

Supporting the adoption of documented farm biosecurity plans through a multi-pronged extension strategy: A case study from the Australian cotton industry

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Abstract. Documented farm biosecurity plans provide a practical framework for identifying and managing biosecurity risks; however, adoption remains limited across many agricultural industries. This case study examined how a participatory, multi-pronged extension strategy supported increased adoption of documented farm biosecurity plans within the Australian cotton industry. Grower consultation identified three key barriers to adoption: perceived complexity, limited knowledge, and lack of perceived benefit. To address these barriers, a coordinated extension strategy was implemented comprising of co-designed resources, discussion-focused workshops, ongoing communication, and integration of the practice within the cotton industry's certification program. Workshop evaluations indicated increased participant knowledge, confidence, and intentions to implement biosecurity practices. Industry-level adoption increased from 44% in 2018 to 64% in 2025. The findings suggest that adoption was supported through the cumulative effects of participatory engagement, social learning, industry reinforcement, and ongoing communication, highlighting the value of coordinated extension strategies in supporting practice change.

Keywords: farm biosecurity, co-design, social learning, best management practice, multi-pronged approach

Introduction

Farm biosecurity plays a critical role in protecting agricultural industries from pests, diseases, and weeds that can impact productivity, profitability, and market access (Waage & Mumford 2008; Nelson et al. 2014; Subasinghe et al. 2023; Mehmedi et al. 2025). In Queensland and New South Wales, legislative changes introduced through the Biosecurity Act 2014 and Biosecurity Act 2015, respectively, place a General Biosecurity Obligation and General Biosecurity Duty on all individuals (NSW Government 2023; Queensland Government 2023). Under this legislation, producers are required to implement reasonable and practical measures to manage biosecurity risks as part of day-to-day farm operations.

Farm biosecurity planning provides a structured and practical framework to meet these legal obligations while embedding effective risk management into farm operations. A documented farm biosecurity plan is a useful training and educational tool that enables producers to systematically identify, assess, and manage risks that are specific to their enterprise (Cardona 2008; Pietrak et al. 2010). Biosecurity risks vary between farms depending on factors such as their geographic location, operational characteristics, available resources, and exposure to specific pest and disease threats (Lewerin et al. 2015). For example, farming enterprises that rely on contractors or share machinery across multiple farms may face higher biosecurity risks associated with machinery compared with enterprises that own and operate equipment exclusively on a single farm. Developing a documented farm biosecurity plan enables producers to identify and manage activities and pathways specific to their operation, supporting a tailored, risk-based approach to on-farm biosecurity management and helping to identify gaps and emerging threats (Cardona 2008; Pietrak et al. 2010).

Despite the recognised value of documented farm biosecurity plans, adoption remains limited across many agricultural industries, with uptake varying between different plant and animal industries (East 2007; Aleri & Laurence 2020). This low uptake may reflect a range of barriers, including challenges in understanding and interpreting legislation, attitudes and perceptions towards biosecurity, capability to identify and assess on-farm biosecurity risks, and implement appropriate biosecurity mitigation practices. While templates, guidelines, and technical resources are commonly used to encourage adoption, evidence suggests that information provision alone is often insufficient for sustainable practice change (Paquette et al. 2020).

Consequently, addressing these barriers requires extension strategies that extend beyond the provision of technical resources alone. Although biosecurity extension has traditionally focused on increasing awareness and knowledge of biosecurity risks and practices as the primary drivers of change (Scott et al. 2018; Gunther et al. 2019; Aleri & Laurence 2020), adoption is also recognised as a socially embedded process (Mankad 2016; Mankad & Curnock 2018; Maclean et al. 2019). Decisions to adopt new practices are influenced by technical and economic factors, but

also by social interactions, trust, peer networks, industry expectations and institutional arrangements, such as assurance programs (Mankad 2016; Mankad & Curnock 2018; Maclean et al. 2019).

