Relational drivers of sustainable agricultural practice change: social networks and collaboration for Great Barrier Reef water quality

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Abstract. The social context in which landholders make decisions shapes adoption of agricultural practices, yet the relationships and networks they rely on remain underexplored. This study investigates how social networks, collaboration, and trust, influence sugarcane growers' adoption of practices to improve water quality in Queensland's Mulgrave–Russell basin. Using semi-structured interviews and participatory network mapping with 35 growers using snowball sampling, we found that practice adoption is deeply socially embedded. Close, trust-based ties (particularly among peers, family, and extension officers) play a central role in legitimising new practices and reinforcing change over time. Contract farmers also emerged as key connectors who accelerate knowledge exchange and supporting innovation. Working alongside extension officers, government, industry partners, and researchers fosters trust and confidence in science and regulations, while supporting long-term engagement and capacity for sustainable practice change. These findings offer practical insights for designing engagement strategies and policy interventions anchored in participatory approaches and aligned with growers' social dynamics, providing actionable evidence to inform collaboration-centred extension policies and projects that leverage peer networks to sustain adoption of sustainable practices.

Keywords: Social Networks, Great Barrier Reef, Sustainable Agriculture, Water Quality, Agricultural Practice Change, Collaboration

Introduction

Encouraging the adoption of sustainable agricultural practices remains a central challenge for improving water quality outcomes in the Great Barrier Reef (GBR) catchments. Despite long-term investment in extension programs, incentives, and regulatory frameworks, uptake of recommended practices has been uneven across farming systems and regions. This includes practices aimed at reducing dissolved inorganic nitrogen (DIN) runoff from agrochemicals such as fertilisers (Brodie et al. 2012; Davis et al. 2019; Waterhouse et al. 2022; GBRF 2024). Understanding what drives or hinders practice change is critical for designing more effective interventions.

Sugarcane farming systems, especially in Queensland's Wet Tropics region, are a major contributor to DIN loads entering the GBR lagoon (Great Barrier Reef Marine Park Authority 2024). The Mulgrave–Russell catchment, which comprises just 9% (194,400 ha) of the Wet Tropics region, contributes over 30% of the total freshwater discharge to the GBR and is among the top five basins contributing DIN loads to the Reef (930 tonnes/year) (Queensland Government 2018; Reef Trust Partnership 2023; Tropwater 2024). The catchment presents complex social-ecological challenges for sustainability, conservation and livelihoods given its reliance on sugarcane production and its location within priority catchments targeted by important water quality initiatives. Notable projects include *Project 25* (2015-2020), which used a bottom-up approach to engage farmers and demonstrate water quality outcomes (Davis et al. 2019), and the *Mulgrave-Russell Water Quality Program* (2021-2024), which supported 82 growers and reported to have achieved a reduction of 9.3 tonnes of DIN in 2024 alone through changed management practices across 11,000 hectares of cane (GBRF 2024). These localised initiatives are part of broader state-level strategies such as the *Reef 2050 Water Quality Improvement Plan* and the *Reef Trust Partnership*, led by Queensland Government (2017-2027) in collaboration with the Australian Government. Over the past two decades, an estimated AUD$1.1 billion has been invested in improving water quality, with 87% of this directed toward technical and financial instruments of extension (Waterhouse et al. 2022). This paper uses the Mulgrave–Russell catchment as a case study to explore the social and relational dimensions of practice changes designed to improve GBR water quality.

Despite considerable progress in developing technical solutions and improved management practices, the formal and informal relational networks that shape adoption processes have received limited attention. Only a limited number of studies—including Shawky et al. (2023), which examined multiple water-quality and agricultural extension projects across Great Barrier

Reef catchments, and Davis et al. (2019) in the context of Project 25 in the Russell–Mulgrave catchment—have recently begun to examine these relational dynamics. To address this gap, this paper explores how social networks and collaborative relationships among farmers, extension officers, and other actors shape the adoption of sustainable practices in sugarcane farming systems, with the goal of informing more effective strategies for improving water quality outcomes in Great Barrier Reef catchments. The study was guided by the following research questions:

1. How do the social context and relationship dynamics of cane growers from the Mulgrave-Russell catchment influence their adoption of sustainable agricultural practices?
2. How do collaborative initiatives shape grower's decisions to adopt these practices?

This study responds to calls for a better understanding of the factors that enable or hinder the adoption of sustainable practices (Hasan et al. 2021). It builds on the work of Barnes et al. (2013) and Shawky et al. (2023), who identified trust and communication gaps between stakeholders, resistance to regulatory policy, and limited training and networking opportunities as key barriers to sustainable agricultural practice change. In addition, the study aligns with Davis et al. (2019) and Cleary et al. (2023) who argue that a deeper understanding of the social context and trust-based relationships among stakeholders, is essential for effective engagement and cost-effective co-management that supports the adoption of agricultural practices in the region.

This remainder of this paper is structured as follows: The next section outlines the study's methods, including site selection, data collection, and analytical approach. This is followed by a presentation of the findings, organised around key thematic patterns emerging from the data. The discussion then situates these findings within broader debates on practice adoption as a socially embedded process. The paper concludes by summarising the main insights and identifying implications for water quality improvement efforts in Great Barrier Reef catchments.

Methods

Study area and participant recruitment

Fieldwork focused in the two major towns of the Mulgrave-Russell catchment, Gordonvale and Babinda, located approximately 20 and 60 kilometres south of the city of Cairns. These towns were selected because they rely primarily on sugarcane production, are part of the prioritised area for nitrogen management (Davis et al. 2019), and share the landscape of rainforests, forested floodplains, woodlands, heaths, and shrublands. A key criterion for selecting these towns was their location within priority catchments targeted by important water quality initiatives, providing a suitable context to explore the adoption of sustainable practices in connection with conservation efforts of the Great Barrier Reef.

