



WA Agricultural Research Collaboration

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Capacity needs analysis for the Western Australian agricultural research, development and extension sector: Literature review

May 2026

By Jane Wightman Consulting for the WA Agricultural Research Collaboration

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1. Executive summary

This literature review was undertaken by an independent consultant, Jane Wightman Consulting. It consolidates the current and future agricultural research, development and extension (RD&E) capacity needs of Western Australia (WA), drawing on multiple state, national, and international sources. All issues identified across literature have been synthesised into a single framework under nine thematic headings, ensuring duplication has been removed while no critical gaps in scope remain. The findings provide a comprehensive overview of the RD&E requirements to build a resilient, innovative, and competitive WA agricultural sector over the next 5–15 years.

The review highlights the scale and significance of WA agriculture. With an annual gross value of production exceeding \$50 billion, supporting close to 180,000 jobs, the sector is a critical driver of state prosperity. At the same time, it faces pressing challenges, climate change, biosecurity threats, workforce shortages, infrastructure constraints, and increasing sustainability expectations from global markets and consumers. These pressures align with megatrends such as climate variability, resource constraints, disruptive technologies, and shifting market demands, underscoring the need for targeted RD&E investment.

This literature review represents a moment in time, providing an evidence-based synthesis of human capacity needs; it does not extend to matters currently under debate, such as prospective Ministerial policy changes or planned investments.

The review identifies nine priority domains where WA can look to strengthen RD&E capacity:

- **Data and digital technologies**
- **Climate adaptation and environmental markets**
- **Biosecurity and market access**
- **Systems agronomy and farm engineering**
- **Genetics and breeding**
- **Water systems and irrigation**
- **Market and consumer intelligence**
- **Trade, policy foresighting and risk analysis**
- **Extension and adoption science**

These areas reflect where future capacity will be most critical for competitiveness, resilience, and growth.

While the literature is clear about future capacity needs, it provides limited evidence about current capacity gaps in WA's RD&E system. Apart from some insights into diversity, gender balance, and inclusion, most reports do not quantify or describe present workforce strengths and weaknesses.

Review findings will be used to shape questions for the next phase of work - a sector-wide online survey to identify areas where greater capacity is required across WA's agricultural RD&E workforce.

2. Foreword

The WA Agricultural Research Collaboration (WAARC) is Western Australia's (WA's) platform for collaborative agricultural research and development, bringing together government, universities, and industry to address key challenges such as climate resilience, productivity, sustainability, and biosecurity. Through its "Team WA" approach, WAARC drives practical, industry-led research that maximises impact while building capacity and strengthening the State's future agricultural workforce.

In August 2025, WAARC commissioned a capacity needs/gap analysis (Needs Analysis) to identify and validate WA's current and future human capacity requirements in the agricultural research, development and extension (RD&E) sector. This work is intended to guide WAARC and others in planning and investment to equip the sector with the expertise, skills and workforce structure to meet emerging challenges over the next 5 to 15 years. The work is a point in time stocktake, conducted by Queensland-based Jane Wightman Consulting.

Five reports relating to the Needs Analysis are now publicly available (May 2026):

1. Capacity needs analysis for the WA agricultural RD&E sector: Summary report
2. Capacity needs analysis for the WA agricultural RD&E sector: Literature review **(this report)**
3. Capacity needs analysis for the WA agricultural RD&E sector: Sector-wide survey
4. Capacity needs analysis for the WA agricultural RD&E sector: Interviews (Workforce pipeline and early career attraction)
5. Capacity needs analysis for the WA agricultural RD&E sector: Interviews (Data, digital and modelling)

Apart from the Summary report, these reports reflect the chronological flow of the study, which began in August 2025 and was completed in December 2025. The reports should not be considered independently of each other, but as a part of a package.

The aim of the Literature review was to ascertain what evidence was already available about needs/gaps in human capacity in the sector for WA, and to use this information to guide the structure and questions for the survey. The sector-wide online survey was the key data collection mechanism for the Needs Analysis, with 92 respondents from middle/senior manager, cross-discipline positions across the WA agricultural RD&E sector. Two focused interview topics were then selected from survey findings, with 15 interviews conducted. The Summary report brings together an overview of the findings from the suite of reports.

At each key step in the Needs Analysis process, feedback and validation were sought from a Strategic Advisory Group, comprised of senior and middle managers from key organisations and businesses across the agricultural RD&E sector.

By the WA Agricultural Research Collaboration, May 2026

3. Introduction

The aim of this Literature review was to ascertain what evidence was already available about current and future needs/gaps in human capacity in the sector for WA, and to use this information to guide the structure and questions for the survey.

Note: Elements of the original Introduction have been deleted to reduce repetition with WAARC's Foreword, which is included for consistency and context across the suite of Needs Analysis reports.

4. Methodology

The literature review was structured to prioritise state-level reports and documents, which provided the initial identification of WA's agricultural RD&E needs and associated capacity requirements.

This was followed by a review of Australian agricultural industry and CSIRO reports, which helped to highlight gaps relating to expected future megatrends and sector-specific priorities.

Finally, global reports were reviewed to provide a comparative perspective, offering insights into cross-country RD&E alignments and differences that can inform WA's positioning in an international context.

5. Agricultural RD&E capacity needs – Western Australian focus

5.1 Current state of agriculture in WA

Western Australia's (WA) agriculture, fisheries, and food industries are a critical part of the state's economy, society, and exports. Together with forestry, they make up WA's second-largest export sector, valued at an estimated \$50.5 billion GVP per annum, and support close to 180,000 jobs (DPIRD 2024). Primary producers, farmers, graziers, and fishers, contribute around \$11 billion annually, which represents about 26% of this value (DPIRD 2024).

Current situation

The sector is highly export-oriented, with approximately \$16.22 billion in primary industry exports in 2022–23, dominated by cereal grains (55%, \$8.9 billion), oilseeds (20%, \$3.2 billion), and meat and live exports (9%, \$1.5 billion). WA is geographically isolated and free from many pests, diseases and weeds present in other parts of the world, a biosecurity advantage that underpins access to premium overseas markets (DPIRD 2024).

Agriculture is diverse but dominated by grains and livestock. Grains remain the largest agricultural sector, with nearly 8.5 million hectares cropped in 2023, producing about 14.5 million tonnes. Grain exports alone were worth \$9.2 billion in 2023–24. The sheep industry (meat and wool) contributed \$1.14 billion in 2022–23. Cattle and dairy industries (disposals and milk) contributed \$1.19 billion in 2022–23, with dairy production itself valued at around \$270 million. Horticulture was valued at \$1.66 billion in 2023 at wholesale level, with strong growth in irrigated fruits, vegetables, and wine grapes. Fisheries and aquaculture contributed \$815 million, with an additional estimated \$1.1 billion from recreational fishing. WA's food and beverage industry further adds about \$8.55 billion in sales and services, reflecting growing domestic and international demand for value-added products.

Priorities

WA's agricultural priorities are shaped by its reliance on export markets and the need to adapt to global and environmental pressures. These include safeguarding biosecurity to protect WA's pest- and disease-free status, enhancing market access and competitiveness (particularly in Asia and the Middle East), diversifying production to reduce reliance on grains and live exports, investing in RD&E and innovation (including genetics, digital tools, water-use efficiency, and carbon-smart farming systems) and building climate resilience (with emphasis on soil health, rainfall variability, and sustainability).

Strengths

WA agriculture is underpinned by several competitive advantages. Strong export capacity ensures agriculture contributes over \$16 billion to WA exports, with dominant shares in grain and livestock products. The large-scale grains sector ensures WA remains a global supplier

of wheat, barley, and canola. High-value diversification is evident, with horticulture, aquaculture, and the wine industry growing in importance. The food and beverage manufacturing sector adds over \$8.5 billion in value, strengthening WA's capacity for value-added production. WA's geographic isolation and strong biosecurity systems also provide a crucial edge in maintaining access to international markets.

Challenges/weaknesses

Despite these strengths, WA agriculture faces pressing challenges. Climate change and resource constraints, including declining rainfall, rising temperatures, and fragile soils, put long-term productivity at risk. Heavy reliance on export markets such as China and Japan creates vulnerability to trade shocks. Labour shortages, including seasonal worker gaps and an ageing workforce, constrain sector growth. Infrastructure bottlenecks in port, rail, and logistics limit efficiency, particularly for grain exports. Finally, policy and market pressures around animal welfare, carbon emissions, and sustainability requirements may reshape production systems.

5.2 WA agricultural RD&E capacity needs

Western Australian State agricultural RD&E strategies, reports, and papers were reviewed and analysed. Future RD&E needs and subsequently RD&E workforce capacity needs were identified and amalgamated under nine themes.

References reviewed to identify the RD&E capacity needs were CSIRO 2024, Department of Primary Industries and Regional Development (DPIRD) 2025a, 2025b, 2024, 2022 and 2021, Government of Western Australia 2025, Western Australian Agriculture Authority & DPIRD 2023b, Western Australian Government Department of Jobs Tourism, Science and Innovation 2024.

The nine themes identified for future RD&E needs are as follows:

1. Data and Digital (AI, IoT, robotics, data governance)

- Edge analytics, AI, and machine learning for yield, disease, and resource-use prediction.
- Robotics for harvesting, spraying, and autonomous operations.
- Machine vision for monitoring crop and animal health.
- UAVs/drones, remote sensing, and edge analytics for real-time crop and soil monitoring.
- Interoperability standards for farm data platforms (WA-specific).
- Precision agriculture applications (variable-rate seeding, spraying, fertiliser).
- Data governance: linked datasets, interoperability, secure sharing, productised decision-support tools.
- Regional connectivity infrastructure (5G, IoT, satellite) to enable adoption.
- Digital twins and integration of big data into farmer-ready tools.

2. Climate Adaptation and Environmental Markets, Measurement Reporting and Verification (MRV)

- Development of biomass and bioenergy systems in marginal areas as alternative land-use under declining rainfall.
- Research for urgent decarbonisation strategies across farming systems.
- Integration of renewable energy systems into agricultural production (solar, wind, bioenergy, hydrogen) to support decarbonisation.
- Drought- and heat-tolerant crop and livestock varieties.
- Climate-smart cropping and grazing practices to lower emissions (methane, nitrous oxide).
- Soil carbon sequestration and regenerative agriculture.
- Low-emission farming systems and carbon-neutral pathways for livestock.
- Climate variability modelling and seasonal forecasting for decision-making.
- Adaptation economics: profitability vs. climate risk trade-offs.
- MRV systems for carbon and biodiversity markets.
- Integration of biodiversity conservation, habitat restoration, and ecological stewardship into farming landscapes.
- Circular economy approaches for waste and nutrient recycling.

