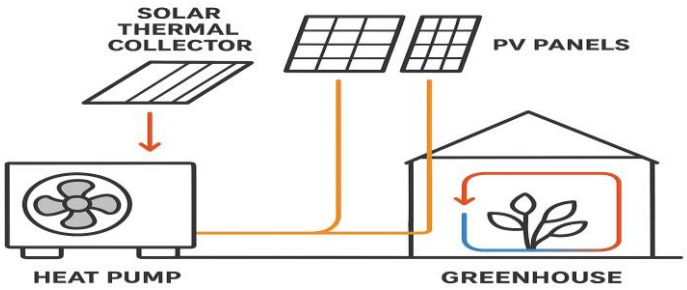
Potential Funding: Student Funding

The increasing demand for energy-efficient and environmentally sustainable cooling technologies has highlighted the limitations of conventional vapour-compression systems, which consume significant electricity and may rely on refrigerants with high global warming potential. Although liquid desiccant cooling systems offer an alternative by removing moisture from the air, a research gap remains in optimising lithium bromide (LiBr) solution performance and in integrating evaporatively cooled water circulation into the heat exchanger section to enhance heat rejection and overall cooling effectiveness. This project aims to design, develop, and evaluate a liquid desiccant cooling system that uses a lithium bromide solution and evaporatively cooled water circulation in the heat exchanger section. The methodology will involve system design, component selection, fabrication or simulation, and experimental testing under varying operating conditions, including desiccant concentration and flow rate, air temperature and humidity, water circulation rate, and regeneration temperature. The specific objectives are to determine the system's dehumidification capacity, cooling performance, energy consumption, and coefficient of performance, and to identify optimal operating conditions to improve thermal performance, reduce energy demand, and develop a cost-effective and sustainable cooling solution.

For further information, contact Professor TS Workneh (Seyoum@ukzn.ac.za)

Hybrid Heat Pump and Solar Energy System for Smart Greenhouses

MSc or PhD student
Potential funding: UKZN

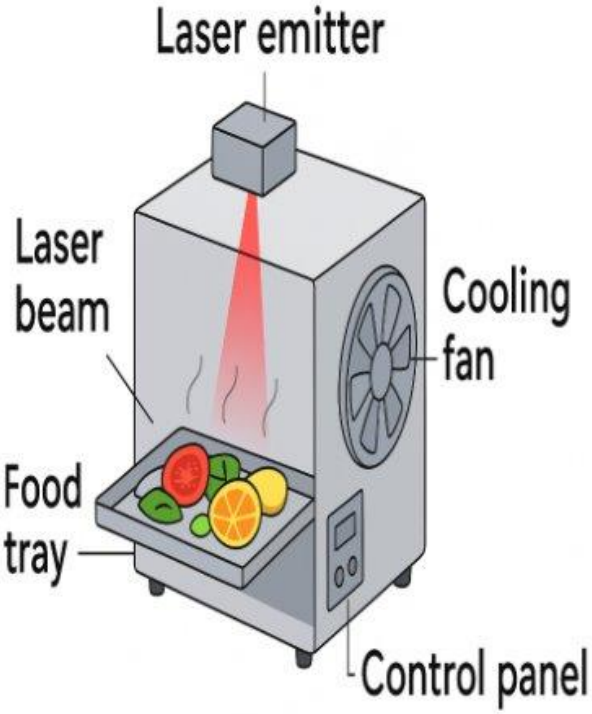


The hybrid heat pump–solar energy system project addresses the pressing issue of high operating costs and greenhouse gas emissions from fossil-fuel-based greenhouse and agricultural facility heating. Current systems are costly, unsustainable, and increasingly vulnerable to climate and energy price fluctuations, creating the need for renewable, efficient, and climate-smart heating alternatives. This project proposes the integration of solar thermal collectors, photovoltaic panels, and a heat pump into a hybrid system, with objectives including the design and prototyping of the system, performance testing of energy efficiency and microclimate control, and sustainability and cost analyses to assess scalability and economic viability. The expected outcome is a renewable energy heating solution that lowers energy costs and emissions, ensures stable growing conditions for year-round crop production, and provides scalable models for widespread adoption, ultimately contributing to climate-resilient and sustainable agriculture.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).

Development of a Laser Food Dryer

MSc or PhD student
Potential funding: UKZN



Conventional food drying methods are often characterised by long drying times, uneven moisture removal, high specific energy consumption, and deterioration in product quality, limiting their effectiveness for high-value agricultural produce. Although laser-assisted heating offers the potential for precise energy delivery and improved process control, there is limited empirical evidence on its drying performance, energy efficiency, product quality, and economic viability in food processing applications. This knowledge gap hinders the adoption of laser-based drying technologies within the agri-food sector. The purpose of this project is therefore to design, develop, and experimentally evaluate a prototype laser food dryer. The project will generate measurable outcomes by quantifying the drying rate, moisture reduction, specific energy consumption, drying efficiency, product quality attributes (such as colour retention and nutrient preservation), and operational costs, and by comparing these indicators with conventional drying technologies to determine the technical and economic feasibility of laser-assisted food drying.

For further information, contact Professor Tilahun Seyoum Workneh (Seyoum@ukzn.ac.za)

Development of a Simple Fruit and Vegetables Dryer

MSc Eng student
Potential funding: UKZN, NRF



The laser food dryer project aims to address the challenge of high postharvest losses in fruits, vegetables, and herbs, which are often caused by inefficient conventional drying methods that lead to uneven drying, nutrient loss, and reduced product quality. There is a clear need for innovative and energy-efficient food preservation technologies that can retain nutritional and sensory attributes while reducing waste. To meet this need, the project will focus on designing and prototyping a laboratory-scale laser dryer, evaluating its drying kinetics, energy efficiency, and product quality, and conducting sustainability and techno-economic analyses to compare its performance with traditional methods. The expected outcome is a novel drying technology that significantly reduces food losses, enhances product quality, and provides scalable solutions for both smallholder and commercial agriculture while fostering stronger research–industry–farmer collaborations.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).

Development of an Environmentally Controlled Direct Solar Water Heated Chick Brooder House

MSc Eng student
Potential funding: UKZN, NRF



Approximately 60 % of chicks hatched in rural areas die during the first eight weeks of their life. The use of haybox brooding technology has the potential to reduce the loss of chicks and this simple technology has been successfully adopted in some parts of Africa. The technology makes use of cheap and locally available materials. It deals with insulation and conservation of the metabolic heat of the chicks, to keep them warm during the cold periods by using readily available materials. One of the drawbacks associated with this simple technology is external parasites, which tends to proliferate in the fibrous, bulky, and dry organic substances that are used for insulation. Ants also attack the material and may result in significant losses. There is thus a need to improve the existing hay-box chick brooding system. Based on existing information, a small mechanised-commercial brooding system for smallholders or emerging poultry farmers can be designed, constructed, and evaluated. Solar energy could be used as a source of heat during cold periods of the day or during night by circulating solar heated water.