This paper uses the Australian cotton industry as a case study to examine how a participatory, multi-pronged extension strategy supported the increased adoption of documented farm biosecurity plans. Between 2018 and 2025, industry adoption of documented farm biosecurity plans increased substantially, from 44% to 64%, providing an opportunity to explore how different extension mechanisms may have collectively contributed to practice adoption. Specifically, the study examines how co-designed resources, targeted training, peer learning opportunities, ongoing communication, and integration of biosecurity planning within the Best Management Practice (myBMP) program addressed barriers to adoption and supported grower engagement with biosecurity planning. In doing so, the paper contributes to extension and adoption literature by examining adoption as a socially embedded process shaped by participatory engagement, industry reinforcement, and social learning rather than information provision alone. The study therefore aims to: i) identify barriers influencing the adoption of documented farm biosecurity plans, ii) examine how a multi-pronged extension strategy addressed those barriers, and iii) explore how these mechanisms may have contributed to increased industry adoption. The findings may have relevance for other agricultural industries or community groups seeking to strengthen enterprise and farm-level biosecurity planning and encourage the adoption of risk-management practices.

Methodology

Case study: Australian cotton industry

Australian cotton production extends from Central Queensland to southern New South Wales, with emerging production areas in northern Queensland, north-western Western Australia and the Northern Territory (Cotton Australia 2026). The industry comprises up to 1,500 cotton farms nationally, although the number of farms growing cotton fluctuates between seasons in response to water availability (Cotton Australia 2026). The movement of people, vehicles, and machinery between farms and regions creates potential pathways for the introduction and spread of pests, weeds and diseases (Biosecurity 2026), making farm-level biosecurity planning an important component of industry preparedness.

Study design

This study used the Australian cotton industry as a case study to examine how a participatory, multi-pronged extension strategy supported the adoption of documented farm biosecurity plans. Grower consultation, program evaluation, and adoption monitoring were used to examine barriers influencing adoption, intermediate extension outcomes, and changes in industry-level adoption over time (Figure 1). Evidence sources included: i) grower consultation to identify barriers to adoption, ii) co-design and implementation of extension activities, iii) workshop evaluation using a Knowledge, Attitudes, Skills and Aspirations (KASA) framework, and iv) industry-level adoption monitoring through the Cotton Research and Development Corporation (CRDC) Cotton Grower Survey.

