

Final Report

Driving on-farm productivity with augmented technologies for fruit growers

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Think Digital Studios Pty Ltd

Project code:

AS23002

Project:

Driving on-farm productivity with augmented technologies for fruit growers (AS23002)

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Public summary

Hort Innovation and Think Digital partnered to explore the potential of immersive technologies such as virtual reality (VR) and augmented reality (AR), with a specific focus on viewing and interacting with agronomy data (immersive data visualisation), as a digital twin or in situ on farm, to enhance on-farm productivity and decision-making in the Australian table grape and berry sector.

The project engaged 25 industry representatives including growers, agronomists, educators, and advisors through interviews and focus groups in Mildura, Coffs Harbour, and Adelaide to assess industry appetite, identify practical applications, and understand adoption barriers.

The research revealed that while immersive analytics holds long-term potential, there is currently no clear or viable industry-wide application for immersive data visualisation in these sectors. Key barriers include poor on-farm connectivity, limited and inconsistent data capture (particularly in the berry sector), challenges integrating disparate data systems, and strong reliance on experience-based knowledge among growers. Many growers expressed that simply visualising existing data in new formats provides limited value without addressing fundamental data infrastructure gaps.

However, the project identified significant opportunities for immersive technologies in workforce development and training. These include streamlining onboarding processes for seasonal workers, delivering safety training in multiple languages, simulating complex tasks such as picking and pruning, supporting remote assistance through wearable devices, and training future agronomists and advisors in educational settings. Lower-cost wearable technologies combined with AI-enabled tools for disease identification, fruit ripeness assessment, and pruning guidance show particular promise.

The project's key recommendations prioritise investment in data literacy and data capture infrastructure, development of industry-aligned immersive training modules that can be adapted across farms, piloting immersive training in universities and TAFEs, and ensuring strong extension support accompanies any technology rollout. While immersive data visualisation is not an immediate priority, immersive technologies can play a valuable role in building a future-ready horticultural workforce when implemented alongside robust extension services and grounded in real-world grower needs.

Technical summary

This exploratory research project assessed the technical and practical feasibility of deploying immersive analytics (AR/VR data visualisation) for productivity enhancement in Australian table grape and berry production systems. Through qualitative research, the project conducted structured interviews and focus groups with AR/VR technology demonstrations and 25 stakeholders across two primary production regions.

Findings indicate that current on-farm data infrastructure is insufficient to support meaningful immersive data visualisation at scale. The berry sector demonstrated particularly low data maturity, with minimal systematic data capture beyond basic production records. The table grape sector showed higher data literacy levels driven by export market requirements, though data remains siloed across proprietary platforms limiting integration opportunities.

Technical constraints identified include hardware limitations (cost, durability, battery life, sunlight visibility), infrastructure gaps (connectivity, offline capability), and human factors (surveillance concerns, preference for tacit knowledge over formalised data systems). Only one site (Talia Farms) demonstrated sufficient data infrastructure to theoretically support immersive analytics implementation.

Alternative applications in workforce capability development showed higher near-term viability, with potential ROI through reduced training time, improved safety outcomes, multilingual delivery, and remote expert support. The project recommends prioritising data infrastructure investment and immersive training applications over data visualisation tools in the current context.

Keywords

Augmented reality; virtual reality; immersive technology; data visualisation; workforce training; table grapes; berries; on-farm productivity; digital literacy; horticulture; digital twin.

Introduction

Background

This project was undertaken as part of Hort Innovation's commitment to supporting digital innovation and future-ready workforce development in Australian horticulture. Hort Innovation determined that we focus on the table grape and berry sectors. They were selected as focus areas due to their high-value, labour-intensive nature and increasing reliance on timely, context-specific decisions for crop management, quality control, and workforce coordination.

Traditional approaches to farm data visualisation through dashboards and mobile applications have limitations in field environments where growers and workers need hands-free, contextually appropriate information delivery. Immersive technologies including virtual reality (VR) and augmented reality (AR) offer potential alternatives by placing data in spatial, interactive environments that could enhance decision-making speed and accuracy.

Rationale

Despite growing interest in immersive technologies across agriculture globally, few market-ready solutions exist for on-farm productivity enhancement in horticulture. Barriers include hardware limitations, connectivity challenges, development costs, and uncertain return on investment. Think Digital, as a leading provider of immersive technology solutions for agriculture, recognised the need for evidence-based research to assess genuine industry appetite and practical applications before significant development investment.

The project aimed to answer fundamental questions: Do growers and agronomists see value in immersive data visualisation? What are the practical barriers to adoption? Where are the highest-value applications? What infrastructure and support would be required for successful implementation?

Industry Significance

Both target sectors face significant workforce challenges including seasonal labour shortages, training inefficiencies, and difficulty transferring knowledge to culturally and linguistically diverse workforces. Additionally, increasing pressure for data-driven management (ESG reporting, market access requirements, sustainability metrics) creates tension between data collection requirements and practical on-farm utility.

Understanding the realistic potential and limitations of immersive technologies in these contexts provides valuable intelligence for future R&D investment decisions, helps prevent costly development of unviable solutions, and identifies genuine opportunities for technology-enabled productivity gains.

Project Linkages

This project aligns with Hort Frontiers' strategic focus on emerging technologies and workforce capability. Foundational learnings build on Think Digital's previous work presenting at Hort Connect and RUBUS workshops on labour optimisation, where conceptual applications of VR/AR for productivity were discussed but lacked empirical validation of industry demand and practical constraints.

Methodology

Research Design

The project employed qualitative research methods to gather rich, contextual insights about grower perceptions, operational constraints, and technology adoption factors. The University of Adelaide were contracted to help undertake the research component.

Participant Recruitment

Target Population: Growers, agronomists, farm advisors, and educators in table grape and berry sectors across Australia.