For more information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).

Naturally Ventilated Combined Direct Solar Cereal Grain Drying and Storage Bins for Use in Africa

MSc Eng, PhD student

Potential funding: UKZN, NRF



The quality of cereal grain depends on the environmental conditions during harvest and during the initial period of storage. Wet harvesting combined with a wet storage period leads to significant grain loss because of the reduction in grain quality. This impacts on the famers across Africa because their grain may rot in storage very quickly mainly due to the high moisture content. This could be prevented using cold storage, but it is not feasible in most of Africa due to a lack of capital and because the electricity power supply is unreliable, and technical back-up for the servicing of the refrigeration units is not reliable. A solution for this could be maintaining low air relative humidity, even if the temperatures are high. The objectives of this study will be to study this concept in terms of fruit and vegetables storage life and quality and losses due to rot, to measure the temperatures, RH and air flow with variable designs, especially for varying chimney diameters, heights, solar roof gaps, up flow versus downflow, head space, bottom suction space, and to measure the impact of storage on a range of fruit and vegetables (e.g. onions, tomato, potato, sweet potato, cabbage, citrus, mango, avocado). In addition, the quality, rot, and loss of weight will be evaluated.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).

Building Resilient Food Systems through Circular Agriculture: Integrating Waste and Biomass Processing for Sustainable Food Production and Processing

Two MSc Eng and Two PhD students
Potential funding: UKZN, NRF, ARC



A circular food production and processing economy can use biogas and solar energy to create closed-loop systems that minimise waste and maximise resource reuse. The main objectives include transforming food waste into biogas to reduce fossil fuel reliance and greenhouse gas emissions and employing solar energy across food production and processing stages to reduce carbon footprints. Waste processing will produce valuable by-products, such as organic fertilizers, that can improve soil fertility and agricultural yield. This study aims to develop integrated systems with an experimental, appropriate, and sustainable greenhouse, dryer, thermal processor, anaerobic digester, composting trench, greywater collection, and control systems for data acquisition from the integrated system. Together, these elements embody circular food production, food processing and organic waste processing principles and build resilient, sustainable food systems.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).

Chimney Assisted Natural Ventilation of Evaporatively Cooled Piggery

MSc Eng, PhD student
Potential funding: UKZN, NRF

Pigs need to be cooled in summer in most of the regions in Africa. It is necessary to optimise their growing conditions as uncomfortable heat reduces their ability to metabolise pig feed. The use of fan-and-pad units or air conditioning units are not feasible in most of Africa due to a lack of capital, and because the electricity supply is universally unreliable. The advantages of a naturally ventilated evaporatively cooled piggery will be:

1. no need for electricity,
2. uses a chimney to suck air through a wet wall,
3. the wet wall uses a gravity fed dripper to wet a hessian wet wall. Use copper in PVA to protect the hessian from degradation,
4. use Thermo shield paint to treat the outside of the roof of the building: it is a paint in which are ceramic beads that insulate effectively, and
5. use spray-on polyurethane to treat the inside of the roof for additional insulation. Compare the two insulations: ease of application; lifespan, cost, efficiency. And efficiency when both are used together.

The objective of the study is to prove the concept in terms of pig growth, evaluate the performance the system in terms of its efficiencies in maintaining the desirable ranges of temperatures, relative humidity and air flow for variable designs including the number of chimneys (single or two or multiple), the chimney diameter and height, the use of a hessian wet wall versus alternatives. The effects of water dripping onto the wet wall, and the use of different insulation options such as no insulation, a solar shield and use of polyurethane could be investigated.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za) or Professor Mark Laing (Laing@ukzn.ac.za).

Greenhouse, Pig House and Chicken House Heating Systems for South Africa

MSc Eng, PhD student
Potential funding: UKZN, ARC, NRF



Plants and animals require a comfortable equivalent environmental temperature and relative humidity for the proper functioning of their physiology. Temperature and relative humidity are the major environmental factors that affects the growth of animals and plants. Summer temperatures are too high for some animals and plants and inhibit their growth. On the other hand, winter temperatures may be too low for plants, pigs and chickens to grow optimally. Although several technologies have been developed to maintain desirable temperatures and relative humidity, there is limited information available on proven low-cost heating and cooling technologies for application in South Africa. It is therefore vital to review current and potential heating or cooling systems that might lead to effective convective and radiant heat transfer to the micro-environment surrounding plants and animals and, to enable control of the temperatures to the optimum range that is comfortable for plants or animal (pigs and chickens). Investigation into the potential of electricity or gas; coal; solar heat; heat pumps with air-to-water or soil-to-water as a medium of heat exchanger using hot water pumped through the floor of the houses, may be some of the alternatives of thermal energy sources that can be used to heat or cool plants and animals' environment. Investigation on capital requirements and subsidies; running costs, MCB charges; delivery issues; maintenance costs, complexity, frequency; control systems, energy conversion, energy efficiency, performance of selected modes of heat transfer and alternative heat exchangers under all potential conditions is also required. The main objectives of this project will be to critically review literature to search for best alternative heating and cooling systems, further develop a selected technology and to evaluate the efficiency of selected systems for South African conditions.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za) or Dr Alaika Kassim (KassimA@ukzn.ac.za).

Development of a Portable Anolyte Water Producing Unit

MSc or PhD student
Potential funding: UKZN



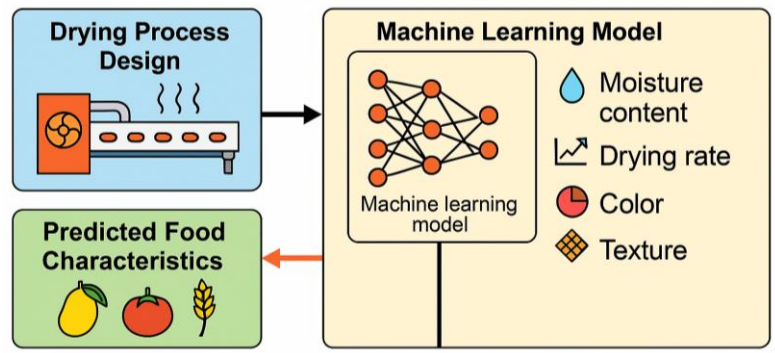
Electrochemically activated water (ECA) or anolyte water can be described as a saltwater solution having an electrical charge (Bakhir, 1997). During this process, the molecular state of water is changed from stable to metastable where two ECA's are produced, anolyte and catholyte. The anolyte, which has an oxidation-reduction potential (ORP) of +1000 mV, is better suited for its antimicrobial, disinfecting effect and the catholyte, which has an ORP of -800 mV, is preferred for its cleaning and detergent ability.
According to Mehandjiev *et al.* (2017) the following reaction takes place at the cathode:
$2H^+ + 2e^- \rightarrow H_2$
While at the anode the following reaction occurs:
$2O_2^- - 2e^- \rightarrow O_2$
The uses of anolyte water extend from the food production industry to hospitality and textile industries with regard to its germicidal effects. Buck *et al*. (2002) recommends the use of anolyte water for disinfection due to it being environmentally safe and effective. Due to the extensive use of anolyte water, the need to create a portable unit to be used in remote locations, for instance, is required. Areas that do not have easy access to disinfectants of cleaning materials would benefit from this.