Data collection occurred over two rounds of fieldwork conducted between May 2023 and March 2024. In the first stage, we recruited 17 participants with support from industry and extension services organisations. Recognising that this initial sample may have been skewed towards growers already engaged with programs provided by these organisations, in the second stage we adopted a snowball sampling recruitment strategy. This approach relied on referrals from farmers themselves to ensure a more diverse and representative sample of sugarcane growers in the region, resulting in 18 additional interviews. Snowball sampling is commonly employed in social network analysis to access hard-to-reach populations and leverage existing social connections to facilitate network mapping (Robins 2015). Our resulting sample thus included 35 farmers.

Interview protocol and data collection procedure

To elicit relational dynamics in greater depth than quantitative surveys typically capture, we conducted semi-structured interviews. These lasted between 40 minutes to 1 hour and 45 minutes and began with general questions about participants' farms, including the production area, the main crops grown, their perceptions about farming and brief elements about their life as farmers such as the number of properties they manage, and their life experience in the sugarcane industry. The second part of the interview focused on the collection of social network data. The third part of the interview focused on identifying factors influencing practice change. We also explored perceptions about benefits and trade-offs of sustainable agricultural practices, and the influence of social connections in attitudes and adoption preferences. We used these questions to better understand the context that influences the perceptions, attitudes and behaviours of the study participants. Data were collected during the interviews using a custom tool developed on the REDCap platform, deployed on tablets to facilitate convenient entry. Interviews were audio recorded and transcribed for later analysis. The interview structure followed diffusion and social network methodological principles articulated by Valente (1996), Crossley et al. (2015) and

Centola (2018), emphasising the role of adopter context and interpersonal influence in shaping innovation adoption.

To collect the social network data, we used an ego-centric network mapping approach, which focuses on mapping the relationships between each participant (the "ego") and their social contacts ("alters") (Crossley et al. 2015; Perry et al. 2018). This method enables the visualisation and analysis of both formal and informal networks ("ego-nets") by identifying the key individuals with whom growers communicate about farming practices. By combining ego-centric network mapping with participant narratives we also capture the stories and meanings that participants associate with their relationships (Schiffer & Hauck 2010), providing a deeper insight into the social dynamics that shape decision-making. As a result we can categorise our methodological approach as a form of Social Network Analysis (SNA) method which is an approach used to examine the structure of relationships among actors (Wasserman & Faust 1994; Scott & Carrington 2014; Robins 2015), and becomes particularly valuable when used to explore how these patterns of connections shape environmental governance, decision-making and collective action (Guerrero et al. 2013;2015; Bodin 2017).

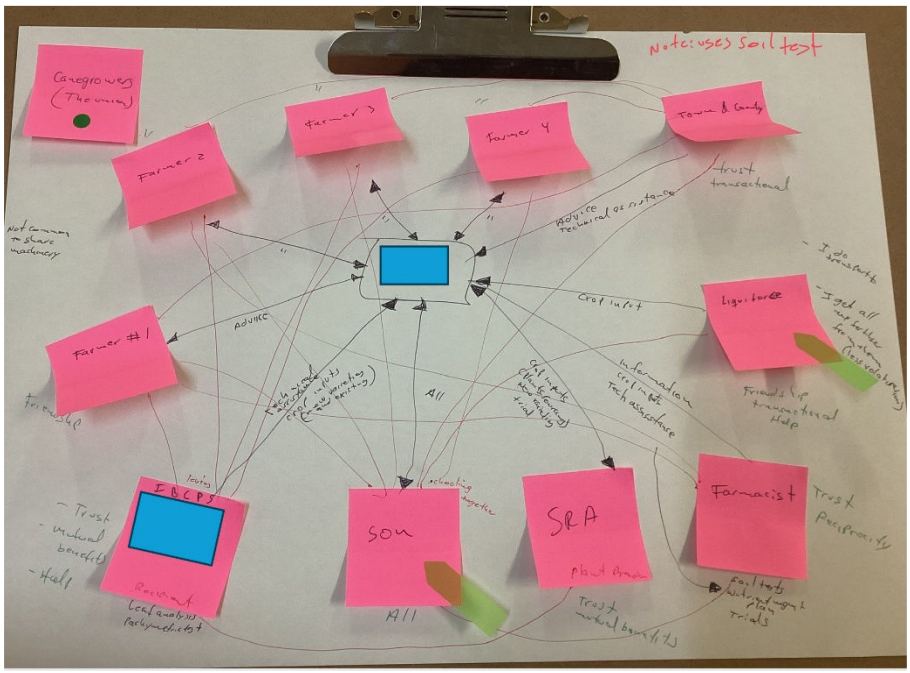
Ego-network mapping procedure

To collect ego-net data we used the Net-Map tool, an interview-based mapping method, to help participants visualise and discuss situations involving multiple actors who influence outcomes (Schiffer & Hauck 2010, Hauck et al. 2015) (Plate 1). In an interview setting, Net-Map supports the elicitation of implicit knowledge and the exploration of complex formal and informal networks that shape a particular aspect of a farmer's life. We adapted the tool to first identify and map the individuals with whom each participant communicates about their farming practices (alters), using a position generator approach similar to that described by Yang (2024). Participants were prompted with categories such as "agricultural extension officer", "farmer", "supplier of farming products/services", "friend", "wife". Second, we asked participants to describe the nature of their interactions with each alter, for example, whether they sought information, technical assistance, advice, or crop inputs. Third, we explored the type of relationship participants had with each alter. To do this, we presented a typology of relationship types adapted from social network theory (Uzzi 1996; Mentzer et al. 2001; Gonzalez-Mon 2022). This allowed us to examine how different types of interactions are embedded within strong (e.g. family, friendship, or trust-based) or weak (e.g. transactional or casual) social ties, offering insights into the relational dynamics that underpin practice adoption. Lastly, we asked participant growers to identify who they consulted specifically for advice on fertiliser application. This data was crucial for mapping the advice network related to fertiliser use. This process not only helped evoke participants' practice adoption pathways but also shed light on the role of different types of relationships and the interplay between formal and informal networks shaping those decisions. A full description of the procedures used are provided in Guerrero & Cruz (2025).