3. Biosecurity and Market Access

- Predictive modelling and surveillance tools for emerging biosecurity threats (climate-linked and trade-driven).
- Advanced diagnostics, mobile kits, and rapid response systems.
- Genetic resistance in crops and livestock to priority pests/diseases.
- Cross-commodity biosecurity (grains, horticulture, livestock).
- Resistance management for herbicides, fungicides, and insecticides.
- Logistics and distribution systems engineering for agile, flexible supply chains and regional processing innovation.
- Expansion of protected agriculture / controlled environment systems (indoor cropping, hydroponics, vertical farming) to reduce climate risk and service premium markets.
- Compliance systems for trade, export certification, and biosecurity readiness.

4. Systems Agronomy and Farm Engineering

- Crop sequencing, early sowing, and sowing depth optimisation.
- Farming systems modelling at whole-farm and landscape scales.
- Integration of livestock into mixed farming systems for profitability and soil fertility.
- Soil constraint management (acidity, compaction, non-wetting, salinity).
- Soil water retention strategies (cover crops, stubble, amelioration).
- Engineering solutions for farm automation and regional processing.

5. Genetics and Breeding

- Crop breeding for resilience, productivity, and stress tolerance.
- Livestock genetics for eating quality, fertility, feed efficiency, and welfare.
- Wool breeding for reproductive efficiency, fibre quality, and flystrike resistance.
- Genetic resistance breeding for pest and disease management.
- Novel germplasm development and integration into WA systems.

6. Water Systems and Irrigation

- Sustainable water resource management: recycled water, groundwater recharge, desalination.
- Precision irrigation and fertigation systems.
- Regional water-use efficiency strategies across crops and grazing.
- Catchment-scale water and salinity management.
- Modelling and planning of water systems at landscape level.

7. Market/Consumer Intelligence and Provenance

- Traceability and provenance systems for premium markets.
- ESG (environmental, social, governance) reporting, sustainability verification, and certification schemes.
- Consumer-facing packaging innovations and circular economy solutions.
- Market foresight and intelligence on consumer preferences and trade shocks.
- Post-harvest innovation and shelf-life extension.
- Development of high-value products (plant proteins, functional foods, low-carbon beef, premium beverages).
- Agritourism market research: visitor impact, branding, and regional marketing strategies.

8. Trade/Policy and Risk Analysis

- Research into adaptation to multipolar trade dynamics and geopolitical risk.
- Enhanced capacity for science communication and public engagement, recognising the need to explain agricultural science and sustainability outcomes to the wider WA community, not just to farmers, to sustain social license and policy support.
- Risk management frameworks integrating seasonal, market, and climate risk.
- Infrastructure and governance to support trade resilience and market diversification.
- Research into social license, consumer trust, and ethical farming systems (animal welfare, transparency, 'morality of farming') as critical enablers of premium market access.
- Scenario planning for foreign ownership, vertical integration, and investment models, including implications for value chains and community benefit.

9. Extension and Adoption Science

- Co-design frameworks with growers, agribusiness, Indigenous partners, and industry.
- Behavioural and adoption science to improve uptake of innovations.
- Extension specialists with skills in digital tools, facilitation, and communication.
- Grower group and demonstration-based adoption models.
- Living labs and participatory research platforms.
- Building trust and engagement in R&D translation.
- Strategies for youth engagement and leadership development in agricultural innovation, ensuring younger generations with digital and tech skills are positioned as future RD&E leaders.

Future RD&E workforce capacity needs for Western Australian agriculture, as aligned to the future RD&E needs above, are presented in Table 1 below.

The alignment of future RD&E needs and capacity requirements to WAARC program areas can be found in Appendix 1, and to DPIRD's Strategic Intent focus areas in Appendix 2.

Table 1: WA agricultural RD&E needs vs. future capacity needs

RD&E theme	Future capacity needs
1.Data and digital (AI, IoT, robotics, data governance)	Data science, AI and Machine Learning (ML) model development, predictive analytics IoT system integration and on-farm sensing technologies Robotics engineering (field robotics, automation systems) Machine vision and image analysis for plant/animal health Software engineering for farm data platforms and decision-support tools Cybersecurity and data governance (privacy, interoperability, standards) Skills in drone/UAV operation, remote sensing, and geospatial data analysis
2.Climate adaptation and Environmental markets (MRV)	Climate science and seasonal forecasting expertise Plant/animal physiology under heat and drought stress Soil carbon science, regenerative agricultural methods Emissions modelling and greenhouse gas accounting MRV system design and implementation Environmental economics (adaptation trade-offs, risk economics) Ecology and biodiversity integration into production landscapes Circular economy and resource efficiency expertise

3. Biosecurity and Market access	Plant pathology, entomology, weed science Veterinary epidemiology and livestock disease diagnostics Molecular biology and genetic resistance breeding techniques Surveillance system design and modelling of pest/disease spread Rapid diagnostic and portable testing technologies Resistance management expertise (herbicides, fungicides, insecticides) Controlled environment agriculture expertise Certification and compliance systems science Policy and regulatory knowledge in biosecurity compliance and trade Risk communication and stakeholder engagement for outbreak response Logistics and distribution systems engineering
4. Systems agronomy and Farm engineering	Advanced agronomy (crop sequencing, sowing strategies, nutrient management) Farming systems modelling (whole-farm, mixed systems, landscape scale) Soil science (amelioration, compaction, salinity, non-wetting soils) Crop–livestock integration and pasture agronomy Farm engineering (mechanisation, equipment optimisation, automation) Hydrology and soil–water interactions Experimental design for long-term field trials across diverse environments
5. Genetics and breeding	Quantitative genetics, genomics, and molecular breeding techniques Germplasm development and evaluation Animal breeding and reproduction technologies Livestock genomics for fertility, feed efficiency, welfare traits Crop improvement for resilience, yield, and quality traits Bioinformatics and computational genetics Genetic resistance breeding against pests and diseases Ethical and welfare knowledge in livestock breeding programs
6. Water systems and Irrigation	Irrigation engineering (design, precision irrigation, fertigation) Hydrology and water resource modelling (catchment to farm scale) Soil–water–plant interaction knowledge Desalination, groundwater recharge, and recycled water technologies IoT-enabled water monitoring systems Climate resilience in water allocation and water-use efficiency Policy and governance knowledge for water sharing and licensing
7. Market / Consumer intelligence	Market economics and consumer behaviour analysis Supply chain management and logistics expertise Traceability systems (blockchain, QR, IoT-enabled provenance tracking) ESG reporting, certification schemes, and sustainability standards Food science and post-harvest technology

and provenance	Packaging technology and circular economy design Product development (plant proteins, functional foods, premium products) Agritourism business modelling, marketing, and regional branding Economic diversification analysis
8. Trade / Policy and Risk analysis	Agricultural economics and trade policy analysis International market access regulations and compliance Risk analysis and scenario modelling (climate, trade, biosecurity) Political economy and geopolitical risk expertise Policy design for carbon, biodiversity, and sustainability markets Legal knowledge in IP, certification, and trade agreements Infrastructure economics for regional supply chain resilience Skills in multi-stakeholder negotiation and governance
9. Extension and adoption science	Extension theory and practice (adult learning, adoption science) Behavioural science and psychology of decision-making under risk Co-design methods with growers, Indigenous groups, and industry Communication and facilitation skills, including digital engagement Participatory research and “living labs” facilitation Knowledge brokerage and translation of science into practice Monitoring, evaluation and learning (MEL) frameworks to assess adoption impact Skills in trust-building and long-term stakeholder relationships Public communication and engagement specialists Youth leadership and innovation capacity building

5.3 System-level enablers and constraints

As well as identifying RD&E capacity needs in the state the recently published Western Australian Agricultural R&D Ecosystem Report (DPIRD 2025) and the Future of Agriculture in Western Australia: Think Tank Report, Perth, (Western Australian Agriculture Authority & DPIRD 2023b) also highlighted system-level enablers and constraints that determine whether RD&E capacity can be sustained, mobilised, and translated into impact. These are pertinent to the objectives of this literature review and include the following:

Institutional & organisational capacity

- University funding model resilience: Strategic foresight and planning for vulnerabilities in WA universities’ reliance on international student revenue, which underpins agricultural research capacity.
- Research capacity in governance models and institutional design to reduce transaction costs and duplication across WA’s complex RD&E system.

- CSIRO WA presence: Capacity planning to address risks from CSIRO's reduced footprint in WA, including strategies to retain local expertise and ensure strong national integration.

Funding, productivity & policy influence

- Productivity justification: Capacity to measure, model, and communicate the productivity impacts of R&D investment, to advocate for sustained funding.
- Policy and economic capacity to position WA agricultural R&D as a driver of statewide economic diversification (linking to food and beverage manufacturing and regional value-adding).
- Policy capacity in ESG certification, carbon/biodiversity markets, and export compliance.

Infrastructure & research platforms

- RD&E capacity to support renewal of WA's ageing agricultural research infrastructure, ensuring labs, field stations, and facilities meet modern climate and sustainability requirements.
- Long-term field platforms across agro-ecological zones for adaptive farming systems research.

Strategic alignment & coordination

- Alignment with national and international RD&E strategies (e.g. GRDC, MLA, National Primary Industries Research, Development and Extension Framework).
- Integration with national biosecurity strategies and policies.

Emerging systemic & global pressures

- Ecosystem services as core outputs: RD&E capacity to position carbon sequestration, biodiversity, and landscape stewardship as marketable products alongside food and fibre.
- Geopolitical dependence on Asia: While trade/policy analysis is included, the Think Tank specifically identifies WA's vulnerability to China/Asia market shifts, suggesting a need Stocktake of for capacity in geopolitical foresight linked directly to Asian export dynamics.

5.4 Megatrends and their influence on WA's future RD&E capacity needs

Several interacting changes will influence agriculture on a global, national and local level, bringing opportunities and challenges with them. Information from the Stocktake of megatrends shaping Australian agriculture (Hatfield-Dodds, Hajkowicz & Eady 2021) has been reviewed and analysed in relation to WA's future capacity RD&E needs.

1. Growth juggernaut – three billion empowered consumers

What the megatrend says (signal): Rising incomes in Asia will keep shifting diets toward protein, fruit and vegetables, and premium attributes (health, provenance, sustainability), with reputation and biosecurity central to market access.

