THE UNIVERSITY OF WESTERN AUSTRALIA | Institute of Agriculture

THE UWA INSTITUTE OF AGRICULTURE

Strategic Plan

2021-2025

CONTENTS

FOREWORD

The University of Western Australia (UWA) established The Institute of Agriculture (the Institute) in 1936. The Institute was re-established in 2007 with a mandate to integrate UWA's research, education, training and communication in agriculture and food production systems and environmental challenges facing the Western Australian agri-food sector.

The Institute has built an enviable reputation by focusing on effective communication of agricultural research and research training activities at UWA, and deepening UWA's engagement with progressive farmers and farmer groups, agri-food businesses, national and international collaborators, funding bodies and alumni.

Communication and engagement activities related to UWA's agricultural research, development and training activities continued throughout 2020. The Institute researchers published more than 300 journal articles, book chapters, and reports in 2020, and a total of 21 media statements were distributed throughout the year generating coverage in regional, national and international media.

These achievements ensured UWA's strong position in agricultural sciences, for which UWA was ranked #1 in Australia and #17 in the world according to the 2020 Academic Ranking of World Universities. Committed international partners, dedicated UWA staff across the several schools and disciplines, and strong support from funding bodies and industry have made these significant achievements possible.

As we look forward to the next decade, there is wide recognition that while we have been successful to date, the world as we know it is fundamentally changing at such a rate that the status quo will no longer suffice.

The UWA Institute of Agriculture's Strategic Plan 2021-2025 will guide the Institute and its partners, collaborators and funders as they adapt, pivot to new directions where required and set the base for Western Australia's agri-food sector to become future focused, agile and sustainable over the next decade.

We will respect and celebrate our heritage while creating future environments and experiences that reflect the innovative nature of our education and research, and the cultural richness of our diverse communities.

Professor Kadambot Siddique
AM CitWA FTSE FAIA FNAAS FISPP FAAS
Hackett Professor of Agriculture Chair and Institute Director

29 January 2021

VISION, MISSION AND VALUES

VISION

Our Vision is to empower communities and individuals in Australia, and the Indian Ocean Rim, to improve their food, nutritional and health security, enhance local and regional prosperity and exercise responsible environmental stewardship.

MISSION

As an international leader in dryland agricultural systems we develop and communicate innovative evidence-based solutions for ethical food production, environmental sustainability and agribusiness advancement in state, national and international settings that enrich peoples' lives.

VALUES

Excellence: We consistently pursue international standards that drive the highest levels of achievement and create the best outcomes possible for our communities, partners and stakeholders.

Integrity: We are honest and ethical and show respect and appreciation for each other, our partners and our communities while valuing our differences and similarities.

Innovation: We are constantly and creatively seeking, improving and adapting knowledge to drive step-changes in agriculture and food production.

Collaboration: We share our collective intelligence to achieve more than we could achieve alone.

Equity: We are committed to ensuring everyone we engage with has equitable access to opportunities, experiences and outcomes. The Institute recognises and values Indigenous peoples' rights, knowledge, culture and values.

FOCUS ON THE FUTURE

The next decade will see the convergence of powerful forces for change with the potential to radically disrupt global industries and food systems.

Variability is not new to primary producers and agribusinesses, but climate change, challenging geopolitical events, technological advances and increasing demands for energy, food and water are impacting the sector more than ever before. Consumer preferences are rapidly changing, driven by macro trends in demographics, population growth and mass urbanization along with demands for convenience, provenance and social/environmental responsibility.

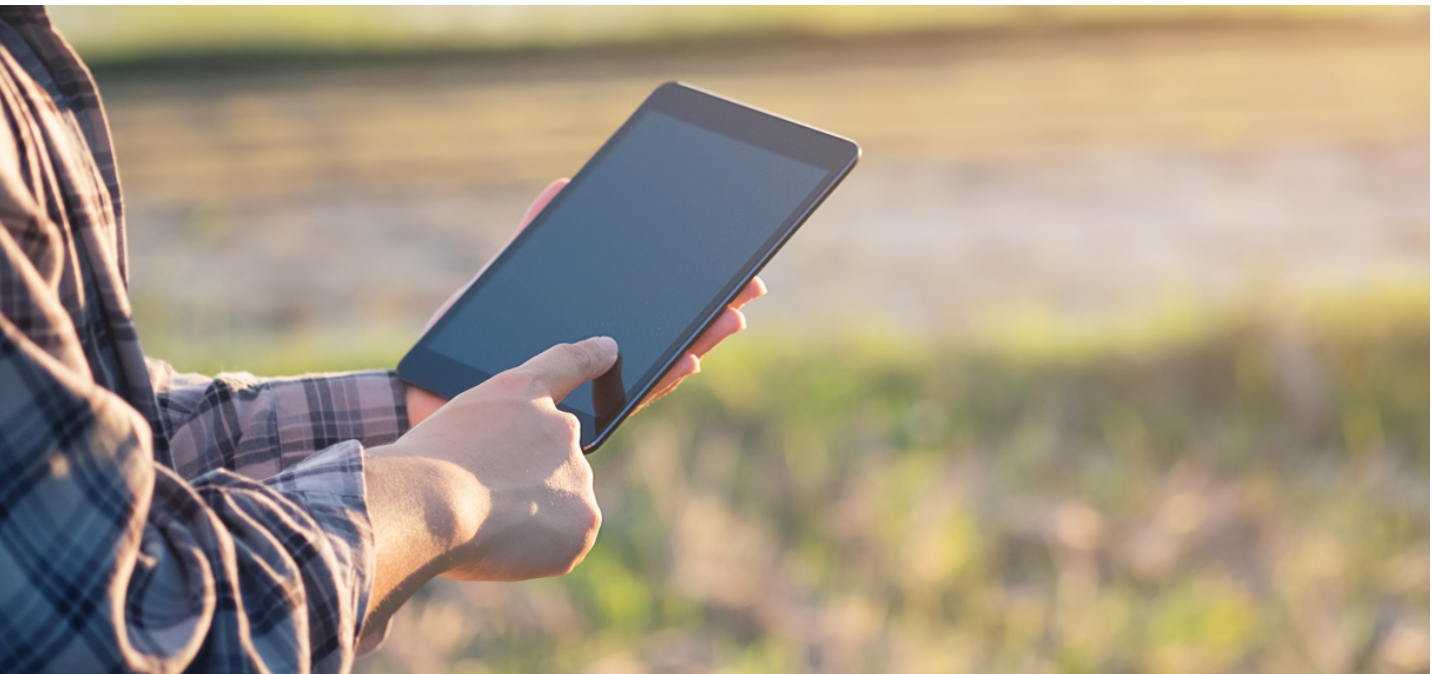
Agriculture and food production are major pillars of the Western Australian economy and key drivers of economic, social and environmental prosperity and well-being for all Western Australians. However, our State is facing a hotter, drier and more variable climate that will require the agri-food sector to become more innovative, agile and responsive if it is to remain competitive and productive.

High quality science, technology and education that helps to build the requisite capacity and skills in Western Australia will be critical to enabling transformational, industry-led investment and innovation that leads to sustainable agricultural systems that enable economic growth and prosperity. We also recognise the long-standing indigenous knowledge and culture provides a rich and unique lens through which we can view and understand our environment.

In late 2019, an industry-wide workshop[1] explored plausible scenarios for what Western Australia's future food production systems, food processing and logistics and consumers and customers may look like in 2035. The workshop concluded that continuing with the current approach and trajectory would leave the Western Australian agri-food sector highly vulnerable to rapid shifts in production, markets and consumer demands.

The insights from the workshop create an opportunity to stimulate a larger, more influential discussion about change and adaptation in the Western Australian (and Australian) agri-food sector.

[1] *Future of Agriculture in Western Australia - Think-Tank Workshop Report – Australian Institute of Agriculture's 'AgFutures2035 Conference 2019' https://bit.ly/3cjYuWi*



The Institute held a workshop in August 2020 to finalise the Strategic Plan 2021-2025. Key leaders from The University of Western Australia and the agriculture industry attended.

The Institute's track record in developing and facilitating collaborative, cross-disciplinary approaches to major initiatives means it is well positioned to take a leadership role across industry, governments and academia in planning and delivering a sustainable, profitable agri-food sector in Western Australia in 2030.

Such a venture is consistent with the *UWA 2030* vision and *UWA Strategic Plan 2020-25*. The Institute has therefore included in this Strategic Plan 2021-25 a major initiative entitled ***Sustainable agriculture and food systems for Western Australia's future***.

In recognition of UWA's strategy to form deep partnerships that reinforce its key roles in the Indian Ocean Rim, the Institute has included a second, complementary, major initiative entitled ***Food, nutrition and health security for prosperity in the Indian Ocean Rim***.

The Institute will partner widely to tackle the impacts of climate change, and other global challenges, on agriculture and food systems that threaten the security and prosperity of countries of the Indian Ocean Rim.

OPERATIONAL CONTEXT

UWA is committed to excellence across the sciences and humanities where UWA has disciplinary strength, world-class staff and infrastructure, and a significant strategic advantage offered by place and time.

The Institute draws its broad capabilities from promoting collaborations across the disciplines of science, medicine, business, law, arts and humanities, computer science, mathematics and engineering.

Given these strengths, the Institute has a key responsibility for mobilising the intellectual and physical capital present within UWA towards identification and resolution of major issues and opportunities facing agricultural systems and environmental stewardship in Western Australia and around the Indian Ocean Rim.

The Institute's role in developing and facilitating partnerships and collaborations so that cross disciplinary approaches can be brought to bear on agricultural and environmental issues is critical. Modern sustainable agricultural production systems and healthy environments need more than the traditional fields of plant, animal and soil sciences, agri-business and resource management.

Future success will depend on implementation of advanced business practices and risk management, computing, robotics and remote sensing. In addition, social science expertise focused on human behaviour and well-being is critical to support communities and individuals facing rapid and disruptive change.

In the current model, responsibility for undergraduate education and post-graduate training remains with the University's Schools. The Institute retains a role in communicating and linking undergraduate students to career opportunities in agriculture and resource management. It also plays a role in integrating the opportunities for postgraduate training in agriculture-related disciplines.

An overarching principle of the Institute's operations is that its impact will be within Schools and Centres, with all students and research grants attracted to UWA through the Institute's activities placed within, and managed by, a School or Centre (with Institute input where appropriate).

As a matter of policy, all research grant and postgraduate research student training income received by the University because of Institute-sponsored activities, flows back to the Institute's members[2] in their respective Schools. Outputs from scientific research are credited to Schools and Centres with suitable acknowledgement of its byline the Institute.