Data analysis

The research adopted a bottom-up methodology and a systems approach, following the recommendations of Davis et al. (2019) and Hasan et al. (2021), and employed a constructivist perspective to help address the gap in understanding how social networks, collaboration, and trust influence sugarcane growers' adoption of practices. The social network data were organised and analysed using a combination of quantitative and visual tools, including R (2024.12.1, Build 563) and Power BI data visualisation tools. Social network data were processed and visualised to identify trends in participant characteristics, network structures and diversity of actors, interactions, and relationship types. Interview transcripts were analysed using Nvivo 14, where a process of inductive thematic analysis was carried out. Lastly, it is important to mention that this study followed the Ethical guidelines of the National Statement on Ethical Conduct in Human Research (2007/2018), as well as the guidelines set by the QUT Ethics Committee (Approval #6723).

Plate 1. Example of a net map*



*Central node represents the grower. Other nodes (Post-it notes) represent their contacts. Light green tags indicate contacts who provide fertiliser advice. Green dot represents leaders in the region

Findings

Findings are presented in two sections. The first section examines communication networks and describes the social dynamics underpinning practice adoption, including the role of peer interactions in shaping adoption decision-making. The second section analyses how collaboration and trust influence adoption. It explores the role of knowledge sharing in joint capacity building and considers how collaborative relationships foster the trust necessary for practice change.

Communication networks

The analysis revealed substantial variation in the size and composition of growers' communication networks, ranging from as few as five to as many as 20 individuals (Figure 1). These networks include a mix of close ties, such as friends, relatives and trusted advisors, and more distant ties, including suppliers and other agricultural service providers. Growers engaged in contract farming (n = 6) tend to have larger networks within this range. Overall, growers most frequently discuss farming practices with neighbours and fellow farmers (42%), followed by agriculture extension officers (17%), relatives (16%), and suppliers of farming products and services (10%) (Figure 2). However, the composition of these networks shifted depending on the specific practice. For example, when seeking advice on fertilising practices, cane growers most often consulted agriculture extension officers (43%), followed by suppliers of farming products and services (24%), then relatives (17%) (Figure 3).

> A lot of people learn off the family and from the farm. […] If you've got experience in other industries, your communication network just naturally becomes entrenched in you. (Grower #18)

> If somebody's doing something, you always can get on the phone and have a talk to them. It's not hard to find phone numbers. If you want to talk to somebody, you ring up and say, "I saw you doing something the other day. What were you doing?" And 99% of the time the farmer will tell you what they've been doing. (Grower #10)

> With the growers' group and with neighbours, there are family ties and friendships. We're really good friends; we've been so for a long time. We trust what they're saying most of the time. So, there are mutual benefits. If something works for them, it might work at my place, and back and forth. (Grower #17)

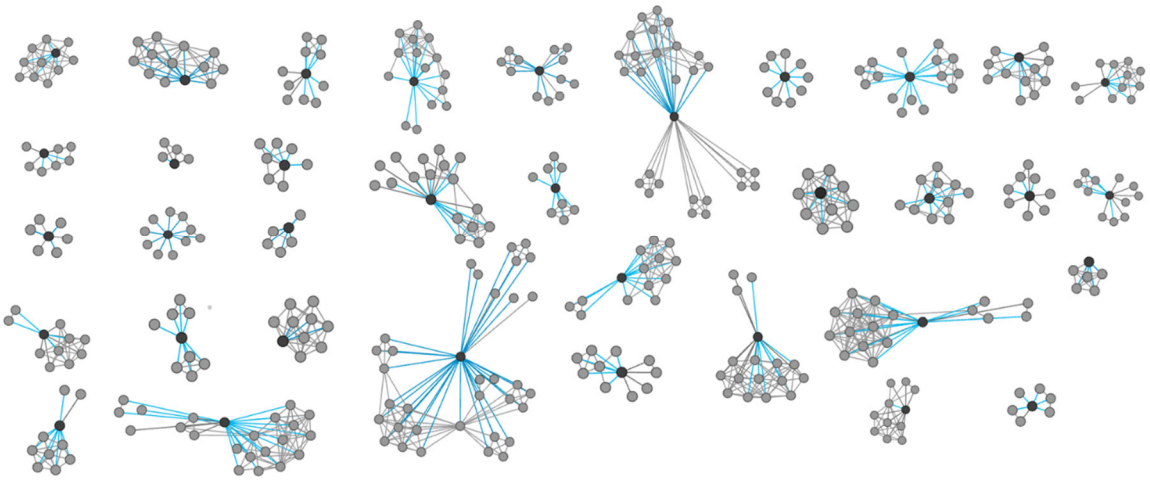
While family members and fellow farmers were most commonly associated with trust-based relationships, agricultural extension officers and, in some cases, suppliers were also identified as trusted individuals by several participants (Figure 4). This suggests that under certain conditions nonpeers, such as extension officers and suppliers, can become influential in growers' decision-making.