RD&E capacity needs for WA - Discipline coverage and depth

- Market-facing science that verifies health, provenance, sustainability, and ethics attributes; stronger food safety/traceability and assurance systems that can be audited for export markets.
- Human nutrition and product development (linking WA grains, pulses, livestock and horticulture to health claims).
- Market intelligence and consumer insights for Asian segments (behavioural economics, branding science).
- Biosecurity science (risk pathways, surveillance analytics) to support safe market diversification. Export-facing QA/traceability RD&E (certification/testing). Rapid paddock-to-port validation that on-farm practices match claims.
- Food science + supply-chain informatics + marketing/behavioural science + biosecurity to turn farm practices into verified, monetisable attributes.

2. Fractal politics – volatility, uncertainty, complexity, ambiguity (VUCA)

What the megatrend says (signal): Multipolar geopolitics leading to more market access risk; firms need options across destinations and trusted information to maintain reputation. Managing VUCA requires better information, specialist capability, and collaboration.

RD&E capacity needs for WA - Discipline coverage and depth

- Trade policy and market access analytics integrated with commodity/biosecurity science.
- Reputation management science (traceable evidence platforms; transparency metrics).
- Risk science (scenario modelling, stress testing for supply chains and regional industries).
- Inter-disciplinary capability: Policy-science-industry triads: economists + data scientists + commodity/biosecurity specialists co-produce actionable export risk dashboards.

3. More from less – the permanent race for advantage

What the megatrend says (signal): Productivity must keep rising; Australia is trending to fewer, larger farms; gains come from genetics, management and uptake; labour inputs keep falling; skills and supply-chain strength matter.

RD&E capacity needs for WA - Discipline coverage and depth

- On-farm systems engineering (automation, variable-rate, irrigation optimisation).
- Genetics and breeding (heat/drought tolerance in WA cereals, legumes; livestock methane-reduction lines).

- Adoption and extension science/human factors (closing yield gaps through practice change).
- Breeders + systems agronomists + data analysts + behavioural scientists to convert genetics and tech into whole-farm profit at scale.

4. Cascading planetary risks – climate, biosecurity, ecosystem markets

What the megatrend says (signal): Australia will get hotter and drier in the south; droughts, fires, floods intensify; broadacre profitability already down ~22% since 2000 due to climate shift; access to premium markets will require environmental stewardship; carbon/biodiversity markets could transform landscapes and returns.

RD&E capacity needs for WA - Discipline coverage and depth

- Climate adaptation agronomy for WA (heat/dry-tolerant genetics, shifting planting windows, soil water management).
- Water systems and markets (governance, on-farm water efficiency for irrigation districts).
- Carbon and natural capital measurement/MRV (measure, report, verify) methods suited to WA vegetation/soils; low-emissions livestock systems.
- Disaster risk and resilience modelling; biosecurity readiness under climate stress.
- Combine crop/livestock science + hydrology + economics + MRV/data science + Indigenous knowledge to co-design profitable adaptation pathways and environmental services income.

5. Disruptive technologies – digital, automation, genetics, data governance

What the megatrend says (signal): Digital/IoT/automation/robotics and genetic gains will transform production and traceability; within-industry and cross-industry data collaboration offers the biggest value uplift; Australia's digital readiness lags and will require new shared data ecosystems and standards.

RD&E capacity needs for WA - Discipline coverage and depth

- On-farm digital systems & robotics (sensing, autonomy in broadacre/fruit/veg/livestock; edge analytics).
- Data engineering and governance (standards, linking keys, privacy, platforms; 'collect once, use many times').
- Quant genetics and phenomics leveraging objective data streams to accelerate WA relevant gains.
- Supply-chain informatics (real-time quality, provenance, biosecurity compliance).
- Inter-disciplinary capability: agronomists + roboticists + data engineers + breeders + social scientists, jointly measured on uptake and profitability, not just prototypes.

6. Positioning for the future – surf the waves, don’t get dumped

What the megatrend says (signal): Australia’s edge relies on constant innovation, better RD&E outcomes, reduced fragmentation, and enabling investment in cross-cutting technologies; policy must keep supporting change rather than protecting the past.

System-level workforce and capacity settings for WA - Discipline coverage and depth (portfolio design)

- Substantial allocation of new human-capital spend to cross-cutting skills (data governance, adaptation economics, supply-chain informatics, extension science, biosecurity analytics), not just commodity silos.

5.5 Megatrend capacity heatmap

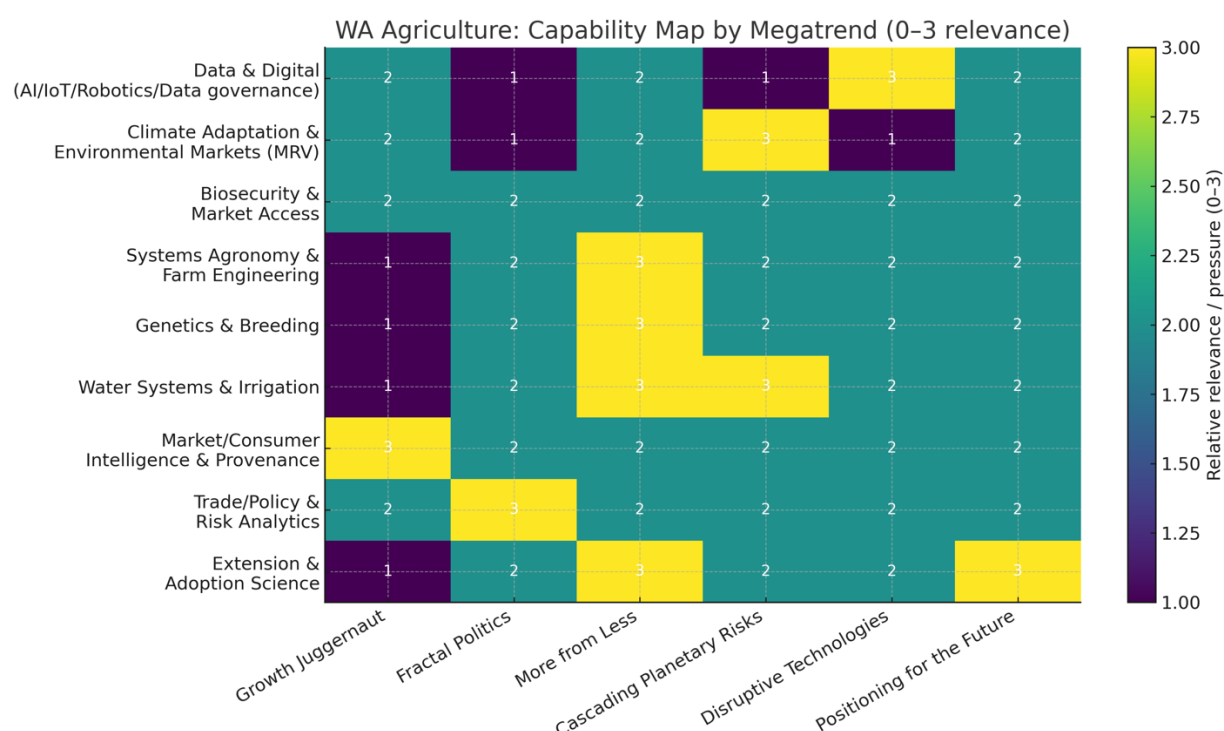


Figure 1: Megatrend capacity heatmap

The megatrend capacity heatmap (Fig 1) shows how different areas of WA’s agricultural RD&E align with global ‘megatrends’. A brief explanation of the justification of capacity relevance by megatrend for each of the WA capacity domains can be found in Appendix 3.

Axes

- Vertical axis lists the capacity domains in WA agriculture; these are the areas of research and capability.
- Horizontal axis lists the megatrends driving change in agriculture. These represent big forces shaping agricultural RD&E priorities.

Colour shading

The colour scale (from dark purple through green to bright yellow) shows the level of relevance/pressure (0–3 scale):

- 1 (dark purple) = Low relevance/low pressure.
- 2 (green/teal) = Moderate relevance/medium pressure.
- 3 (bright yellow) = High relevance/high pressure.

This indicates how strongly each capacity domain is affected by, or relevant to, each megatrend.

Numbers inside the cells

- Each cell has a number (1–3), which matches the colour scale.
- Example: In the row '*Market/Consumer Intelligence & Provenance*' under '*Growth Juggernaut*', the value is 3, this area is considered highly relevant and under strong pressure from growth-driven consumer demands.

How to interpret patterns

- Look across a row, it shows how one capacity domain (e.g. *Data & Digital*) is impacted by different megatrends.
- Look down a column, it shows how one megatrend (e.g. *More from Less*) influences different capacity domains.
- Bright yellow clusters show priority intersections (where WA agriculture needs strong RD&E responses).

Key insights – top three capacity megatrend intersections

1. Resource efficiency under pressure (More from Less)

- Highest impact on Systems Agronomy & Farm Engineering, Genetics & Breeding, and Water Systems & Irrigation (all scored 3).
- Indicates WA agriculture must prioritise innovations that deliver higher productivity with fewer inputs (land, water, fertiliser) while maintaining profitability and resilience.

2. Technology-driven transformation (Disruptive Technologies)

- Strongest impact on Data & Digital (AI, IoT, robotics, data governance) (score 3).
- Highlights the need for WA to accelerate digital capability, including agtech adoption, automation, and trustworthy data governance systems to stay globally competitive.

3. Future positioning & resilience (Positioning for the Future)

- Highest impact on Extension & Adoption Science (score 3).
- Shows that future competitiveness will rely not only on research but also on farmer adoption, knowledge co-creation and integration, and co-innovation systems to scale solutions rapidly.

Additional signals

- Climate adaptation (MRV) is most pressured by Cascading Planetary Risks (score 3), pointing to the pressing need for WA RD&E in measurement, reporting, verification (MRV) of carbon, biodiversity, and sustainability markets.
- Market/Consumer Intelligence & Provenance is strongly driven by Growth Juggernaut (score 3), reflecting growing consumer demand for traceability, trust, and ethical production.
- Trade/Policy & Risk Analytics scores highest under Fractal Politics (3), signalling the importance of building WA's capacity to manage geopolitical shocks, trade disruptions, and policy volatility.

WA's RD&E system should consider strengthening its capacity in digital transformation, sustainable resource use, resilience to planetary risks, consumer-focused provenance systems, and rapid adoption pathways. Analysis of the Megatrends report against the nine WA RD&E capacity areas - these are the most critical pressure points shaping WA agriculture's future.

5.6 Comparison of WA RD&E capacity needs and megatrends

Table 2 summarises a comparison between the WA capacity needs analysis findings from the literature review and the megatrends capacity map. It identifies RD&E areas already captured in the needs analysis findings that megatrend findings suggest need greater focus and emphases.