[2] *Members of The UWA Institute of Agriculture are those academic and research staff with an interest in agriculture and related areas, and who personally commit to membership of the Institute through participation in one of the Institute's themes; or who have expressed interest in the Institute's activities in other ways. Most are staff or adjuncts of one of the Schools in agriculture and related areas or relevant Centres, but membership also extends across all Schools of the University.*

OPERATIONAL MODEL

Within our operational context, the Institute will continue to harness UWA's strengths and diversity through:

INTEGRATION

Bringing together UWA's agricultural research, and communication activities; integrating complementary activities across disciplines and organisational units and providing a focus for leading-edge research and innovation (R&I).

COMMUNICATION

Strengthening links with regional industries, farmer groups and the broader regional, national and international scientific communities, in line with the Institute's Communication Plan.

CONNECTING

Fostering national and international linkages and alliances that bring new knowledge and expertise to Western Australia and allow our institutions to share its knowledge with the world.

RESOURCING

Increasing the pool of resources available for investment in critical R&I in Western Australia and relevant to national and international issues.

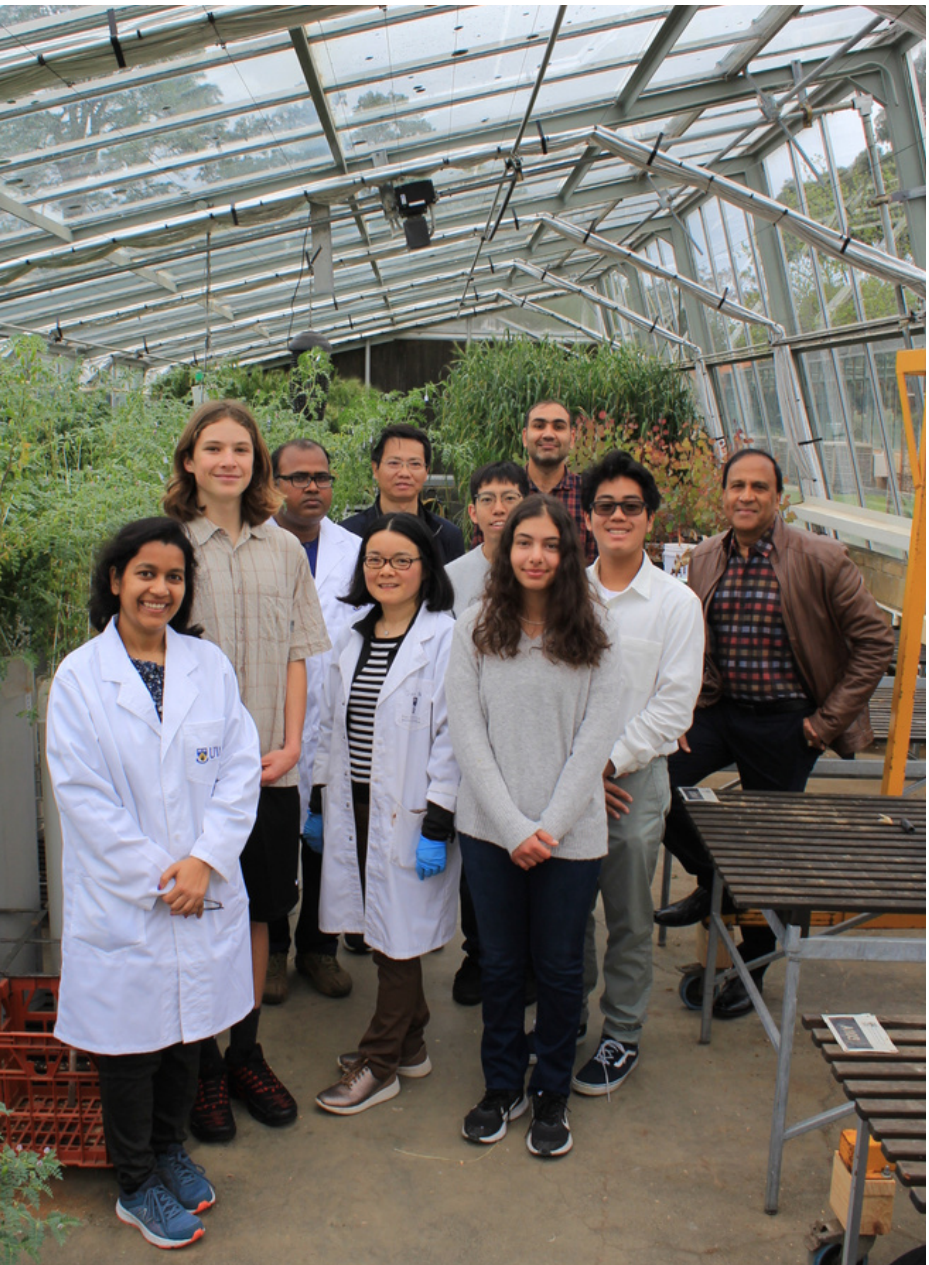
Key Performance Indicators (reported annually) for these operational pillars for the period 2021–2025 are:

INTEGRATION

- At least two new, cross-disciplinary research projects initiated through the Institute's actions involving groups inside and outside the University.
- The Institute delivers a highly-rated impact case study for the 2023 Excellence in Impact Assessment; and the University achieves a rating for agriculture of 5 in the 2024 Excellence in Research Assessment.
- Evidence of adoption of technologies and products developed by Institute-facilitated programs.

COMMUNICATION

- Increase domestic awareness of the Institute and its objectives amongst its audience groups, which include industry, growers, agricultural advisors, researchers, policy and decision makers and influencers.
- Increase national and international awareness of the Institute's strategic objectives to provide leadership in capacity-building and training to improve food, nutrition and health security in the Indian Ocean Rim.
- An increase by 5% each year in the number of students successfully applying for higher degree by research (HDR) post-graduate studies in agricultural sciences at UWA.



CONNECTING

- Initiate at least two formal joint initiatives with other Australian universities with mutual benefits.
- Strengthen relationships with key state and national stakeholders.
- Develop at least two University-level agreements on collaboration in joint research and HDR research training of agricultural sciences with international Universities where UWA can offer special expertise.

RESOURCING

- Attract to UWA at least two major national research initiatives in agriculture by 2025 (minimum life-time budget of $5 million each).
- Identify and attract new and novel sources of investment to help tackle the impacts of climate change on agriculture and food systems in countries of the Indian Ocean Rim.
- A target of 10 (minimum of five) full-fee paying HDR students in agricultural science at any one time.

STRATEGIC CONTEXT

UWA has recognised that the next ten years will provide opportunities to build on its strong foundations, transforming in response to the changing external environment to ensure UWA stays at the leading edge of knowledge creation and its translation for societal benefit.

Released in 2019, the *UWA 2030* vision and *UWA Strategic Plan 2020-25* chart an ambitious agenda for the future; one that tests the image of the traditional public research-intensive university.

Importantly, UWA has chosen to implement a *Grand Challenges* approach to critical issues facing humanity, using its world-class teaching and research capabilities to solve difficult multi-faceted problems facing agriculture and food production and advance the prosperity and welfare of our communities.

The Institute's strategic initiatives address pressing global challenges through the engagement of six Research Themes to bring together a community of practice:

Sustainable Cropping Systems
Sustainable Animal Production Systems
Water for Food Production
Food Quality and Human Health
Engineering for Agriculture
Agribusiness Ecosystems

The performance of each of the Research Themes will be measured by the number, quality and impact of:

- Innovations adopted by Western Australian primary producers
- Peer-reviewed publications in the top 20 per cent of journals in the field
- HDR post-graduates and Masters' by coursework students successfully competed
- External funding agreements and their dollar value
- Communications with industry stakeholders
- Formal and informal collaborations nationally and internationally

RESEARCH THEMES

The Institute's existing research strengths include: agricultural economics, conservation agriculture, crop science, crop genomics, greenhouse gas emission abatements, herbicide resistance management, integrated pest management, plant abiotic stress tolerance, plant breeding and genetics, plant mineral nutrition, sheep nutrition, reproduction and production, soil biology and weed science.

In the next five years, the Institute will support six Research Themes that develop cross-disciplinary approaches and cover a wide range of applications including sustainable production systems; water availability and protection; healthier foods and food ingredients; and agribusiness development.

SUSTAINABLE CROPPING SYSTEMS

Enabling sustainable intensification of agriculture

The Sustainable Cropping Systems research theme plays a key role in bringing together researchers with expertise across plant production systems and linking them with cross-disciplinary partners to develop solutions to real-world problems.

As we face a changing climate and an increasing global population, sustainable intensification of agriculture through the maintenance or increase of yields whilst environmental impact is reduced, is a clear imperative to ensure future food supply.

We use our world-class research and critical mass of researchers to address this complex generational issue through four interlinked subthemes: enabling technologies and pre-breeding; plant physiology; belowground processes; and farming systems and technology.

SUSTAINABLE ANIMAL PRODUCTION SYSTEMS

Develop animal production systems that are 'clean, green and ethical' and optimise the interactions among genotype, environment and management

Within agriculture, beef, sheepmeat and wool are major sources of export income for Australia and Western Australia. A significant challenge for the future of these animal industries is to develop systems that will be able cope with a more variable climate whilst maintaining a 'clean, green and ethical' ethos to meet consumer expectations.

Our livestock production systems are primarily based on grazing, so systems that improve the sustainability of grazing are essential. Our grazing systems fall into two main types: extensive rangeland systems and mixed crop-pasture systems. UWA has been actively researching the 'feedbase' and animal production nexus in both systems so we can develop innovations in grazing management that improve livestock productivity, reduce environmental footprint, and improve the landscape health.

The rangeland and mixed cropping livestock systems both offer opportunities for improvement that we try to capture by collaborating across the themes in the Institute, as well as with colleagues in disciplines ranging from medical research to remote sensing technologies and social sciences with other local, national and international Research, Development and Extension partners. Most importantly, we value direct engagement with industry. Our researchers partner with producers, beginning with project development, and target improvements in grazing systems, reproductive efficiency, and animal nutrition, health and welfare.

WATER FOR FOOD PRODUCTION

To create sustainable solutions for water use in agriculture, that seek to maximise water efficiency and minimise environmental impacts

To meet the food needs of an increasing world population, we need to improve the efficiency of irrigated agriculture and make better use of rainfall and finite water resources. The challenge is to produce food with less water, and to reduce the negative impacts of food production on water quality and environmental water resources.

This theme is underpinned by teaching (undergraduate, Masters and PhD) and research components: economics, plant water use, agronomy and irrigation design. There will be a strong focus on industry collaboration and engagement, water balance and irrigation modelling, postgraduate training and technology exchange.

FOOD QUALITY AND HUMAN HEALTH

To develop healthier foods and food ingredients that can make a positive contribution to human health and the Australian economy

Development of healthier foods and food ingredients can make a positive contribution to both the Australian economy and human health. The development and validation of healthy foods that meet consumer desires is an exciting challenge for the Australian agri-food industries. To satisfy this growing need, we must train the next generation of scientists and industry champions and provide guiding knowledge on policy development for the Australian academic and industry bodies.