If we didn't have those organisations, research, and other bodies that help us, we'd go out of business. I think we're all connected. I think I've been dealing with the same people for most of my life. (Grower #13)

There are some transactions through research organisations. There are also family ties through the staff working there, so you've got your friendship and commitment and trust. Sometimes we ask them to help solve problems. I do trials for them. (Grower #13)

Extension officers provide technical assistance about crop inputs. Because, with the Reef regulations, you can only put so much fertiliser. They will then work out how much nitrogen, after doing a soil test, that you can put on your blocks. I haven't got time to play around with stuff like that. I'll leave it to the service. The Reef Trust has given them money to do that. I'm quite happy to let them do it. (Grower #17)

Figure 1. Ego-networks from participant growers*



*Dark circle represents the farmer interviewed. Grey circles represent their advice contacts. Blue lines represent ties with family, friends and other relationships based on trust.

Figure 2. Proportion of actor types in the entire network

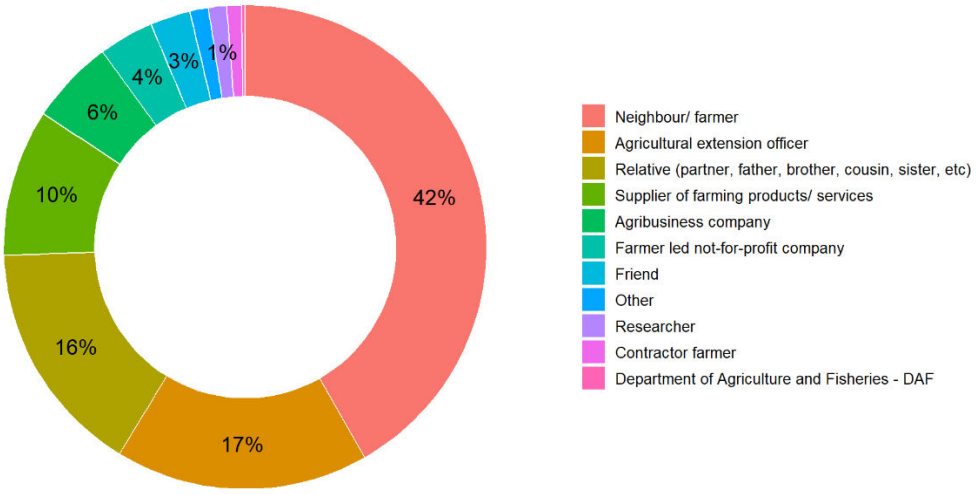


Figure 3. Proportion of actor types specific to the fertilising advice network

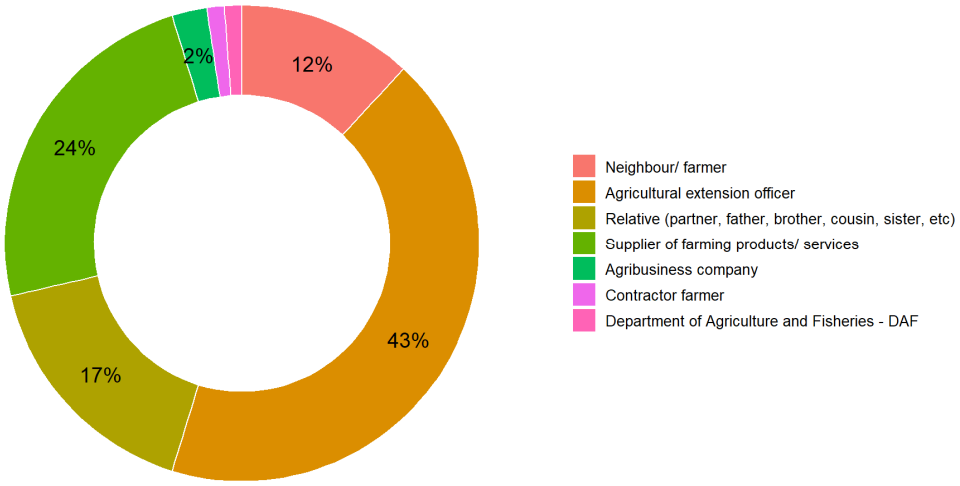
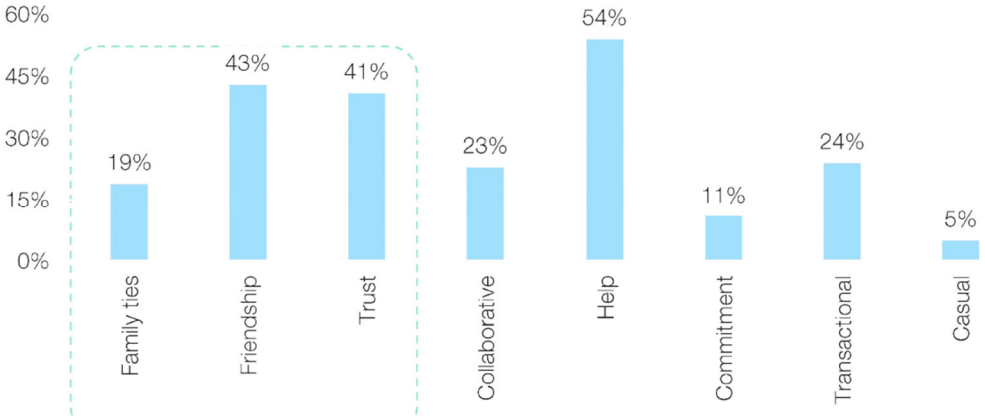


Figure 4. Distribution and overlap of relationship types across the networks



Social dynamics in practice adoption

Different types of relationships played distinct roles in either supporting or resisting practice adoption. Peers were instrumental in legitimising new practices and enhancing their credibility. In contrast, the role of family in farming decisions is multifaceted, as it can act as both a barrier and a driver of practice change. In some cases, resistance from relatives delayed the introduction of new practices, while in others, close relatives actively encouraged and accelerated their adoption. Shifts in authority within families, whether through generational transitions or sibling dynamics, also influenced these processes in both negative and positive ways, underscoring how agricultural practice choices are deeply intertwined with family relationships. We expand on this result in a forthcoming publication (Guerrero & Cruz, forthcoming), where we provide more details on how adoption of sustainable farming practices emerges through complex, socially embedded reinforcement, requiring multiple trusted signals across farmers' personal networks rather than simple information diffusion.