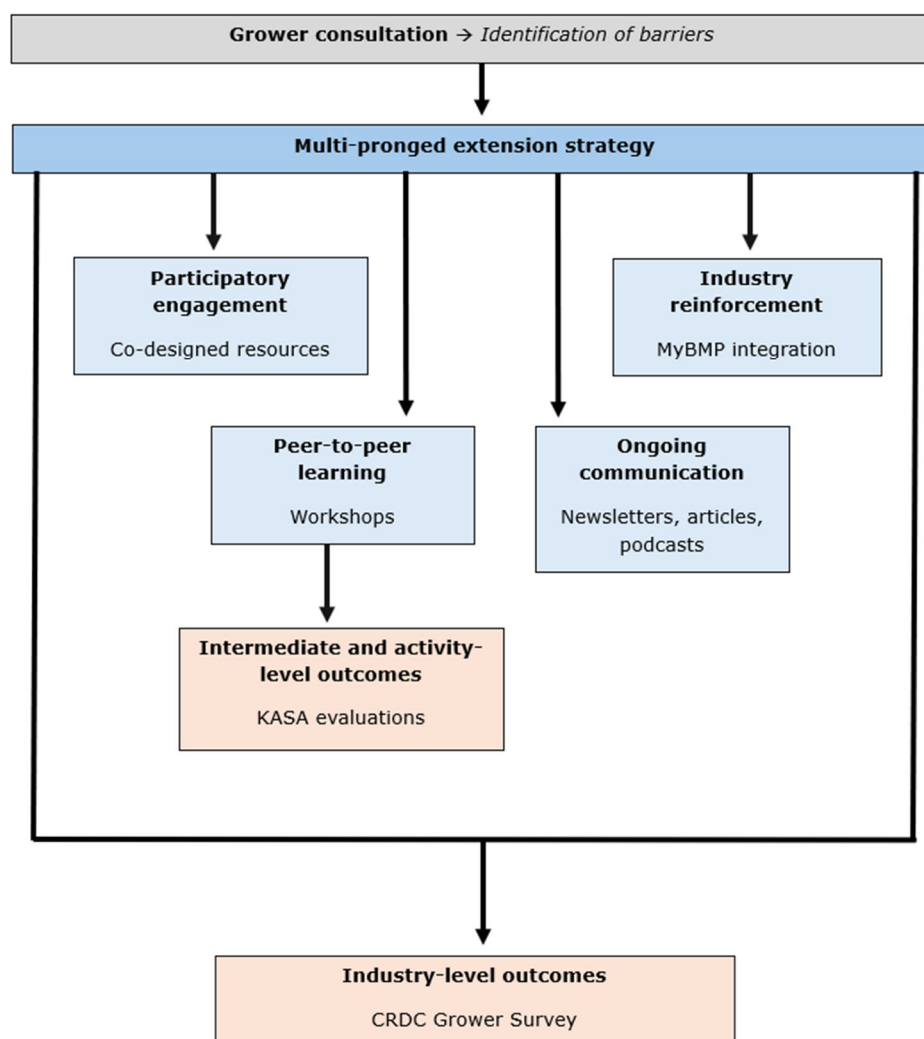
Identification of barriers to adoption

A participatory extension approach was used to identify barriers influencing the adoption of documented farm biosecurity plans (Chambers 1994; Wijeratne 2024). Informal discussions with Australian cotton growers were undertaken during industry meetings and on-farm interactions in 2017. These discussions drew on growers' experiences and perspectives on farm biosecurity planning and implementation. Themes emerging from these discussions were used to identify key barriers to adoption and inform the design of subsequent extension strategies and activities.

Development and implementation of a multi-pronged extension strategy

The extension strategy to increase the adoption of documented farm biosecurity plans was delivered through CottonInfo, the industry's extension program (CottonInfo 2025), and formed part of broader industry biosecurity extension and communication activities. The strategy was developed in response to barriers identified through grower consultation.

The extension strategy was informed by participatory extension and behaviour change literature recognising that adoption may be influenced by social, behavioural, and institutional factors (Vanclay 2011; Rose et al. 2018; Dean & Schultz 2023), in addition to access to technical information. Consequently, the program incorporated co-design, experiential and social learning, peer-to-peer interaction, and adult learning principles to support practical and farm-relevant learning. Four complementary extension mechanisms were implemented:

Figure 1. Conceptual overview of the case study design used to examine adoption of documented farm biosecurity plans within the Australian cotton industry

Grower consultation informed identification of barriers to adoption (grey box), which guided the development of a multi-pronged extension strategy comprising participatory engagement, peer-to-peer learning, industry reinforcement, and ongoing communication (blue boxes).

Outcomes were evaluated through workshop-level KASA assessments and industry-level adoption monitoring using the CRDC Cotton Grower Survey (orange boxes).

Participatory engagement through co-designed resources

A farm biosecurity plan template was developed collaboratively with biosecurity officers and personnel from NSW Department of Primary Industries and Regional Development, Biosecurity Queensland, and the Grains Farm Biosecurity Program (Plant Health Australia 2024). Draft versions of the template were reviewed by growers throughout development to ensure relevance and usability within broadacre cotton and grain production systems. This co-design process aligns with participatory extension principles (Chambers 1994), ensuring the resource reflected grower needs, perspectives, and operational realities. The resulting template guided growers through the identification of biosecurity risk pathways, assessment of enterprise-specific risks, and selection of appropriate mitigation measures. The template was developed as an interactive digital document to facilitate completion, review, updating and sharing.

Industry reinforcement through integration into myBMP

In 2021, documented farm biosecurity plans were incorporated as a required practice within the myBMP (Best Management Practice) program (myBMP 2025). MyBMP is the Australian cotton industry's voluntary farm and environmental program, facilitated by Cotton Australia, the industry's peak body (Cotton Australia 2025). The program consists of ten modules covering key aspects of cotton production, including a dedicated biosecurity module. Integration of biosecurity

planning within myBMP was intended to reinforce the value of documented biosecurity planning and embed the practice within existing industry systems and expectations.

Peer-to-peer learning through discussion-focused grower workshops

A series of grower workshops were delivered between 2021 and 2023 across cotton-growing regions of Queensland and New South Wales in partnership with the Grains Farm Biosecurity Program. Workshops were designed as small-group, discussion-based sessions informed by adult learning principles (Rogers 1993) and emphasised experiential learning, practical problem-solving, and peer-to-peer interaction. Workshop objectives were to assist participants to i) understand relevant biosecurity legislation, ii) identify and assess enterprise-specific biosecurity risks, and iii) develop or update documented farm biosecurity plans. Participants were recruited through CottonInfo regional extension officers and Cotton Australia regional managers and industry communications.

Ongoing communications

Communication activities were undertaken to reinforce workshop messages and maintain industry awareness of farm biosecurity planning. Activities included articles in Australian Cotton Grower Magazine, CottonInfo e-newsletters, CRDC Spotlight Magazine, and multimedia resources such as the CottonInfo Crop to Top podcast. These activities targeted growers, agronomists, consultants, and other industry stakeholders.

