

WATER **RESEARCH ROADMAP**

Guiding research with impact for resilient regional communities



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INTRODUCTION

The University of Newcastle is committed to delivering evidence-based knowledge and practice to build community resilience and safeguard water systems.

Water is a critical resource, fundamental to our economic, social and environmental health. If not wisely managed, the demands on this vital resource will exceed its sustainable capacity.

The safeguarding of our water resources in Australia, and internationally, is a shared challenge calling governments at all levels, research institutions, industry and communities to work together to meet our future water needs.

In consultation with industry and government stakeholders The University of Newcastle has produced this Water Research Roadmap to ensure our capacity building initiatives are positioned to best assist the water sector, and support greater resilience in regional and urban centres.

Through our 'Looking Ahead' Strategic Plan, The University of Newcastle is committed to delivering the highest quality research and education to address the next generation of resources in relation to water productivity, efficiency, sustainability and reliability.

Specifically, our University is focused on the delivery of applied research that informs decision making and policy to address:

- The impacts of climate variability on water resources and enabling factors for optimal management, modelling, restoring and/or rehabilitating rivers, catchments and coasts;
- Challenges and opportunities for improvement and sustainable development in the water sector; including future training and workforce needs.

This Roadmap identifies the guiding principles and priority actions necessary to support a quality, sustainable water supply into the future. These actions demonstrate a coordinated approach to water resource capacity building. Our priority is to ensure that the sector can adapt and respond to current and future uncertainties in order to:

- Meet current and future water needs
- Sustain healthy communities
- Support the regional economic prosperity
- Protect and restore ecosystems and biodiversity values.

This Roadmap focuses on supporting the University's research centres to deliver research with impact through:

- Tools and response capabilities for water resource quantity and quality management
- Highly skilled human resources for future challenges
- Cross-disciplinary and cross-boundary approaches to shared problems
- Engagement with government, industry and community.

SECTOR SNAPSHOT

Over the coming years a number of challenges and opportunities will shape decision making about the management of our water resources.

POPULATION GROWTH AND INCREASED DEMAND

The world's population is predicted to surpass 9.5 billion people by 2050, inherently increasing demand for essential water and wastewater services. Water resilience and long-term supply and demand management will be required to future-proof urban and rural centres and overcome the pressures of increased human consumption, while maintaining the ecological health of our natural environment.

CLIMATE CHANGE

By 2025, it is estimated that globally 1.8 billion people will live in regions with absolute water scarcity. Greater climate variability leading to rising temperatures, varied rainfall patterns and extreme weather events including flood and drought will continue to impact communities leading to a greater emphasis on adaptive planning for sustainable water resource management. Multidisciplinary and cross-sectoral collaboration is key to addressing increasingly complex water sector challenges. The exploration of alternative sources of water and sustainable solutions to ensure the availability of water will drive water sector priorities well into the future.

WATER VALUES

Placing communities at the centre of decision making and increasing transparency and consultation in water management, policy and process will have a positive impact on the management of resources. Socially and demographically regional populations will grow and shift, as will customer, consumer and community expectation and behaviour in the face of greater climate variability. The liveability of our urban and rural centres will continue to be influenced by the recreational opportunities provided by our water systems. Access and availability to water requires balance, as well as recognition of the cultural and spiritual importance of water to indigenous communities.

TECHNOLOGY AND INNOVATION

Investment into science and innovation is a major factor for long-term water security and will allow water to be generated from new supply sources.

New technologies and innovation in water utilisation, management and recycling will be deployed into the sector, enhancing sustainable water supply for communities and industry, and ensuring quality and quantity in future years.

The University of Newcastle aims to deliver important environmental, social and economic benefits for the sector through collaboration, strategic partnerships and leadership.

GUIDING PRINCIPLES

Our goal is to support urban and regional resilience. Through research and education, we will deliver greater sector productivity, sustainability and education opportunities to support highly skilled professionals and future leaders.

Through our Strategic Plan 2020-2025, Looking Ahead, we're committed to partnering with the water sector to develop solutions to real world problems.

SUPPORT THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Through this Roadmap we will work with governments, relevant agencies and industry to deliver on the 17 water-related SDGs addressing safe water and sanitation within Australia and the greater Asia Pacific region.