> We do discuss things and I force the issue that this is what you got to do. So mostly they do what I tell them [brothers] to do. I have to push them. See, everyone's got a different idea of what they should be doing, but I said to them, you can't do that anymore. You've got to do what you're supposed to be doing [regulations]. One of my close relatives is the factor one why I delayed making fertilising changes. (Grower #17)

> My father is retired now. He's got different ideas. When we were together, we'd work seven days a week and we never got ahead. He had a farm elsewhere with a different crop. I took up fertilizer box and stool splitting and he said, no, you can't do that. We had a lot of arguments because it was different to his previous type of crop. (Grower #33)

> We make plenty of decisions, but because I'm the oldest. I control them a little bit. It was easier when our father was alive because he used to tell us all what to do. When he passed, it was harder for me

> because he was everybody's father but I'm only their brother. So I've got to be in my role now. I've got to be very careful because we're all equal. (Grower #16)
>
> I do change. I'm not that old fashioned. The son said, well dad, if you want to farm, this is what you're going to do now. That's why I'm not the boss anymore. (Grower #9)
>
> With my son it's a one-way street. It's his way. If he wasn't there, I wouldn't be doing this [new practices]. I'm only doing it because he wanted to do it. (Grower #28)
>
> I've got a son, he made these changes [Control Traffic System]. That's how I made the change. (Grower #28)

Contract farmers emerged as key actors in connecting with other stakeholders, facilitating knowledge exchange, and serving as key communication links. Their work across multiple farms provides them with broad networks and firsthand knowledge of which practices succeed or fail. They share insights from research and peer experiences, encourage others to try new approaches, and often lead innovation through practical adaptations—such as modifying machinery. Their influence is amplified by existing trust and shared experience, making them effective conduits for spreading knowledge and fostering openness to new practices among growers.

> It's through the contract harvesting and planting that I've got to meet these other growers in different areas and become friends with them over the years. I am using new practices after getting information coming from SRA on fertiliser rates, all the results of their trials over the years. Information also coming from other growers as well. Fertiliser costs made everybody more aware. (Grower #15)
>
> Because I contract harvest, I cut probably another 15 farms other than our own […]. I say, "Hey, listen, have you ever thought about doing that job this way? It works for me. You get a better outcome". He'd say, "Oh yeah, I'll give that a go". So many of the farmers over the years now have gone, "Geez, why didn't we think of doing that? (Grower #20)
>
> A fellow grower. He was outspoken and he used to have a harvesting contract when I was harvesting. And that's when we modified the harvester because we had a new variety of cane Q113, very hard to cut. And back in those days, we went from brown cane to green cane. We had to modify all our gear to try and harvest this cane. And eventually we did. That's why you got harvesters like you got today really. My friend has all these ideas and he talks to a lot of people too, which is good. (Grower #3)
>
> 99% of farmers, especially the ones left in the game today, are open to ideas. There's not too many headstrong people out there anymore. You can't be, there's not enough money in it to be headstrong. If you tell someone they can save a little bit more money and do it quicker and grow a better crop, or even just to save a little bit of money and save a little bit of time, most people now are happy to give it a go. (Grower #20)

How peer interactions shape adoption

Adoption of sustainable agricultural practices among cane growers was found to be deeply socially embedded. It was not solely driven by access to information and training, but by the relationships and interactions that shape how that information was received, interpreted and acted upon. Adoption was rarely a one-off decision; rather it required reinforcement over time, often through repeated contact with peers who had already implemented the practice.

A culture of experimentation, peer-to-peer learning, and informal knowledge exchange emerged as a key enabler of practice adoption. Participant growers reported frequently conducting small-scale trials on their own properties and sharing results with peers, helping to reduce individual risk and accelerating collective learning. This collaborative approach fostered innovation, particularly in nutrient management, machinery modification and alternative cropping systems. Growers often "look over the fence" or initiate conversations after observing practices in the field, leading to informal peer endorsement. Communication through local networks, contracting work and intergenerational knowledge exchange also play a role in shaping adoption decisions.

> We always compare, because he might do something that you haven't […]. So, you do one trial on one farm, the other bloke does a different trial, and the third one does a different trial. We discuss, and we say one works the best. So, it can help you change things by not doing it all by yourself. If you've got a few people you know are playing with nutrients, trying to get the best you can with less inputs, it saves one person just taking all the brunt of the cost. (Grower #10)
>
> We network a lot. You look over the fence. So, if somebody's tried something and you realise, oh, that works all right, we go from there. We did some trials with nutrients. A lot of people followed what we were doing. (Grower #25)
>
> You'll find this [growers communicating with a wider network] in a lot of the younger generation coming through now because of their education […]. A lot of farmers these days have two jobs, so that's why they can communicate better […]. See, a lot of guys when you get to a certain age don't look to the younger generation for advice; they think themselves more experienced. I'll tell you what: the younger generation has got some good ideas too. Everyone can share. (Grower #18)

How collaboration and trust shape adoption

Growers highlight how trust has grown through collaboration in recent projects, contrasting with earlier approaches that lacked collaborative engagement. Trusted relationships with organisations involved in regional water quality initiatives, such as natural resource management organisations, government agencies and research institutions, have developed over time through open communication, shared goals and personal connections. Participant growers express confidence in science, regulations and new practices when they are introduced through long-term partnerships based on trust. They value its role in supporting farming operations and meeting environmental goals simultaneously. This trust, cultivated through sustained collaboration, appears to play a reinforcing role in growers' decision-making, helping to overcome common barriers to the uptake of new practices, such as scepticism or uncertainty, by enhancing credibility and confidence.