Evaluations

Two complementary evaluation approaches were used to assess the outcomes of the extension strategy to increase the adoption of documented farm biosecurity plans. Workshop outcomes were evaluated using a KASA (Knowledge, Attitudes, Skills and Aspirations) framework to assess intermediate outcomes resulting from the extension activity. Consistent with Bennett's Hierarchy of Program Outcomes, KASA indicators were interpreted as measures of changes in participants' knowledge, attitudes, skills, and aspirations rather than direct evidence of adoption (Bennett 1975). Industry-level adoption was assessed separately through the CRDC Cotton Grower Survey, which was used to monitor changes in the uptake of documented farm biosecurity plans across the Australian cotton industry.

Workshop evaluation

Participants completed a standardised post-workshop evaluation survey following workshop completion. The survey collected quantitative and qualitative feedback relating to participants' knowledge of biosecurity obligations, confidence in assessing biosecurity risks, confidence in developing and updating farm biosecurity plans, and intentions to implement biosecurity-related changes. Quantitative responses were measured using five-point Likert scales (Batterton & Hale 2017). Qualitative responses were reviewed and summarised to identify recurring themes regarding workshop value and intended practice changes.

Monitoring industry-level adoption

Industry-level adoption of documented farm biosecurity plans was monitored through the CRDC Cotton Grower Survey. This annual survey collects information on grower practices, perceptions, and adoption of research, development, and extension outcomes across the Australian cotton industry. Questions relating to documented farm biosecurity plans were included in surveys conducted in 2018, 2021, 2023, and 2025. Adoption data were analysed descriptively to examine changes in the proportion of growers reporting that they maintained a documented farm biosecurity plan.

Results

Identification of barriers to adoption

Grower consultation identified three key barriers influencing adoption of documented farm biosecurity plans: i) perceived complexity, ii) limited knowledge, and iii) lack of perceived benefits (Table 1). Perceived complexity was associated with the lack of practical, industry-specific planning resources. Existing resources were generally paper-based and designed for broad agricultural audiences, limiting their perceived relevance to cotton production systems. Limited knowledge related to uncertainty regarding what documented farm biosecurity plans involved, how plans should be completed, and how biosecurity risks should be assessed and managed at the farm-level. Growers also identified a lack of perceived benefit in formally documenting practices, despite many undertaking biosecurity practices as part of routine farm operations. These findings suggested that increasing adoption would require an extension strategy that addressed both practical and perceptual constraints associated with documented farm biosecurity plans (Table 1).

Table 1. Key barriers influencing the adoption of documented farm biosecurity plans and corresponding extension responses and activities

Characteristic	Barrier	Activity	Extension mechanism
Perceived complexity	No relevant resources in place; the resources available were paper-based and whole of agriculture focused	Develop an easily accessible, online resource specific to broadacre production systems	Participatory engagement through co-design
Limited knowledge	Limited understanding of what a documented farm biosecurity plan entails, how to complete a plan and undertake a risk assessment matrix with respect to biosecurity	Deliver workshops to growers in regional locations; develop communication material to improve knowledge of documented farm biosecurity plans and practices	Social learning, peer-to-peer interaction
Lack of perceived advantage	No perceived benefits in documenting their biosecurity processes	Reflect the value of biosecurity planning by integrating the practice into the myBMP program	Industry reinforcement

Development and implementation of a multi-pronged extension strategy

Participatory engagement through co-designed resources

To address the barrier of perceived complexity, a farm biosecurity plan template was developed through a co-design process involving growers, biosecurity officers, and representatives from partner organisations. The template guided growers through identification of biosecurity risk pathways, enterprise-level risk assessment, and selection of mitigation measures. Development of an interactive digital format improved accessibility and enabled growers to review, update, and share plans more easily.

Industry reinforcement through integration into myBMP

In 2021, documented farm biosecurity plans were incorporated as a required practice within the myBMP program. As of 2024, 542 farms were accredited under the myBMP program (Cotton Australia 2025).