Sampling Strategy: Purposive sampling to ensure representation across:

- Geographic regions (Mildura, Coffs Harbour, Adelaide regions)
- Farm sizes and production systems
- Market orientations (export vs domestic focus)
- Technology adoption levels

Final Sample: 25 participants comprising:

- Table grape growers and agronomists
- Berry growers and agronomists
- Agricultural educators and researchers
- Industry association representatives

Partner Organisations Engaged:

- Australian Table Grape Association Inc.
- OZGroup Coop
- Talia Farms
- SJDC Produce
- Independent agronomists (Andy Clarke, Owen Williams)
- University of Adelaide (Dr Emily Buddle - Research Lead)

Data Collection Methods

Field Visits: Representatives from University of Adelaide and Think Digital conducted on-site visits:

- Mildura: 10 April 2025
- Coffs Harbour: 28-29 April 2025
- Adelaide region: 27 May 2025

Interview Format:

- Face-to-face interviews at farm sites
- Video interviews via Zoom for additional participants
- Focus group discussions at key locations

Technology Demonstrations: During field visits, Think Digital demonstrated:

- Collaborative VR data analysis environments
- AR wearables (HoloLens) for in-field data overlay
- AI-enabled smart glasses (Meta) for recognition tasks
- Interactive digital twin concepts
- VR training simulations

Data Analysis

All interviews and focus groups were audio recorded with participant consent, professionally transcribed, and analysed using thematic analysis to identify:

- Key opportunities for immersive technology application
- Barriers and constraints to adoption
- Data infrastructure requirements
- Training and support needs
- Social and cultural considerations

Research Team Adaptation

Note on Research Personnel: The project originally planned to engage a PhD student through University of South Australia's CSIRO Augmented Human Operations program. Due to recruitment delays and timeline constraints, the project pivoted to engage Dr Emily Buddle from University of Adelaide as research lead. This adaptation maintained research quality while ensuring project deliverables could be met within the contracted timeframe.

Project Reach and Target Audience

Geographic Reach: Regional (Victoria, New South Wales, Queensland and South Australian table grape and berry production regions)

Primary Target Audiences:

- Commercial table grape and berry growers
- Agricultural consultants and agronomists
- Farm managers and supervisors
- Seasonal workforce coordinators
- Agricultural educators and training providers

Secondary Target Audiences:

- Hort Innovation investment decision-makers
- Technology developers and service providers
- Industry peak bodies and associations

Results and discussion

Key Finding: No Clear Industry-Wide Application for Immersive Data Visualisation

Despite targeted questioning about data visualisation needs, the research found no clear, or immediate, or viable applications of immersive analytics that would benefit the table grape or berry sectors at an industry-wide scale. While individual businesses expressed interest in innovative technologies, consistent barriers emerged that prevent meaningful near-term adoption.

Primary Barriers to Immersive Analytics Adoption

1. Poor Connectivity Infrastructure

Limited on-farm internet access remains a fundamental constraint. While emerging satellite technologies like Starlink may address connectivity in future, current infrastructure gaps make real-time data streaming and cloud-dependent applications impractical for many operations.

2. Lack of Consistent Data Capture

The most critical barrier is that the data required for meaningful visualisation is often not being collected:

- **Berry Sector:** Data capture is largely absent or in early stages. Regular systematic data collection beyond basic production records is uncommon. Without reliable data streams, immersive visualisation cannot add value regardless of technology sophistication.
- **Table Grape Sector:** More advanced data practices exist, driven by export market requirements for traceability and quality assurance. Growers collect soil testing, sap analysis, and production data. However, data remains fragmented across multiple proprietary platforms, limiting integration and comparative analysis opportunities. Growers expressed frustration navigating multiple apps to access information.

3. Market Orientation Drives Data Culture

Clear differences emerged in data appetite based on market destination:

- **Export-Oriented (Table Grapes):** Strong incentives for data capture to meet international quality standards, traceability requirements, and maintain Australia's premium market reputation. This creates pull for investment in digital tools that enhance efficiency and supply chain transparency.
- **Domestic-Oriented (Berries):** Lower regulatory pressure and consumer demands for data-driven traceability reduce perceived value of systematic data collection. ROI for data infrastructure investment is less evident.
- **Data Driven Decision Making Gap:** More research is needed to identify what specific data is required to allow for a meaningful data visualisation model for agronomists and growers to make more informed decisions.

4. Experience-Based Knowledge vs Formal Data Systems

Many growers described deep, intuitive knowledge of their land, crops, and climate built over years or generations. This tacit knowledge creates resistance to formalised data collection and visualisation:

- Growers feel data often confirms what they already know through observation
- Value proposition unclear unless data offers genuinely new insights or solves specific problems
- Technology seen as potentially interrupting rather than enhancing existing decision-making processes

5. Integration and Literacy Challenges

Even when data exists, growers face:

- Difficulty managing large datasets
- Inability to integrate data across proprietary systems
- Limited data literacy to interpret complex visualisations
- Perception that data analysis is responsibility of managers/advisors rather than field workers

Hardware and Technical Constraints

Beyond data availability, multiple hardware limitations constrain field deployment:

Cost: High upfront investment for VR/AR hardware, particularly when scaled across large seasonal workforces. Current devices too expensive for widespread workforce distribution.

Durability: Most AR/VR equipment unsuitable for agricultural environments:

- Poor visibility in direct sunlight
- Short battery life inadequate for full work shifts
- Susceptible to dust, moisture, and physical damage
- Uncomfortable for extended wear in hot conditions

User Experience: Current devices not optimised for:

- Quick information access during active work
- Hands-free operation during manual tasks
- Simple interfaces for workers with varying digital literacy
- Multilingual support for diverse workforces

Social and Human Factors

Important non-technical concerns emerged:

Surveillance and Trust: Wearable devices with cameras and tracking capabilities raised concerns about:

- Worker privacy and autonomy
- Potential erosion of employee trust
- Workplace culture impacts
- Use of data for monitoring rather than support

Erosion of Human Connection: Service providers (agronomists, extension officers, technical representatives) provide dual value:

- Expert technical advice
- Social interaction and support, particularly important in isolated rural contexts
- Trust built through face-to-face relationships
- Contextual understanding from on-ground presence

Technology replacing these roles risks losing valuable social infrastructure alongside technical knowledge transfer.

Previous Technology Failures: Growers referenced past digital tool rollouts that failed due to:

- Lack of ongoing support after implementation
- Unclear value propositions
- Tools designed without genuine user input
- Insufficient training and extension services

Positive Finding: Significant Opportunities in Workforce Development

While data visualisation showed limited near-term viability, substantial opportunities emerged for immersive technologies in training and workforce capability:

Training and Onboarding: VR/AR could significantly reduce training time for:

- Picking and pruning techniques
- Equipment operation and safety
- Quality assessment and grading
- Packing shed procedures

Multilingual Training Delivery: Particularly valuable for seasonal workforce with limited English proficiency. VR simulations with visual demonstrations reduce language barriers and improve comprehension and safety outcomes.

Pre-Employment Assessment: VR environments could help workers understand job requirements and assess suitability before arrival, potentially improving retention and job satisfaction.