ESTABLISH PRIORITY SETTING CYCLES

Priority setting that keeps pace with the rate of change in the sector will encourage stability to undertake large scale endeavours. Our programs will complement government policy with an emphasis on public-private sector partnerships.

LEAD STRATEGIC PARTNERSHIPS & REGIONAL INITIATIVES

As outlined in the University's Strategic Plan 2020-2025, we will prioritise activities that drive innovation and sustainability, leading to better health, environmental and economic outcomes for our regions.

Our initiatives will feature partner-led problem solving through a "Living Lab" approach that stretch innovation beyond the boundaries of the University, reflect indigenous water values, build multidisciplinary networks and engagement pathways.

BUILD HUMAN CAPACITY THROUGH KNOWLEDGE TRANSFER AND SKILL DEVELOPMENT

Strategies aligned to workforce needs will enhance career pathways for our work ready graduate and postgraduate students and deliver regionally relevant programs. Novel delivery methods will be explored to enhance research training opportunities.

STRATEGIC ELEMENTS

In consultation with major stakeholders, we will seek to ensure our research and education programs meet sector productivity and environmental sustainability challenges. Underpinned by strong partnerships, our approach will focus on delivering four interconnected and mutually reinforcing strategic elements. Through our actions regional benefits will be derived from applied research, enhanced capacity and greater communication and knowledge translation, in turn leading to the delivery of innovative products and services.

KNOWLEDGE BROKERAGE

The University will focus on building relationships, synthesising and translating knowledge to support the delivery of high quality, timely information for the optimal management of water resources. Through NIER's engagement model, collaboration opportunities, and strategic partnerships will increase dialogue between researchers and stakeholders leading to greater dissemination of shared knowledge, products, practical tools, applications and processes.

APPLIED RESEARCH

Through NIER, the University will actively seek research partners in the development and implementation of research activities that support evidence-based best practice, ensuring strategic alignment to regional needs. Multidisciplinary teams will work in four key areas: water security, coast and catchment water management, water utilisation and water recovery.

REGIONAL ENGAGEMENT & INNOVATION

With a focus on collaboration and partnerships, research activity will be driven by innovation, providing an avenue for research excellence and practical enterprise development for improved capacity and funding capture. As one of Australia's leading regional universities, the University will work locally and with our Pacific Island neighbours to provide additional expertise to help address pressing environmental challenges in our regions.

EDUCATION & TRAINING

The University will explore and develop innovative education and training modalities such as micro-masters, tailored short courses and professional training to boost experiential, interdisciplinary and regionally focused learning opportunities to meet water industry challenges. Doctoral training will be prioritised to equip Higher Degree Research students with the skills to lead technical programs while solving industry identified problems. Undergraduate students will also be offered work integrated learning to enhance their education experience.

DEVELOPMENT ACTIVITIES

DRIVE APPLIED RESEARCH THROUGH DEDICATED RESEARCH CENTRES

Utilising NIER's unique enabling platform, and in concert with the University's Strategic Plan 2020-2025 'Looking Ahead', a practical program that reinforces and supports existing water-related research centres will be delivered in four major areas aligned to water sector trends. These research focus areas are:

- Regional water security
- Coast and catchment water management
- Water utilisation
- Water recovery.

The University's involvement in two water-related Australian Research Council (ARC) Centres of Excellence in resource engineering and biotechnology will also be leveraged as part of this approach.

In particular, activity will be focused in the Upper Hunter, Central Coast and Pacific regions where the University has an existing presence. These regional nodes will deliver shared solutions, leading to regional development opportunities and important social and health outcomes.

ENHANCE REGIONAL CAPABILITY AND HARNESS COLLECTIVE CAPACITY

The University will support an innovation ecosystem that responds to government and industry needs. Targeted strategic initiatives, activities and events will promote knowledge sharing, deliver improved management tools and human resource capabilities to meet sector challenges.

Collaboration spaces and industry-facing support programs such as NIER's Innovation Launchpad for small to medium enterprises, Doctoral Training Centres and the University's entrepreneurial network I2N will be tailored to harness a multidisciplinary network of expertise, decision support tools and thought leadership.