For further information contact Dr Alaika Kassim (Kassima@ukzn.ac.za) or Professor Tilahun Workneh (Seyoum@ukzn.ac.za) or Professor Mark Laing (Laing@ukzn.ac.za).

Development of an AI-Powered Digital Twin for Intelligent Hybrid Food Drying Systems

MSc or PhD Eng students

Funding: Application for Funding in Progress



Drying is a critical food preservation process, but conventional drying systems are often energy-intensive, time-consuming, and difficult to optimise. Traditional dryer design and operation rely largely on trial-and-error approaches, resulting in increased operating costs and inconsistent product quality. This project proposes the development of an AI-powered digital twin platform that integrates machine learning, drying kinetics, thermodynamic analysis, and Computational Fluid Dynamics (CFD) to predict and optimise drying performance in real time. The platform will support intelligent decision-making by enabling virtual testing of drying conditions, reducing energy consumption, improving product quality, and accelerating the design of efficient hybrid drying systems.

Objectives

1. Develop machine learning models to predict drying performance, energy consumption, and product quality under different drying conditions.
2. Create a digital twin of a hybrid food dryer by integrating drying kinetics, thermodynamic analysis, and CFD simulations.
3. Optimise dryer design and operating conditions to improve energy efficiency, reduce drying time, and maintain product quality.

For further information contact Mrs Khuthadzo Ntsowe (mugodok@ukzn.ac.za) or Mr Muleki Sinqadu (SinqaduM@ukzn.ac.za).

Optimisation of an In-vessel Composting System

MSc or PhD Eng students
Funding: Application for Funding in Progress



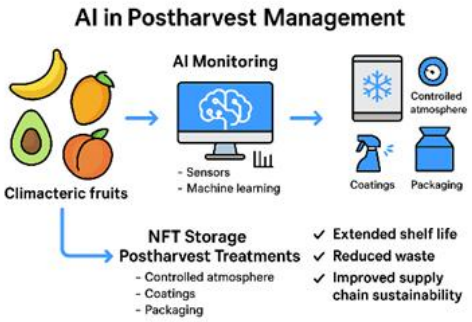
Organic waste management practices, particularly in landfills, continues to be a significant environmental concern. The generation of methane, a potent greenhouse gas, and leachate, which can contaminate soil and water resources, are primary consequences of this mismanagement. To address these issues, a semi-automated in-vessel composting system was previously developed. This system represented a step forward in waste management by reducing labour requirements and improving overall efficiency in the composting process. However, the limitations of semi-automated composting systems have become apparent, particularly in their reliance on static control mechanisms. These systems lack the ability to adapt dynamically to various factors such as changes in waste composition, fluctuations in ambient conditions, or variations in microbial activity. This inflexibility hampers their scalability and effectiveness across diverse settings, limiting their potential for widespread adoption and impact. Recognising these constraints, the current project seeks to optimise the existing design and develop a working prototype for demonstration purposes. This enhanced system aims to incorporate dynamic response capabilities, potentially through the integration of sensors and adaptive control algorithms, to create a more versatile and efficient composting solution that can be effectively implemented in a variety of environments and scales.

For further information contact Mrs Khuthadzo Ntsowe (mugodok@ukzn.ac.za) or Dr Kassim (kassimA@ukzn.ac.za).

Reducing Postharvest Losses Through AI-Enhanced Near-Freezing Temperature Control in Climacteric Fruit Storage

MSc (Bioresources Systems), MSc Eng

Potential Funding: UKZN, NRF



Climacteric fruit are characterised by an increase in the ethylene production rate after harvest and when moved from cold storage to room temperature. This production of ethylene in turn results in accelerated ripening and senescence. Climacteric fruit are generally stored at temperatures between 0°C and 5°C. However, a novel way of storing these fruits is at near freezing temperature storage (NFTS), which is essentially storage between the super-cooling point and freezing point of an individual material. NFTS has been used as a preservation technique for fruit and vegetables and has been found to improve the shelf life and inhibit deterioration in the postharvest fruit quality for up to 60 days of storage. NFTS has proven effective in slowing physiological changes, but its success depends on precise monitoring and control. Traditional methods often lack the sensitivity and predictive capacity required for optimal postharvest management. Artificial Intelligence (AI) presents an opportunity to revolutionize storage and handling by enabling real-time monitoring, predictive modelling, and adaptive control of storage environments. Integrating AI with NFT and/or complementary treatments (anolyte water, controlled atmosphere storage, ethylene inhibitors, and advanced packaging) can enhance fruit quality, extend shelf life, and reduce waste along the supply chain. anolyte water to determine the effects on fruit quality and storage life.

Objectives of this study:

1. To develop an AI-driven monitoring system for real-time assessment of storage conditions (temperature, humidity, respiration, ethylene).
2. To optimize NFT storage conditions in combination with other postharvest treatments using machine learning models.
3. To predict shelf life and spoilage timelines of climacteric fruits under varying treatment combinations.
4. To evaluate the potential of AI-enhanced NFT systems in reducing postharvest losses and improving supply chain sustainability.

For further information contact Dr Alaika Kassim (Kassima@ukzn.ac.za) or Ms Khuthadzo Ntsowe (mugodok@ukzn.ac.za).

Development of Sustainable Greenhouse Systems for Small Scale Farmers/ Sustainable Greenhouse Incorporating Cogeneration and Biodegradable Construction Materials

MSc Eng, PhD students

Potential Funding: UKZN, NRF





Giuliano et al. (2010)

Sustainable development alternatives and solutions in agriculture is the direction that many countries are headed due to increased populations and climate change. According to Akrami et al. (2020), open field agricultural systems are highly dependent on location, soil properties and weather conditions. However, greenhouse systems can be more precisely controlled as well as offering protection to fruit, vegetables and ornamentals against adverse environmental conditions. In addition, greenhouse systems have been shown to dramatically reduce irrigation requirements by up to 90%, compared to open-field systems (Akrami et al., 2020). The type of ventilation, water circulation system, heating and cooling systems, control of the micro-climate such as temperature, humidity, carbon dioxide, construction material, pest management, fertiliser application, greenhouse shape and orientation, to name but a few of the vital aspects that can be converted to more sustainable arrangements. In addition, the concept of cogeneration can be combined in this study as a source of energy together with sourcing and utilizing biodegradable construction materials.