Remote Expert Support: Low-cost wearable devices (POV cameras) could enable:

- Real-time remote assistance from agronomists
- Quality control checks without on-site presence
- Knowledge transfer from experienced to new workers
- Reduction in agronomist travel time and fatigue

Educational Applications: Strong potential for university and TAFE programs to integrate immersive technologies for training future agronomists and advisors in:

- Crop assessment and diagnostics
- Pest and disease identification
- Machinery operation and safety
- Data interpretation and decision-making

Sector-Specific Insights

Table Grapes:

- Longer crop cycles (permanent plantings) provide better ROI justification for data infrastructure investment
- Export focus drives stronger data culture
- Higher baseline digital literacy
- Greater potential for eventual adoption of data visualisation once infrastructure matures

Berries:

- Shorter crop cycles make ROI harder to justify for expensive monitoring systems
- Domestic market focus reduces data capture incentives
- Lower current digital maturity creates larger capability gap
- May benefit more from basic data literacy and data capture extension programs before advanced visualisation tools

Potential Adopter Site: Talia Farms, Sunraysia Region

Only one participant site (Talia Farms) demonstrated sufficient data infrastructure, capture consistency, and digital maturity to potentially support meaningful immersive analytics implementation. This outlier highlights that applications are possible but require significant foundational investment in data systems before visualisation technology adds value.

Outputs

Table 1. Output summary

Output	Description	Detail
Research Report	Comprehensive analysis of immersive technology opportunities and barriers in table grape and berry sectors	Written report supplied as part of Final Milestone Report (190).
Industry Presentation	Panel presentation delivering research findings and recommendations	Live presentation with recording, delivered to industry participants, Hort Innovation staff, PRG members. Delivered via google meeting on 17 September, 2025.
Stakeholder Engagement	25 interviews and focus groups across two production regions	Face-to-face and virtual meetings with growers, agronomists, educators. Conducted April-May 2025.
Technology Demonstrations	Live demonstrations of VR data analysis environments, AR wearables, and AI-enabled smart glasses	On-site demonstrations conducted April-May 2025 with research participants
Final Milestone Report (190)	Summary of achievement against milestone criteria for PRG decision-making	Written report for Hort Innovation, PRG. Delivered October 2025

Photos/images/other audio-visual material

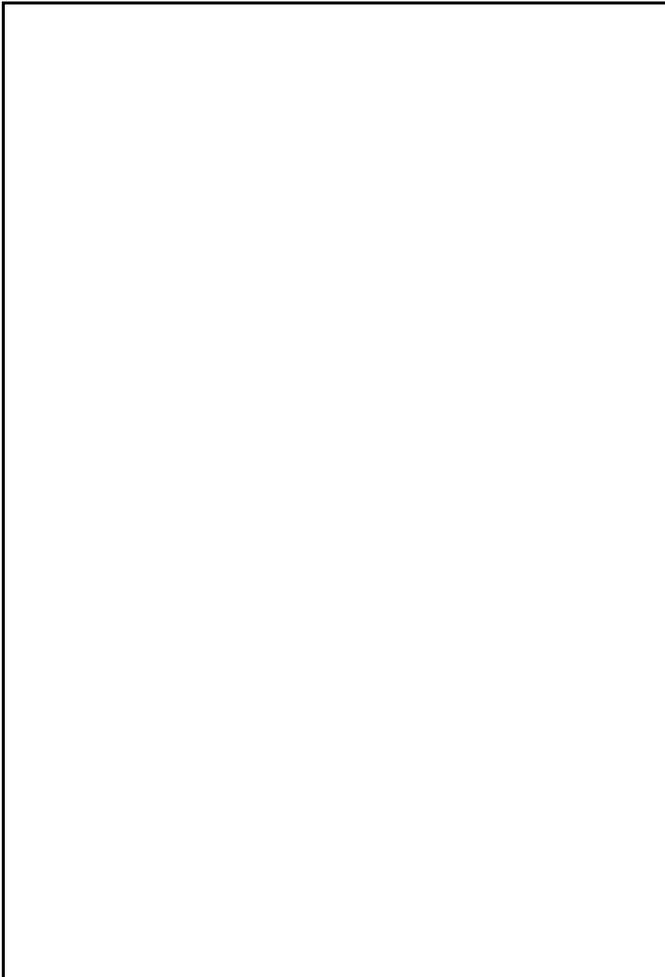
<p>Focus group and tech demonstrations conducted at the Tablegrape Association Meetup in Mildura</p>	
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On farm interview and demonstrations conducted at Talia Farms, Sunraysia region



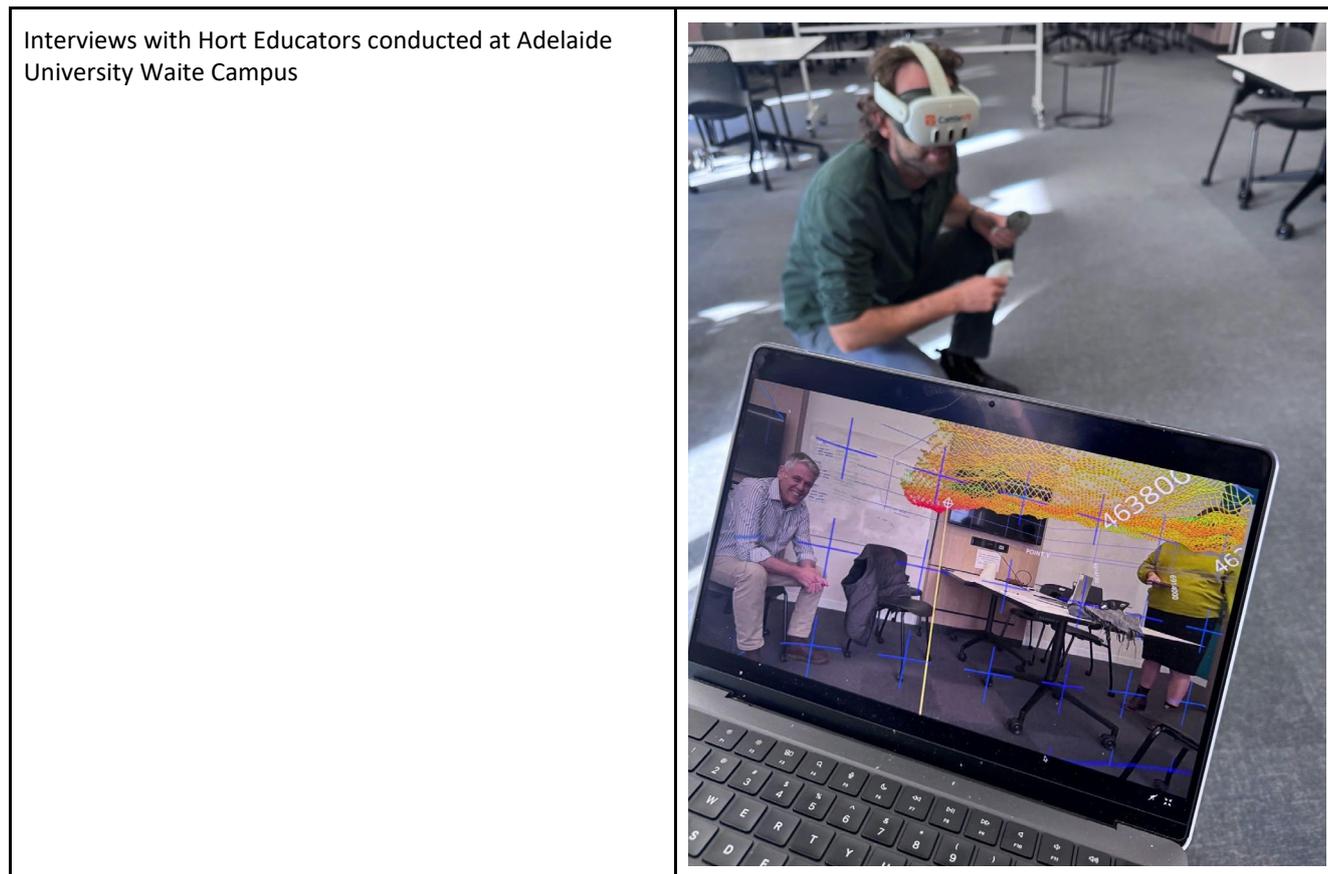
Focus group and tech demonstrations conducted at the Tablegrape Association Meetup in Mildura