Table 2: Megatrend areas that provide further focus to specific RD&E capacity needs analysis findings

Already identified in RD&E capacity needs analysis findings	Megatrend areas that provide further focus to RD&E capacity needs analysis findings
Digital tools	AI ethics, data security/governance, automation & robotics adoption pathways
Climate adaptation & carbon markets	MRV systems for carbon, biodiversity & water markets
Agronomy efficiency & sustainable practices	Resource-use efficiency framed as planetary risk (energy, fertiliser, land use)
Breeding trait focus	Stress-resilient genetics for climate extremes, pests & water scarcity
Water-use efficiency	Whole-of-system water resilience strategies (recycling, desalination, catchment-scale management)

Provenance and traceability	Consumer trust systems, certification, traceability technology for premium markets
Market access mentioned	Trade risk modelling, geopolitical foresighting & scenario planning tools
Extension & adoption	New adoption science models (digital platforms, behavioural economics, peer-to-peer learning)

5.7 Industry-specific RD&E needs

Overall, the WA-wide needs analysis captured most of the larger individual industries (grain, horticulture, sheep meat, beef and wool) priorities, but there are several that are not explicitly included in the WA-focused needs analysis findings. Table 3 below presents these industry-specific needs. Appendix 5 further documents these issues and associated RD&E skills and knowledge required.

Table 3: Industry-specific needs not explicitly captured in the broader needs analysis findings

RD&E Themes	Industry	Industry-specific needs not explicitly captured in the broader needs analysis findings
1.Data and digital (AI, IoT, robotics, data governance)	Beef	End-to-end digital traceability using blockchain (beyond general “traceability” noted in WA analysis). Interoperable data platforms linking genetics, grading (MSA), and market feedback. Digital QA tools for food safety and quality (not mentioned in WA analysis, which focused more on production data).
2.Climate adaptation and Environmental markets (MRV)	Beef	Research on balancing beef production with deforestation-free supply chain commitments.
	Sheep/ wool	Flystrike resistance breeding (captured under genetics in WA report but not explicitly linked to climate adaptation pressures).
	Grains	Salinity-specific adaptation pathways for WA cropping (the WA analysis mentions soil constraints generally but not salinity adaptation as a climate-focused risk).
3.Biosecurity and Market access	Beef	Specific emphasis on lumpy skin disease and FMD rapid diagnostics (WA analysis covers diagnostics generally, not tailored to northern beef disease risks). Parasite control (ticks, worms) with resistance management strategies.
4.Systems agronomy &	Beef	RD&E into farm infrastructure/logistics (roads, ports, cold-chain, processing), which is not explicitly in the WA analysis.

Farm engineering	Sheep/wool	Optimisation of shearing, wool harvesting technology, and labour efficiency – mentioned in wool report but absent in consolidated needs.
5.Genetics and breeding	Beef	Genomic pathways for low-methane cattle (WA report covers low-emission systems but not tied to cattle genomics).
	Sheep/wool	Wool fibre quality improvement beyond flystrike and reproduction (covered in industry report, but WA analysis just has broad “wool breeding” reference).
6.Water systems and irrigation	Beef	Research into water governance for northern finishing systems (WA analysis focuses on irrigation efficiency more for crops).
7.Market/Consumer intelligence and provenance	Beef	Value-based marketing linking genetics, MSA grading, and eating quality. RD&E into reducing contaminants and ensuring beef eating quality consistency.
	Horticulture	Post-harvest handling/shelf-life research is stronger in horticulture reports than the WA summary.
8.Trade/Policy and Risk analysis	Beef	Explicit RD&E into policy and regulatory hurdles for live export.
	Sheep	Industry-level RD&E on the future of live sheep export markets, not strongly represented in the consolidated WA analysis.
9.Extension and adoption science	Beef:	Emphasis on Indigenous participation and workforce retention in northern beef regions, absent in WA-wide summary. Focused training on workplace safety and leadership in beef enterprises.

Findings for this section of the report culminated from the following references (industry reports and documents): Meat and Livestock Australia 2019 and 2025, Australian Wool Innovation 2018 and 2025, Foster et al. 2024, Kingwell 2022, Kingwell & Pannell 2005, Strickland Park Economics 2023, Australian Export Grains Innovation Centre 2025, DPIRD 2023b, Grains Research and Development Corporation, 2023, National Grains Industry Research Development Extension Committee 2017, Wiedemann, McRae & Longworth 2022, Roth 2024, National Horticulture Research Network (NHRN) 2023, The Centre for International Economics 2025.

6. Agricultural RD&E capacity needs – Australian and New Zealand perspective

6.1 CSIRO Ag2025 Scenarios Report

The Ag2050 Scenarios Report (CSIRO, 2024) explores how Australia's agricultural and food systems might evolve over the next three decades in response to major global, environmental, technological, and societal shifts. Using a scenario-based approach, the report sets out four plausible futures that consider the impacts of climate change, energy and water pressures, shifting consumer expectations, technological disruption, and geopolitical uncertainty. Its purpose is not to predict a single outcome but to highlight the range of challenges and opportunities Australia may face, and to identify the research, development, and innovation capabilities required for agriculture to remain productive, sustainable, and globally competitive in a rapidly changing world.

The report shares a lot of common ground with RD&E capacity needs identified from WA state-based strategies and documents (digital agriculture, climate resilience, biosecurity, genetics, extension), but also identifies several additional capacity needs not explicitly captured.

It calls for research capacity to:

- Design net-zero, circular, regenerative food systems.
- Capacity in cultured, microbial, and plant-based protein technologies plus consumer adoption science.
- Embed Indigenous knowledge systems and stewardship in RD&E.
- Research at the intersection of energy, water, and food (e.g. hydrogen, renewables integrated into farming).
- Expertise in foresight, scenario planning, behavioural economics, and institutional design to guide transitions.
- RD&E capabilities for pandemic, trade war, and climate shock preparedness.
- Capacity in policy, governance innovation, and equity research (who benefits, who is excluded).

6.2 Strategic examination of R&D: Discussion paper

The Department of Industry, Science and Resources 'Strategic Examination of R&D: Discussion paper consultation findings and analysis' (July 2025) provides a national stocktake of Australia's R&D system, drawing on almost 500 submissions and extensive stakeholder input. It identifies challenges such as fragmented funding, weak industry linkages, workforce pressures, and underinvestment in infrastructure, while calling for a more mission-oriented and collaborative approach. For WAARC, the review offers a valuable national benchmark to align WA agricultural RD&E priorities with broader system reform.

The panel's initial conclusions include:

- Focus on the whole pipeline – R&D for innovation (R&D and innovation)
- A cohesive system aligned to national need – coherent, related, synergistic
- High-quality basic research is a cornerstone of Australia’s knowledge-based economy
- Driving effectiveness of public and institutional investment across the system
- Supporting high-risk, high-reward research and entrepreneurship
- Public investment cannot substitute for private initiative
- Build the talent pool, and support it
- Government as an exemplar, the purchasing power of government, should be used
- Boosting private capital flows to support R&D and innovation activities
- Strengthening performance measurement
- Sustained growth in productivity and living standards required
- Innovation - invest in our capabilities and their application.

Appendix 4 includes a more detailed review of the Strategic Examination of R&D: discussion paper consultation findings and analysis (July 2025), in relation to key question areas from the Needs Analysis of Human Capacity in WAARC RD&E Sector.

6.3 Agriculture R&D Investment in Australia

A recommended percentage split between public and private investment for RD&E in agriculture in Australia could not be found, although the following information from ABARES (Department of Agriculture, Fisheries and Forestry, 2024) reports on public and private agricultural investment in 2023–24.

- Total agricultural R&D funding: about A\$2.98 billion.
- Private sector funding: about A\$1.52 billion.
- Government funding (federal + state): about A\$1.47 billion.

The percentage split for 2023-24 is roughly:

- Private sector: ~ 51%
- Government: ~ 49%
- The private sector is doing increasingly more agricultural R&D, with R&D expenditure growing at an average annual rate of 6.85%
- Meanwhile, the Australian Government and State Governments are doing less of the agricultural R&D, with expenditure dropping by 2.41% and 1.77% each year on average.

6.4 New Zealand agricultural RD&E capacity needs

NZ Science System Advisory Group report (2024) outlines several current and future agricultural RD&E needs for New Zealand, framed within a broader science and innovation context.

Findings for this section of the report have culminated from the following industry reports: Gluckman et al. 2024 and Research, Science and Innovation New Zealand 2025.

Why this matters for WA

New Zealand exhibits parallels to Western Australia: small, advanced economy, export-focused agriculture, strong agritech ambition, and regional RD&E structures.

Learning from New Zealand's system reconfiguration, targeted capacity development (New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)), and agritech pipeline development can offer models for WA's future strategy. Detailed insights into early-career support, diversity initiatives, and greenhouse gas mitigation RD&E may inform WA's planning for discipline coverage, career pipelines, and professional development.

Current needs

- **Stronger translation of science into practice:** Improving how agricultural research outputs are taken up by farmers, processors, and supply chains, including more effective extension and innovation systems.
'Strengthen the connection between research and application in key sectors such as food and fibre, ensuring that science translates into tangible practice change on farms and through value chains.'
- **Sustained investment in core capabilities:** Maintaining specialist skills in areas like animal health, plant breeding, and biosecurity where capacity takes years to build and is difficult to replace.
- **Cross-disciplinary integration:** Combining expertise from biological sciences, environmental science, engineering, data analytics, and social sciences to solve complex on-farm and value chain challenges.
- **Better national coordination:** Avoiding duplication across institutions and ensuring alignment between Crown Research Institutes, universities, and industry-led bodies.
'Improve alignment between Crown Research Institutes, universities, and industry bodies to reduce duplication and increase national impact.'

Future needs

- **Climate change adaptation and mitigation:** Developing climate-resilient farming systems, low-emissions livestock and crop production, and tools to manage climate risk.
- **Sustainable land and water management:** Research on regenerative practices, improved nutrient management, and ecosystem services to meet environmental regulations and consumer expectations.
- **Advanced technologies:** Accelerating RD&E in precision agriculture, robotics, genomics, and digital decision-support to maintain productivity while reducing environmental footprint.
'Accelerate uptake of advanced technologies such as robotics, artificial intelligence, and genomics in the food and fibre sector.'