Knowledge sharing for joint capacity building

Growers report that the adoption of agricultural practices is strongly supported by collaborative networks, technical assistance, and incentive programs. Central to this process is the role of agronomists and extension staff (e.g. Farmacist, SRA, Canegrowers), who provide trusted, science-based recommendations and help growers navigate regulatory requirements. These organisations facilitated access to equipment, farm redesign and expert services, reducing financial and technical barriers to change.

Training programs and peer interaction through courses fostered knowledge exchange and positive attitudes towards innovation. Overall, a collaborative approach, where growers work alongside agronomists, government agencies, universities and industry partners, emerged as a key enabler in building trust, reducing risk and facilitating the transition toward more sustainable and compliant farming practices.

> Reef Rescue would've been the first one. That's when we went from fertilising side-dress to stool-splitting. They helped us buy a stool-splitting fertiliser box. Project Uplift was another one that allowed us to do farm layout redesign for drainage and introduce legumes during fallow. That allowed me to get the GPS tractor too. (Grower #14)

> We sit down with Farmacist and they'll work it out for us. We're going to cut this particular block early. That might be at the middle of the year and that one there at the end of the year. We'll put a little bit more fertiliser on this one. This one will have the normal rate, and the other one very little fertiliser. That's all through this nutrient management plan that they work in for us. It's terrific. What they do comes in a nice little booklet; it's got a picture of your farm maps in there. Then every block's sort of on there as well, and then there's all the particulars for particular blocks: fertiliser rates for you to apply on there. If you stick to that plan, which we do, happy days – and you are within the regulations as well. I don't have to worry about anything. (Grower #15)

> That's why these people [agricultural extension staff] are important, because they've got nothing to gain or lose. They've got a job. They're trained agronomists and most agronomists that we've dealt with have all been very good. None of them has got a different view. None of them has come along and said, don't worry about that rubbish. It's just rubbish we learnt at uni. No, no. Every one of them actually tried to cut us back in use of fertiliser. Well, I suppose they've proven that you don't need that much fertiliser. (Grower #16)

> With the Reef rules and regulations, like your soil tests, you need to abide by them. That's why we talk to them [extension officers]. We'll work out a plan on how much nitrogen. That agronomy comes from Farmacist. That's why we work with them with that fertiliser rate stuff. They help you to comply with the regulations properly. (Grower #19)

> We did courses like Digging Deeper (Terrain NRM). It's a soil health course. And through doing that, you meet growers from other mill areas and you establish friendships there and spread the ideas around. And definitely getting the government assistance helped: the Reef Trust IV Grant, Commonwealth funding around 2016. (Grower #35)

Growers expressed trust in the expertise of scientists, particularly when collaboration is part of the process. They valued scientists' training and experience, recognising the role of science in helping them comply with regulations, improve soil and nutrient management and adopt new technologies. While acknowledging that some farmers may be sceptical, participants emphasised their confidence in scientists' qualifications and their long-term involvement in the industry.

> They're all scientists. They've all got degrees in something. I've always believed in what they tell me. (Grower #17)

> I just trust them. They've been doing it a long time. They've always offered really good advice. They know the rules and regulations to abide by as well now – soil tests and how to comply with the rules. (Grower #20)

> I've always trusted that. Scientists are involved in it. They're trained. I know some farmers are a bit critical; they're biased. But, to me, people have got scientific background, and they learn to be unbiased about stuff, I think. So, I've always trusted. (Grower #26)

The role of collaboration in building trust

Participant growers reflected on how early projects, which lacked collaboration between producers and scientists, differed from more recent, cooperative initiatives, emphasising the positive impacts of collaboration on trust and subsequent sustainable practice adoption. Additionally, some growers describe how Canegrowers played a key bridging role in translating policy into practical terms and helping Government better understand farming realities.

> They came out guns blazing when it first happened and said we were wrecking the Reef. Then they took a step back. It was probably too forceful. It was years ago when they started bringing regulations in. They started saying we were polluting the Reef. If you go back through the media releases, "nitrogen leaching" and we're "killing the Reef". That was pretty hardcore. They then backed off a bit and started working with us. (Grower #19)

> It should have been a two-way street. The scientist should have been out in the paddock, farmer in the paddock […]. They should all be there at the table together. And then the paddocks see reality. (Grower #10)

> Well, it's good. Like we did at Project 25. We had a flood going on and one of the farmers waded this deep in the water trying to save the monitoring station. He could've just said, "Let it drown". But because they went together and people from JCU [James Cook University] had been up enough times, we were doing it together, it was collaboration. Four years ago, no farmer would've gone swimming in crocodile-infested water trying to save a station that tests your water for a nutrient runoff. People would've pushed it in the river instead. It changed because we were working together. (Grower #10)

> I trust the water sampling. The science is right. We talked the Minister into doing that on the banks of the river, with Canegrowers here, the Reef and Rainforest Research Centre, James Cook University. Because, with the initial modelling, growers were sceptical. The department had only an end of catchment point. But where did the nitrogen come from? Could have come from the pigs in the rainforest. (Grower #22)

In addition to adopting sustainable practices, participant growers also report actively contributing to partnerships through on-farm trials, collaborative research, and knowledge exchange. These contributions were often driven by long-standing relationships and mutual benefits. Growers describe how partnerships are strengthened through honest, long-term engagement, supported by personal connections, including friendships and family ties with staff in partner organisations. These relationships are seen to build confidence in the process and encourage participation.