Packing House tour conducted at the OZGroup Coffs Harbour





Technology Demonstrations Conducted

During field visits, Think Digital demonstrated multiple immersive technology applications:

1. Collaborative VR Data Analysis Environment - Interactive platform allowing users to explore agronomy data across X, Y, and Z axes in virtual space, simulating how growers and agronomists could analyse spatial data collaboratively
2. AR Wearable Devices - Demonstrated HoloLens devices showing potential for overlaying data directly in field environments (digital twins, heat maps, plant growth information)
3. AI-Enabled Smart Glasses - Showcased Meta glasses with AI recognition capabilities for potential applications in fruit ripeness assessment, pest identification, remote support, and quality grading
4. VR Training Simulation - Presented simulation developed for another industry demonstrating how tactile activities (such as fruit packing) could be taught through immersive environments with haptic feedback

Evidence-Based Decision-Making Output

Critically, the project's most valuable output is the finding itself: preventing investment in a technology solution that would not have delivered industry-wide value. This evidence-based decision-making:

- Saves potential wasted investment in premature technology development
- Redirects focus to higher-value applications (workforce training)
- Identifies prerequisite investments (data infrastructure and literacy)
- Provides clear guidance for future R&D prioritisation

Stakeholder Reach

- **Direct engagement:** 25 industry representatives
- **Geographic coverage:** Mildura, Coffs Harbour, Adelaide regions
- **Organisations engaged:** 8+ industry organisations and commercial operations
- **Presentation reach:** Industry panel presentation to PRG and broader stakeholder group (September 17, 2025)

Outcomes

Table 2. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Evidence-based technology assessment	Hort Frontiers: Driving innovation and emerging technologies in horticulture	Generated robust empirical evidence about immersive technology viability and applications in target sectors	25 stakeholder interviews, comprehensive research report, industry presentation
Identified workforce development opportunity	Workforce capability and skills development	Discovered high-value application area for immersive technologies in training and capability building	Consistent stakeholder feedback on training challenges and technology potential
Prevented premature investment	Efficient use of Frontier funds and strategic R&D investment	Evidence shows immersive data visualisation not currently viable, saving potential misallocation of R&D funds	Research findings presented to PRG for continuation decision
Highlighted data infrastructure gap	Digital agriculture readiness and data-driven decision-making	Revealed fundamental need for data literacy and capture investment before advanced visualisation tools can add value	Documented lack of data availability particularly in berry sector
Built industry understanding	Enhanced grower, agronomist, and advisor knowledge of immersive technology with integrated Ai potential and limitations	Enhanced grower, agronomist, and advisor knowledge of immersive technology potential and limitations	Technology demonstrations, stakeholder discussions, accessible research communication

Intermediate Outcomes

Changed Knowledge and Attitudes:

- Industry stakeholders gained realistic understanding of immersive technology capabilities and constraints
- Growers and agronomists exposed to emerging technologies previously unfamiliar to many participants
- Enhanced appreciation for data infrastructure requirements to support advanced digital tools
- Recognition of workforce training as high-priority application area

Changed Practice:

- Project pivot from PhD student to University of Adelaide experienced researcher demonstrated adaptive project management when circumstances changed
- Think Digital's business model and go-to-market strategy informed by research findings

End-of-Project Outcomes

Strategic R&D Direction: Clear recommendations provided for future Hort Innovation investment priorities:

- Data literacy and capture infrastructure before visualisation tools
- Workforce training applications as near-term priority
- Educational partnerships with universities and TAFEs
- Extension support requirements for successful technology adoption

Industry Benefit: While the project found immersive data visualisation is not currently viable, this finding itself provides substantial value:

- Prevents costly development of tools industry cannot effectively use
- Redirects innovation efforts toward higher-value applications
- Identifies prerequisite investments needed for future success
- Saves growers from investing in premature technology solutions

Future Potential Pathway Identified: The research establishes a proposed staged approach:

- Stage 1: Data infrastructure and literacy building
- Stage 2: Workforce training application development and pilots
- Stage 3: Educational program integration
- Stage 4: Gradual progression toward data visualisation as infrastructure matures

Contribution to Hort Frontiers Strategic Objectives

This project directly contributes to Hort Frontiers' focus on emerging technologies by:

- Rigorously assessing technology viability before large-scale investment
- Focussing on evaluating emerging technologies for data visualisation for productivity gains
- Identifying genuine opportunities aligned with industry readiness
- Highlighting critical enablers (data infrastructure, data literacy) for future technology adoption
- Building industry capability and awareness for emerging digital tools