Critical for achieving desired outcomes is development of cross-disciplinary collaboration, collaboration with other researchers from both within Western Australia as well as and outside Western Australia, and collaboration with relevant industries and their representative bodies. This research theme integrates the complementary skills, knowledge and activities across disciplines and organisations will result in increased success.

The research is leading towards the development of a collection of healthy functional foods and ingredients, as well as improved processes for their production/manufacture. The research will deliver scientifically validated evidence for the promotion of new foods, as well as significant added value to agricultural industries.

ENGINEERING FOR AGRICULTURE

Engineering a sustainable agriculture future

This theme focuses on providing engineering solutions to agriculture for sustainable growth of net farm-yield, reduction of wastage, and minimisation of environmental impact. Worldwide food shortages and population growth pose substantial challenges to Australia's sustainable agriculture future. These challenges are compounded by conflicting pressures resulting from Australia's drying climate across the major agricultural regions of southern Australia and growing agricultural sector. Due to Australia's dependence on reliable agricultural exports, these challenges also present significant risks to our economic security.

UWA holds a premier international position in university-level agriculture. To maintain and enhance that position in an industry that is transforming rapidly, UWA aims to incorporate engineering into its mainstream agriculture training and research programs. For engineering at UWA, a dramatic shift away from research and training on mining development has presented a unique setting to embrace opportunities arising from the burgeoning worldwide interest in food security. From a national perspective, achieving this combination of goals could help compensate for the loss of manufacturing capacity, leading to major employment opportunities driven by technology-based agriculture.

The operational structure of this cross-disciplinary theme facilitates 'collaborative exchange' through interactions among the researchers. Through this theme, collaborative exchange allows for new knowledge to be developed and applied (creatively), thus advancing the state-of-the-art of the sector through rapid implementation of research outcomes, and commercialisation for delivery to the agricultural sector.

AGRIBUSINESS ECOSYSTEMS

Enhancing economic, social and environmental outcomes through network analysis

The Agribusiness Ecosystems theme aims to advance knowledge and best practice on how local and global agri-food systems work, evolve, and perform, and how public policy and management practice can be used to address the many challenges faced by firms and industries in the ecosystem.

The issues to focus on include changing consumer preferences for different products and services, evolving business models and governance approaches in food systems, commodity trade and risk management, performance bench-marking of agribusiness firms, adoption of agricultural innovations and impact evaluation, value chain development, new venture creation, and suitable production among others.

This theme will collaborate and complements the other research themes in identifying and proving solutions to the complex challenges facing the global food systems.

STRATEGIC DIRECTIONS

MAJOR INITIATIVES

Under The UWA Institute of Agriculture's Strategic Plan 2021-2025, the Institute will pursue two high-level cross-disciplinary initiatives aligned with UWA's Global Challenge approach.

Sustainable, agriculture and food systems for Western Australia's future

The Institute will take a lead role across industry, government and academia in planning and delivering a sustainable, profitable future of agriculture and food production in Western Australia in 2030.

Food, nutrition and health security for prosperity in the Indian Ocean Rim

The Institute will partner widely to tackle the impacts of climate change in agriculture and food systems that threaten the security and prosperity of countries of the Indian Ocean Rim.

The Vision, Priorities and Strategies for the Major Initiatives are outlined in Table 1 of the following section.

STRATEGIC OBJECTIVES

The Institute's role is to facilitate and co-ordinate to best advantage the R&I undertaken by UWA's academic resources. This may involve extending existing research areas, fostering of new research interests, either with existing staff or making new appointments to develop new areas of research, and a stronger focus on commercialisation of R&I outputs and other intellectual property.

The UWA Strategic Plan 2025 contains three positioning strategies - Research and Innovation; Education; and Global Partnerships and Engagement - which are supported by UWA-wide plans for Sustainable Environments; People and Culture; and Effective and Sustainable Operations.

Each of the Institute's Research Themes has the capability and fit to deliver value to UWA's positioning strategies. The Institute will develop three overarching Strategic Objectives, based on the positioning strategies, that will guide the Institute over the next four years, with reviews and updates as necessary.

The Institute will pursue the Objectives, Strategies and Desired Outcomes described for each of the three Strategic Objectives in Tables 2, 3 and 4 in the following section.

The overarching Outcome sought is:

Targeted high quality R&I solutions, educational experiences and global partnerships that drive measurable improvements in food and nutritional security, environmental sustainability and agribusiness advancement.

Strategic Objective #1

The Institute's R&I activities are focused on solving the most difficult issues and mitigating the greatest risks facing agricultural and food systems.

Strategic Objective #2

The Institute's innovative post-graduate activities create unique and globally relevant educational experiences for a diverse cohort of students.

Strategic Objective #3

Build deeper and broader partnerships with industry, governments and not-for-profit organisations to inform and translate our research and educational offerings.


WONGAN STEEL
CHASER BIN

TABLES: OUR MAJOR INITITIATIVES AND STRATEGIC DIRECTIONS

TABLE 1: THE INSTITUTE'S MAJOR INITIATIVES **2021-2025 SUMMARY**

Build deeper and broader partnerships with industry, governments and not-for-profits to inform and translate our research and educational offerings

OUR VISION	OUR PRIORITIES	OUR STRATEGIES
Initiative 1: Sustainable Agriculture and Food Systems for Western Australia's Future		
A future-focused, agile and confident Western Australian agri-food sector competing successfully in global markets	• High-level capabilities in managing food production systems in a changing climate • High-value crops and food products with a clear sustainability proposition • Efficient and socially responsible technology-based food processing and manufacturing • A customer-centric approach to export and domestic markets	• R&I, education and training to build flexible production systems with a range of options to manage risk in various scenarios • Promote water-efficient high-value crops, low-emission ethical animal products and better use of finite water resources • Enable new technologies to reshape food production, processing and distribution; and increase understanding of consumer needs
Initiative 2: Food, Nutrition and Health Security for Prosperity in the Indian Ocean Rim (IOR)		
Reduce hunger and malnutrition by 20% in selected IOR regions by 2025 through the sustainable production and distribution of food, education and training and capacity building	• Improve regional prosperity and stability by increased food nutrition and health security • Provide leadership in research, research training, and capacity-building to improve food, nutrition & health security in the Indian Ocean Rim • Alignment with the UN's Sustainable Develop-ment Goals, and Land Degradation Neutrality Commitments	• Engage and create strong partnerships with stakeholders in the IOR to ensure the environmental and developmental aspirations of the region are respected • Cross-disciplinary collaborations to tackle climate change, environmental damage and population growth that have negative impacts on food, health and social security

TABLE 2: STRATEGIC OBJECTIVE #1
RESEARCH AND INNOVATION

The Institute's R&I activities are focused on solving the most difficult issues and mitigating the greatest risks facing agricultural and food systems

OBJECTIVES

- Enhance UWA's contribution to the advancement of sustainable agricultural systems in international, national and regional settings
- Provide research-based solutions to ensure food and nutritional security, environmental sustainability and agribusiness ecosystems
- Increase the rate of adoption and extent of use of the UWA's agricultural research outputs by industry, farmer groups and rural communities
- Enhance UWA's identity and reputation for high quality agricultural research and timely delivery of outcomes
- Develop programs to support emergence of more 'High Citation' individuals among Institute members and collaborators
- Play a decisive role in UWA's Grand Challenges that can benefit from the Institute's strengths
- Manage the UWA Farm Ridgefield to maximise its value for research, teaching, technology development and exchange and industry partnerships

STRATEGIES

- The Institute's six Research Themes will identify and resolve impactful issues threatening economic viability
- Focus on root processes/interactions and soil biotic/abiotic environments in drought, transient waterlogging and mineral nutrition to enhance crop performance
- Focus on 'clean, green ethical' animal production to meet requirements of future markets
- Improve efficiencies in irrigated agriculture and make better use of finite water resources to produce more food with less water
- Develop healthy functional foods and ingredients and improve processes for their production, manufacture and validation
- Deliver engineering solutions for sustainable growth in net farm yield, waste reduction and minimal environmental impact
- Address governance issues of agribusiness firms along food value chains with a focus on consumer behaviour changes in response to a wide range of factors, many of which are outside the firms' control

DESIRED OUTCOME

Current and emerging agricultural, food and environmental challenges are identified and resolved with measurable improvements in productivity, profitability, sustainability and prosperity

TABLE 3: STRATEGIC OBJECTIVE #2
EDUCATION AND TRAINING

The Institute's innovative post-graduate activities create unique and globally relevant educational experiences for a diverse cohort of students.

OBJECTIVES

- Draw together UWA's personnel with research, teaching, training and communication expertise in agriculture and related areas, under the umbrella of the Institute
- Respond proactively to the changing education and research environment faced by the University, and identify needs and opportunities that this change provides
- Establish formal research, postgraduate teaching and training relationships between UWA and leading international universities and other research organisations with complementary expertise and interest in agriculture and food production in the Indian Ocean Rim
- Develop and maintain a vigorous HDR program in agriculture, accessing both Australian and international sources for high quality students and HDR funding

STRATEGIES

- Increase the Institute's engagement with educational activities more broadly across disciplines at UWA
- Promote the profile of Institute researchers and the value of the Institute's activities to Western Australia and the Indian Ocean Rim
- Attract high performing visitors to UWA to research and publish with academic staff and interact with postgrad students
- Formal mentoring for postgraduate students in the Agricultural Science Major and Master's in Agriculture programs
- Enhance UWA's mainstream agricultural teaching, training and research programs by stronger emphasis on engineering
- Identify cohorts of students with interests in agriculture and provide extra-curricular activities in a well-defined and resourced program of events
- Utilise the UWA Farm Ridgefield to maximise its value for research, teaching, technology development and exchange and industry partnerships

DESIRED OUTCOME

Enhanced student experiences and targeted educational initiatives attract high quality students from a wider range of countries

TABLE 4: STRATEGIC OBJECTIVE #3
STRATEGIC PARTNERSHIPS AND ENGAGEMENT

Build deeper and broader partnerships with industry, governments and not-for-profits to inform and translate our research and educational offerings

OBJECTIVES

- Increase the overall quantum of R&I applied to regional, national, and international issues to improve outcomes for agriculture
- Develop strong and committed consultative links with WA-based tertiary institutions and government agencies to harness the state's academic resources more effectively in agriculture
- Build strategic relationships and partnerships with the private sector that have valuable skills and capabilities
- Commence at least two new, cross-disciplinary research projects initiated and administered through UWA involving groups inside and outside the University
- Facilitate agreements for joint research, research training (HDR) and teaching in agricultural sciences with two Universities in the Indian Ocean Rim, and two other international Universities where UWA can offer special expertise
- Identify and engage one new and novel source of investment each year for agricultural research from agribusiness and government that add value for all partners

STRATEGIES

- Foster national and international linkages and alliances that bring new knowledge and expertise to Western Australia and allow us to share our knowledge with the world
- Increase the pool of resources available for investment in critical R&I in Western Australia and relevant to national and international issues
- Identify new opportunities for UWA research, teaching and training in areas related to agriculture and resource management
- Strengthen and promote internal collaborations that increase the Institute's visibility and relevance to UWA schools, centres and institutes that are currently not engaged
- Form a cross-disciplinary educational and research initiative to develop a climate change response platform for Western Australia
- Build a high level of mutual understanding and respect between the Institute and key industry stakeholders, farmer groups and rural communities

DESIRED OUTCOME

Enhanced partnerships in collaborative research projects and postgraduate research student supervision across UWA and with key external partners that delivers measurable benefits

ACCOUNTABILITY AND GOVERNANCE

INSTITUTE MANAGEMENT BOARD

Reflecting the diversity of UWA's potential contributions to agriculture and food production, the Institute is governed by an Institute Management Board (IMB) chaired by the Deputy Vice Chancellor (Research).