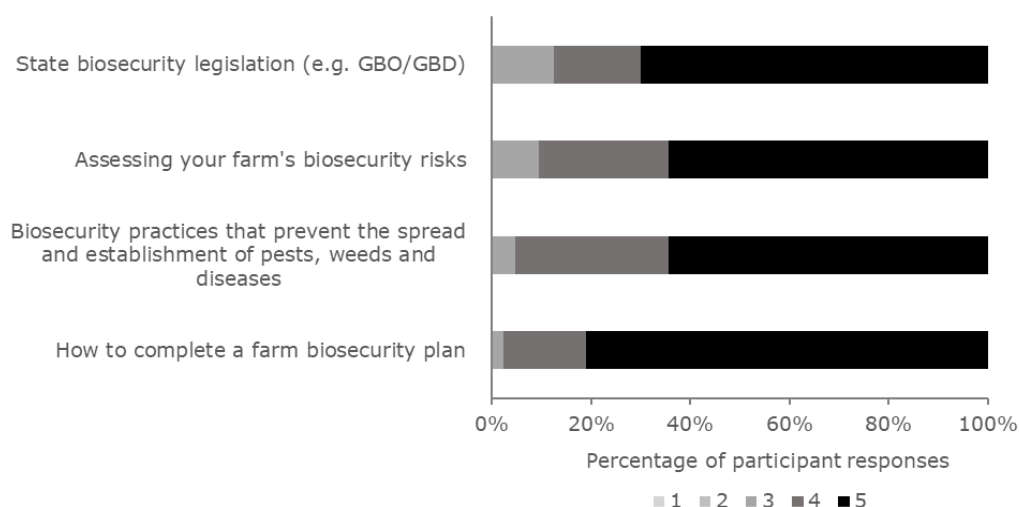
Peer-to-peer learning through discussion-focused grower workshops

A total of eight workshops were delivered between 2021 and 2023, with 46 growers from 41 enterprises participating. Collectively, these enterprises managed approximately 192,000 hectares of cropping land. Prior to attending the workshops, 76% of participating enterprises were aware of documented farm biosecurity plans but did not have one in place.

Workshop evaluation

Knowledge outcomes

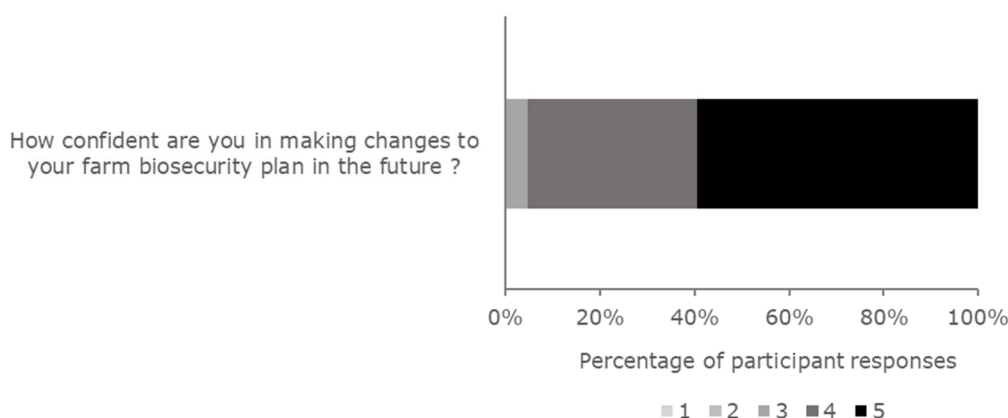
Participants reported increased knowledge across all assessed areas following workshop participation. Most participants agreed (rating ≥ 4 on a five-point Likert scale) that they gained new knowledge regarding state biosecurity legislation (88%), assessment of farm biosecurity risks (91%), biosecurity practices to prevent the establishment and spread of pests, weeds, and diseases (95%), and completion of documented farm biosecurity plans (98%) (Figure 2). Qualitative feedback suggested that participants valued the practical nature of the workshops and the opportunity for discussion with peers. Comments included “good workshop – very practical and helpful” and “good crew and open discussions – thank you”.

Figure 2. Knowledge gained by workshop participants

Five-point Likert scale, where 1 indicates strongly disagree and 5 indicates strongly agree

Skills

Participants also reported increased confidence in their ability to develop and maintain documented farm biosecurity plans. Ninety-five percent of participants agreed (rating ≥ 4 on a five-point Likert scale) that they were confident in making future changes to their documented farm biosecurity plan (Figure 3).

Figure 3. Confidence of workshop participants in ability to make changes to their biosecurity plans

Five-point Likert scale, where 1 indicates strongly disagree and 5 indicates strongly agree

Aspirations and intended practice change

All participants indicated an intention to make changes to their farm biosecurity practices within the following 12 months. Intended actions included increasing staff training, implementing or improving visitor registers, strengthening biosecurity documentation, communicating biosecurity plans with agronomists and consultants, and installing biosecurity signage at property entrances.