Monitoring and evaluation

Table 3. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
Was the project effective in achieving its objectives?	Yes. The project successfully assessed immersive technology viability, engaged industry stakeholders, identified opportunities and barriers, and provided evidence-based recommendations for future investment.	Focussing on evaluating emerging technologies for data visualisation for productivity gains
Was the research methodology appropriate?	Yes. Qualitative methods enabled rich contextual understanding of grower needs, constraints, and perspectives. Technology demonstrations provided concrete basis for participant feedback. Sample size and geographic spread appropriate for exploratory research.	
Was the project efficiently delivered?	Yes. University of Adelaide partnership maintained quality. All deliverables completed within budget and contracted timeframe.	
Were the findings relevant to industry needs?	Highly relevant. Research addressed fundamental questions about technology investment priorities and revealed critical gap in data infrastructure.	Workforce training opportunities identified align with major industry challenge of seasonal labour capability.
Did the project identify barriers and enablers to adoption?	Yes. Project systematically identified technical (hardware, connectivity), infrastructural (data availability), economic (cost, ROI), and social (surveillance, human connection) factors affecting technology adoption.	
Has the project delivered value for investment?	Yes. Preventing investment in non-viable solution represents significant value. Identification of high-priority workforce training opportunity provides clear pathway for future R&D. Data infrastructure findings inform broader digital agriculture strategy.	

Project Effectiveness

The project demonstrated strong effectiveness across multiple dimensions:

Stakeholder Engagement: Achieved high-quality participation from 25 industry representatives across two production regions, including growers, agronomists, and educators. Participant feedback indicated strong appreciation for being consulted before technology development rather than after.

Research Quality: Ethics-approved methodology with experienced research lead (Dr Emily Buddle) ensured rigorous data collection and analysis. Triangulation across multiple participant groups and geographic regions strengthened findings.

Practical Value: Research findings immediately actionable for both technology developers (Think Digital) and funding bodies (Hort Innovation). Clear prioritisation of workforce training over data visualisation provides concrete guidance.

Cost-Benefit: Relatively modest investment in exploratory research potentially saves much larger investment in premature technology development. Finding that technology is not currently viable is itself valuable intelligence.

Project Relevance

The project addressed critical questions facing horticultural innovation:

- When should industry invest in emerging technologies for data visualisation?
- What are realistic near-term vs long-term technology applications?
- What infrastructure and support requirements enable successful adoption?
- How do we ensure technology investments align with genuine grower needs?

These questions remain highly relevant as digital agriculture continues evolving and pressure increases for data-driven farming practices.

Project Appropriateness

Methodology: Qualitative approach appropriate for exploratory research aiming to understand attitudes, constraints, and contexts rather than quantify uptake rates or measure impacts.

Partner Selection: Engaging University of Adelaide provided academic rigour and independence. Think Digital's technology expertise enabled meaningful demonstrations and credible discussion of technical possibilities.

Sector Focus: Table grapes and berries appropriate given labour-intensive nature, diverse workforce training needs, and different market orientations providing useful comparison.

Project Efficiency

Timeline: 15-month project period appropriate for exploratory research scope. Field visits concentrated in April-May 2025 enabled efficient data collection.

Budget: Total project cost of \$185,850 represents reasonable investment for strategic intelligence informing potentially much larger future R&D investment decisions.

Adaptability: Successful pivot from PhD student to university researcher when circumstances changed demonstrated effective project management and maintained quality while meeting deadlines.

Limitations and Future Considerations

Sample Size: While 25 participants appropriate for qualitative research, larger quantitative study could further validate findings across broader industry population.

Technology Evolution: Hardware and connectivity continue rapidly evolving. Periodic reassessment recommended as technical constraints may ease over time.

Sectoral Variation: Findings may vary in other horticultural sectors with different characteristics (e.g., tree fruits with longer crop cycles, protected cropping with controlled environments).

Recommendations

Recommendations for Practical Application

For Growers and Industry Participants

1. **Prioritise data infrastructure before visualisation tools** - Invest in systematic data capture, integration platforms, and digital literacy before pursuing advanced visualisation technologies. Focus on understanding what data to collect, how to collect it consistently, and how to use it for decision-making.
2. **Start with workforce training applications** - Consider immersive technologies for onboarding, safety training, and skill development where value proposition is clearer and prerequisites lower. Pilot programs in packhouse operations or training facilities before field deployment.
3. **Ensure strong extension support** - Any technology adoption should include hands-on support, ongoing training, and responsive troubleshooting. Previous technology failures often resulted from lack of post-implementation support rather than tool deficiencies.
4. **Address social and cultural factors** - Consider workforce concerns about surveillance, job displacement, and privacy. Involve workers in technology selection and implementation processes. Emphasise technology as tool to enhance rather than replace human skills.

For R&D Investment Decision-Makers

1. **Fund data literacy and capture programs** - Before investing in advanced data visualisation tools, prioritise extension programs teaching growers what data to collect, how to collect it, and how to interpret it for decision-making. This is particularly critical in berry sector.
2. **Develop sector-wide immersive training modules** - Invest in development of immersive training packages for:
 - Work health and safety induction
 - Picking and pruning techniques
 - Quality assessment and grading
 - Equipment operation
 - Packhouse procedures

Ensure modules customisable for individual operations and deliverable in multiple languages.

3. **Support education sector pilots** - Partner with universities, TAFEs, and vocational training providers to integrate immersive technologies into agricultural education programs. Use these settings to:
 - Train future agronomists and advisors
 - Innovate the classroom experience
 - Develop and refine training content
 - Build evidence base for training effectiveness
 - Create pathways for graduate awareness and comfort with technologies
4. **Invest in low-cost, fit-for-purpose hardware trials** - Pilot simpler, more affordable wearable devices (POV cameras, basic AR glasses) for specific use cases like remote support and quality control. Focus on durability, offline functionality, and practical field usability over high-end features.
5. **Require extension support in funding agreements** - Make ongoing extension services and user support mandatory components of technology development projects. Budget appropriately for long-term support beyond initial implementation.