The role of the IMB is to establish policy and high-level strategic direction, ensure appropriate governance and accountability, monitor the Institute's performance, and advise and support the Institute's Director and Associate Directors. The IMB holds six-monthly meetings.

The members of the IMB are:

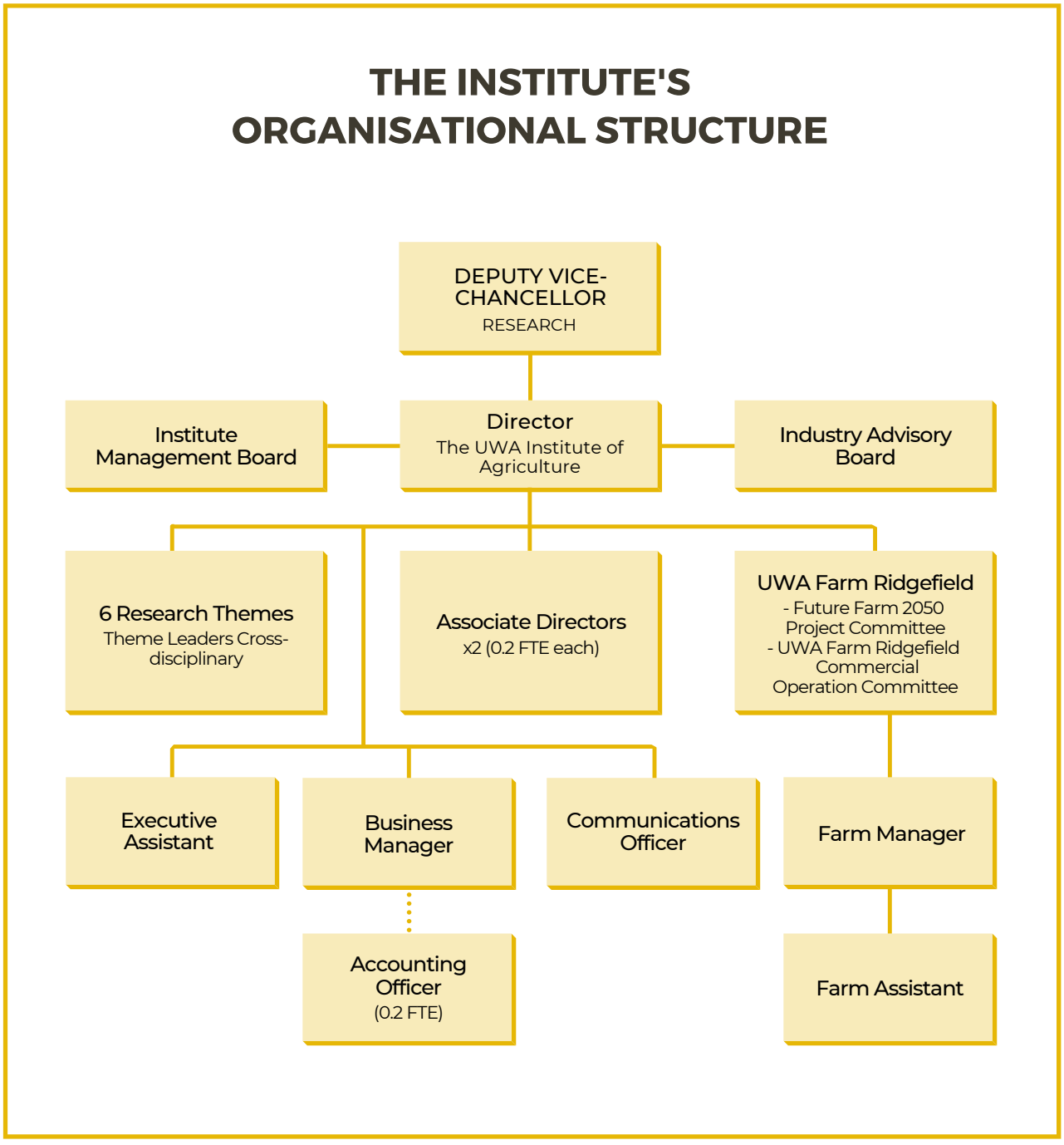
- Deputy Vice Chancellor, Research (Chair)
- Director, The UWA Institute of Agriculture
- Head of UWA School of Agriculture and Environment
- Head of UWA School of Biological Sciences
- Head of UWA School of Molecular Sciences
- Head of UWA Business School
- Head of UWA Medical School
- Head of UWA School of Engineering
- Business Manager (*Executive Officer*), The UWA Institute of Agriculture
- Chair of The UWA Institute of Agriculture Industry Advisory Board (*invited member*)

INDUSTRY ADVISORY BOARD

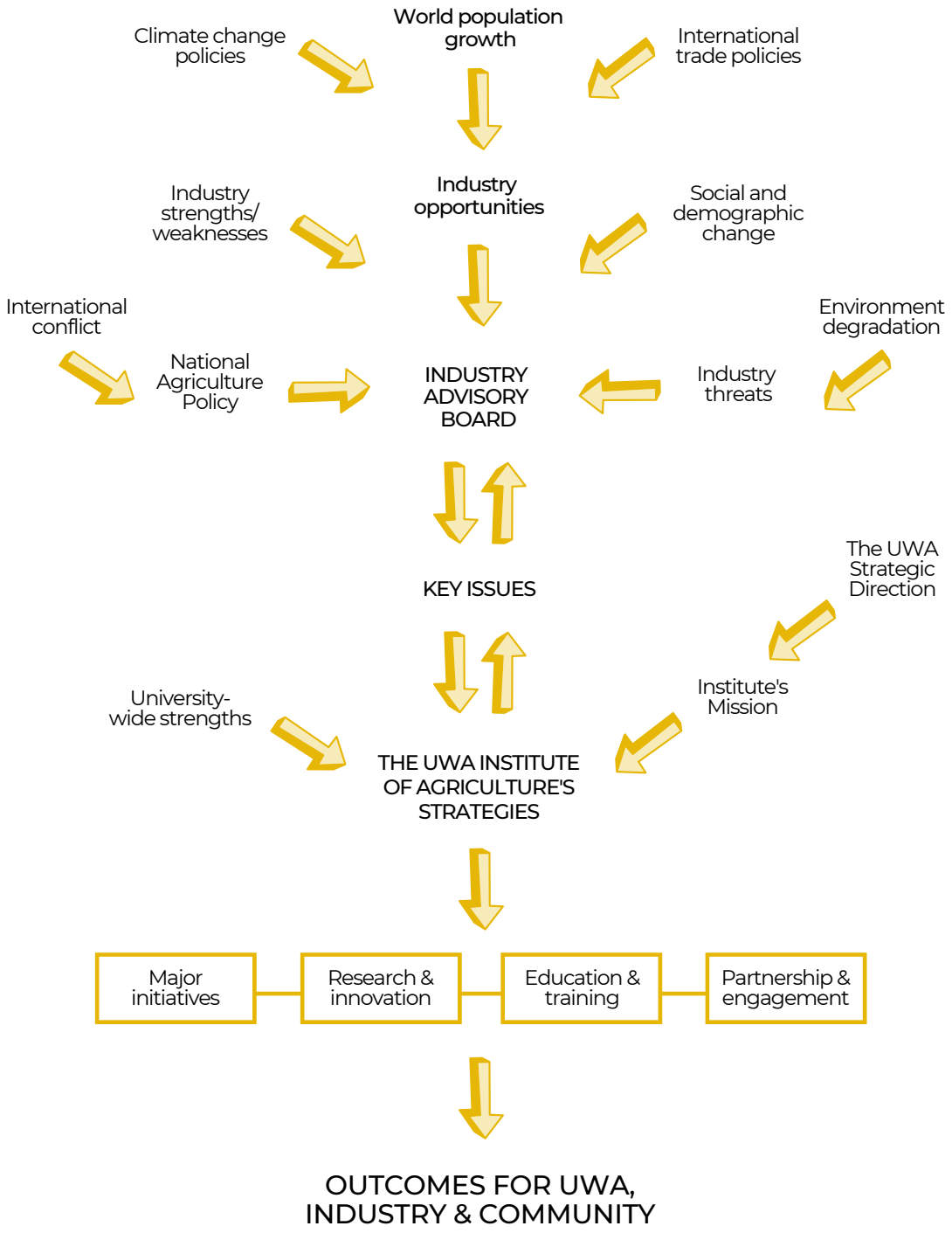
An Industry Advisory Board (IAB) is the key source of the Institute's high level industry interaction, advice and feedback. The IAB has an independent Chairperson, and members chosen from a cross section of the agri-food sector. The Director of the Institute is also a member of the IAB.

The key responsibilities of the IAB are:

- High-level feedback on agricultural industry trends, needs and issues including the skills and experiences required by our graduates to be able to contribute to industry
- Provide guidance to the Institute's Director and management team on strategic planning and policy settings and formulating the Institute's responses to strategic issues relevant to the sector
- Enhancing the profile of the Institute and UWA to the industry and wider community
- The IAB holds six-monthly meetings



THE INSTITUTE'S FRAMEWORK FOR STRATEGIC PLANNING



RESEARCH THEMES

The role of the UWA Institute of Agriculture (the Institute) is to facilitate and coordinate to best advantage the research undertaken by The University of Western Australia's (UWA) academic resource. This may involve extending existing research areas, or the fostering of new research interests, either with existing staff, or through identifying key staff appointments to develop new areas of research. Existing research activities include: soil biology, greenhouse gas emission abatements, plant breeding and genetics, weed science and herbicide resistance management, conservation agriculture, plant abiotic stress tolerance, sheep nutrition and production and agricultural economics.