For further information contact Dr Alaika Kassim (Kassima@ukzn.ac.za).

Tomato Postharvest Supply Chain Management Strategies

MSc (Bioresources Systems), MSc Eng, PhD students (Packaging Technology), Postdoctoral (Food Science and Technologist)

Good post-harvest handling practices positively affect the quality of fresh tomatoes. Postharvest handling strategies offer important avenues in reducing tomato losses. Effects of different supply routes, storage environments and pre-storage treatments were investigated. The influences of tomato handling practices on several fresh tomato quality indicators and marketability were explored and a large tomato quality data were collected. Some useful postharvest technologies that that were found to provide solutions to challenges of the postharvest tomato supply chain were developed. However, several postharvest problems, that require research have been identified. The list of potential outstanding areas of tomato postharvest research are:

1. development of a mobile cooling system for the cooling of tomatoes during long distance transportation from farms / packaging houses to whole/retail sell markets using truck,
2. development of a combined physical and biological treatmen technology for control tomato decay before transportation and storage,
3. develompent of a compartmentalised-multi-layered tomato transport bin for use during long distance transportation,
4. integrated tomato treatment and cold Storage technology for small scale farmers in Limpopo province of south Africa, and
5. evaluation of the effectiveness of a combined cooling and microbial filter technology in tomato storage systems or during long distance tansportation.

For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).

Identification of Renewable Energy Sources as well as their Integration with Vegetables Production and Postharvest Technology and Management Systems

MSc (Bioresources Systems), MSc Eng, PhD students
Funding: Application for Funding in Progress

Energy is required for all agricultural production and product processing. Energy is part of the unit cost of a product and since energy is expensive, some farm or postharvest operations phase challenges accessing sufficient amount of energy especially during their early stage of business development. Fissile-based energy is known to affect the environment and contributes towards the effect of climate changes in food insecurity as well as the unsustainable environment. With the current advancement in the development of renewable technology, integration of renewable energy technology to other agriculture production and postharvest technologies is believed to have a significant role in reducing food insecurity, poverty alleviation as well as implementing technologies that help to adapt to climate changes. Renewable energy can be generated from either solar, biomass, wind, geothermal or biofuel from resources that are being produced from a smart farming village.

The objectives are:

1. To assess different energy sources (solar, biomass, potential by-products).
2. To develop model for renewable energy technology integration to smart vegetable, poultry and sustainable environment farming system.
3. To develop theoretical renewable energy integration model for selected proven low-cost/low-energy agro-processing and preservation technologies for the smart farming village.

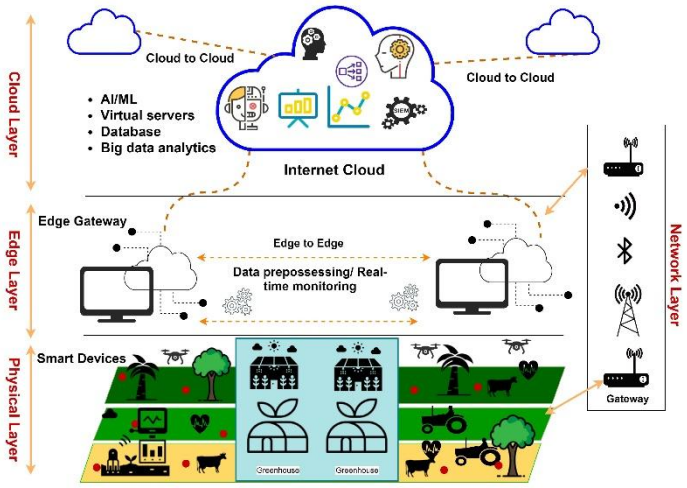
For further information contact Professor Tilahun Workneh (Seyoum@ukzn.ac.za).



Developing a Small-Scale Demonstration Facility of Precision Horticulture

MSc (Bioresources Systems), MSc Eng

Funding: Application for Funding in Progress



Smallholder farmers with an aptitude for commercial agriculture have not been able to completely realise the horticultural agri-business because they are unable to generate sufficient profit to support themselves. This is exacerbated by the inability to cultivate high-value commodities, such as potatoes, lettuce and tomatoes, due to a lack of know-how to optimise production using efficient, low-cost technologies. In recent years agricultural production is undergoing progressive digitalisation, and that includes the production of horticultural commodities. Precision horticulture is an information-based management system that can assist farmers at any production scale in maximizing yield. Utilising sensing technologies and systems to collect data, such as, weather, soil conditions and that, which is plant-specific is essential for making informed decisions regarding management practices, such as fertilisation and irrigation. Precision agriculture benefits include reduced production costs, increased profitability and reduced environmental impact of agricultural. However, there is limited application of precision horticulture in South Africa.

The objectives of this study are:

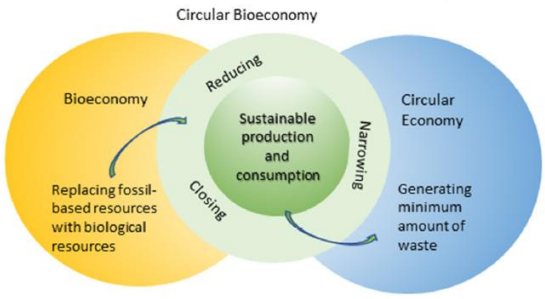
1. Design and develop a small-scale facility that will demonstrate precision horticulture techniques.
2. To optimise the production of a selected crop, using precision agriculture techniques.