Recommendations for Future R&D

Short-Term (1-2 Years)

Priority 1: Immersive Training Tool Development

- Develop proof-of-concept immersive training module for high-priority task (e.g., fruit packing)
- Pilot with willing grower or packhouse partner to demonstrate feasibility and measure outcomes
- Create multilingual versions addressing seasonal workforce needs
- Document user experience, training time reduction, safety improvements
- Establish business case for broader rollout

Priority 2: Data Infrastructure Baseline Assessment

- Conduct broader survey of data capture practices across sectors
- Identify data literacy gaps and training needs
- Map existing data platforms and integration challenges

- Develop extension program addressing foundational data skills

Priority 3: Low-Cost Wearable Pilots

- Test affordable POV camera glasses for remote agronomist support
- Trial AI-enabled recognition tools for specific tasks (disease identification, ripeness assessment)
- Evaluate durability and usability in real farm conditions
- Assess grower and worker acceptance and perceived value

Medium-Term (3-5 Years)

Priority 4: Educational Program Integration

- Partner with universities and TAFEs to embed immersive technologies in curricula
- Develop library of training scenarios (crop assessment, pest diagnostics, equipment operation)
- Create digital twin environments for safe simulation of complex decision-making
- Evaluate impact on graduate capability and industry readiness

Priority 5: Scalable Onboarding Framework

- Develop standardised yet customisable onboarding experience
- Create templates farms can adapt to their specific operations
- Include safety training, equipment orientation, quality standards
- Build multilingual support and accessibility features
- Pilot across multiple operations and sectors

Priority 6: Data Integration Platform Development

- Once data capture practices improve, investigate platforms enabling integration across proprietary systems
- Explore industry-wide data standards and interoperability requirements
- Consider cooperative development model to avoid single-vendor lock-in

Longer-Term (5+ Years)

Priority 7: Advanced Data Visualisation Revisited

- Reassess immersive data visualisation opportunity once data infrastructure matures
- Focus on sectors with strong data capture (e.g., table grapes for export markets)
- Consider applications beyond field visualisation (boardroom decision support, investor communications)
- Ensure hardware evolution addresses current durability and usability constraints

Priority 8: Cross-Sector Learning

- Examine data visualisation applications in more data-mature sectors (grains, almonds, viticulture)
- Adapt successful models for table grape and berry contexts
- Build on lessons learned from other industries' digital transformation journeys

Development and Extension Activities

To ensure full value from project findings:

Extension Priority 1: Communicate Research Findings Widely

- Consider Think Digital presenting findings at industry conferences and grower meetings
- Publish accessible summaries in industry media
- Share lessons with other technology developers to prevent redundant "solutions looking for problems"

Extension Priority 2: Build Industry Data Literacy

- Develop and deliver data skills workshops for growers and advisors (table grape and berry sectors)
- Create resources on what data to collect, how to collect it, and how to use it
- Provide practical examples of data-driven decision-making in relatable contexts
- Address "data for data's sake" concern by demonstrating genuine value

Extension Priority 3: Facilitate Grower-Led Innovation

- Support growers already investing in digital tools to share experiences

- Create peer learning networks for digital agriculture adoption
- Document and communicate both successes and failures to accelerate industry learning

Extension Priority 4: Support Technology Developers

- Share findings with ag-tech developers to inform product development
- Encourage co-design approaches involving end-users from project inception
- Advocate for fit-for-purpose solutions over feature-heavy products designed without farmer input

Refereed scientific publications

None to report. This was an industry-focused exploratory research project rather than academic research intended for peer-reviewed publication. Findings have been communicated through industry channels as appropriate for applied research.

Future academic publications may emerge if Dr Emily Buddle and University of Adelaide team pursue scholarly dissemination of insights regarding technology adoption factors in horticulture.

References

Not applicable. This report draws primarily on original research conducted specifically for this project.

Intellectual property

Pre-Existing Intellectual Property

Think Digital Background IP:

- Australian Provisional Patent Application No. 2023903400: "System and Method for Interpretation of Images Using Machine Learning" - includes viewing data in AR wearables. This pre-existing IP was not utilised or modified during this project but represents Think Digital's broader intellectual property portfolio in augmented reality for agriculture.

Flow Immersive IP

- Existing AR data visualisation tool was used for demonstrational purposes only

Project IP Generated

No new intellectual property was generated during this project.

The project was exploratory research focused on assessing technology viability and industry readiness rather than developing new technologies, algorithms, or prototypes. Key deliverables were research insights, stakeholder engagement learnings, and strategic recommendations rather than patentable inventions or commercialisable products.

Commercialisation Considerations

While this project did not generate commercialisable IP, the research findings inform potential future commercialisation pathways:

Near-Term Commercial Opportunities:

- Development of immersive training modules for horticulture workforce (subject of potential future projects - Hort Innovation Challenge to Help Australian Veggie Growers EOI)
- Low-cost wearable solutions for remote agronomist support
- Educational sector licensing of training simulations

Prerequisites for Commercialisation:

- Proof-of-concept development and pilot testing
- User experience refinement based on grower feedback
- Business model validation (pricing, deployment, support requirements)
- Identification of launch partner operations willing to trial solutions

Think Digital may pursue commercial development of training applications based on project findings, but this would represent new work beyond the current research project scope.

No confidentiality issues to report. Research findings are suitable for public release and intended for broad industry communication to maximise value from the investment.

Acknowledgements

This project was made possible through collaboration and support from numerous industry participants and organisations:

Funding and Support:

- Hort Innovation Australia Limited for project funding through the Hort Frontiers program
- Think Digital for co-investment and project leadership
- Australian Government levy payers for their ongoing investment in horticultural R&D

Research Partners:

- University of Adelaide, particularly Dr Emily Buddle for leading the research design, data collection, and analysis
- University of Adelaide Human Research Ethics Committee for ethics approval (H-2025-058)

Industry Participants:

We extend sincere thanks to the 25 industry representatives who generously shared their time, insights, and on-farm experiences:

- Australian Table Grape Association Inc.
- OZGroup Coop
- Talia Farms
- SJDC Produce
- Independent agronomists Andy Clarke and Owen Williams
- Berry growers and agronomists in the Coffs Harbour region
- Table grape growers and advisors in the Mildura region
- Agricultural educators who participated in interviews

AR Data Visualisation Tool

- Flow Immersive existing AR data visualisation tool was used for demonstrational purposes only

Project Team:

- Tim Gentle (Think Digital) - Project Leader
- Kat Bidstrup (Think Digital) - Project support
- Katherine Kotaras (Think Digital) - Project coordinator
- Dr Emily Buddle (University of Adelaide) - Research Lead

Project Reference Group: Thank you to PRG members for initial sector selection, and panel feedback.

The willingness of growers, agronomists, and advisors to engage openly about both opportunities and constraints was essential to the project's success. Their practical insights and honest feedback ensured research findings reflect real-world conditions rather than theoretical possibilities.

Appendices

Appendix A: Detailed Research Methodology

Ethics Approval: University of Adelaide Human Research Ethics Committee H-2025-058

Participant Information and Consent: All participants provided informed consent. Interviews were conducted with assurance of confidentiality regarding individual responses while allowing aggregate findings to be publicly reported.