- **Global market alignment:** Innovation to meet changing export market demands, including traceability, biosecurity assurance, and low-carbon product credentials. 'Maintain New Zealand's premium position in export markets by investing in innovation for traceability, biosecurity assurance, and low-carbon product credentials.'
- **Workforce capability:** Investing in future scientists, technicians, and extension practitioners, particularly in emerging skill areas such as AI for agriculture, data integration, and complex systems modelling.

7. Agricultural RD&E capacity needs - Global perspective

7.1 OECD Report

This section is consolidated from the reference: Organisation for Economic Co-operation and Development (OECD) Agricultural Policy Monitoring and Evaluation (APME) Report 2024 (Organisation for Economic Co-operation and Development 2024)

OECD is an intergovernmental organisation with 38 member countries that produces policy analysis and recommendations, including agriculture. The APME report is OECD's annual flagship report that tracks and assesses agricultural policies across member and partner countries. It analyses support to farmers, trade measures, and RD&E priorities, and makes country-specific recommendations.

Table 4 below is a cross-country comparative matrix pulling together the OECD APME-2024 recommendations translated for Australia, New Zealand, EU, Canada, Brazil, India, UK, US, and China into RD&E priorities and researcher capacity. An acronym glossary can be found in Appendix 6.

Global common core, seen across most jurisdictions

RD&E themes: Climate-smart productivity (methane/N₂O/soil-C), water efficiency, nutrient stewardship (N/P), digital/precision/Earth Observation (EO), enabled MRV, outcome-based policy design and evaluation, and stronger extension/AKIS to speed adoption.

- **Capabilities to scale:** soil & GHG scientists; hydrology; ag-data/RS engineers; systems modellers, ag economists (policy + TEA); behavioural/extension specialists; natural-capital accounting & LCA; biosecurity/diagnostics.
- **Platforms:** credible, low-friction MRV data spines (EO) + sensors + farm records, on-farm experimentation networks, and translation units (co-design, training, productisation).

Table 4: Global competitive matrix

Jurisdiction	Priority RD&E themes (from OECD signals)	Capability/capacity to build
Australia	Lift SPG under climate stress; index-based risk tools; water allocation & infrastructure impacts; scale extension; carbon/biodiversity markets; methane mitigation	Climate & risk modellers; ag insurance/actuarial; hydrology & water econ; extension/behavioural; MRV & LCA; livestock methane science
New Zealand	Low-emission livestock; nutrient surplus management; GHG pricing-ready MRV; adaptation metrics; evaluate land-use & extension programs; biosecurity/IHS	Livestock genetics & rumen; nutrient/soil specialists; MRV engineers & env economists;

		program evaluators; biosecurity epidemiologists
European Union	Biodiversity & water with productivity; EIP-AGRI diffusion evidence; stronger AKIS/advisory; performance-based conditionality; trade resilience	Agroecology & water; innovation-systems & adoption research; advisory/lifelong learning; EO/RS monitoring; policy design & evaluation
Canada	Results-based programs (Sustainable CAP); mitigation/adaptation dual aim; market-based risk tools; reverse GSSE decline; protected sectors reform	MRV & data engineers; rumen/soil-GHG; actuarial/climate risk; extension rebuild; policy & trade economists; product/food tech
Brazil	Biome-adapted sustainable intensification; enforce Forest Code; green credit & insurance with robust MRV; scale extension for small/medium farms; ABC+ Plan M&E	Agroecology, GIS/land-use RS; sustainability finance & MRV; climate-risk insurance design; participatory extension; policy impact modellers
India	Smallholder productivity; SPG targets/metrics; align support away from input subsidies; irrigation + water governance; FPO-led diffusion; e-NAM & logistics; labour transition	Low-cost agronomy; data/M&E for SPG; digital extension; irrigation engineering & hydrogeology; rural econ/organisation design; market & cold-chain engineers
United Kingdom	TFP recovery with lower inputs; nutrient stewardship; scheme additionality/permanence; natural-capital revenue streams; possible ETS coverage; adopt at scale	Soil biogeochem; livestock GHG & manure; EO/RS MRV + causal evaluation; natural-capital accounting & LCA; extension & HCD; policy modellers
United States	Make IRA-scale investments durable; redirect generic support → SPG; insurance integrity & parametrics; inclusion for underserved producers; sugar MPS transition	Breeding/soil/water & AI/robotics; ag economists (microsim/GE); actuarial + geospatial antifraud; extension & entrepreneurship; food tech & consumer science
China	High N/P & water pressure; explicit SPG targets; greened/direct payments; mitigation (enteric, paddy CH ₄ , N ₂ O) + adaptation; soil & water monitoring/enforcement; GSSE upshift; structural change skills	Soil/biogeochem & hydrology; SPG/MRV data science; policy eval & behavioural econ; rumen/rice/soil-GHG experts; EO/AI compliance; ag-robotics/FMIS; food safety diagnostics

Stand-out, country-specific emphases

- Methane livestock frontier: New Zealand, Australia, Canada, United Kingdom, and United States, with particular emphasis on New Zealand and Australia. Focus is on research and innovation to reduce methane (CH₄) emissions from ruminant livestock.
- Paddy CH₄ (methane from flooded rice systems) & groundwater governance: China, with additional relevance to northern India's severe water stress. Research priorities include methane mitigation in paddy rice cultivation and sustainable groundwater management.
- Biome and deforestation compliance: Brazil, centred on the Forest Code (Brazil's legal framework for forest protection), CAR (Cadastro Ambiental Rural, the national rural environmental registry), and ZARC (Zoneamento Agrícola de Risco Climático, Brazil's climate risk agricultural zoning system). These underpin compliance and sustainability in sensitive biomes such as the Amazon and Cerrado.
- Smallholder scale-up and market integration: India, focusing on strengthening FPOs (Farmer Producer Organisations) to improve aggregation and bargaining power, and e-NAM (electronic National Agricultural Market), a pan-India trading platform for agricultural commodities.
- Performance-based CAP/AKIS diffusion: European Union, where CAP (Common Agricultural Policy) reforms and AKIS (Agricultural Knowledge and Innovation Systems) strategies aim to improve uptake of sustainable practices through performance-based approaches and wider knowledge co-development and integration.
- Insurance integrity and parametrics tied to outcomes: United States, Canada, Australia, and Brazil, with a focus on improving agricultural insurance systems, using parametric insurance (payouts triggered by measurable parameters like rainfall or temperature) and linking coverage to sustainability or productivity outcomes.
- Trade/biosecurity specifics: New Zealand, addressing IHS (Import Health Standards) gaps for certain livestock products, and European Union/United Kingdom, managing agricultural trade disruptions from Ukraine conflict, strengthening supply chain resilience, and maintaining market stability.

7.2 GRAPE Overview

This section is taken from the following reference: Global Research on Agriculture: A global dataset of public agricultural RD&E investment: 1960–2022 Overview (Van Dijk et al. 2025)

GRAPE (Global Research on Agriculture: Personnel & Expenditures) dataset from WUR (Wageningen University & Research) and the USDA-ERS (United States Department of Agriculture, Economic Research Service) provided internationally comparable long-term data on agricultural RD&E spending and researcher capacity across 190 countries. The GRAPE dataset is current, comprehensive, and likely to remain available as a trusted benchmark for global agricultural R&D analysis. The USDA-ERS dataset likewise remains ongoing but is potentially vulnerable to domestic budget and policy changes, especially affecting

international and university-level research programs. If this data set is to continue, WAARC can consider benchmarking WA's investment and workforce capacity against global peers, supporting evidence-based decisions on where to strengthen research systems to remain competitive and meet future industry needs.

It provides information on public agricultural RD&E expenditures and the numbers of public agricultural researchers. Its purpose is to inform science and technology policy, assess agricultural productivity growth, and monitor progress toward Sustainable Development Goals (SDGs).

Key insights

Importance of public agricultural RD&E

- Investment in agricultural RD&E is a major driver of productivity growth.
- High rates of return reported: ~34% in high-income countries, ~42% in low-income countries.
- It plays a central role in improving global food security, climate resilience, and reducing agriculture's environmental footprint.

Global trends

- Many low and middle-income countries have increased their agricultural RD&E investments, especially in Asia and parts of Africa.
- Some high-income countries have seen stagnation or decline in public agricultural RD&E spending.
- Differences in RD&E intensity (share of agricultural GDP spent on RD&E) are large between regions.

Implications for Western Australia's future agricultural RD&E

Although the paper is global in scope, it highlights trends relevant to WA:

- Need for sustained and increased investment in public agricultural RD&E to maintain competitiveness.
- Cross-disciplinary research capacity (agriculture, environment, economics, social science) is essential to address emerging challenges.
- It would be best practice for WA to benchmark its RD&E spending and workforce capacity against other advanced agricultural economies.
- Ensuring long-term continuity in data collection is vital for evaluating RD&E impacts.

Benchmarking WA in a global context

- The GRAPE data shows that high-income agricultural economies (like Australia) often have strong baseline RD&E capacity but risk losing global competitiveness if investment plateaus.
- Western Australia's grains, livestock, and horticulture sectors operate in global export markets, meaning RD&E investment levels need to keep pace with competitor nations such as Canada, the US, and EU countries.

- WA has the opportunity to track its RD&E intensity (share of agricultural GDP invested in RD&E) against these competitors annually, using GRAPE methodology.

Key strategic risks for WA

- **Investment stagnation:** Global patterns show that flat public RD&E budgets can erode productivity growth and limit innovation adoption.
- **Shifting research needs:** Climate adaptation, environmental sustainability, and supply chain resilience are emerging as top drivers globally also central to WAARC's climate resilience and value chain program areas.
- **Capacity drift:** Without deliberate planning, WA risks losing specialised expertise in niche areas (e.g. biosecurity diagnostics, robotics in agriculture) that have long lead times to rebuild.

Implications for WA's future RD&E needs

Using GRAPE's global trends and WAARC's strategic program areas, priority WA RD&E needs include:

- **Climate resilience and low-emissions farming** (aligning with WAARC Program 1) to match global investment in adaptation and mitigation RD&E.
- **Biosecurity innovation** (Program 2) leveraging predictive analytics and genetic diagnostics to maintain market access.
- **Digital agriculture, robotics, and AI** (Program 3) ensuring WA remains competitive in precision production.
- **Natural capital and ecosystem services research** (Program 2 and 5) aligning with global focus on climate-smart agriculture and sustainable production systems.
- **Global market and value chain intelligence** (Program 4) to navigate shifting trade geopolitics.