For the period 2021-2025, recognising industry opportunities and the existing staff strengths of the University, the Institute proposes to support members to further develop research themes in the following areas:

Sustainable Cropping Systems

Sustainable Animal Production Systems

Water for Food Production

Food Quality and Human Health

Engineering for Agriculture

Agribusiness Ecosystems

SUSTAINABLE CROPPING SYSTEMS

Leaders: Professor Megan Ryan, Dr Janine Croser and Dr Nicolas Taylor

Mission: Enabling sustainable intensification of agriculture

The ancient weathered soils of Western Australia pose a unique challenge for broad scale agricultural production. For more than a century, scientists have worked with farmers to develop solutions to complex abiotic and biotic problems across highly diverse landscapes from Kununurra to Esperance. The need for innovative solutions has given rise to a rich agricultural research heritage at UWA. The Institute plays a key role in bringing together researchers with expertise across plant production systems and linking them with cross-disciplinary partners to develop solutions to real-world problems.

As we face a changing climate and an increasing global population, sustainable intensification of agriculture through the maintenance or increase of yields (whilst environmental impact is reduced), is a clear imperative to ensure future food supply. We use our world-class research and critical mass of researchers to address this complex generational issue through four interlinked subthemes: enabling technologies and pre-breeding; plant physiology; below-ground processes; and farming systems and technology.

ENABLING TECHNOLOGIES AND PRE-BREEDING

Whole system phenotyping, underpinned by enabling technologies and breeding pipelines, allow us to efficiently capture and exploit critical traits. At UWA, we have substantial expertise in subcellular, cellular, whole plant and population level phenotyping under laboratory, controlled environment and field conditions. We work hand-in-hand with pre-breeding and plant genetic improvement programs based at UWA, across Australia and internationally to translate our trait discovery outcomes. Our expertise includes mapping genomes, understanding gene function, metabolic analysis and biochemistry, the application of novel gene insertion technologies and accelerated breeding. Together these confer a pipeline from gene discovery to paddock application.

This plant improvement pipeline, interwoven from expertise across UWA, allows us to extend our fundamental and applied research outcomes to industry, whether by the development of climate-resilient genotypes for improved production, the development of associated agronomy packages or support for new plant species or production systems to best suit different environments. Our researchers also deliver novel platforms to quickly introgress traits of agronomic value into the national genetic improvement programs and mine wild relatives for traits. They contribute to international efforts to map and understand genome structure of key species and have the capability to utilise novel technologies such as CRISPR-Cas9 to better understand gene function. Together we explore the boundaries of biotechnology as it relates to improving plant productivity and traits of agronomic interest with the aim of developing diverse new cultivars of pastures and crops to give producers the tools they need to construct resilient systems tailored to the needs of their individual farm enterprise.

PLANT PHYSIOLOGY

An in-depth understanding of plant physiology underpins molecular phenotyping at UWA. UWA has expertise in analytical plant physiology including proficiency in nutrient uptake and nutrient use efficiency as well as the impacts of soil constraints such as high aluminium or boron. This is coupled to extensive experience in impact and tolerance of heat, chilling, frost, drought and transient waterlogging.

Knowledge of these abiotic stress responses is complemented by research focused on pest and disease tolerance and, together, they are harnessed to reveal underlying biochemical mechanisms to aid the screening of germplasm or design of new crops with enhanced tolerance. This expertise is backed up by state-of-the-art controlled environment facilities, field research sites and specialised equipment. Research has a focus on scalability, by taking results from the laboratory to the glasshouse and finally to the field for application in grower-initiated research. Our activities reflect the diversity of soils, environments and the farm enterprises that characterise the Western Australian agricultural landscape.

BELOWGROUND PROCESSES

The interactions of the plant with surrounding soil through roots, exudates and rhizosphere chemical and biological processes mediated by the soil microbial community is a particular area of focus at UWA, backed up by leading soil science expertise. UWA has developed approaches for screening root morphology and physiological traits as well as root exudates in both controlled environments and in the field. An improved understanding of the ways by which plant roots influence the rhizosphere and rhizosphere microbes and how these microbes, in turn, impact plant growth is a growing area of interest. At UWA, we are harnessing the latest technological advances to link this research to prebreeding pathways.

FARMING SYSTEMS AND TECHNOLOGY

At the farming systems scale, UWA has well-developed strengths in farming system ecology including weed ecology and the multidisciplinary approaches needed to tackle the problem of herbicide-resistant weeds and the likelihood of a future with fewer herbicide options. Harnessing beneficial interactions among organisms including insects to achieve biocontrol of pests is area of interest. UWA researchers excel at developing novel crops and pastures, as well as original uses, as a means to diversify our agricultural systems. This is strengthened by ongoing research on physiology and agronomy of crop and pasture legumes, and how diversity can be harnessed for system-level benefits through, for instance, use of natives as livestock feed or use of shrubs to address environmental problems. Closing of nutrient cycles by engineering of urban organic waste such as biosolids or horticultural waste into new products through, for example, composting or digestion by insect larvae, is a growing area of interest being developed with local industry partners. A growing capacity in high tech agriculture, with input from the Institute theme Engineering for Agriculture, including use of UAVs and satellite data, will aid our researchers to quantify yield and other parameters across a range of scales as well as develop novel tools for farmers.

Clear understanding of farming systems enables UWA researchers to quickly react to emerging problems and deliver solutions effectively to producers. Our recent discovery of a substantial problem throughout southern Australia from resurgence of highly oestrogenic outdated cultivars of annual pasture legumes followed rapidly by a communication and extension initiative demonstrates this capacity as does our on-going activities in the area of combatting herbicide-resistant weeds. Underlying all systems research at UWA is the drive to deliver not only sustainable profits to producers, but also improved environmental outcomes for producers and the broader rural and urban communities in Western Australia.

To enable sustainable intensification, we therefore propose the following:

- To position UWA as a hub for plant physiology and phenotyping from subcellular to satellite
- To develop cross-disciplinary partnerships to engineer and apply advanced technologies, including Machine Learning (ML) and Artificial Intelligence (AI)
- To use and develop our pre-breeding and breeding pipelines to deliver from gene to paddock
- To strengthen impact within Western Australia as well as nationally and internationally through close engagement with industry stakeholders as well as expert collaborators
- To facilitate collaboration among the Institute's themes to develop large multidisciplinary projects to develop new tools for Western Australian producers and deliver sustainable profits through conferring yield resilience, enterprise agility and environment benefits.

SUSTAINABLE ANIMAL PRODUCTION SYSTEMS

Leaders: Dr Dominique Blache and Professor Shane Maloney

Mission: *Develop animal production systems that are 'clean, green and ethical' and optimise the interactions among genotype, environment and management*

Within agriculture beef, sheep meat and wool are major sources of export income for Australia and Western Australia. A significant challenge for the future of these animal industries is to develop systems that will be able cope with a more variable climate whilst maintaining a 'clean, green and ethical' ethos to meet consumer expectations.

Our livestock production systems are primarily based on grazing, so systems that improve the sustainability of grazing are essential. Our grazing systems fall into two main types: extensive rangeland systems and mixed crop-pasture systems. UWA has been actively researching the 'feed-base' and animal production nexus in both systems so we can develop innovations in grazing management that improve livestock productivity, reduce environmental footprint, and improve the landscape health.

The rangeland and mixed cropping livestock systems both offer opportunities for improvement that we try to capture by collaborating across the themes in the Institute, as well as with colleagues in disciplines ranging from medical research to remote sensing technologies and social sciences with other local, national and international R, D & E partners. Most importantly, we value direct engagement with industry. Our researchers partner with producers, beginning with project development, and target improvements in grazing systems, reproductive efficiency and animal nutrition, health and welfare.

GRAZING SYSTEMS

Grazing ruminants can thrive on variety in their diet. This is not surprising because ruminants have evolved to deal with diversity, and they can learn and be trained, which presents options for a more diverse feed-base. Feed-base diversity and biodiversity conservation go hand-in hand as we look to future grazing systems. Feed-base diversity also offers other benefits. A prominent issue is that ruminants produce methane, a potent greenhouse gas, putting them in the spotlight when it comes to global warming. However, methane emissions are also a waste of carbon-energy and, if the animal could retain it, production efficiency would be significantly improved.

To tackle this issue, we bring world-class strengths in rumen microbiology, ruminant nutrition, animal behaviour and organic chemistry, and we collaborate with many local, national and international researchers, as well as industry. We apply the same skill set and core scientific principles to both the sheep-dominant mixed cropping-livestock systems in the south and the cattle-based, richly diverse, mosaic feed-base in the north. In both scenarios, we see perennials playing multi-functional roles in livestock productivity and landscape health. In particular, our Australian native plants, with their plant secondary compounds, can help us manage methane emissions and emissions intensity in extensive systems.

With these plants, there is great potential for behaviour-based management practices to improve feed utilisation and grazing patterns, and therefore ground cover and carbon retention in the landscape. We work closely with our experts in remote sensing technology to help connect animal movement, grazing behaviour and the nutritional value of the feed-base. Our expertise will lead to the development of tools that allow producers in extensive production systems to more easily make better and timelier decisions.

HEAT STRESS AND ADAPTATION OF LIVESTOCK TO CLIMATE CHANGE

In sheep and cattle, extreme heat events affect development, growth and reproduction. The frequency and amplitude of heatwaves has increased, and will continue to increase with climate change, so thermal stress in our livestock will be more frequent and intense in the future. This issue is especially acute for the extensive pasture and pastoral-based systems that are typical of Australia, where livestock often have little

access to shade. During the natural breeding period, animals are often exposed to conditions that challenge their ability to regulate body temperature, with poor outcomes for well-being and reproductive function.

To reveal and understand the effects of heat events on production efficiency in grazing animals, UWA is applying its strengths in animal physiology and behaviour, reproduction, engineering and mathematics. This combination of skills and expertise allows us to collect long-term thermal data in grazing ruminants under a variety of climatic conditions in diverse production settings. These data are the foundation for the development of management strategies that producers can use to manage the impacts of a more variable climate.

REPRODUCTION

Reproductive capacity is the limiting factor in livestock production. Reproduction can be facilitated or challenged by environmental factors such as climate and nutrition. The UWA livestock team is investigating the impact of nutrition on reproduction in both sheep and cattle, working with our colleagues in pasture science and organic chemistry to better understand the impact of plant secondary compounds on male and female reproduction. We are also collaborating with the agricultural engineers at UWA to develop new diagnostic tools for the early detection of dysfunction in the reproductive tract that can reduce reproductive efficiency.

Our strengths in thermal stress and reproduction are helping to develop novel approaches to prevent lamb hypothermia and improve lamb survival, and better understand the role of edible shelter in preventing neonatal lamb mortality. In the northern beef industry, a key to improving reproductive efficiency is the development of grazing systems that better utilise the mosaic rangeland feed-base.