For further information contact Mrs Khuthadzo Ntsowe (MugodoK@ukzn.ac.za)

Circular Bioeconomy: Bioconversion Processes of Biogenic Waste into Bio-Energy Products

MSc Eng, PhD students

Funding: Application for Funding in Progress



Agricultural and municipal waste have been shown to produce bio-based energy, which is a valuable commodity. By combining the growing demand of food and the increase in the waste produced, researchers have entered in to the circular bioeconomy (CBE). CBE can be explained as the "waste-to-wealth" concept to overcome and replace the "take, make and dispose" model. This concept focuses on producing new technologies, employment opportunities, improved livelihood while still adhering to the intrinsic environmental benefits. If these wastes are not managed adequately and sustainably, they could have a negative degenerative impact on the environment such as pollution, creating toxic ecosystems and the release of greenhouse gasses into the atmospheres. Landfills release greenhouse gases into the atmosphere in the form of methane gas. There lies enormous scope in the valorisation of agro-industrial wastes in the generation of renewable energy products, which is also closely linked to biorefineries. The current methods used in South Africa for valorisation of organic waste include food redistribution, conversion to animal feed, composting, anaerobic digestion which produces biogas, biorefining with composting and anaerobic digestion. Further research and development must be undertaken in the other conversion methods. Biorefineries possess immense potential, even on a small scale, and a large amount of research has been directed to this area in South Africa. There is limited research available on the concept of CBE in South Africa, although there is enormous scope in this area. This project aims to conceptualize and contextualize CBE in the KwaZulu-Natal agro-industries on a small scale and large scale so as also to create a comparison between these. Some of the questions that can be answered are:

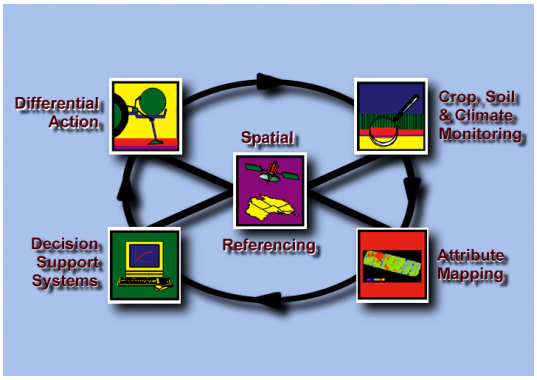
(i) What is the level of awareness of circular bioeconomy amongst stakeholders?
(ii) What are the current practices relating to circular bioeconomy?
(iii) What are suitable bio-genic wastes that can be used as raw materials for the valorisation process?
(iv) What are the most suitable practices for valorisation of biogenic waste?
(v) How and where can these processes be successfully implemented?

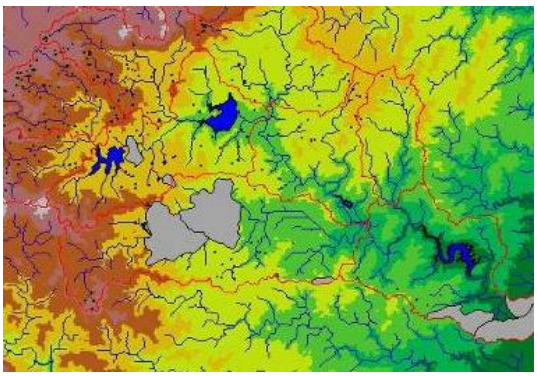
For further information contact Dr Alaika Kassim (Kassima@ukzn.ac.za).

Application of Technology for Precision Agriculture Applications in South Africa

MSc, MSc Eng, PhD or post-doc students

Potential Funding: UKZN





The use of sophisticated technology in agricultural production systems is increasing rapidly and is commonly referred to as Precision Agriculture (PA). This refers to agricultural practices which are precise and spatially variable so as to ensure the optimum use of resources and limit the impacts of agricultural production on the environment and thus promotes sustainable production. Spatial variability within fields is accounted for using variable rate technologies (e.g. application of fertiliser, irrigation) and this requires the sensing of variability within a field. This may be sensed during field operations (e.g. yield sensing during harvesting) or can be remotely sensed using satellites or Unmanned Aerial Vehicles (UAVs). UAVs can be used to carry sensors to detect heights and reflectance from crops which can be used, for example, to determine plant stress and crop yields. This project will focus on the application of PA technology in agricultural production in South Africa with a focus on the use of remotely sensed data to make management decisions.

For further information contact Dr Shaeden Gokool (GokoolS@ukzn.ac.za) or Dr Maqsooda Mahomed (MahomedM@ukzn.ac.za).

Development of a Sustainable Campus Food Garden to Support Student Food Security



According to the U.N. Food and Agriculture Organization (FAO), food insecurity exists when "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". In contrast, many tertiary-level students lack access to basic nutrition, particularly for students from financially disadvantaged households. This can have a detrimental effect not only on their physical well-being but also on their mental health. A study conducted by Sabi et al. (2020)* found that 44% of students experienced moderate levels of vulnerability to food insecurity and 9.2% were highly vulnerable (n = 456). Currently, the University of KwaZulu-Natal runs the UKZN Food Security Programme to support financially distressed students and food-insecure students. Included in this initiative is the aim to establish sustainable campus food gardens and student-led food cooperatives. It requires an integrated approach to agricultural production, water management, energy utilisation, waste recovery, postharvest handling, and financial sustainability. Agricultural Engineering offers an opportunity to address these challenges through the design and development of efficient food production systems. This project seeks to investigate the development of a sustainable campus food garden that integrates agricultural production, resource recovery, and food distribution to support student food security. The objectives of this project are to:

1. assess the food requirements and potential demand for fresh vegetables within the selected campus,
2. determine the land, water, energy, and infrastructure requirements for establishing a campus food garden,
3. design an appropriate vegetable production system,
4. investigate the recovery and reuse of organic waste for compost production and nutrient recycling, and
5. evaluate appropriate postharvest handling, storage and preservation technologies to minimise food losses.

*Sabi, SC, Kolanisi, U, Siwela, M and Naidoo, D. 2020. Students' vulnerability and perceptions of food insecurity at the University of KwaZulu-Natal. *South African Journal of Cinical Nutrition* 33(4):144-151.

For further information contact Dr Alaika Kassim (Kassima@ukzn.ac.za).

Opportunities for Research Support from the uMngeni-uThukela Water Chair in Water Resources Research and Innovation

The University of KwaZulu-Natal (UKZN) and uMngeni-uThukela Water (UUW) have had a long and fruitful relationship and have collaborated on a number of mutually beneficial projects in teaching, research and technical services. This has been formalised through a Memorandum of Agreement (MoA) between the institutions and through UUW's support for the Umgeni Water Chair of Water Resources Research and Innovation. Through the MoA and facilitated by the Chair, funding is available to support Post-doc, PhD, MSc and Honours level studies focused on water resources and related research needs identified by UW. Funding to support students working on appropriate research projects is available depending on the project and availability of funds.

Research opportunities are summarised in the UUW Research & Development Plan, and the following research project fields have been prioritised:

(i) Renewable energy and efficient energy utilisation at UUW
(ii) Alternate disinfection solutions and dealing with chlorine resistant bacteria
(iii) Identification and processing of contaminants of emerging concern
(iv) Control and beneficiation of alien invasive weeds/plants
(v) Hydrology and water resources management
(vi) Assessment and development of ground water resources
(vii) Distribution systems and losses
(viii) Water quality, sediment yield and interventions
(ix) Use of innovative technologies (e.g. robotics, remote sensing and AI technologies)
(x) Catchment management and ecological infrastructure
(xi) Wastewater management and treatment
(xii) Citizen science and community engagement
(xiii) National Flood Studies Programme
(xiv) Aquatic health

In addition to the above prioritised research project ideas, all expressions of research interest in fields relevant to UUW operations will be considered.