Ongoing communications

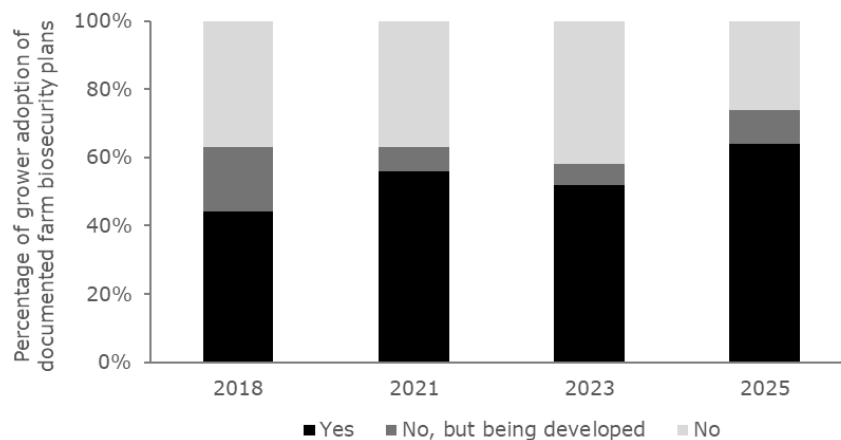
Communication activities included articles in Australian Cotton Grower Magazine, CottonInfo e-newsletters, CRDC Spotlight Magazine, and multimedia resources such as the CottonInfo Crop to Top podcast.

Monitoring industry-level adoption of documented farm biosecurity plans

Industry-level survey data collected through the CRDC Cotton Grower Survey indicated an increase in adoption of documented biosecurity plans over time. The proportion of cotton growers reporting that they maintained a documented farm biosecurity plan increased from 44% in 2018

to 64% in 2025 (Figure 4). The number of survey responses was 180 in 2018, increasing to 233 in 2021 and remaining relatively stable at 217 and 216 responses in 2023 and 2025, respectively.

Figure 4. Percentage of growers adopting documented farm biosecurity plans from 2018 – 2025



Source: CRDC Cotton Grower Survey

Discussion

This case study examined how a multi-pronged extension strategy supported increased adoption of documented farm biosecurity plans within the Australian cotton industry. Between 2018 and 2025, the proportion of growers reporting that they had a documented farm biosecurity plan increased from 44% to 64% (Figure 5) (Cotton Research and Development Corporation 2025). This increase provides an opportunity to examine how multiple extension mechanisms may operate together to support the adoption and normalisation of documented farm biosecurity plans. Notably, 76% of workshop participants reported being aware of documented farm biosecurity plans prior to attending a workshop, however, did not have a plan in place. Together, these findings suggest that adoption was not simply a consequence of increased awareness alone. Rather, adoption appeared to be supported through the combined and reinforcing effects of participatory engagement through co-designed resources, social and peer-to-peer learning through discussion-focused workshops, ongoing communication activities, and integration of documented farm biosecurity plans within the myBMP program. While causal relationships cannot be established from the available data, the observed increase in adoption coincided with the implementation of multiple complementary extension mechanisms operating across the industry over an extended period.

Despite the observed increase in adoption, the findings suggest that legislative obligations alone were insufficient to drive widespread uptake of documented farm biosecurity plans. While legislative frameworks such as the Biosecurity Act 2014 and Biosecurity Act 2015 require producers to implement reasonable and practical measures to manage biosecurity risks, legislative obligations alone did not inherently lead to the adoption of documented biosecurity practices that support verification or demonstration of compliance at the farm level. Consistent with previous studies (Hayes et al. 2017), growers faced persistent barriers related to perceived complexity, uncertainty regarding how to develop a documented farm biosecurity plan, and limited perceived benefit. Together, these findings highlight the need for extension approaches that address practical, behavioural, and institutional dimensions of adoption alongside regulatory requirements.