CREATE WORK-READY GRADUATES THROUGH A DEDICATED DOCTORAL TRAINING CENTRE

NIER will work with University Faculties to establish a Doctoral Training Centre (DTC) in Water. Through this process, we will provide a supportive environment for the current generation of engineers and scientists to mentor future leaders in water and environmental policy and practice.

The DTC will bring postgraduate students and researchers together with industry, business and government partners to inspire new ideas, new ways of working and smarter solutions to industry challenges. As a collaborative initiative, the DTC will provide industry partners with unprecedented access to a pool of knowledge for co-designed projects that support students to gain industry ready skills.

Flexible research education delivery mechanisms will be explored such as micro-credentialing, short courses and skill development partnerships. Opportunities for work integrated learning at an undergraduate level will also provide practical industry exposure and training.

ENABLE INDUSTRY READY APPLICATION THROUGH THE PROVISION OF SPECIALISED FACILITIES

Investment in the University's existing research facilities will be made to ensure infrastructure such as open access laboratories, testing facilities and demonstration plants support the development of industry ready applications. Working closely with the University's commercial arm TUNRA, we will ensure our assets are highly visible to potential partners.



RESEARCH FOCUS AREAS

The water sector is addressing a number of important challenges and opportunities that will be integral to Australia's long-term water security. In meeting future demands, the University will leverage its existing expertise to solve challenges and develop opportunities across four key areas including:

- REGIONAL WATER SECURITY
- COAST AND CATCHMENT WATER MANAGEMENT
- WATER UTILISATION
- WATER RECOVERY

REGIONAL WATER SECURITY

Increasing our understanding of hydrological, ecological and climate processes to maximise environmental, social and economic benefit

In Australia and globally the water cycle is being significantly influenced by climate change leading to more extreme weather events such as the current drought. Combined with increasing population demands, significant impacts and risks to regional water security are being felt. Hotter conditions are leading to declines in soil moisture, and reduced rainfall has led to less runoff into streams, rivers, lake and dams, while a warmer atmosphere is increasing the risk of flash flooding in some areas.

Managing water related infrastructure and balancing the delivery of secure water supplies to households and critical industries is a complex challenge for regions. The University of Newcastle is contributing evidence-based knowledge, enabling technologies and improved management tools to optimise water resources for environmental, social and economic benefit. The University is also focused on understanding the socio-economic impacts of climate variability to support long-term resilience measures in regional and remote communities.

THE UNIVERSITY AT A GLANCE

- Quantification, stochastic modelling and management of climate-related risks and variability
- Flood and drought risk assessment and estimation
- Climate change impacts on water quality and water supply management
- Rehabilitation of wetlands, in-stream and estuarine ecology
- Remote sensing of ecosystems function and soil moisture
- River and bank erosion assessment and transport processes
- Interactions and feedbacks between ecohydrology, landforms and morphodynamic processes
- Modelling, simulation and optimisation of complex water resource systems and long-term water availability
- Hydrological and economic modelling

- Atmospheric water generation, water recycling systems and energy efficient desalination
- Social impacts of drought on human health and wellbeing
- Community attitudes, behaviour change and water use

MAJOR INDUSTRY R&D PRIORITIES

- Social impacts and behaviour change
- Water quality and quantity management, optimisation and reuse innovation for alternative sources of water
- Scenario development, testing, planning and response models in the face of uncertainty
- Water governance, regulatory systems and planning for water supply and access

CASE STUDY

IMPACT OF DROUGHT ON REGIONAL AND REMOTE COMMUNITIES

Drought is a pervasive and recurrent characteristic of the global climate system, especially in areas prone to extreme rainfall and variability.

Researchers at the University of Newcastle are investigating the complexities associated with hydrometeorological aspects of drought related to environmental, social, health and financial effects experienced in rural communities in NSW.

Researchers at the Centre for Water, Climate and Land are investigating drought-related stress amongst farmers in NSW. Farmers aged between 18-35 years who live and work on farms in isolated areas and experience financial hardship, were found to be more likely to experience drought-related psychological stress.

Personal and social impacts develop as a result of the unfamiliarity, unpredictability and longevity of drought. Community impacts can include loss of business and professional services, loss of community connections and social networks, changes in countryside including dry paddocks, not being able to water gardens, and reduced water quality.