Interested postgraduate students or supervisors should submit a short expression of interest and include the project title, name of the student and supervisor (if known) to **Dr KB Tadesse** (TadesseK@ukzn.ac.za) **or Dr A Jumman** (JummanA@ukzn.ac.za) . Details of a contact person at UUW and potential funding will then be provided. The final proposal should be developed in collaboration with a contact from the UUW Division relevant to the research proposed.



Remote Sensing, AI and the LG Sonic MPC-Buoy for Monitoring, Predicting and Controlling Algal Blooms in Albert Falls Dam

MSc, MSc Eng. & PhD

Potential Funding: UUW for MSc/MSc Eng

Problem: Aquatic weeds, eutrophication and harmful algal blooms (HABs) degrade water quality. Traditional in situ sampling is costly, labour-intensive and too sparse to capture rapid bloom events. Chlorophyll-a (Chl-a), the key proxy, relates non-linearly to nutrients.

Aim: To establish a cost-effective framework for assessing, predicting and controlling the water quality impacts of aquatic weeds and algal blooms using Remote Sensing (RS), Artificial Intelligence (AI) and the LG Sonic MPC-Buoy (Monitoring, Predicting and Control Buoy).

Objectives:

1. Develop ML models to retrieve Chl-a and Total Suspended Solids (TSS) from Sentinel-2/3 imagery, calibrated with real-time buoy data.
2. Estimate Total Nitrogen (TN) and Total Phosphorus (TP) indirectly from remotely sensed Chl-a and TSS.
3. Map spatiotemporal impacts and persistent seasonal eutrophication hotspots.
4. Forecast bloom onset and spread using satellite and buoy time series.
5. Evaluate the buoy's ultrasonic algae control in reducing Chl-a and bloom intensity.

Methods: Imagery is atmospherically corrected and processed with indices such as NDCI. Random Forest and XGBoost retrieve water quality parameters, and LSTM/GRU models forecast blooms. The LG Sonic MPC-Buoy provides continuous real-time monitoring (Chl-a, phycocyanin, turbidity, pH, DO, temperature) for calibration, validation and early warning, and activates ultrasonic control on predicted or detected blooms. Control effectiveness is assessed by comparing Chl-a and bloom extent before and after activation and inside and outside the treatment zone. Models are validated using R^2, RMSE and cross-validation.

Expected outcomes: Validated ML models, hotspot maps, bloom forecasts, evidence of ultrasonic control performance, and a transferable monitor-predict-control framework for South African reservoirs.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

Development of Precision Irrigation and Mechanized Water-Saving Systems

MSc, MSc Eng. & PhD

Agriculture in South Africa faces severe challenges from water scarcity, inefficient irrigation practices, and climate variability, with irrigation accounting for nearly 60% of total water withdrawals. Conventional scheduling approaches, often based solely on soil-water status or fixed calendars, fail to capture dynamic plant and atmospheric drivers of crop water stress, leading to over- or under-irrigation, yield losses, and resource inefficiencies. This research aims to develop precision irrigation and mechanized water-saving systems adaptable to both field and greenhouse conditions by integrating soil, plant, and meteorological data into automated irrigation decision-making. The objectives are to:(1) design and prototype a precision irrigation system combining soil moisture sensors (capacitance/TDR), canopy temperature/thermal indices, and weather parameters (ET_o, VPD); (2) determine crop water stress index (CWSI) thresholds for selected crops and compare them with conventional soil water-based management allowed depletion (MAD) levels to trigger and stop irrigation; (3) automate irrigation control of mechanized systems (drip, sprinkler, centre pivot in fields; micro-irrigation in greenhouses) using real-time and predictive models; (4) evaluate water use efficiency, yield response, and energy requirements across multi-season field and greenhouse trials; and (5) benchmark outcomes against conventional FAO-56-based scheduling. Multi-season experiments will deploy sensor networks, infrared radiometers, and weather stations linked to automated controllers, with data analysed using breakpoint analysis, ROC curves, and mixed-effects modelling to determine robust water stress thresholds. Expected impacts include a validated precision irrigation prototype that reduces water use, enhances yield stability, and improves irrigation water productivity under South African conditions. Scientifically, the project advances irrigation engineering by integrating soil–plant–atmosphere interactions into mechanized water delivery; practically, it equips farmers with cost-effective decision-support tools; and strategically, it strengthens climate resilience, water security, and sustainable intensification, with global relevance to semi-arid regions.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

Canopy Temperature-Guided Irrigation Scheduling of Oil Crops under Greenhouse Conditions to Maximise Seed Oil Yield

MSc and PhD Eng./Bioresources System

Background and problem: Oil crops such as canola, carinata, sunflower and soybean supply edible oil, protein and biofuel feedstock, and South Africa is increasingly water limited. Oil yield is the product of seed yield and seed oil content, and both respond to water supply, with flowering to seed fill usually the most sensitive stage. Canopy temperature offers a low-cost, plant-based stress signal: the crop water stress index (CWSI) scales canopy minus air temperature between wet and dry baselines, giving a 0 to 1 value that can trigger irrigation. However, CWSI baselines are scarce for many oil crops, thresholds have rarely been tested against seed oil yield, water production functions under controlled water supply are limited, and it is unknown whether CWSI-triggered irrigation saves water relative to soil-sensor scheduling without lowering oil yield.

Aim: To identify the irrigation level and CWSI-based scheduling rule that maximise seed oil yield and oil produced per litre of water in greenhouse-grown oil crops.

Objectives: (1) Establish wet and dry CWSI baselines against vapour pressure deficit. (2) Quantify how graded and stage-specific water supply affect seed yield, oil content and oil yield. (3) Relate CWSI to substrate water content, visual stress and final yield. (4) Derive CWSI irrigation thresholds and compare them with soil-sensor-based and full irrigation. (5) Determine the optimum water level for oil yield and for oil per litre of water.

Approach: Pot experiments (20 to 25 L pots) in randomised blocks with nine water treatments: full irrigation, 75% and 50% deficit, minimal water, vegetative and reproductive deficit, two CWSI triggers (for example midday CWSI above 0.3 and 0.5) and a soil-sensor benchmark. One narrow field-of-view infrared radiometer per monitored pot logs canopy temperature every 10 minutes, analysed in a midday window and calibrated against a water bath. An air temperature and humidity logger supply the vapour pressure deficit, soil water sensors are used only where required, and pots are weighed to record water applied. Measurements cover phenology, biomass, seed yield, oil content (NMR or solvent extraction) and fatty acid profile. Quadratic and quadratic-plateau water production functions and mixed-effects models (with block) locate the optimum and test thresholds.