Implications for WA's future RD&E capacity

Based on the dataset's investment and workforce data:

- **Sustained funding:** Maintain or increase WA's agricultural RD&E expenditure growth rate above inflation to avoid global competitiveness loss.
- **Interdisciplinary research teams:** Recruit and train researchers skilled in both traditional agricultural sciences and emerging fields (data science, behavioural economics, systems modelling).
- **International benchmarking and collaboration:** Participate in global RD&E networks to share knowledge and co-develop technologies.
- **Long-term talent pipelines:** Invest in postgraduate and postdoctoral fellowships in strategic skill shortage areas identified by WAARC and DPIRD.
- **Data infrastructure:** Build capacity in RD&E data collection and impact evaluation to support evidence-based funding decisions.

8. Diversity and inclusion

One of the RD&E needs analysis areas is:

- Diversity and inclusion – gender balance, Indigenous participation, and international recruits; how diversity affects innovation and collaboration.

The following findings have been generated from a review of state, national and international papers and reports.

A snapshot: where WA (and Australia) sits now

Public sector diversity (not agri-food specific, but a useful proxy for DPIRD-style agencies).

The Public Sector Commission (March 2025) records employment representation relative to aspirational targets, for a range of diversity groups, as presented in Table 5 below.

Table 5: Public sector employment statistics at March 2025

Diversity groups	March 2025 representation	Aspirational target
Women in the SES	51.2%	50%
Aboriginal and Torres Strait Islander people	2.8%	3.7%
People with disability	1.7%	5%
Culturally and linguistically diverse people	18.5%	15.5%
Youth (aged 24 and under)	5.8%	5.8%
Mature (>45 years)	47.7%	n/a

*Senior Executive Service

At this time, the WA public sector employed 142,317 full-time equivalent (FTE) employees. DPIRD employed 1,982 (2%) of these FTE.

Within DPIRD specifically, the Access & Inclusion Plan notes disability representation rose to 4.4% (DPIRD 2023a) and outlines commitments aligned to WA Multicultural Policy Framework and Reconciliation Action Plan actions (Office of Multicultural Interests 2020).

Table 6 below documents diversity statistics in public sector leadership roles in 2023-24 (Public Sector Commission 2024).

Table 6: Diversity representation in public sector leadership roles 2023-24

Diversity group	Total representation (management and non-management)	Representation in SES* (public sector only)	Representation in management tiers** public sector	Representation in management tiers** other government
Women	66.7%	49.9%	53.5%	41.4%
Aboriginal and Torres Strait Islander employees	2.8%	2.6%	2.1%	2.4%
Employees with disability	1.9%	2.3%	2.2%	1.5%
Culturally and linguistically diverse employees	19.6%	8.2%	14.7%	14.1%

*Senior Executive Service

** Management tiers refer to employees in top three tiers of authorities relating to management and decision-making responsibilities rather than salary.

WA population context (talent pool and demand for inclusive services)

From the 2021 Census highlights, 32.2% of Western Australians were born overseas; 55.6% have one or both parents born overseas. Aboriginal and Torres Strait Islander peoples are 3.3% of WA's population. These figures show the community is more diverse than the public sector workforce at management level (WA Office of Multicultural Interests 2021).

Australia-wide STEM/research pipeline

The STEM Equity Monitor (Department of Industry, Science and Resources 2024) shows persistent gender gaps across the STEM pipeline (e.g. women comprise a smaller share of STEM qualified occupations), but women are relatively well represented in 'scientific research services' and gender pay gaps are narrowing in STEM industries. It includes intersectional views (e.g. overseas born) and teaching/research workforce breakdowns.

Indigenous participation: Universities Australia's 2023 Indigenous Strategy Annual Report highlights progress (more senior Indigenous leaders; cultural safety training) but most universities report difficulty meeting Indigenous academic staffing targets, citing a highly competitive market and pipeline constraints, (Universities Australia 2023).

Policy lever for future pipeline: since 2024, all Aboriginal and Torres Strait Islander students accepted into non-medical courses are guaranteed a Commonwealth supported place (extending to medicine from 2026) (Clarke 2025).

International recruits (capacity in regional WA)

WA has paused State Nominated Migration Program (SNMP) invitations from 1 July 2025, affecting one common pathway to recruit international talent into WA-based roles. Employers

can still use federal pathways, but the pause reduces one state lever. (Government of Western Australia Department of Training and Development 2025).

What the research says about diversity leading to innovation and collaboration

Ethnic/cultural diversity is linked to higher scientific impact (Freeman & Huang 2015 AlShebli, Rahwan & Woon 2018). Large-scale analyses of millions of US-authored papers show teams with more ethnic diversity (and collaborators across locations) publish in higher-impact journals and receive more citations, while homophilous (same-ethnicity) teams underperform on these metrics.

Gender-diverse teams show higher 'collective intelligence' (Woolley et al. 2010, page 2007). Classic experiments find groups perform better when social sensitivity is high and participation is balanced; a higher proportion of women is associated with better group performance through these mechanisms.

Cultural diversity brings creativity and variety of knowledge but needs inclusive management (Stahl et al. 2010, Cox & Blake 1991). Meta-analyses in international teams indicate cultural diversity tends to boost creativity/innovation while potentially increasing process frictions unless supported by clear norms, psychological safety, and inclusive leadership.

Where the likely capacity gaps are for WAARC-relevant RD&E

Gender balance in leadership and technical streams. While women are ~43% of WA public-sector leaders, gaps can persist in specific STEM sub-disciplines and senior research roles (pay and progression gaps persist nationally). For RD&E programs, this can constrain idea variety and decision-making breadth if not addressed at project-lead level, (Western Australian Government, Public Sector Commission 2020).

Indigenous researchers: pipeline and retention. Universities report chronic difficulty meeting Indigenous academic staffing targets. Discovery schemes exist, but pipeline measures (Higher Degree by Research (HDR) scholarships, Early Career Researcher (ECR) support, career pathways in agencies) remain critical. For WAARC partners, this means limited Indigenous research leadership capacity and fewer opportunities to integrate Indigenous knowledge into ag innovation unless targeted action is taken (Universities Australia 2023).

Culturally and Linguistically Diverse (CaLD) and Non-English-Speaking Background (NESB) representation at management level. This may reduce language/cultural brokerage capacity in stakeholder-facing RD&E (e.g. extension with NESB growers, international collaboration).

International recruitment friction. The SNMP pause removes a convenient state pathway and may slow hiring into niche roles (e.g. bioinformatics, ag systems modelling) in regional WA; programs will lean more heavily on federal visas or short-term collaborations.

Inclusion capacity in teams. Evidence shows diverse teams outperform only when supported by inclusive practices such as psychological safety and structured collaboration (Edmondson 1999, Shore et al. 2011, Nishii 2013, Stahl et al. 2010). Without that, diversity can increase coordination costs and reduce knowledge sharing, an implementation gap in many research programs.

9. Conclusion

This literature review has consolidated evidence on the future agricultural RD&E capacity needs of Western Australia, drawing on State, national and international sources. It identifies nine priority areas where WA can look to strengthen RD&E capacity over the next five to 15 years, to enhance resilience and competitiveness of the sector.

- 1. Data and digital technologies**
- 2. Climate adaptation and environmental markets**
- 3. Biosecurity and market access**
- 4. Systems agronomy and farm engineering**
- 5. Genetics and breeding**
- 6. Water systems and irrigation**
- 7. Market and consumer intelligence**
- 8. Trade, policy foresighting, and risk analysis**
- 9. Extension and adoption science**

In terms of gaps, while the review has been effective in mapping what will be required in the future, it has not provided a full picture of the current capacity gaps in WA's agricultural RD&E system. In addition, the review provides insights into diversity, gender balance, and inclusion challenges, but found limited evidence about where WA's workforce strengths and weaknesses currently lie.

The findings of this literature review serve as a foundation for the next stage of the WAARC Needs Analysis. The evidence base presented here will guide the design of a sector-wide online survey structured to identify the priority capacity needs/gaps of WA's agricultural RD&E workforce, as well as barriers and enablers relating to these capacity needs.

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11. Appendices

Appendix 1: Alignment of future RD&E capacity needs to WAARC program areas

WAARC Program Area	Future RD&E Research Needs	Future Workforce Capacity Needs
Program 1 - Northern Agriculture	Climate-smart intensification for the North, biosecurity for tropical pests, digital/automation for remote contexts, market development for irrigated systems and beef.	Hydrologists, irrigation engineers, climate modellers, biosecurity scientists, edge-computing developers, culturally capable extension; regional trial hubs, irrigation platforms, IoT connectivity.
Program 2 - Grains Transformation	Resilient rotations, water/nutrient efficiency, soil amelioration, genetics for climate resilience, digital grains, provenance/MRV, biosecurity management.	Systems agronomists, geneticists, phenomics specialists, automation engineers, ML/data scientists, MRV experts; phenomics platforms, robotics, data standards, trial sites.
Program 3 - Resilient Agricultural Futures	Adaptation economics, supply chain resilience, natural-capital aligned farming with MRV, cross-sector biosecurity.	Climate/risk modellers, natural capital analysts, MRV experts, trade economists; modelling environments, data-linkage systems, embedded evaluation frameworks.
Program 4 - Agricultural Technologies	On-farm automation/robotics, edge analytics, protected cropping tech, standards & cybersecurity.	Roboticians, data engineers, privacy/standards specialists, UAV analysts; testbeds, imaging suites, robotics labs, data governance.
Program 5 - Aboriginal Science Engagement	Indigenous-led ag science: native foods/fibres, cultural land/water stewardship, co-design for adaptation and biodiversity.	Co-design facilitators, culturally competent extension scientists, natural-capital analysts; partnerships with Traditional Owners, governance frameworks, Aboriginal researcher pathways.
Program 6 - Capacity Building and Extension	Adoption science, digital extension, evaluation frameworks, scalable training across ag sectors.	Extension scientists, evaluation specialists, data stewards, cross-trained early-career researchers; scholarships, placements, training hubs, continuous improvement evaluation.