This research is essential to helping understand the wide-ranging impacts of drought and wellbeing, and the importance of structures, planning, policy and community involvement and engagement. Successful adaptation and resilience to drought is essential for the survival of rural communities and residents impacted by drought.



COAST AND CATCHMENT WATER MANAGEMENT

Balancing cultural and economic values while ensuring coastal and catchment resilience for healthy functioning ecosystems

Our coastlines and catchments provide important economic, social and cultural benefits that are underpinned by good water quality, healthy habitats and diverse and abundant marine life. Supporting sustainable practices and conserving coasts and catchments threatened by greater pollution, climate variability and growing populations is vital for the healthy functioning of environmental assets.

The University integrates knowledge across a wide range of areas encompassing coastal habitat protection, marine systems, catchment and estuarine health and pollution control. With a focus on decision support, education and awareness, the University is working collaboratively with industry, government and community stakeholders to achieve sustainable growth.

THE UNIVERSITY AT A GLANCE

- Event-based impacts on marine environments
- Impacts of environmental pollution in marine systems
- Hydrodynamics, water management and water efficiency technologies
- Rapid response environmental monitoring programs addressing water quality and biodiversity
- Disturbances on estuarine and coastal ecosystems
- Aquatic toxicology, algal blooms and fish kills
- Microbial communities and water quality in both pristine and degraded ecosystems
- Water quality in drinking water storages and catchments after bushfires and extreme weather events
- Social determinants of health
- Innovative remediation methods and technologies for contaminated aquifers, groundwater and soil
- Emerging technologies for water quality monitoring and ecosystem health
- Waste characterisation
- Ecological and human health risk assessment
- Bioaccessibility/bioavailability assessment
- Sediment transport and salinity

MAJOR INDUSTRY R&D PRIORITIES

- Protecting coastal and marine habitats and ecosystems including threatened and protected species
- Protecting indigenous cultural values and community engagement
- Water quality improvement and pollution reduction including litter and land-based runoff
- Data monitoring and early warning systems for real time application in extreme weather events
- Rapid response systems for ecosystem health
- Modelling, restoring and rehabilitating catchments and coasts

CASE STUDY



WATER QUALITY AND ECOSYSTEM HEALTH IN LAKE MACQUARIE

Coastal and marine environments are sources of recreation, food, energy, and other valuable resources however these vital ecosystems are under increased pressure from climate change, pollution and urban development.

Researchers at the Coastal and Marine Science Research Group are undertaking industry-led research investigating physical and biological processes that support the sustainable use of resources within coastal catchments and marine environments.

One research project is determining the impacts of sewage overflows on the benthic environment in Lake Macquarie which includes monitoring and assessing seagrass, macro vertebrates and micro communities. Researchers are using this information to develop evidence-based environmental monitoring programs to address water quality and ecosystem health within this important coastal environment.

WATER UTILISATION

Delivering enabling technologies and integrated solutions for greater water efficiency and productivity to support diverse industries, vibrant communities and healthy environments

Historically Australia's water sector has performed well in delivering safe, reliable and affordable water to businesses and households over many years across most of the country. Many industries, including agriculture, mining and manufacturing, have used efficiently provided productive water to support growth, particularly in regional areas.

Climate change, population growth, ageing assets, and competing interests are placing increased pressure on limited resources. Rapid advances in eco-efficient technology is needed to transform the way water is utilised and wastewater services delivered – moving from a capture, use and dispose approach to an integrated water-cycle management where we use less, recycle and reuse water resources.

The University's research expertise includes transformational technologies to dramatically reduce water wastage and increase water productivity to achieve unprecedented change in water management practices.