MSc scope: One oil crop (for example canola or carinata) in one greenhouse cycle with seven treatments in four blocks (28 pots). It builds the CWSI baselines, describes CWSI under five water levels, quantifies oil yield and water productivity, and makes a first test of one CWSI trigger against soil-sensor and full irrigation, providing pilot data and protocols for the PhD.

PhD scope (extends the MSc): Two to three oil crops with contrasting water-use and stress responses (for example carinata or canola, sunflower and soybean) over three greenhouse cycles with all nine treatments (36 monitored pots per cycle). It builds a water production function and optimum for each crop, tests whether CWSI baselines and thresholds can be generalised across oil crops or need crop-specific values, identifies the growth stage at which CWSI best predicts oil yield, and calibrates, refines and validates thresholds against full and soil-sensor irrigation.

Expected outputs and impact: CWSI baselines for several oil crops, water production functions for seed oil yield, validated thresholds with an estimate of water saved, a crop-comparison guide, open data and protocols, one paper from the MSc and three from the PhD. Pot results give mechanisms and relative rankings that need later field validation.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

Optimizing Spray Drone Operating Parameters for Deposition Quality, Drift Reduction, and Cost Efficiency in South African Agriculture

MSc, MSc Eng.

Background and problem: Spray drones are being adopted quickly in South Africa, but operators rely mainly on manufacturer defaults and overseas data that do not reflect local crops, field shapes, wind conditions or chemical programmes. Poor settings cause uneven coverage, drift, wasted chemicals and possible crop or environmental damage.

Aim: To determine the operating parameters that give acceptable spray quality at the lowest cost.

Objectives

- Quantify how flight height, speed, flow rate and droplet size affect deposition, coverage and uniformity.
- Measure effective swath width and downwind drift under varying weather.
- Develop predictive models and identify optimal settings.
- Compare field capacity and cost per hectare with knapsack or boom spraying.

Methods: Replicated field experiments in a randomized or split-plot design on one or two major crops. Tracer dye and water-sensitive paper replace agrochemicals for deposition measurement, and wind, temperature and humidity are logged for every flight. Image analysis, mixed-model ANOVA and response surface regression identify the best settings, followed by a partial budget analysis.

Expected outputs: Validated recommended settings by crop, a simple decision guide for operators and contractors, baseline data for local best practice and regulation, and one or two journal papers.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

An Integrated Decision Framework for Imagery-Guided Spray Drone Operations in South African Fields

PhD Eng./Bioresources System

Background and problem: Spray drone operations rest on three linked decisions: where to spray, how to spray, and how to route and resupply the drone. These are usually studied separately, which limits efficiency gains on small, sloped and irregular fields common in South Africa. Blanket spraying also wastes chemicals where weeds or pests are patchy.

Aim: To develop and validate an integrated framework that minimizes chemical use, time and cost without reducing efficacy.

Objectives

- Model how operating parameters affect deposition and drift.
- Derive spray zones from drone RGB and thermal imagery and test them against blanket spraying.
- Develop and compare constrained route and refill-point optimization algorithms that account for slope, tank and battery limits, and variable-rate zones.
- Integrate the modules and evaluate them in whole-farm trials with a techno-economic analysis.

Methods: Replicated deposition and efficacy trials, image classification using machine learning, simulation of routing algorithms on real field shapes followed by flight validation, and economic modelling for farmers and contractors, across multiple seasons.

Expected outputs: Validated models, an open decision-support tool, evidence of savings in chemicals, time and cost, and three to four peer-reviewed papers. MSc and PhD students can share data and equipment.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).



Smart Modelling of Tractor Fuel Use, Slip and Field Efficiency Using Telematics and Instrumented Tests in South Africa

MSc Eng. and PhD Eng.

Background and problem: Tractor operations are a major energy and cost item on South African farms, yet operators lack local evidence on how soil, implement, speed, depth and tyre settings affect fuel use, wheel slip and field efficiency. Modern tractors record telematics data, but it is seldom combined with controlled field measurements to give practical, real-time guidance.

Aim: To develop validated models that predict tractor fuel consumption, slip and field efficiency, and use them to recommend efficient operating settings.

MSc scope

- Analyse telematics data (engine load, fuel rate, speed, area worked) from commercial tractors.
- Run controlled tests on two contrasting soils, varying implement, depth, speed and tyre pressure or ballast; measure draft, slip and fuel use with a drawbar load cell, slip sensor and fuel flow meter.
- Compare regression and machine learning models and deliver a simple operator decision tool.

PhD scope (extends the MSc)

- Expand to multiple soils, implements, tractors and seasons.
- Develop hybrid physics-informed and machine learning models and test transferability across machines and sites.
- Build a real-time advisory algorithm using live telematics data and evaluate it in on-farm trials for fuel, efficiency, compaction and cost.

Methods: Replicated factorial or split-plot experiments with soil characterization (moisture, texture, bulk density, cone index), telematics data under a data-sharing agreement, cross-validated modelling and techno-economic analysis.

Expected outputs: Validated and transferable models, recommended settings for South African soils and implements, an operator tool and prototype advisory system.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

Livestock Security Collar Performance and Decision Support for Theft and Predator Protection in South Africa

MSc and PhD, Eng./Bioresources System

Background and problem: In 2024/25 about 190,000 sheep, goats and cattle were reported stolen to SAPS in 25,606 cases, and AfriForum estimates direct losses of about R880 million a year, with predation adding further losses. GPS and mobile-network security collars are increasingly used, but there is little independent evidence on how reliably they detect real theft or predator events, how terrain and network coverage affect them, how quickly alarms lead to a response, or whether they pay for themselves. Farmers also lack tools to decide where, and in how many animals, to deploy collars.

Aim: To evaluate the field performance of commercial security collars (MSc) and to develop an intelligent, cost-effective security framework that improves detection, verification and deployment decisions (PhD).

MSc scope (evaluation): (1) Measure alarm reliability, false alarm rate and alert latency. (2) Assess GPS positioning accuracy. (3) Determine the effects of terrain and mobile coverage. (4) Estimate cost per animal and the effect of collar numbers and placement for different herd sizes. Methods: controlled disturbance trials and long-term alarm-log analysis on cooperating farms, farmer interviews on management and response times, descriptive and inferential statistics and a cost-benefit model. Output: deployment guidelines and one or two papers.