Appendix 2: Alignment of future RD&E capacity needs to DPIRD strategic intent

Strategic Intent Focus Area	Future RD&E Research Needs	Future Capacity Needs
Dynamic regions and primary industries	Digital, automation and data-driven production & value chains: on-farm robotics, edge analytics, data stacks, decision-support tools. Market diversification & trade resilience, plant proteins, functional foods, sustainability certification, risk analysis for multipolar trade shocks. Value-adding & post-harvest performance: storage, packing, shelf-life. Cross-sector biosecurity RD&E: early detection, predictive surveillance, resistance management.	Skills: data engineers, roboticists, edge-computing developers, provenance scientists, trade/policy analysts. Infrastructure: phenomics/imaging, robotics benches/testbeds, data governance/connectivity. Partnerships: co-investment models and cross-industry collaboration.
Management and stewardship of WA's land and aquatic assets	Climate adaptation & low-emissions pathways: resilient genetics, rotations, precision water use, MRV. Soil & water stewardship: solutions for acidity, compaction, sands; nutrient efficiency; recycled water use. Biosecurity for environment & markets: predictive modelling, diagnostics. Natural capital & circular economy: biodiversity restoration, waste/nutrient cycling.	Skills: climate/agro-climate modellers, MRV methodologists, natural capital analysts, systems agronomists, hydrologists. Infrastructure: biosecurity facilities, controlled environments, regional trial hubs, linked data platforms. Governance: embed MRV and evaluation into policy-linked programs.
Capable and empowered communities	Adoption science & extension models: co-design, behavioural insights, digital extension, embedded evaluation. Aboriginal science engagement: Indigenous-led research on native foods/fibres, land/water stewardship. Workforce & training innovations: cross-disciplinary skills aligned to regional needs.	Skills: extension scientists, behavioural scientists, co-design facilitators, early-career researchers with hybrid skillsets, culturally competent practitioners. Pipelines: scholarships, industry placements, regional hubs, Aboriginal researcher pathways. Partnerships: structured collaboration across government, industry, communities.

Appendix 3: Justification of capacity relevance by megatrend

The Megatrend capacity heatmap section of this report (Fig 1, p16-17) shows how different areas of WA's agricultural RD&E capacity needs align with global 'megatrends'. This Appendix 3 provides a brief explanation of the justification of capacity relevance by megatrend for each of the WA capacity domains.

RD&E Capacity needs themes	Growth Juggernaut	Fractal Politics	More from Less	Cascading Planetary Risks	Disruptive Technologies	Positioning for the Future
Data & Digital (AI/ IoT / Robotics / Data Governance)	3 – Digital technologies unlock scale and efficiency gains, critical to WA's grain and livestock growth.	2 – Data sovereignty and governance are political, but less core to WA agriculture's productivity.	2 – Data helps optimise inputs but needs adoption and integration to achieve impact.	2 – Risk forecasting and monitoring supported, though not yet fully embedded in decision-making.	3 – Foundational to automation, robotics, and emerging platforms shaping production.	3 – A long-term enabler for competitiveness, especially in export-oriented WA.
Climate Adaptation & Environmental Markets (MRV)	2 – Growth relies on adaptation in marginal zones, but less immediate than genetics or markets.	2 – Carbon and biodiversity markets are politically contested.	3 – Essential to meet 'produce more with less' by capturing value in MRV systems.	3 – Directly addresses cascading risks (climate shocks, drought, carbon).	2 – Emerging tech (satellite, sensors) underpins but don't drive adaptation alone.	3 – Strong future positioning as WA differentiates on sustainability credentials.
Biosecurity & Market Access	3 – WA's clean status underpins export growth.	2 – Trade barriers and politics influence, but not always controllable.	2 – Efficiency gains less biosecurity-driven.	3 – Climate shifts increase pest/disease risks; maintaining access is critical.	1 – Tech plays more of a support role (surveillance) than a driver.	2 – Sustained but not transformative; a hygiene factor for WA's premium exports.
Systems Agronomy & Farm Engineering	3 – Core to intensification and sustaining WA's productivity.	2 – Policy settings affect system adoption but less critical.	3 – Directly reduces input reliance and boosts efficiency.	3 – Key to resilience in the face of variable climate and global shocks.	2 – Enabled by tech, but agronomy systems are more than just digital.	3 – Essential foundation for WA's future systems-based competitiveness.

Genetics & Breeding	3 – Drives yield gains and resilience in WA's crops and livestock.	2 – Some intersection with trade/IP rules, but less political leverage.	3 – Direct route to 'more with less' through input-efficient varieties.	2 – Important for adaptation but slower cycle than agronomy.	3 – Gene editing, genomics are disruptive forces.	3 – Positions WA as globally competitive in export-focused commodities.
Water Systems & Irrigation	2 – Not WA's growth bottleneck compared to dryland systems.	2 – Water allocation and regulation are politically sensitive.	3 – Efficiency in irrigation critical where systems are used.	3 – Affected directly by climate volatility and scarcity.	2 – Tech assists (smart irrigation), but adoption slower in WA.	2 – Long-term value, but WA remains mostly dryland-dominated.
Market / Consumer Intelligence & Provenance	3 – Differentiation drives premium exports.	3 – Consumer standards increasingly shaped by politics and traceability.	2 – Efficiency less central, but waste reduction supports margins.	2 – Consumers expect sustainable responses, but less direct for risks.	2 – Tech (blockchain, QR traceability) enables provenance claims.	3 – Essential to securing WA's place in premium markets.
Trade/Policy & Risk Analytics	2 – Trade knowledge underpins but doesn't directly drive production.	3 – High exposure to fractal politics/geopolitics in export-oriented WA.	2 – Efficiency less linked to trade analytics.	2 – Supports risk mitigation but not core production response.	2 – Modelling and foresight tools emerging, but less transformative.	3 – Critical to navigating volatility and positioning WA globally.
Extension & Adoption Science	3 – Scaling adoption of research is critical to productivity growth.	3 – Strong extension mitigates misinformation and political contest.	3 – Adoption ensures efficiency and input-saving practices land with growers.	2 – Extension aids resilience but can't remove external shocks.	2 – Tech alters extension delivery but doesn't replace human networks.	3 – Long-term competitiveness depends on effective adoption pathways.

Appendix 4: Review of ‘Strategic examination of R&D’ paper

The following information includes a more detailed review of Strategic Examination of R&D: discussion paper consultation findings and analysis (Department of Industry, Science and Resources July 2025), in relation to key question areas from the Needs Analysis of Human Capacity in WAARC RD&E Sector.

1. Attraction and retention factors

(Salary competitiveness, contract security, career progression, research infrastructure, cost-of-living pressures)

- **Salary and pay:** Stakeholders called for higher pay for early-career researchers and PhD candidates, and for competitive salaries to attract top talent.
- **Contract security:** Submissions highlighted the reliance on short-term contracts as a barrier to retention, with calls for more permanent positions and long-term funding.
- **Career progression:** The need for clearer career pathways, structured mentoring, and leadership development programs was emphasised.
- **Research infrastructure:** The lack of sustained national funding for infrastructure (labs, digital systems, technical staff) was identified as a problem, with calls for a dedicated infrastructure fund and long-term planning.
- **Cost-of-living pressures:** The report notes recommendations to raise HDR (PhD) stipends to minimum wage and tie them to cost-of-living measures.

2. Pipeline and career pathways

(Graduate enrolments, PhD completions, postdocs, industry secondments, retention in Australia)

- **Graduate enrolments/PhD completions:** The report does not provide statistics on enrolments or completions.
- **PhD stipends and support:** Concerns that stipends are inadequate and not attracting the ‘best and brightest’, calls to raise them and provide more targeted funding.
- **Post-doctoral positions:** Early-career researchers (postdocs) identified as needing more secure, funded positions.
- **Industry secondments/mobility:** Multiple references to flexible fellowships, ‘innovation sabbaticals’, and structured industry PhD programs to strengthen pathways between universities and business.
- **Retention in Australia:** Concerns that Australia may lose talent overseas due to low stipends, insecure jobs, and global competition for skilled migrants. Example: over 60% of Australia’s engineering workforce is migrant based; risk of losing capability.

3. Diversity and inclusion – gender balance, indigenous participation, and international recruits; how diversity affects innovation and collaboration

Gender balance/Women in STEM

- Submissions highlighted that focusing only on STEM and excluding HASS in the discussion paper further disadvantaged women and marginalised groups.
- Workforce recommendations included targeted programs at every stage (school, university, early career) to build a larger and more diverse R&D workforce, specifically supporting women and underrepresented groups.
- STEM education and training section emphasised improving the inclusion of women in STEM alongside other underrepresented groups.

Indigenous participation

- Elevating First Nations R&D was a dedicated theme. Feedback included:
 - Co-design principles, ethical engagement, and culturally appropriate research. Calls for Indigenous-led CRCs, an Office of Indigenous STEM, and Indigenous Innovation Showcases.
 - Fewer than 1% of Indigenous Australians hold a university STEM qualification – highlighting a major challenge.
 - Recognition of Indigenous knowledge as vital to sustainability and national R&D outcomes.

International recruits/global mobility

- Australia's engineering workforce is heavily reliant on migrant talent, with over 60% of the workforce born overseas. Submissions warned that global competition may threaten Australia's ability to attract and retain these recruits.
- Submissions emphasised better use of skilled migration and talent visas, particularly in high-demand areas like AI and clean energy.

Diversity and innovation/collaboration

- Promoting diversity and inclusion in the R&D workforce was linked to strengthening innovation and collaboration outcomes. Submissions stressed that embedding equity and diversity into workforce strategies improves the system's resilience and effectiveness. Suggested R&D metrics included tracking gender diversity and Indigenous participation as part of measuring societal and innovation impact.

4. Interdisciplinary capability

(Capacity to form teams that integrate agronomy with data analytics, economics, and social science for systems-level problems)

- The report refers broadly to multidisciplinary and mission-oriented approaches rather than specific integration of agronomy/data/economics/social science. Example: submissions highlighted that the UK's R&D Missions Program encourages multidisciplinary approaches to address national needs.

- Stakeholders emphasised that Australia should prioritise R&D in critical sectors (AI, biotech, agriculture, etc.) using multidisciplinary research teams.
- The culture change section also notes a need for interdisciplinary collaboration across government, academia and industry to overcome silos
- The references remain general to multidisciplinary research.

5. Industry–research linkages

(Effectiveness of pathways that move talent between universities, government agencies, grower groups, RDCs, and private sector)

- Collaboration section: Strong emphasis on improving university, industry collaboration through incentives, shared infrastructure, IP reform, and industry PhD programs. Specific mechanisms mentioned include:
 - Industrial PhD programs and targeted personnel movement between university and industry.
 - Secondments and ‘innovation sabbaticals’ across academia–industry–government to enable mobility.
 - Intellectual property and technology transfer section: Notes that effective collaboration requires flexible IP and career pathways allowing movement between academia, industry and government.
 - Workforce challenges section: Calls for structured pathways such as industry PhD programs, hybrid appointments, secondments, and mobility schemes across academia, government, start-ups and business.
 - One stakeholder quote: ‘Academics need to be interested in industry and industry problems, and they can’t do that if they haven’t worked with or in industry. We need to get better at encouraging academics and industry people to move back and forth between the sectors’ (Business Council of Australia).