THE UNIVERSITY AT A GLANCE

- Water-saving processing technologies
- Hydrodynamics of foam fractionation and flotation for particle recovery
- Adaptive management of industrial processes and water scarcity
- Agricultural yield optimisation, soil productivity and water quality
- Water-energy nexus
- Design of resilient pipelines for water transport
- Performance of buried pipelines
- Renewal of ageing infrastructure
- Futureproofing infrastructure for climate change
- New generation waste containment systems for emerging contaminants
- Energy efficient wastewater treatment plants involving aeration power reduction, dewatering and enhanced oxygen transfer efficiency

- Integrated waste processing and utilisation with recovery and generation
- Second generation dewatering systems
- Estimation and control for complex networked dynamic systems
- Data and maintenance planning tools

MAJOR INDUSTRY R&D PRIORITIES

- Water resource management and adaptive planning for industry productivity and efficiency
- Regional economic development impacts and water dependency
- Managing industrial processes in drought
- Residential approaches to utilising water and community engagement

CASE STUDY

ECO-EFFICIENT BENEFICIATION FOR GREATER WATER PRODUCTIVITY

Through a \$35 million Australian Research Council (ARC) Centre of Excellence for Enabling Eco-Efficient Beneficiation of Minerals, The University of Newcastle will be working towards achieving zero-emission mining by doubling energy and water productivity and reducing the loss of high value metals during processing by up to 90 per cent. The multidisciplinary structure of the centre provides an opportunity to make a practical difference to the future of our mineral resources, whilst ensuring a sustainable and competitive future for a critical Australian industry, involving a whole new generation of scientists and engineers.

Some minerals are becoming difficult to access and extract, whilst requiring high usage of energy and water in processing, making operations expensive and environmentally demanding. These pressures require urgency in the transforming the value addition of mineral processing, known as beneficiation, to achieve a step-change reduction in the environmental footprint.

The funding will enable world-leading research into developing more efficient and environmentally friendly mineral processing.

The Centre involves collaboration with researchers from Australian universities, CSIRO, industry partner organisations, as well as leading international research institutions.

WATER RECOVERY

Advancing science and technology for next-generation resource recovery

Significant advances in science and technology for water harvesting, reuse and recycling are delivering water systems and industrial processes that are cost-effective, sustainable and carbon neutral.

At the University of Newcastle, novel next-generation resource recovery technologies and processes in wastewater utilisation, management and treatment are delivering productivity co-benefits. These measures are allowing industry to reduce inputs and increase outputs, in turn minimising the impacts of wastewater pollution on the environment.

THE UNIVERSITY AT A GLANCE

- Beneficial utilisation of waste resources for value-added products
- Microbiology and chemistry of water supplies and wastewater
- Next generation technologies for wastewater treatment to manage emerging contaminants
- Atmospheric water generation and wastewater treatment technologies
- Stormwater quality monitoring tools and treatment technologies
- Water governance and regulatory systems
- Hydrothermal treatment of wastewater
- Bioremediation, biotechnological approaches to nutrient contaminants from wastewater
- Potable and wastewater treatment including activated sludge and algae systems
- Innovative remediation methods for contaminated soils and groundwater
- Advanced wastewater treatment technologies and water recycling systems
- Understanding pathogenic microorganisms and their risk to ecosystem and public health
- Black water and grey water recycling for building systems
- Water management for dust suppression
- Water efficient mineral processing technologies
- Analysis of physicochemical parameters of wastewater
- Supportive strategies for community awareness and behaviour change

MAJOR INDUSTRY R&D PRIORITIES

- Long-term planning and regulation for water supply and access
- Water harvesting, reuse and recycling technologies
- Treatment technologies for stormwater and wastewater
- Behavioural change and community engagement

CASE STUDY

MITIGATING THE RISK OF CYANOBACTERIAL BLOOMS IN WASTEWATER PONDS

Cyanobacterial blooms in wastewater treatment plants impact on effluent quality and the utility of recycled water, posing a significant risk to the economy, the environment and public health.

Biotechnology experts at the University of Newcastle are working towards mitigating the risk of cyanobacterial blooms in wastewater ponds, aiming to understand the causes of cyanobacterial blooms in pond-based wastewater treatment plants and the risks they pose.

The project is using the latest molecular techniques to examine how the microbial communities within these systems interact with each other and their surrounding environment to form blooms and produce toxins and other harmful metabolites.

The research involves collaboration with the University of Western Australia, University of Melbourne and Melbourne Water Corporation, Hunter Water Corporation and Port Stephens Council. The knowledge developed will inform risk assessment and provide strategies for the mitigation of future bloom events, improving the security of our increasingly valuable recycled water resources.

ENGAGE WITH US

For more information visit the Newcastle Institute for Energy and Resource website.



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