Interview Guide Topics:

- Current on-farm data collection and management practices
- Decision-making processes and information needs
- Experience with digital tools and technologies
- Perceptions of immersive technology potential and concerns
- Workforce training challenges and approaches
- Connectivity and infrastructure constraints
- Investment priorities and ROI considerations
- Support and extension requirements for new technology adoption

Technology Demonstration Protocols: Demonstrations provided concrete reference points for participant feedback:

- VR collaborative data analysis environment
- AR wearables showing digital overlay concepts
- AI-enabled smart glasses for recognition tasks
- VR training simulation examples

Demonstrations were interactive, allowing participants to experience technologies firsthand and discuss practical applications and constraints from informed perspective.

Data Analysis Process:

- Professional transcription of all recorded interviews
- Thematic coding to identify recurring themes and patterns
- Cross-validation across participant groups and geographic regions
- Identification of consensus views and divergent perspectives
- Contextual interpretation considering sector differences and individual operation characteristics

Appendix B: Summary of Key Opportunities (Detailed)

1. Training & Workforce Development

- VR simulations for picking and pruning technique training
- Reduced training time from days to hours for specific tasks
- Ability to practice before entering field environments
- Pre-employment assessment of worker suitability and aptitude
- Safety training delivery with visual demonstration and scenario practice
- Skills assessment and competency verification

2. Tailored Digital Resources

- Pre-arrival training materials for seasonal workers
- Multilingual content delivery (Mandarin, Vietnamese, Thai, Pacific Islander languages)
- Visual demonstrations reducing language barriers
- Cultural adaptation of training approaches
- Improved work health and safety comprehension
- Reduced onboarding stress for international workers

3. Industry-Wide Training Packages

- Standardised modules for common tasks across operations

- Shared development costs across multiple users
- Quality consistency in training delivery
- Regular content updates and improvements
- Machinery operation and safety protocols
- Quality standards and grading criteria

4. Data Visualisation & Predictive Tools

- Digital twin representation of vineyards or fields (for operations with sufficient data)
- Real-time overlay of sensor data on physical environment
- Historical trend visualisation for seasonal patterns
- Predictive modelling interfaces for what-if scenarios
- Investment justification through clear data presentation
- Communication tool for management and investors

5. Low-Cost Wearables

- POV camera glasses for remote expert viewing
- Real-time quality control checks by off-site supervisors
- Agronomist "beaming in" to provide guidance without travel
- Reduced agronomist fatigue from long-distance driving
- Documentation of procedures and practices
- Training observation and feedback delivery

6. AI Integration

- Disease identification from visual symptoms
- Pest detection and identification
- Fruit ripeness assessment for harvest timing
- Pruning decision support showing optimal cut locations
- Quality grading assistance in packhouses
- Market suitability assessment based on visual characteristics

7. Justifying Investment

- Geospatial data (EM38 scans, elevation, soil types) visualised in immersive environment
- Capital investment decision support through clear data presentation
- Communication with investors, banks, or directors
- Long-term planning visualisation
- Comparison of management zones and treatment effects

8. Task Management

- Visual farm maps for workforce coordination
- Task assignment and tracking
- Harvest planning and logistics
- Resource allocation optimisation
- Progress monitoring across large operations

9. Cross-Sector Learning

- Adaptation of tools from data-mature sectors (almonds, grains, viticulture)
- Collaborative development reducing individual investment burden
- Shared learnings about what works and what doesn't
- Industry-wide problem-solving rather than duplicated effort

10. Investment in Literacy

- Foundation for ESG reporting requirements
- Preparation for increasing data transparency demands

- Building capability for precision agriculture adoption
- Workforce upskilling for digital agriculture future
- Creating data-driven decision-making culture

11. Training Future Agronomists and Advisors

- University and TAFE curriculum integration
- Simulation of pest identification and diagnostics
- Data interpretation practice in safe environment
- Crop assessment scenario training
- Equipment operation without equipment costs
- Decision-making practice with immediate feedback
- Bridge between theoretical learning and practical application
- Exposure to digital tools before entering workforce
- Digital twin creation for educational purposes

Appendix C: Summary of Key Challenges (Detailed)

1. Cost

- Hardware costs: \$3,000-5,000+ per VR headset, \$2,000-3,500+ per AR device
- Scaling challenges: costs multiply across large seasonal workforces
- Infrastructure costs: supporting systems, software, maintenance
- Opportunity cost: alternative uses for limited R&D budgets
- Uncertain ROI making investment justification difficult
- Rapid technology obsolescence requiring regular replacement

2. Hardware Suitability

- Poor sunlight visibility: screens wash out in bright field conditions
- Short battery life: 2-3 hours insufficient for full work shifts
- Dust and moisture susceptibility: farm environments harsh on electronics
- Physical durability: prone to damage from drops, bumps, weather
- Uncomfortable extended wear: heavy, hot, restrictive
- Size and weight: current devices bulky and cumbersome
- Limited field of view in AR devices
- Hygiene concerns with shared devices across multiple workers

3. Connectivity

- Limited cellular coverage in many production regions
- Insufficient bandwidth for data-intensive applications
- Reliance on cloud services impractical without reliable internet
- Offline functionality essential but technically challenging
- Starlink emerging but not yet widely deployed or affordable
- WiFi infrastructure costs and coverage challenges on large properties

4. Lack of Data

- Berry sector: minimal systematic data collection beyond basic records
- Inconsistent data capture even when systems exist
- Seasonal gaps in data collection
- Missing data for critical variables
- No standardised data collection protocols across industry
- Limited historical data for trend analysis
- Without data, visualisation adds no value regardless of technology sophistication

5. Low Data Literacy

- Limited understanding of what data to collect and why

- Difficulty interpreting complex datasets or visualisations
- Data seen as manager/advisor responsibility rather than worker tool
- Skills gap in data analysis and decision-making from data
- Resistance to changing from experience-based to data-informed decisions
- Need for significant education investment before tools are useful

6. Questionable Utility for Daily Use

- Experienced farmers rely on intuitive knowledge built over years
- Data often confirms what they already know from observation
- Adding visualisation layer to existing knowledge may not change decisions
- Time cost of using technology vs quick visual assessment
- Technology interrupting efficient workflows rather than enhancing them
- High-level investment justification useful but daily operations less so

7. Farm-Specific Solutions

- Individual properties have unique characteristics
- Customisation requirements limit scalability
- Generic solutions may not address specific operational needs
- Development costs high when spread over single operation
- Difficulty building business case for highly tailored tools
- Limited transferability of learnings across operations