6. Professional development and upskilling

(e.g. Mid-career training in AI, remote sensing, carbon accounting, IP management, science communication)

- The document makes general references to the need for professional development, leadership training, and career development opportunities:
 - Calls for continuous professional development opportunities in leadership, entrepreneurship, and commercialisation.
 - Mentorship and structured career pathways to support researchers at different career stages.
 - Upskilling in commercialisation and industry collaboration skills.

7. Succession risk mapping

(Identifying ‘single-point-of-failure’ roles where a small number of individuals hold unique expertise)

- Workforce challenges are discussed (job insecurity, diversity, attracting talent, mobility between sectors, but not succession planning or risk of knowledge concentration).

8. Discipline coverage and depth – needs/gaps by area of expertise

- The report discusses the need to prioritise critical technology sectors (AI, quantum, blockchain, biotech, energy storage, agriculture, materials science, aerospace) as areas of national strategic focus and to avoid dispersing effort across too many stakeholders. It also highlighted that R&D definitions should broaden to capture non-traditional disciplines, such as social innovation, humanities, arts, and service sectors.

9. Geographical distribution – regional hubs vs city-based institutions; impact on RD&E delivery

- The role of regional universities is mentioned under infrastructure: ‘Regional universities without access to additional sources of funding cannot invest in maintenance, sustainment, and purchase of research infrastructure except on a piecemeal basis’.
- Submissions suggested regional collaboration hubs could be integrated into National Collaborative Research Infrastructure Strategy (NCRIS) to expand access and strengthen regional capacity. STEM education recommendations also referenced the need to promote Tech Schools and STEM outreach in regional locations, so that students in regional communities can see and access R&D career pathways.

10. Comparison of findings from the WA agricultural RD&E capacity needs analysis, national/global content, and Strategic examination of R&D: discussion paper consultation findings and analysis

Table 7 below provides a brief comparison of findings from the WA agricultural RD&E capacity needs analysis and national/global content, both from this literature review, and the Strategic Examination of R&D: discussion paper consultation findings and analysis (Department of Industry, Science and Resources, July 2025).

Table 7: Comparison of findings from the WA agricultural RD&E capacity needs analysis and national/global content

(Both from this literature review and the Strategic Examination of R&D: discussion paper consultation findings and analysis)

Issue	WA-Specific Findings	National/Global Findings in WA Review	Strategic Examination of R&D
Attraction & Retention	Workforce shortages in WA RD&E. Current workforce strengths and weaknesses to be identified via survey and interviews. Need to	WA universities’ reliance on international student revenue underpinning capacity.	Workforce and capacity indicators; inclusion and retention measures; infrastructure as an enabler.

	renew ageing WA research infrastructure.		
Pipeline & Career Pathways	Current and forecast workforce gaps to be identified via survey and interviews.	Recommendation to benchmark WA against other agricultural economies.	Training programs, multi-year funding. Metrics on PhD employment, retention, and diversity.
Diversity & Inclusion	Low CaLD/NESB representation at management level. International recruitment friction in WA regions.	Public sector diversity snapshot including women in senior roles and Indigenous participation.	Inclusion of First Nations women in STEM, disability. Metrics include gender diversity and Indigenous participation.
Interdisciplinary Capability	Systems approach interdisciplinary teams including social sciences. Need extension/behavioural science for adoption.	Cites CSIRO megatrends, OECD frameworks, and national strategies on systems approaches.	Mission-oriented, multidisciplinary research promoted nationally.
Industry–Research Linkages	WAARC links DPIRD, CSIRO, GGA, Curtin, Murdoch, and UWA. Need to reduce transaction costs and duplication in WA RD&E.	Align with industry, and global strategies.	Industrial PhDs, personnel mobility, IP/contracting reform, and collaboration metrics.
Professional Development & Upskilling	Capacity needs will be identified via the online survey and interviews.	RD&E areas and skills identified via WA strategies are compared against approaching megatrends.	Training programs, commercialisation/IP literacy, and workforce capacity metrics.
Succession Risk Mapping	Data and intelligence to be gathered via survey and interviews.	Mentions international and national risk of expertise loss.	No explicit succession risk or single-expert mapping; focus on workforce diversity and capability.
Discipline Coverage & Depth	Data and intelligence to be gathered via survey and interviews.	References to benchmarking WA capacity coverage against national and global agricultural R&D disciplines.	Highlights critical technologies (AI, biotech, energy, agriculture) as priorities. Notes under-recognition of social sciences, HASS, and service sectors.
Geographical Distribution	Notes challenges in attracting and retaining expertise in regional WA. Dependence on Perth-based universities and DPIRD hubs for capability. Regional delivery constrained by remoteness.	References national and international comparisons of urban vs regional R&D concentration.	Regional universities face infrastructure challenges. Suggestion to create regional collaboration hubs. Emphasis on outreach and STEM pathways in regional areas.

Appendix 5: Specific industry RD&E issues not captured in broader analysis

Appendix 5 identifies specific industry RD&E issues not captured (or significantly highlighted) in the WA agricultural RD&E capacity needs analysis findings from this literature review.

RD&E issue not captured in broader consolidated capacity needs analysis findings	RD&E skills and knowledge required
Beef: End-to-end digital traceability (blockchain, data interoperability across genetics, grading, market feedback).	Blockchain technology, agri-data interoperability, supply chain informatics, digital QA systems.
Beef: Digital QA tools for food safety and eating quality.	Food safety science, sensor technologies, digital quality assurance systems.
Beef: Deforestation-free supply chain research.	Sustainability certification systems, land-use monitoring, supply chain governance.
Sheep/Wool: Flystrike resistance breeding linked to climate adaptation.	Animal genetics, parasitology, and climate resilience breeding methods.
Grains: Salinity-specific adaptation pathways for WA cropping systems.	Soil science, plant physiology, salt-tolerant crop breeding, hydrology.
Beef: Lumpy skin disease and FMD rapid diagnostics.	Veterinary epidemiology, virology, molecular diagnostics, rapid response systems.
Beef: Parasite control (ticks, worms) with resistance management.	Veterinary parasitology, integrated pest management, drug resistance modelling.
Beef: Farm infrastructure/logistics (roads, ports, cold chain).	Ag engineering, supply chain logistics, infrastructure economics.
Sheep/Wool: Shearing, wool harvesting tech, labour efficiency.	Ag engineering, robotics, workforce innovation, labour studies.
Beef: Genomic pathways for low-methane cattle.	Animal genomics, methane physiology, bioinformatics.
Sheep/Wool: Wool fibre quality improvement beyond reproduction/flystrike.	Textile science, fibre genetics, wool quality measurement.
Beef: Water governance in northern finishing systems.	Water resource economics, hydrology, rangeland management.
Beef: Value-based marketing (genetics, MSA grading, eating quality).	Ag economics, meat science, consumer behaviour, marketing analytics.
Horticulture: Post-harvest handling and shelf-life.	Post-harvest physiology, packaging technology, food preservation science.
Beef: Policy/regulatory RD&E for live export.	Trade policy, regulatory science, live export compliance.

Sheep/Wool: Future of live sheep export markets.	Trade policy, risk analysis, Middle East/Asia market intelligence.
Beef: Indigenous participation and workforce retention.	Rural sociology, Indigenous engagement, workforce development.
Beef: Workplace safety and leadership in beef enterprises.	Ag workforce safety, HR development, leadership training.

Appendix 6: OECD Acronym Glossary

Acronym	Full Term	Notes/Context
ABC+ Plan	Plano ABC+ (Brazil's Low Carbon Agriculture Plan)	Brazil's program for sustainable agriculture and emissions reduction
AKIS	Agricultural Knowledge and Innovation Systems	Networks linking researchers, farmers, advisors, and policymakers to drive innovation and adoption
APME	Agricultural Policy Monitoring and Evaluation	OECD's annual flagship report assessing agricultural policies, support, trade, and RD&E
CAP	Common Agricultural Policy	The EU's primary agricultural policy framework
CAR	Cadastro Ambiental Rural	Brazil's national rural environmental registry, tied to land-use compliance
CH ₄	Methane	Potent greenhouse gas produced from livestock and paddy rice systems
EIP-AGRI	European Innovation Partnership for Agricultural Productivity and Sustainability	EU initiative supporting agricultural innovation and adoption
EO	Earth Observation	Satellite or airborne sensing technologies for monitoring land, crops, water, and emissions
ERS	Economic Research Service	Agency within the USDA (United States Department of Agriculture)
ETS	Emissions Trading Scheme	Market system where emission allowances can be traded
FMIS	Farm Management Information Systems	Digital tools/software for farm planning, operations, and compliance
FPO	Farmer Producer Organisation	Collective entities of smallholder farmers in India for bargaining power and market access
GE	General Equilibrium modelling	Macro-economic modelling capturing interactions across the economy
GHG	Greenhouse Gas(es)	Includes CO ₂ (carbon dioxide), CH ₄ (methane), N ₂ O (nitrous oxide)
GIS	Geographic Information System	Mapping/analysis technology often paired with remote sensing
GSSE	General Services Support Estimate	OECD measure of government support to agriculture not linked directly to farmers
HCD	Human Capacity Development	Programs to build workforce skills and knowledge
HIS	Import Health Standards	Sanitary requirements regulating agricultural imports (used in New Zealand)

IRA	Inflation Reduction Act	Major US legislation with large investments in climate and agriculture
LCA	Life Cycle Assessment	Method to assess environmental impacts of products/systems over their full life cycle
MPS	Market Price Support	Government policy raising domestic farm prices above world prices
MRV	Measurement, Reporting and Verification	Frameworks for quantifying and validating emissions, carbon sequestration, or environmental outcomes
Microsim	Microsimulation modelling	Economic modelling at the household or farm level to simulate distributional impacts of policy or technology change
N ₂ O	Nitrous Oxide	Potent greenhouse gas from fertiliser use and soils
RS	Remote Sensing	Collection of information about the Earth via satellites or aircraft
SPG	Sustainable Productivity Growth	Increasing agricultural output while reducing environmental impact
TEA	Technology Evaluation and Assessment	Analysis of costs, benefits, and adoption pathways of technologies
TFP	Total Factor Productivity	Measure of productivity growth considering all inputs and outputs
USDA	United States Department of Agriculture	US federal agriculture agency
WUR	Wageningen University & Research	Netherlands-based agricultural university and research organisation
ZARC	Zoneamento Agrícola de Risco Climático	Brazil's climate risk agricultural zoning system
e-NAM	electronic National Agricultural Market	Pan-India online trading platform for agricultural commodities