PhD scope (extends the MSc): (1) Build and validate anomaly-detection models on collar GPS and movement time series that separate theft, predator and normal events, using labelled trials, logged alarms and simulation to cover rare events. (2) Test thermal drone verification, in which a drone locates and counts animals after an alarm, measuring detection accuracy and time to locate. (3) Model mobile-network coverage with terrain GIS to predict coverage gaps and optimize collar placement. (4) Combine detection performance, response time and costs in a risk-based economic model and decision-support tool for deployment by herd size, terrain and theft risk, validated on partner farms across several areas.

Novelty and outputs: An independent, terrain-aware evaluation of operating collar systems, linked to detection analytics, drone verification and coverage planning in one framework. Outputs are evidence-based guidelines, validated models, an open decision tool, recommendations for manufacturers and farmers.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

Hydrogeochemical Facies, Processes and Contaminant Sources Controlling Groundwater Quality in the Upper uMngeni Catchment, South Africa

MSc and PhD, Eng./Bioresources System
Potential Funding: uMngeni-uThukela Water

Background and problem: The upper uMngeni Catchment is the headwater of the system supplying Pietermaritzburg and Durban through Midmar, Albert Falls, Nagle and Inanda dams. Farms, schools and rural households rely on boreholes and springs in weathered and fractured Karoo sedimentary rocks and dolerite. DWS hydrogeological mapping of KwaZulu-Natal shows that these hard-rock aquifers have low storage and variable quality, and an earlier UKZN study found that major-ion concentrations differ strongly by rock type, with dolerite waters the least mineralised and Dwyka tillite waters the most. Karoo Basin work further shows that saline, sodium-chloride groundwater near dolerite intrusions can be traced with ionic ratios and isotopes. Yet monitoring in the upper uMngeni has focused on surface water, so the controls on groundwater chemistry, the contribution of groundwater to the dams, and the natural versus human sources of nitrate, fluoride, iron, manganese and microbial risk remain poorly known. Without this, indices alone can mislead and safe use of untreated groundwater cannot be guided.

Aim: To explain what controls groundwater chemistry and quality in the upper uMngeni Catchment, separate natural from human influences, and model quality for drinking, livestock and irrigation use.

MSc scope (baseline and processes): About 30 to 40 boreholes and springs stratified by lithology (sedimentary, dolerite, contact zones) and land use, sampled in wet and dry seasons. Major ions, nutrients, alkalinity, field parameters and selected trace elements will be classified into facies (Piper, Durov, Stiff) and interpreted with Gibbs plots, ionic ratios, PHREEQC saturation indices, PCA and cluster analysis, then screened against SANS 241 and irrigation indices. Output: a seasonal baseline, facies map and conceptual model of dominant processes.

PhD scope (extends the MSc): About 60 sites including streams and rainfall over two or more seasons, adding F^-, Fe, Mn and E. coli, and stable isotopes ($\delta^{18}O$, $\delta^{2}H$) for recharge and mixing, with $\delta^{15}N$-NO_3 on selected samples. PHREEQC inverse and reaction-path models will trace recharge-to-discharge evolution, nitrate, chloride, sulfate and fluoride will be apportioned between geogenic and anthropogenic sources, groundwater inputs to the dam will be estimated, and health risk (hazard quotients for infants, children and adults) and vulnerability will be mapped. A low-cost monitoring indicator set will be proposed.

Novelty and outputs: The first process-based, isotope-constrained groundwater chemistry model for the upper uMngeni headwater, with source apportionment and hotspot maps for water managers, municipalities and communities; one or two papers from the MSc and three to four from the PhD, plus a policy brief and stakeholder workshop.

For further information contact Dr Kassahun Tadesse (TadesseK@ukzn.ac.za).

Life Cycle Cost Analysis and Investment Appraisal of Centre Pivot, Permanent and Semi-Permanent Sprinkler Irrigation Systems in South African Sugarcane Production

MSc. Eng

Potential Funding: South African Sugarcane Research Institute

Background and Problem Statement

Ageing infrastructure, rising irrigation input costs (including electricity, labour, water and fertiliser) and advances in irrigation technology are prompting sugarcane growers to reconsider their irrigation systems. Modern technologies offer opportunities to improve irrigation management but generally require higher initial capital investment. Farmers therefore face difficult decisions about which systems and technologies to invest in.

Semi-permanent sprinkler systems have relatively low capital costs and are widely used in the industry. However, their limited flexibility and greater dependence on labour may constrain irrigation management and efficiency under certain conditions. Permanent sprinkler and centre pivot systems offer greater flexibility and automation potential but require higher initial investment. Advanced technologies, including variable-speed and variable-rate application in centre pivots, may offer further benefits. The extent to which these investments improve irrigation performance, reduce operating costs and increase attainable sugarcane yields remains to be quantified under different soil conditions.

Building on an earlier project focused on drip irrigation, this study will compare centre pivot, permanent sprinkler and semi-permanent sprinkler systems to establish when alternative irrigation systems and technologies represent economically viable investments for South African sugarcane production.

Aim

The aim is to conduct a life cycle cost analysis and investment appraisal of the selected irrigation systems, evaluating whether higher initial capital investments can be justified by potential improvements in irrigation performance, reduced operating costs and increased sugarcane yields, particularly under challenging soil conditions.

Materials and Methods

The study will primarily involve engineering design, costing and economic analyses, supported by engagement with sugarcane growers, extension personnel, irrigation designers and equipment manufacturers to identify representative irrigation systems, technologies and operating conditions. Sugarcane crop models may be used to estimate irrigation water use and attainable yields under different irrigation system designs, technologies and soil conditions. These estimates will inform the assessment of irrigation operating costs, potential production benefits and investment viability.

Expected Outcomes

The study is expected to provide an evidence-based framework to support irrigation investment decisions in South African sugarcane production, identifying the conditions under which alternative irrigation systems and advanced technologies may offer the greatest economic and agronomic benefits.

For further information contact Dr Ashiel Jumman (jummana@ukzn.ac.za)



Additional Information for New Students:

Post graduate students are provided with a personal computer and office space. The university normally provides remission of fees, one year for fulltime MSc students and three years for fulltime PhD students. The projects listed above have funding as indicated. Students must check with supervisors to ensure that a bursary and/or research expenses are covered by the project funding before registering for the Post Graduate Degree. Full access to research equipment, e.g. laboratories, library databases, the World Wide Web, a telephone, printing and faxing are provided by the School. In return, post graduate students are required to be at their work place from 08:00 to 16:30 and to help with undergraduate tutoring and general assistance from time to time.

For more information please contact Dr Ashiel Jumman (JummanA@ukzn.ac.za) or visit our web page: http://efwe.ukzn.ac.za/.