A key insight arising from this case study is that extension activities should not be viewed as operating independently or as sole drivers of the observed increase in industry-level adoption of documented farm biosecurity plans (Figure 5). Individual activities, such as workshops, reached a relatively small proportion of growers and were unlikely, in isolation, to generate substantial industry-wide changes in adoption. Rather, the activities formed part of a coordinated, multi-pronged extension strategy delivered over approximately eight years, during which different extension mechanisms and strategies were introduced, refined, and reinforced through ongoing engagement. Growers engaged with biosecurity planning through different pathways and at varying levels of intensity over this period. For example, some growers developed documented farm biosecurity plans through participation in facilitated workshops, while others may have accessed and used the co-designed resources independently. For some growers, biosecurity

planning was reinforced through integration within the myBMP program, while others were exposed to biosecurity planning through newsletters, podcasts, and industry publications. Consequently, adoption was likely influenced by multiple and overlapping extension mechanisms operating over time rather than participation in any single activity.

The multi-pronged extension strategy was designed to address these barriers through a combination of complementary extension mechanisms that targeted different dimensions of adoption. The co-designed farm biosecurity plan template addressed perceived complexity by providing a practical, industry-specific resource tailored to broadacre cotton and grain production systems. Participatory extension approaches emphasise the importance of involving end-users in the development of resources and solutions to ensure that they reflect local knowledge, operational realities, and user needs (Chambers 1994). By incorporating grower feedback throughout development, the template provided a practical mechanism through which existing biosecurity practices could be translated into a documented plan. This aligns with research suggesting that co-design can increase relevance, ownership, and engagement with new practices by ensuring that resources reflect the realities of end users.

The discussion-focused workshops provided a complementary extension mechanism by supporting experiential and social learning. Workshop participants reported increased knowledge, confidence, and intentions to implement biosecurity-related changes. However, the importance of the workshops extended beyond knowledge transfer alone. The workshops encouraged growers to apply biosecurity concepts directly to their own enterprises, discuss practical challenges, and share experiences with peers. Previous research has demonstrated that growers place considerable trust in the experiences and perspectives of other growers (Coutts & Roberts 2003; Palmer et al. 2009; Maclean et al. 2019). Peer-to-peer discussion can reduce uncertainty, provide social validation, and help growers evaluate the practicality of implementing new practices. The positive qualitative feedback provided by participants suggests that these opportunities for discussion and shared problem-solving were valued components of the extension process. Furthermore, farmers are more likely to engage with and act on biosecurity recommendations when they have actively participated in their planning process and invested their own time and effort, reinforcing ownership and commitment to change (East et al. 2006; Kaine et al. 2010).

The findings also highlight the importance of industry systems in supporting practice adoption. Integration of documented farm biosecurity plans into the myBMP program represented more than the addition of a new accreditation requirement; it embedded biosecurity planning within an established industry assurance framework and reinforced its status as a recognised best management practice. Research increasingly recognises that practice change is shaped not only by individual knowledge and attitudes, but also by institutional arrangements and industry expectations (Pannell et al. 2006; Mankad & Curnock 2018). By incorporating documented farm biosecurity plans into myBMP, the practice became increasingly visible, legitimate, and aligned with broader industry objectives. This industry reinforcement provided growers with an additional rationale for adopting documented farm biosecurity plans beyond regulatory compliance alone. This integration created an additional incentive for adoption and is consistent with evidence from Australian livestock industries, where the integration of farm biosecurity planning into assurance schemes such as Livestock Production Assurance (Integrity Systems 2025) has supported adoption of farm biosecurity plans by linking the practice to market access requirements.

Ongoing communication activities provided a further mechanism through which biosecurity planning remained visible within the industry. Articles, newsletters, and podcasts reinforced workshop messages and exposed growers to biosecurity planning through multiple pathways. While individual communication activities are unlikely to influence adoption independently, repeated exposure to consistent messages may contribute to maintaining awareness, reinforcing perceived value, and supporting broader engagement with a practice over time. In combination with workshops, co-designed resources, and myBMP integration, these activities helped ensure that biosecurity planning remained part of ongoing industry conversations.

While participatory extension, peer learning, industry assurance systems, and communication campaigns have each been examined individually within the extension literature, this case study suggests that these mechanisms may operate cumulatively and reinforce one another in supporting practice adoption. The findings contribute to extension and adoption literature by illustrating how multiple socially embedded extension mechanisms may interact to support the uptake and normalisation of documented farm biosecurity planning. This highlights an important consideration for extension programs: practice change may be more effectively supported through coordinated and complementary extension strategies than through single interventions delivered in isolation.