We make use of a combination of animal nutrition, animal behaviour and technology in remote sensing to understand where animals go, how long they stay, and what they eat, in the vast areas grazed in the rangelands. This information is essential for top-level decision-making around grazing and supplementation to improve reproduction.

ANIMAL WELFARE

Animal welfare is a growing concern in Australia. How we monitor and assure welfare is lagging behind the expectations of society and therefore the markets. Instances of inappropriate animal management will undoubtedly continue to receive significant public attention, and may seriously jeopardise the future viability of the industries. This perceived inattention to animal welfare is expected to shift discretionary spending and cause a loss of around $4 billion to animal industries in the next 10 years.

‘Quality of life’ is a central concept in the welfare of animals and laws that govern the use of animals are changing rapidly. In the last decade, world-wide changes in legislation that cover animal welfare have been moving towards new standards that prescribe the expectation of positive experiences for animals, and promote a ‘duty of care’. Taken together, the societal, legal, and economic demands must be addressed to ensure superior welfare outcomes for animals and business continuity for Australia’s livestock producers.

These demands cannot be met without reliable, affordable, real-time tools that assess the welfare of an animal and raise alerts when their welfare might degrade. To do this, we must be able understand how the animal’s brain processes life experiences and thus determine an animal’s quality of life. To this task, we bring world-class expertise in animal welfare, animal ethics, and the animal responses to stress, assessed by neuroscience, behaviour and physiology. By collaborating across these disciplines at UWA, and with external researchers and industry partners, we are identifying objective, quantitative biological measures (biomarkers) of brain function during positive and negative experiences. This information will form the foundation of our ability to assess and thus improve livestock welfare.

To mitigate the reputational risk to animal industries, treatment of livestock through the entire value chain must be consistent with agreed national practices that protect animal welfare. Communicating these ‘recommended practices’ for all key transactions along the value chain is an essential step towards animal welfare becoming embedded into Australia’s livestock trading systems. The UWA livestock team were founding members of a bold and unique national venture, The Animal Welfare Collaborative (TAWC).

TAWC, with its network of more than 500 members, is a platform for communicating with all stakeholders within the sphere of animal welfare. It organises workshops with more than 60 different organisations, including industry peak bodies, state and federal governmental agencies, and about a dozen animal protectionist groups. TAWC offers a safe platform for constructive exchanges of thoughts, opinions and information about animal welfare, at a time when the threat to livestock industries has never been greater and society and thus markets are demanding clean, green and ethical production systems.

RESISTANCE TO PARASITES AND DISEASE

The 'worm-flystrike complex', costing the Australian Merino-based industries about $600m per year, is the outcome of an interaction among three genomes – sheep, helminth worm, and blowfly. Worm infection triggers the sheep immune system to produce diarrhoea, and the diarrhoea attracts the blowfly, leading to flystrike.

This complex poses a serious challenge to our 'clean, green and ethical' vision because there is conflict between two of the goals: i) a reduction in the use of chemicals in livestock production; ii) excellent animal health and welfare. There is pressure to pursue the 'clean' goal because the worms have become resistant to medication ('drench'), but the animal welfare conflict is magnified because 'mulesing' to prevent flystrike is no longer socially acceptable.

To tackle this massive multidisciplinary problem, we need a wide variety of skills and expertise so we are therefore bringing together our world leading strengths in animal production, medical research, genomic analysis, engineering and invertebrate biology. System-based thinking is needed to reveal the relationships between the worms and the host so we can understand the cause of the diarrhoea and how it attracts the blowfly.

The ability of native plants to combat worm development in the gut is a part of our investigations into feed-base diversity, described above. In addition, we are collaborating with DPIRD to investigate immunological processes that sheep use to resist worm infection, and the blowfly biology that is responsible for their attraction to sheep odours.

INTERNATIONAL PERSPECTIVE

Our world-class researchers in livestock production understand the role livestock play as a pathway out of poverty in developing countries as well their contribution to global food security (doi: 10.1038/507032a). Our view is that grazing systems need to address six key problems:

- Consumption of human food by livestock;
- Adaptation of livestock to climate change;
- Poor animal health and welfare resulting in sub-optimal productivity;
- Provision of adequate animal nutrition;
- Reducing the environmental footprint;
- Better application of technology, including machine learning and artificial intelligence, to improve decision-making and in extensive grazing systems.

UWA livestock scientists are addressing these issues as founding members of the Global Farm Platform.

WATER FOR FOOD PRODUCTION

Leaders: Associate Professor Sally Thompson, Associate Professor Matthew Hipsey and Adjunct Professor Keith Smettem

Mission: To create sustainable solutions for water use in agriculture, that seek to maximise water efficiency and minimise environmental impacts

World population is projected to grow from 7 billion in 2014 to 9 billion by 2050. The increase over 50 years will be more than twice the current population of China. This increase is occurring at a time when the area of land under agricultural production throughout the world has reached a static point at about 37 per cent of total land area. About 20 per cent of agricultural land is irrigated but this provides 40 per cent of the world's food and can give crop yields that are two to four times greater than rain-fed agriculture.

Meeting the food needs of an increasing world population will require improved efficiencies in irrigated agriculture and better use of finite water resources. In many parts of the world, adapting to a changing climate also presents a major threat to food security. The challenge is to produce more food with less water.

About 70 per cent of freshwater withdrawals around the world are used for agriculture and the most common technique is flood irrigation, even though conveyance losses can exceed 20 per cent and plants only use about half the water that is actually applied. Inefficient irrigation systems that supply too much water without adequate drainage can also lead to salinisation and soil structure decline, which can reduce crop yields by 10 to 25 per cent. In arid and semi-arid areas salinisation may already be affecting up to 50 per cent of the irrigated area. There is also an increasing awareness of the negative environmental impacts of poorly managed irrigation systems.

Since the 1970s the increasing availability of cheap individual pumps has seen a radical shift from public to private investment in irrigation schemes and about 40 per cent of irrigated land now uses pumps to access groundwater or uses ground and surface water conjunctively. The use of pumps by individual farmers has increased dramatically in India, China and South East Asia and is projected that these countries will increase water withdrawals by about 15 per cent by 2030, placing increasing pressure on already declining groundwater resources. In large areas of India and China, ground-water levels are falling by one to three metres per year, causing subsidence in buildings, intrusion of seawater into coastal aquifers and higher pumping costs.

The use of pumps does however, facilitate the adoption of efficient modern irrigation techniques such as drip or micro-irrigation, which can improve water application efficiency by up to 70 per cent and the area irrigated by these systems, has increased worldwide from less than 2 million hectares (ha) in the 1970s to over 10 million ha in 2014. This is still less than four per cent of the world's total irrigated area, although more than five per cent of India's 39 million ha are now irrigated using these techniques.

Locally, the State Government's Water and Natural Resource Management Initiative overseas investment of more than $50 million directly into building capacity and efficiencies in providing irrigated agriculture for local and international markets. Perhaps the single largest investment is the Gascoyne Food Bowl initiative, in the far northwest of Australia. This program will release 400 ha land and infrastructure for horticulture development, with a further 800 ha identified for future expansion.

The development of such irrigation schemes requires water fit for purpose, delivery systems that are economically and technically efficient, optimisation of on-farm water use for maximum return and minimisation of detrimental impacts on the local environment.

The proposed theme will be underpinned by teaching (undergraduate units, Masters and PhD) and research components: economics, plant water use, agronomy and irrigation design will underpin these components. There will be a strong focus on industry collaboration and engagement, water balance and irrigation modelling, postgraduate training and technology exchange.

PROPOSED OUTPUTS

- Development of a graduate diploma in agricultural engineering, with an emphasis on improving the efficiency of irrigated agriculture, providing a sound economic framework, balancing water supply and demand while protecting surrounding ecosystems.
- Increased research capacity through post-graduate research training, international collaboration and the synergies offered within the centre.
- Improved farm water management strategies to adapt to changing climatic patterns.

POTENTIAL FUNDING SOURCES

There is already a history of project work with the Australian Centre for International Research and AusAID, particularly for funding postgraduate level students. The Food and Agriculture Organization and World Bank are also potential sources for project development.

FOOD QUALITY AND HUMAN HEALTH

Leaders: Professor Trevor Mori and Dr Michael Considine

Mission: To develop healthier foods and food ingredients that can make a positive contribution to human health and the Australian economy

Development of healthier foods and food ingredients can make a positive contribution to both the Australian economy and human health. The development and validation of healthy foods that meet consumer desires is an exciting challenge for the Australian agri-food industries. To satisfy this growing need, we must train the next generation of scientists and industry champions and provide guiding knowledge on policy development for the Australian academic and industry bodies.

Health attributes of foods is an important driver for food choices. Consumption of healthy foods is the cornerstone of efforts to improve diet quality in populations. We know that a higher intake of plant foods is associated with lower risk of chronic diseases. In particular diet quality has a major impact on the development and progression, and prevention and treatment of cardiovascular diseases and their related disorders.

- With a global increase in age and obesity, the role of a healthy diet in preventing non-communicable diseases becomes even more imperative.
- Cardiovascular disease is the number one cause of death worldwide. It is responsible for over 17 million deaths annually (30 per cent of all deaths); mainly due to ischaemic heart disease and stroke.
- Cardiovascular disease is not just a first-world problem; by 2030 it will be responsible for more deaths in low income countries than infectious diseases, maternal and perinatal conditions, and nutritional deficiencies combined.
- High blood pressure (hypertension) is the number one risk factor for total and cardiovascular disease mortality. It affects almost one third of the world's population, and is known as the silent killer because in most people there are no symptoms or warning signs.
- 347 million people worldwide have diabetes. The World Health Organisation projects that diabetes will be the seventh leading cause of death in 2030.

In many countries including Australia more than half the adult population are overweight. Diets rich in fruits, vegetables and legumes are convincingly linked to better cardiovascular health. The desire to increase intake of plant foods is a foundation of dietary guidelines of many countries. However, the translation of this knowledge into better population health can be challenging because there are many barriers to affecting widespread dietary change in the community. One approach is to develop healthier foods and food ingredients that make a positive contribution human health. Because health is a driver of food choice these foods and ingredients could add significant value to Australian agriculture and related industries.

Some of the attributes of plant foods that contribute to health are known. These include:

- Increased proportion of healthy mono- and polyunsaturated fats replacing other than saturated fats;
- Plant protein, complex carbohydrates and fibre;
- Vitamins and minerals;
- Protein and energy for fundamental survival;
- Vitamins such as vitamin C and E;
- Minerals such as potassium, magnesium, selenium and iodine;
- Carotenoids such as beta-caroteneb-carotene, lycopene and lutein;
- Flavonoids such as catechins, flavonols and anthocyanidins;
- Plant protein and specific peptides; and Inorganic nitrate.