> I do a lot of trials at home, like, for SRA, for Farmacist, for reduction of nitrogen. They come to me every time they want something, and I find them a piece of land for them to do their trials […]. I'm happy with that. (Grower #14)

> So, because I've done a lot with these people [SRA], there's sort of friendships. And the thing about all sorts of relationships is that the more you have to do with people, the more there's trust that comes in and problem-solving, obviously. And we're looking for benefits […]. But even if it's a failure, it's still worthwhile […]. It's collective learning. (Grower #12)

> With Farmacist, the mill, the harvesting group, there's trust there; friendships. Once you have an honest relationship with people, then trust comes […]. We build a strong business, which is beneficial to everybody. (Grower #12)

> Last year, we had big a forum here. We organised visits to growers working on composting, wetlands restoration, and new methods of farming […]. It's good to get some ideas. (Grower #17)

Lastly, growers reported actively contributing to water quality improvements and described environmental stewardship as part of good farming. Project 25 was frequently highlighted as a positive example of collaborative, science-based monitoring. Growers expressed trust in the project because it involved cooperation and local data collection, reinforcing growers' commitment to environmental outcomes through on-ground collaboration.

> I know everyone's sugarcane-oriented but there's no reason why everybody cannot just go and do some environmental work […]. It's just part of your business […]. I tell growers that all the time […]. Please put some time aside, 5%, 10% of your farm work, for environmental work. (Grower #17)

> Whatever data Project 25 comes up with is accurate, which is run by JCU. I don't go with hearsay. I don't listen to people who think they know. I listen to the people who are doing the work on the ground monitoring 24/7, and the data should be accurate. (Grower #4)

> I always say that farmers don't like modelling. But monitoring is good, because monitoring is real […]. It's a very good news story because you're basically proving that all the changes that you've made are having a positive impact. (Grower #35)

Discussion

Our findings reveal that participant grower's relational dynamics and experiences of collaboration offer valuable insights for designing context-specific co-management strategies for practice change. The findings highlight the central role of social networks, collaboration and trust in shaping the adoption of sustainable agricultural practices. Importantly the adoption process is not solely driven by access to information; rather it unfolds within a web of diverse relationships surrounding each grower. These relationships support practice adoption by enhancing confidence and credibility, helping to legitimise new approaches and support their uptake within farming communities.

The diversity of fertiliser advice sources, and the trust underpinning these ties, illustrate that practice adoption is a socially embedded process. Among study participants, adoption rarely result from a single interaction; instead, it emerged from multiple, overlapping influences across a spectrum of social ties. These findings highlight that different types of relationships play distinct roles. Close ties, such as friendships, often help "legitimate" new practices by providing social proof, and facilitating innovation and problem-solving. Family ties can be more complex; in some cases they support practice change while in others they reinforce tradition and delay adoption. More loosely connected but trusted actors, who can include service providers and extension officers, contribute by offering credible information, thus enabling social confirmation. This layered social dynamic reinforces the idea that adoption is a socially embedded process, shaped not only by relational depth but also by the diversity of connections. The socially embedded nature of adoption observed here reinforces the idea that effective extension efforts must engage with growers' networks, recognising the diverse roles that different actors play in legitimising and supporting change.

Growers' networks also show that long-standing relationships, such as those with family, friends, respected peers and trusted advisers, carry more weight than high-profile peers when it comes to influencing sustainable agricultural practice adoption. This suggests that trust matters more than visibility or popularity. A clear connection between long-standing relationships, trust and social reinforcement was also evidenced, where contract farmers, for instance, were highly trusted sources of advice given their role as peer-to-peer knowledge brokers, as well as extension officers who are based locally, and who are learning alongside growers in shared trials or projects, while supporting regulations compliance (e.g. Nutrient Management Plans).

Our findings align with early and modern behavioural-extension research recognising that farmer decision-making is socially mediated and shaped by interpersonal influences (Tully et al. 1964; Leeuwis 2013). They also resonate with more recent social network scholarship which highlight that socially central "opinion leaders" are not always the most effective agents of behavioural change, and that trust, local context and peer-to-peer learning can be more influential than centrality in driving sustainable practices (Matous 2023).

Our findings also share elements with those of Hasan et al. (2021), who highlight how family traditions and the prioritisation of maintaining good relationships with other local growers can delay fertiliser practice change, underscoring the role of relational embeddedness in shaping decision-making. However, while Hasan et al. (2021) emphasise how maintaining good relationships may hinder innovation, our results also highlight the enabling role of diverse and trusted ties. Close friends and fellow farmers help legitimise new practices, while contract farmers or extension officers act as credible knowledge brokers, reinforcing adoption through trust and shared experience. This suggests that, although some ties constrain change, long-standing and trusted relationships often function as key enablers of adoption in this context. It is within these trusted networks that collaborative initiatives emerge as key enablers of adoption, providing platforms for shared learning, meaningful engagement, transparency and fairness. Growers expressed frustration, for example, with projects that lacked meaningful engagement, or failed to consider their knowledge and local contexts (e.g., climate, market dynamics, industry demands, limited resources). Our data shows how trust is relational and dynamic, and that fly-in-fly-out programs and extension approaches do not support a trust-building platform to nurture adoption.