As adoption increased and documented farm biosecurity plans became more visible within industry practices and systems, biosecurity planning may increasingly have been viewed as a normal and expected component of farm management rather than an optional activity. This observation aligns with social norms theory, which suggests that the desire to align with commonly valued, accepted, and expected practices within a peer group can be a powerful driver of behaviour change (Nowak 1976; Hu et al. 2006). Informal observations during the delivery of the extension strategy suggested these processes may have occurred, with some growers reporting that they attended workshops after observing neighbouring growers implement visible biosecurity measures, such as farm biosecurity signage, following participation in earlier workshops. While not systematically evaluated, these observations suggest that visible biosecurity practices may act as social cues that stimulate interest, discussion, and engagement among neighbouring growers. In this sense, the multi-pronged extension strategy may have contributed to increasing awareness and capability, but also to broader processes of normalisation within the Australian cotton industry. As the adoption of documented farm biosecurity plans increases, social influence may further accelerate uptake, particularly if growers observe peers successfully implementing and valuing biosecurity planning within their businesses. This highlights the potential value of extension strategies that leverage peer influence, such as supporting growers to champion biosecurity messages, sharing their experiences, and demonstrating the practicality and benefits of maintaining a documented farm biosecurity plan.

Despite these positive outcomes, several limitations should be acknowledged. The KASA-based evaluation should be interpreted alongside the industry-level adoption data and broader extension activities described in this case study. Consistent with Bennett's Hierarchy of Program Outcomes (Bennett 1975), changes in knowledge, awareness, skills, and aspirations (Figures 2, 3 and 4) represent intermediate indicators of movement toward adoption rather than evidence of adoption itself (Bennett 1975). The workshop evaluations demonstrated increased knowledge, confidence, and intentions to undertake biosecurity-related actions, suggesting improved readiness and capability for practice change. While these findings do not demonstrate adoption, they provide evidence that participants were better equipped to implement documented farm biosecurity plans. Workshop participants may also have been more motivated or interested in biosecurity than the broader grower population, and the KASA findings relied on self-reported measures of knowledge, confidence, and intended actions.

Industry-level survey data provided evidence that adoption of documented farm biosecurity plans increased over the study period. However, the observed increase occurred within the context of a coordinated, multi-pronged extension strategy delivered over approximately eight years, alongside broader industry, regulatory, and market influences. Because the study was not designed as an experimental or quasi-experimental evaluation, it is not possible to isolate the relative contribution of individual extension activities to the observed industry-level adoption outcomes. Nevertheless, consideration of workshop-level KASA outcomes alongside industry adoption trends provides insight into how multiple extension mechanisms may have supported adoption over time. Collectively, the findings suggest that adoption was supported through a combination of capability development, social learning, industry reinforcement, and ongoing engagement rather than information provision alone.

Beyond biosecurity planning, this case study contributes to extension and adoption literature by illustrating how multiple extension mechanisms can operate together across individual, social and institutional levels to support practice change. Collectively, co-designed resources, peer-to-peer learning, ongoing communication, and integration within industry assurance systems appeared to reinforce one another, helping to normalise documented farm biosecurity planning within the Australian cotton industry. The findings reinforce growing recognition that agricultural adoption is socially and institutionally embedded and that successful extension programs may require a combination of participatory engagement, social learning, industry reinforcement, and ongoing communication rather than reliance on information provision alone.

Conclusion

This case study examined how a multi-pronged extension strategy supported increased adoption of documented farm biosecurity plans within the Australian cotton industry. Industry-level adoption increased from 44% in 2018 to 64% in 2025, coinciding with the implementation of a coordinated extension strategy that combined co-designed resources, discussion-focused workshops, ongoing communication activities, and integration of biosecurity planning within the myBMP program.

The findings suggest that adoption of documented farm biosecurity plans was not driven by awareness raising or information provision alone. Rather, adoption appeared to be supported through the cumulative and reinforcing effects of participatory engagement, social learning,

industry reinforcement, and ongoing communication operating over time. Collectively, these mechanisms contributed not only to increased adoption, but also to the normalisation of documented farm biosecurity planning as an increasingly recognised component of best management practice within the Australian cotton industry.

While industry-level adoption cannot be attributed directly to any individual extension activity, this case study highlights the value of coordinated, multi-pronged extension strategies for supporting practice change. More broadly, the findings reinforce growing recognition that agricultural adoption is socially and institutionally embedded and is often shaped through multiple interacting influences rather than through information provision alone. As such, the Australian cotton industry provides a useful case study of how coordinated, multi-pronged extension strategies that draw on socially and institutionally embedded processes may support the adoption and normalisation of documented farm biosecurity plans.

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