Knowledge in this area provides the opportunity to work with plant food industries to develop/enhance/ evaluate/validate foods and food ingredients for their potential to improve human health. Foods can be bred/grown/processed to achieve desired levels of particular components. This provides the opportunity to market these foods for their enhanced health properties. UWA has strengths in plant science.

Also critical for achieving desired outcomes is development of cross-disciplinary collaboration, collaboration with other researchers from both within Western Australia as well as and outside Western Australia, and collaboration with relevant industries and their representative bodies. Thus integrating the complementary skills, knowledge and activities across disciplines and organisations will result in increased success.

Examples of ongoing projects that have the objective of adding value to particular agricultural industries by development of foods or ingredients with enhanced health properties include:

- Flavonoid-rich apples and other fruit. Particular dietary flavonoids are linked to better vascular health. The overarching objective of this research is to develop and release Australian-bred apple(s) and potentially other fruit with superior nutritional quality based on their flavonoid composition. This research involves wide local and national collaboration.
- Vegetables rich in nitrate. Current research in this area is establishing the importance of nitrate content of vegetables for vascular health. Future opportunities may exist to develop/produce high nitrate vegetables.
- Use of lupins and other legumes as food ingredients. Many of the positive attributes of legumes can be used to enhance health qualities of more commonly consumed foods, and to develop new foods from these as ingredients.

PROPOSED OUTPUTS

This research is leading towards the development of a collection of healthy functional foods and ingredients, as well as improved processes for their production/manufacture. The research will deliver scientifically validated evidence for the promotion of new foods, as well as significant added value to agricultural industries. Specific examples include:

- Flavonoid-rich fruit with demonstrated health benefits;
- Knowledge of the importance of inorganic nitrate content of vegetables for human health resulting in development and production of nitrate-rich vegetables; and
- Development of lupin-enriched foods.

POTENTIAL FUNDING SOURCES

Grains Research and Development Corporation (GRDC), Horticulture Australia Limited (HAL), PomeWest, Australian Precision Ag Laboratory (APAL), and Lupin Foods Australia (LFA)

ENGINEERING FOR AGRICULTURE

Leaders: Dr Andrew Guzzomi and Dr Dilusha Silva

Mission: Engineering a sustainable agriculture future

In the vision for the Institute and the Future Farm 2050 Project, agricultural science embraces engineering. Teaching and research in agriculture at university level must embrace engineering because, as we head towards 2050 and face the need to feed 50 per cent more people on fewer resources, food production efficiency will become increasingly important and highly dependent on advances in agricultural engineering (ag-engineering). This theme will bring together ag-engineering-related teaching and research across the whole of the UWA, formalise collaborative work already being undertaken between the schools of engineering and science, and allow us to respond efficiently to new challenges and opportunities as they arise.

This theme focuses on providing engineering solutions to agriculture for sustainable growth of net farm-yield, reduction of wastage, and minimisation of environmental impact. Worldwide food shortages and population growth pose substantial challenges to Australia's sustainable agriculture future. These challenges are compounded by conflicting pressures resulting from Australia's drying climate across the major agricultural regions of southern Australia and growing agricultural sector. Due to Australia's dependence on reliable agricultural exports, these challenges also present significant risks to our economic security.

UWA holds a premier international position in university-level agriculture. To maintain and enhance that position in an industry that is transforming rapidly, UWA aims to incorporate engineering into its mainstream agriculture training and research programs. For engineering at UWA, a dramatic shift away from research and training on mining development has presented a unique setting to embrace opportunities arising from the burgeoning worldwide interest in food security. From a national perspective, achieving this combination of goals could help compensate for the loss of manufacturing capacity, leading to major employment opportunities driven by technology-based agriculture.

UWA is well placed to contribute to this field of agricultural engineering because of:

1. Elite undergraduate degrees, both in agricultural science and in engineering;
2. Agricultural Sciences at UWA is ranked number 1 in Australia and 17th in the world in the Academic Ranking of World Universities 2020;
3. A School of Engineering with international-level R&D expertise in computer science, electronic engineering, and civil and mechanical engineering;
4. A stated and strongly pursued engineering research priority of 'Engineering for Remote Operations', that aligns directly with applications in agriculture;
5. Strong, internationally and commercially recognised, engineering research activities in
    a. farm mechanisation;
    b. portable, robust, low-cost sensors for on-farm applications;
    c. robotics and automation;
    d. machine vision; and
    e. data science and deep learning.
6. The biggest competitively funded R&D program in agriculture in Western Australia;
7. A cohort of over 200 postgraduate students;
8. The Future Farm 2050 Project, a commercial-context farm in the grainbelt of Western Australia, that aims to implement, evaluate and demonstrate the latest concepts in mechanisation on UWA Farm Ridgefield;
9. Industry links with
    a. agricultural machinery manufacturers for both R&D and commercialisation of new technologies;
    b. companies with extensive experience in massive-scale mechanisation for the mining sector;
    c. companies commercialising sensors for agricultural applications, and existing

commercialisation pathways for low-cost sensors; and

d. Other ag-centric companies that are keen to be at the forefront of agricultural engineering.

10. An existing research theme at the Institute on Agribusiness Ecosystems, that can assist in developing path-to-market for ag-engineering solutions;
11. Existing profile and momentum generated by a number of prestigious State awards.

The operational structure of this cross-disciplinary theme facilitates 'collaborative exchange' through interactions among the researchers. Through this theme, collaborative exchange allows for new knowledge to be developed and applied (creatively), thus advancing the state-of-the-art of the sector through rapid implementation of research outcomes, and commercialisation for delivery to the agricultural sector.

TEACHING

Graduates need to be 'technology ready', as well as scientifically literate. In undergraduate programs, we can achieve these aims by collaborative teaching in agricultural science and engineering, and through the development of 'work-integrated learning' (internships). There is great scope for short courses for industry (e.g. for farmers and automation technicians), specialised units within the Masters' degree programs, as well as a full Masters' degree program (coursework and research) in agricultural engineering and taught collaboratively by the two disciplines. This will be a timely development as student interest in the agricultural sector is likely to increase in the near future in keeping with its growing economic contribution.

Undergraduate exposure to research material through research projects provides a timely opportunity for dissemination of the technological innovations to a wide spectrum of Australia's industries and farmer groups. In turn this can substantially decrease the cycle time for adoption of new technologies into businesses, providing Australia with a significant international competitive edge.

The structure of this agricultural engineering theme will be highly attractive to potential PhD candidates. Training of researchers and PhD students will subsequently support Australia's advanced technology efforts in the public and private sectors.

PROPOSED OUTPUTS

A recognisable and identifiable agricultural engineering theme presents extensive opportunities for collaboration between farmers and agricultural machinery manufacturers with the Institute at UWA in order to undertake research and development focused on bringing about commercial innovation. The agricultural sector is diverse and, as such, so too are the issues that ultimately need to be addressed.

Potential areas of applicability include:

- Fragile Western Australian soils, susceptible to compaction, non-wetting, low rainfall, etc. can benefit from engineering intervention (e.g. application of engineering understanding of soil mechanics, vehicle loads and improving tillage);
- Mechanical weeding methods, e.g. the Weed Chipper, show great promise. Commercialisation of such research innovation demonstrates capabilities;
- The most important limitation to profitability in the livestock sector is labour, presenting massive opportunities for remote sensing, drone technology and mechanisation/automation;
- Development of control mechanisms for small autonomous roving vehicles and unmanned aerial vehicles (UAVs) presents significant engineering challenges and opportunities for rehabilitation of degraded lands produced from mining;
- Greater use of harvesting mechanisation and refrigeration and storage of fruits/vegetables are necessary in to value add and enhance Western Australia's export competitiveness into Asia;
- Monitoring techniques to improve welfare and overall health of livestock can provide world-leading livestock management methods which also minimise costs associated with disease and loss of livestock, Advanced sensing and computer vision technologies are also necessary for recognising water stress, plant nutrient needs, crop maturity, disease/insect impacts, and weed/pest identification;
- Sensing regimes being developed at UWA for airborne defence sensing/imaging have potential for application in agriculture;
- Data science and processing of the massive quantities of sensor/image data that stand to arise from tomorrow's farms; this information needs to be analysed in a cohesive manner and directed to an action by either the farmer or the automatic farm-control systems;
- Methodologies are needed for improving water and energy efficiency, in particular within irrigation and pumping systems; there is considerable potential to produce biofuels from rehabilitated mine sites and degraded lands; energy harvesting technologies could be used to reduce wastage and dependence on external energy sources.

POTENTIAL FUNDING SOURCES

There is significant potential for funding due to excellent existing track records. Examples include GRDC, Innovation Connection, Global Innovation Linkage, Fisheries Research and Development, Australian Research Council (ARC) Discovery, ARC Linkage programs and leveraging defence funding to develop dual-use technologies with application to agriculture.

AGRIBUSINESS ECOSYSTEMS

Leaders: Dr Amin Mugera and Winthrop Professor Tim Mazzarol

Mission: Enhancing economic, social and environmental outcomes through network analysis

Agribusiness encompasses the entire agricultural-related businesses pre-farm gate, on-the-farm, and post-farm gate. With the need to feed the estimated nine billion people on earth by 2050, the local and global agribusiness industry is poised to grow. However, the industry faces many challenges: agribusiness decisions are made in an environment of increasing risks and uncertainties due to volatile markets and barriers to trade; rapid technological change is disrupting business operations; changing structure of industry and boundaries; changing consumer needs and preferences; and resource constraints to meet the demands for the growing population.

The pressure of climate change and the need for increased levels of agricultural productivity demands a significant investment in the application of science and technology to address those challenges. This is essential for the agribusiness firms to remain competitive in highly competitive global markets.

Diets rich in fruits, vegetables and legumes are convincingly linked to better cardiovascular health. The desire to increase intake of plant foods is a foundation of dietary guidelines of many countries. However, the translation of this knowledge into better population health can be challenging because there are many barriers to affecting widespread dietary change in the community. One approach is to develop healthier foods and food ingredients that make a positive contribution human health. Because health is a driver of food choice, these foods and ingredients could add significant value to Australian agriculture and related industries.

THE WESTERN AUSTRALIAN CONTEXT

The agricultural sector in Western Australia is global in extent as it provides food and fibre for Australia and many other parts of the world. The agribusiness industry makes a direct and indirect contribution to the economic and social well-being of millions of people engaged in the different cropping and livestock value chains. The industry is strategically positioned to tap into the opportunities presented by the growing population with increasing purchasing power and shifting preferences from traditional towards modern foods. The dietary shift in countries like China and India is likely to spur increased demand for meat and dairy products. For instance, meat consumption in China has doubled in the past 20 years and is projected to double again by 2030.