Our findings also align with previous research emphasising the central role of collaboration, trust, and contextual relevance in enabling practice change. Like Shawky et al. (2023) and Davis et al. (2019), who evaluated enablers of practice change in the Wet Tropics region, our results highlight the importance of two-way communication, shared leadership, and recognition of on-farm realities. While these earlier studies emphasised institutional-level enablers, such as government–industry partnerships, adequate funding, improve science-industry communication, and return on investment, our findings provide additional grower-level insights into how extension projects and policies could be framed, co-designed, and facilitated in a way that resonates with the lived-

realities of farmers. This includes fostering two-way communication platforms, training programs, support of community leadership, recognition of on-farm knowledge, access to monitoring results, and opportunities for mutual learning and experimentation.

Our research thus demonstrates that information, advice, and support alone are not sufficient to drive change. Farmers reported adopting a diversity of practices over time, even before major water quality monitoring investments were implemented in the region. This is supported by Hasan et al. (2021), who found that 37% of growers (n=248) had changed their fertiliser calculation method between one and 45 years ago, with a mean of 8.4 years. This indicates that adoption does not only occur in response to extension programs and policies, but as part of a complex social process shaped by growers' networks and contexts. Identifying and supporting these social processes is crucial for enhancing the impact of projects in the region.

Consistent with our findings, the Mulgrave-Russell Water Quality Program report (GBRF 2024), Gongora et al. (2025) and Shultz et al. (2025) emphasised similar key lessons. The importance of continuity with earlier initiatives and partnerships (GBRF 2024; Gongora et al. 2025; Shultz et al. 2025) for instance, and how the engagement of smaller grower groups creates strong opportunities for peer learning (GBRF 2024). The Mulgrave-Russell Water Quality program also underscored how a clearly defined governance framework involving multiple stakeholders improved accountability, transparency and the capacity to adapt. The value of investing in locally developed water-monitoring systems through co-design and shared expertise, which helped rebuild trust in science and stakeholder relationships (GBRF 2024; Shultz et al. 2025). Finally, GBRF (2024) regard the provision of technical support and assistance with drainage management practices as essential for strengthening overall project outcomes. These lessons were echoed by our participants, who emphasised that long-term relationships with scientists and project officers, along with opportunities for dialogue and shared learning, helped sustain commitment to the projects.

The depth and nuance of the insights generated in this study were made possible by the methodological approach, which enabled participants to map and reflect on their social networks during interviews. This process uncovered layers of social influence that are often invisible in conventional surveys and datasets. Because participants actively constructed their networks, they frequently reflected deeply on their relationships and decision-making processes. This approach proved particularly valuable for several reasons. First, it combined visual mapping with narrative inquiry, allowing us to capture not only who is connected to whom, but also the stories and meanings behind those connections, crucial for understanding behaviour change. Second, it surfaced hidden dynamics such as trust, resistance, and informal influence that are often missed in standard surveys or interviews. Third, it was participatory; participant growers actively built and interpreted their own networks, which prompted reflection and often revealed insights they had not previously considered. Fourth, it fostered trust and mutual learning. Growers reported feeling heard and valued (as compared to phone surveys) and many were curious about their own social context. Overall, this method offers a powerful tool for understanding complex social systems and the relational dimensions of practice change (Crossley 2015; Centola 2018).

Lastly, regarding the study's limitations, eliciting and analysing the lived experiences of 35 growers generated a rich, sociologically grounded dataset informed by a constructivist approach. However, the findings should be interpreted carefully, as they reflect the perspectives and experiences of participant growers from the Mulgrave–Russell region. Therefore, future research would benefit from expanding the sample size and including other areas as well to capture potential behavioural trends operating across the broader region and including expanded statistical analyses similar to those conducted by Hasan et al. (2021).

The findings of our study provide relevant evidence to guide the design and implementation of policies and projects that support collaboration-centred extension strategies grounded in existing grower communication networks, where strengthening peer learning, trusted relationships, and sustained engagement support adoption of sustainable agricultural practices over time.

Conclusion

Our study aimed at investigating how the social context and relationship dynamics of cane growers in the Mulgrave-Russell catchment influence their adoption of sustainable agricultural practices, and how collaborative initiatives shape growers' decisions to adopt these practices. Together, these questions examine the extent to which practice change is embedded within social interactions and trust, rather than driven solely by individual or technical factors.

In connection with our first research question, this research highlights the importance of understanding adoption of sustainable practices for water quality in the GBR as a socially embedded process shaped by diverse relationships and interactions. Growers' decisions to adopt

sustainable practices are influenced not only by access to information and advice but by the nature and quality of their social ties, with different relationships playing distinct roles. Exposure to new practices, while necessary, is not sufficient on its own. What matters is how that exposure is reinforced through trusted, meaningful connections, particularly those rooted in family, friendship, and long-standing trusted relationships. Close ties, such as those with peers, often carry more weight than those of highly visible or 'popular' actors. The influence of family networks in shaping adoption decisions deserves closer attention, particularly in intergenerational farming contexts. There is also indication that adoption is rarely a one-off event; rather, it requires reinforcement over time, making repeated contact with peers who have already adopted a critical factor in sustaining change.

In relation to our second research question, we found that collaborative initiatives shape adoption not merely by transmitting technical knowledge but by creating relational spaces where trust, experimentation, and peer validation can develop over time. Their effectiveness depends less on formal structure and more on their capacity to embed growers within repeated, credible, and socially meaningful interactions. Lastly, trust emerged as a central theme, not as a static or universal concept, but as something built through specific social dynamics, including shared experiences, perceived fairness, and the credibility of messengers, which can also be nurtured via genuine collaboration platforms. Supporting the culture of experimentation and peer-to-peer learning that growers have cultivated over time promotes grower-led innovation and shared leadership in practice change. Recognising these dynamics is essential for designing engagement strategies and policy interventions that resonate with growers' lived realities and support long-term sustainability.

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