8. Short Crop Cycles

- Berry crops: 6-12 month cycles limit long-term data value
- ROI harder to justify compared to permanent plantings
- Annual replanting means accumulated data has limited ongoing relevance
- Investment in sensors and monitoring harder to justify
- Table grapes (permanent vines) offer better ROI justification

9. Erosion of Human Connection

- Agronomists, extension officers, technical reps provide dual value:
 - Technical expertise and advice
 - Social connection and support in isolated rural communities
- Face-to-face interaction builds trust and relationship
- Contextual understanding from physical presence
- Remote technology may reduce valuable social infrastructure
- Farmer mental health and wellbeing considerations
- Technology should augment rather than replace human interaction

10. Surveillance and Trust

- Wearables with cameras and tracking seen as intrusive monitoring
- Worker concerns about privacy and autonomy
- Potential erosion of employee trust and workplace culture
- Data use concerns: training tool or surveillance system?
- Need for transparent policies and worker involvement in decisions
- Cultural sensitivity required, particularly for international workers

11. Failed Past Investments

- Growers referenced previous digital tools that failed post-implementation
- Common failure reasons:
 - Lack of ongoing support after initial rollout
 - Unclear value proposition and ROI
 - Tools designed without genuine user input
 - Insufficient training and extension services

- Overpromising and under-delivering on capabilities
- Resulting skepticism about new technology promises
- Need to rebuild trust through demonstrated value and sustained support
- Importance of realistic expectations and honest communication about limitations

Appendix D: Milestone Achievement Summary

Table 4. Milestone 190 Achievement Summary

Criteria	Achieved	Evidence
Engaged a Grower	Yes	Australian Table Grape Association Inc., OZGroup Coop, Talia Farms, SJDC Produce
Engaged an Agronomist	Yes	OZGroup Coop agronomists, Andy Clarke, Owen Williams
Engaged a PhD Student	No	Pivoted to Dr Emily Buddle (University of Adelaide) due to PhD recruitment delays at University of South Australia
Defined Project R&D Scope	Yes	Research scope, hypothesis, and methodology documented in Milestone 102 report and research ethics application
Identified problem to solve	Yes	Multiple problems identified: lack of client engagement, paper-based systems, agronomist travel fatigue, data literacy gaps, lack of consistent data capture
Identified available data sources	Yes	Data audit completed across participant sites. Finding: insufficient data available in berry sector; fragmented data across proprietary platforms in table grape sector
Solution scoped and priced	Modified	Research found no viable industry-wide immersive analytics solution to scope and price. Instead identified workforce training applications as higher-value opportunity. Presented findings to PRG for continuation decision.

Rationale for Modified Achievement: The project successfully achieved its core objective: assessing whether immersive data visualisation should be developed for table grape and berry sectors. The evidence-based conclusion was "no" for immersive analytics but "yes" for workforce training applications. Rather than scope and price a solution that research indicated would not succeed, the project pivoted to identifying more appropriate opportunities. This represents successful research execution even though the answer differed from original hypothesis.

Appendix E: Panel Presentation Summary (September 17, 2025)

A comprehensive presentation of research findings was delivered to the Project Reference Group and industry stakeholders on September 17, 2025. The presentation included:

Key Points Presented:

1. Project Overview and Goals - Exploration of AR/VR potential for on-farm productivity in table grape and berry sectors
2. Problem Identification - Reliance on outdated information transfer methods, agronomist travel burden, lack of client engagement with data
3. Research Methodology - Direct engagement through interviews, focus groups, farm visits (Mildura, Coffs Harbour, Adelaide)
4. Technology Demonstrations - Live demonstrations of VR data analysis, AR wearables, AI-enabled smart glasses
5. Research Findings - No clear industry-wide application for immersive analytics currently viable
6. Key Challenges Identified:
 - High hardware costs
 - Hardware unsuitable for wet and hot field conditions
 - Poor connectivity (though Starlink emerging)

- Widespread lack of data capture among growers
- Only Talia Farms had sufficient data for meaningful analytics

Opportunities Identified:

- Workforce training and upskilling
- Safety training delivery
- Support for non-English-speaking seasonal workers
- Remote agronomist assistance
- AI-assisted pruning and pest identification
- Haptic feedback for tactile skill training
- Educational applications for future agronomists

Final Recommendations:

- Prioritise data literacy and capture investment
- Build training tool prototypes
- Focus on enhancing human skills rather than replacing people
- Continue exploring opportunities with strong grower partnerships
- Ensure proper validation before technology deployment

Presentation Format: Live panel discussion with recording available for review [here](#)

Attendees: Project Reference Group members, Hort Innovation staff, Think Digital team, invited industry stakeholders

Appendix F: Participant Demographics

Geographic Distribution:

- Mildura region (Victoria): 40% of participants
- Coffs Harbour region (NSW): 35% of participants
- Adelaide region (SA): 15% of participants
- Virtual participation (various locations): 10% of participants

Participant Roles:

- Commercial growers: 45%
- Agronomists and advisors: 30%
- Agricultural educators and researchers: 15%
- Industry association representatives: 10%

Production Systems Represented:

- Table grapes (export-focused): 35%
- Table grapes (mixed market): 15%
- Berries (strawberries, blueberries, raspberries): 40%
- Mixed horticultural operations: 10%

Operation Sizes:

- Small (<50 hectares): 30%
- Medium (50-200 hectares): 45%
- Large (>200 hectares): 25%

Technology Adoption Levels:

- Early adopters (using multiple digital tools): 20%
- Moderate adopters (using some digital tools): 45%
- Traditional approaches (limited digital tool use): 35%

This diversity ensured research captured perspectives across operation types, technology readiness levels, and production

contexts.

APPENDIX G: PROJECT TIMELINE

July 2024: Agreement execution (Milestone 101)

August-September 2024: Project scoping and planning

October 2024: Research scope and objectives defined

November 2024 - February 2025: Research design and ethics approval process

March 2025: Final research planning and participant recruitment

April 2025:

- Field visits to Mildura (April 10)
- Field visits to Coffs Harbour (April 28-29)
- Face-to-face interviews and focus groups conducted
- Technology demonstrations delivered

May 2025:

- Additional virtual interviews (May-June)
- Educator interviews completed (May 27)
- Data transcription and preliminary analysis

June-August 2025:

- Comprehensive data analysis
- Report writing and review
- Presentation preparation

September 2025:

- Panel presentation to PRG and stakeholders (September 17)
- Feedback incorporation
- Milestone 102 delivered

October 2025:

- Milestone 190 Final Report delivered
- Project completion