Despite those opportunities, the local agribusiness industry in Western Australia has to overcome several challenges. These include:

- Shortages in skilled and unskilled labour;
- Difficult and complex trading conditions in some international markets;
- Economic, social, and cultural barriers to the adoption of innovations and practices that improve-farm-gate returns;
- Environmental degradation and the associated loss of productive land;
- Land tenure issues, particularly in the Australian rangelands;
- Demographic changes, including out-migration, depopulation, an ageing population, and counter urbanisation pressures;
- Deteriorating levels of social wellbeing in rural communities;
- Constraints in adopting alternative business structures;
- Inadequate measures in enhancing the resilience of farmers to deal with uncertainties such as drought and extreme events;
- Difficulty in attracting private capital into farm investment and fears over foreign ownerships; and
- Lack of incentives to attract and retain young people in agriculture and agricultural career and food wastage and loss.

Those challenges, among others, suggest that the governance of agribusiness firms and industries in the agri-food value chains is becoming more complex and multi-scalar, requiring the involvement of multiple stakeholders including public, private, and civil society actors. The challenges require a multidisciplinary approach to address while maintaining the synergy between public policy, management practice, and research. The interdependence of different business activities requires a business ecosystem approach to agribusiness development.

AGRIBUSINESS AND A BUSINESS ECOSYSTEMS APPROACH

A business ecosystem is an analogy based on the biological ecosystem to explain the business environment. The concept can be traced to Moore (1993) who described the it as "an economic community supported by a foundation of interacting organisations and individuals – the organisms of the business world. This economic community produces goods and services of value to customers, who themselves are members of the ecosystem." Moore described an interdependent business environment where businesses secured a competitive advantage through innovation and their ability to change and adapt within their industries as the industries evolved through different stages. The four main stages of evolution are birth, expansion, leadership, and self-renewal. The ability to learn when to compete and collaborate enables firms within a business ecosystem to adapt to changing business environment or else perish.

Moore (1993) used the automotive industry as an example to illustrate ability of firms such as Ford and General Motors to survive by adapting to change. This resilience and adaptability have been examined in the case of Ford using a framework adapted from ecological economics and socio-ecological research (Mamouni-Limnios and Mazzarol, 2011). The application of the ecosystem approach to business has developed in the past two decades (Iansiti and Richards, 2006; Adner and Kapoor, 2010; Zahara and Nambisan, 2012; Williamson and Arnoud, 2012; Visnjic and Neely, 2011; 2013).

The business ecosystem concept can be adapted to the agribusiness environment. With globalisation, agriculture and food trade are changing with most food products produced in different stages in different countries around the world by multiple parties before reaching the end consumer. Food and fibre supply chains now span across different countries and are interdependent; firms within the supply chains both compete and collaborate. The supply chains use complementary innovations, products, and services from providers that belong to different industries that are agribusiness related or not. Therefore, the local, national, and global value chains in agriculture are better viewed as an agribusiness ecosystem.

Here we provide a conceptual framework to guide engagement in teaching, research and consulting in agribusiness. Figure 1 illustrates a framework that characterises the main components of a business ecosystem and can be used to provide a broad conceptual model for guiding the work undertaken in this Agribusiness Ecosystem theme. It has been developed by reference to the emerging literature on business ecosystems:

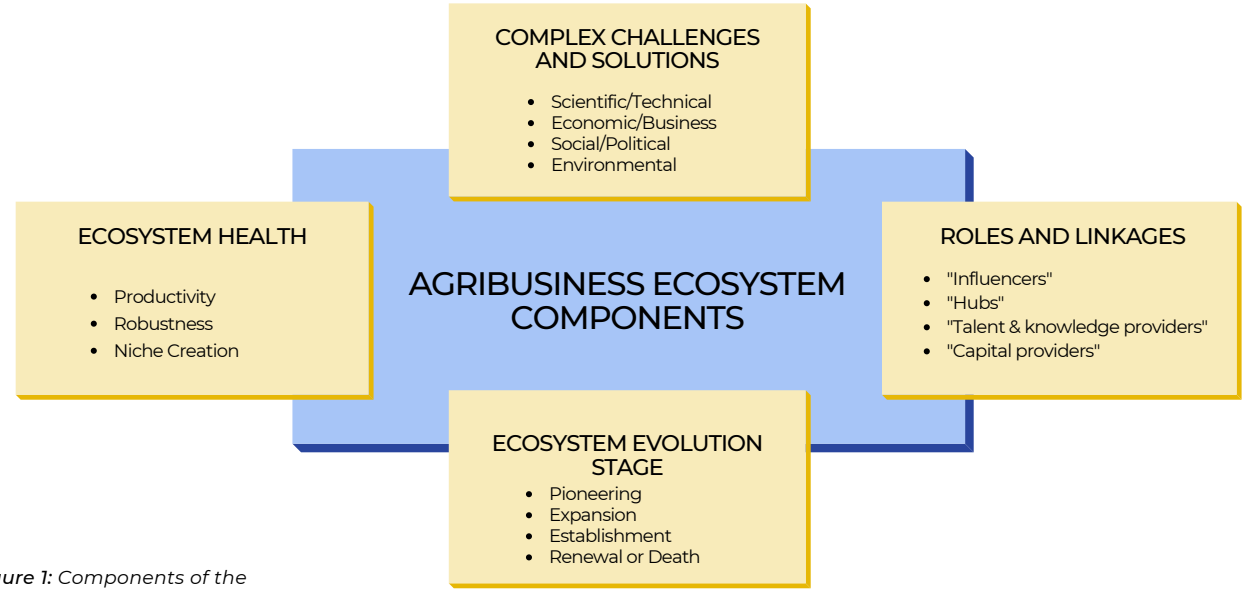


Figure 1: *Components of the Agribusiness Ecosystem*

1. COMPLEX CHALLENGES AND SOLUTIONS

The first component addresses itself to the complex challenges and potential solutions that emerge within a business ecosystem (Visnjic and Neely, 2013). It recognises that an agribusiness ecosystem aims to serve specific set of goals and that all actors within the ecosystem need to play a role to address the challenges the system is facing. The main challenges are likely to be:

- Scientific and technical: For the agri-food system the main challenges are associated with sustainable production of food and fibre to meet the growing population demands. Of particular importance are innovations that significantly provide solutions to complex challenges like sustainable production in the presence of changing climate and consumer preferences.
- Economic and business: This area focuses on providing the necessary entrepreneurial innovations, leadership, business management and financial resources to produce the necessary food and fibre. This can encompass the full value chain of businesses and their related and supporting industries (e.g. financing, transportation, storage and handling, marketing, and communications).
- Social, cultural and political: The agribusiness ecosystem operations can impact or be impacted by social, cultural and political factors that enhance or impede its economic health, such as mental health issues in rural areas, and both social and political unrest. Within this area are governments (i.e. local, state, national), as well as community groups and the wider workforce that participate in the agribusiness ecosystem.
- Environmental: There must be consideration of the natural environment and how sustainable the agribusiness ecosystem is within its natural resource context. For example, soil salinity and carbon emission.

2. ROLES AND LINKAGES

The agribusiness ecosystem involves the interaction of different stakeholders that play different roles. Those include government departments, private sector, not-for-profit organisations, industry associations (e.g. trade and farmers groups) and knowledge providing institutions like universities and research centres. Several classification systems of different actors have been used in the literature but one proposed for this theme comes from Visnjic and Neely (2013):

- Influencers: Actors who may not be direct participants in the ecosystem but maybe playing a key role in another ecosystem that interconnects to the ecosystem in question. Those could be a major international firms that might take the food and fibre products from the agribusiness ecosystem and market or process it within one or more major target markets.
- Hubs: Focal firms or organisations that take a leadership role in ensuring that the ecosystem achieves its primary objectives. They might be large firms that lead the development of an industry (e.g. Woodside/Chevron in LNG). In the grains sector in Western Australia, this would potentially be CBH Group.
- Talent and knowledge providers: Includes organisations that educate and train the skilled workforce, provide specialist knowledge to organisations within the ecosystem, and assist in the problem-solving process. It can include universities, colleges, research centres, and professional services firms (e.g. legal, accounting, and consulting).
- Capital providers: Sources of financing of agribusiness projects. They can include banks, venture capital funders, government funding bodies, and the wider community that might collaborate to provide the capital (e.g. via co-operative or mutual enterprise).

How each of these actors is configured, interconnected and their relative size and power within the ecosystem are of key importance in agribusiness development.

3. ECOSYSTEM EVOLUTION STAGE

Moore (1996) defined four stages for firms in a business ecosystem: The four main stages are birth or pioneering, expansion, leadership or establishment, and self-renewal or death. As these titles describe, firms in the agribusiness ecosystem will move through these stages and meet different challenges at each stage their lifecycle. It is important to identify at what stage each firm or industry is and how to meet and overcome both cooperative and competitive challenges.

At each stage, there are likely to be different levels of willingness to cooperate or compete between actors within the ecosystem, particularly where resources may become scarce and the need for advancing or impeding innovation and new approaches are under consideration.

4. ECOSYSTEM HEALTH

In this area, the health of firms within the agribusiness ecosystem is examined. The measures of a business health include (Iansiti and Levien, 2004):

- **Productivity and efficiency analysis:** The measure of how efficient firms within a given industry transform inputs into new products and delivers innovations.
- **Profitability analysis:** Measures how firms generate profits given their production technology and output-input factor markets.
- **Robustness:** Measures the resilience of firms in a given industry, such as member survival rates over time and the overall growth or decline.
- **Niche creation:** Measure of meaningful diversity created by the ecosystem over time or whether it has remained homogenous and potentially unable to innovate and adapt to change or market opportunities.
- **Cost benefit analysis:** Provides supporting improved decision making about agribusiness projects and policies.

APPLICATION OF THE AGRIBUSINESS ECOSYSTEMS FRAMEWORK

The Agribusiness Ecosystems theme aims to advance knowledge and best practice on how local and global agri-food systems work, evolve, and perform, and how public policy and management practice can be used to address the many challenges faced by firms and industries in the ecosystem. The issues to focus on include changing consumer preferences for different products and services, evolving business models and governance approaches in food systems, commodity trade and risk management, performance benchmarking of agribusiness firms, adoption of agricultural innovations and impact evaluation, value chain development, new venture creation, and suitable production among others.

The Agribusiness Ecosystem theme will collaborate and complements the other the Institute themes in identifying and proving solutions to the complex challenges facing the global food systems.

PROPOSED OUTPUTS

The proposed output from this theme includes:

- High productivity, profitability, and survival of farms and related businesses;
- High competitiveness of agribusiness firms in international markets;
- Increased communication, coordination, and collaboration amongst related industry firms along with the agriculture and food supply chain;
- Better public policy in agribusiness and the rural economy; and
- Improve the wellbeing of rural communities.

POTENTIAL FUNDING SOURCES

- *Local, state, and national governments*
- *Industry actors (e.g. firms engaged in agribusiness)*
- *ARC Linkage*

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