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Regenerative agriculture in Australia: the changing face of farming

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The agricultural and social landscape of rural Australia is changing, with many farmers interested in, and some actively moving towards, regenerative agriculture—but what do we understand of the farmers undertaking these transitions? Regenerative agriculture is a holistic way of managing landscapes that aims to move beyond sustainability to regenerate natural systems, while supporting farming system viability. While several authors have discussed the higher-level philosophical underpinnings of regenerative agriculture, there are few empirical studies exploring the motivators for farmers to implement a suite of practices within the regenerative agriculture tool-kit. By undertaking an online survey targeting regenerative farmers, this study identifies common attributes of regenerative farmers, as well as key motivators for, and barriers to change, including perceived benefits arising from the approach. An online survey was promoted through the social media pages of three farming groups, resulting in 96 self-identifying Australian regenerative farmers included in this analysis. Results demonstrate that a clear and recent shift has taken place for this group, who may feel ostracized within their local community, hence often rely on information from online and international sources of agricultural information. This article builds a core understanding of the goals, attributes, aspirations and challenges of regenerative farmers and offers a definition of regenerative agriculture that is derived from farmer responses.

KEYWORDS

agricultural transitions, regenerative agriculture, definition, survey, farmer goals, Australia

1 Introduction

Agriculture has drastically changed in the last 500 years, moving from traditional horse drawn carts through to tractors and the dramatic changes of the green revolution. While these advances have allowed us to increase the scale and productivity of our agricultural systems and feed a growing population, the longer-term impacts of some of the associated practices are now better understood (Campbell et al., 2017), and some are not sustainable (Kopittke et al., 2019; Steffen et al., 2015).

A growing use of fertilisers has led to increased eutrophication of waterways, while the use of pesticides has simplified our landscapes, reducing ecological resilience in our farmlands (Campbell et al., 2017; Heeb et al., 2019). The industrialisation of agriculture has increased farmer dependency on fossil fuels, directly, through the increased use of machinery, and indirectly, through mechanisms such as the Haber-Bosch process for nitrogen production (Malerba et al., 2022a,b; Vechi et al., 2022; White et al., 2021). The resulting emissions from broadly accepted agricultural practices are contributing to our climate being altered, with farmers around the world finding themselves on the front line of extreme weather events of increasing frequency (Cogato et al., 2019; Lesk et al., 2016; Malik et al., 2022). Ameliorating these impacts will involve change in agriculture practice through the increased uptake of new approaches, innovations, and technologies (Darnhofer, 2021).

As new knowledge, innovation, and technological advancements arise, reconsidering and changing farming practices is important for reducing agricultural impacts while building resilience to future extreme events (Chausson et al., 2020; Seddon et al., 2020). Regenerative agriculture is an approach to farming that appears to be growing in popularity globally, aimed at improving ecological, economic, and social issues surrounding the farm and local community, while also having the potential to positively impact on both small- and large-scale earth systems (Brown et al., 2022; Colley et al., 2019; Elevitch et al., 2018; Massy, 2017).

Rodale (1983) originally defined regenerative agriculture as an approach to farming which aims at:

> *'increasing levels of productivity, increases our land and soil biological production base. It has a high level of built-in economic and biological stability. It has minimal to no impact on the environment beyond the farm or field boundaries. It produces foodstuffs free from biocides'.*

While there is currently no widely accepted definition, it can be described as an umbrella term for best-practice farming that aims at improving the health of soils and landscapes while maintaining a productive farming business (Elrick et al., 2022). What has been called the 'regenerative agriculture movement' is notable in that it is being led by farmers (Burns, 2020), and only recently have academics started to discuss what regenerative agriculture is, and is not. Crucial to this, is building an understanding of farmers already active in this space.

1.1 Regenerative agriculture principles and practices

The complexity of defining the concept was highlighted by Gordon et al. (2023), suggesting there are nine philosophical discourses in regenerative agriculture, ranging from adapting existing approaches, such as organics and permaculture, to holism and more culturally focused paradigms. In terms of definition through goals and outcomes, a review by Newton et al. (2020) suggested that improving ecosystems, soil and water health while increasing biodiversity are core goals of regenerative farmers. A practice-based definition centred on soil conservation, reducing tillage and increasing soil cover (Schreefel et al., 2020).

Approaches fostering regenerative farming systems aim to minimise soil disturbance to preserve the integrity of soil structures and maintain vital biology and nutrient pathways (Six et al., 1999; Begum et al., 2019; Schreefel et al., 2020). Synthetic inputs are phased out to allow natural systems to function effectively (De Ponti et al., 2012; Morgan and Murdoch, 2000; Pretty, 1999), while integrating organic inputs fosters microbial activity and enriches soil nutrients (Larney et al., 2006). Incorporating perennial plants helps maintain soil cover, stabilises soil against erosion, and promotes nutrient cycling through deeper root systems (Vukicevich et al., 2016; Cox et al., 2006). Diversification of enterprises and crop rotation strategies can enhance resilience against crop failure and market fluctuations while supporting soil health (Lin, 2011; Bullock, 1992). Increasing biodiversity within agricultural systems not only supports pollination and pest control but also has been reported to enhance resilience to climate change, improve soil health and offer economic benefits (Blaauw and Isaacs, 2014; Carvalheiro et al., 2011; Kremen and Merenlender, 2018).

1.2 Adoption of practices

The adoption of new practices is reported to occur when a landholder invests in a new technology or innovation, believing it will enhance their farming operation and achieve their personal goals (Pannell et al., 2006). Rogers (1962) Diffusion of Innovation Theory has infused itself as a major framework for the adoption of innovations in Australian farming. The adoption of new practices follows a bell-shaped curve, from 'early adopters' to 'laggards' being the last to adopt (Rogers, 2003). The theory identifies five attributes that drive or limit adoption, including relative advantage and trialability for farmers (Pannell et al., 2006). Vanclay (2004) describes potential barriers to the uptake of a new innovation, including: complexity of the innovation; non-divisibility (hard to trial in bite-size pieces); non-compatibility with farmer goals; they hinder flexibility; not perceived as profitable; costly; steepness of learning curve; considered high risk; conflicting information; no perceived need to change; as well as experiencing a lack of necessary physical and social infrastructure. Vanclay (2004) describes social infrastructure as an important community knowledge bank for farmers and a source of education on a range of farming practices.

To understand decisions made by farmers and land managers, we need to understand the complexity and multidimensionality of individuals and their context (Edwards, 1954), including underlying social-psychological processes that drive decision-making and change. Three main types of decisions are simple, complicated, and complex (Nicholson, 2015). Decisions become more complex as more and more interrelated variables intersect, and as more stakeholders are involved (Snowden and Boone, 2007). An increasing number of academics and farmers argue that there is a need to embrace a more holistic viewpoint that acknowledges and works with complexity (Darnhofer, 2021; Gosnell et al., 2019; Massy, 2013; Seymour and Connelly, 2022). This involves a shift away from the idea that farmers are facing complicated problems with a clear answer, to being more comfortable with the dynamic complexity required to work with our ecology, whilst also navigating the social and economic dimensions of farming industries and systems.

Advocates of regenerative agriculture often argue that farmers need to change more than their farm management, and that a shift in how we think about farming is needed, to a more holistic approach (Massy, 2017). The idea of a paradigm shift was introduced in 1962 by Thomas Kuhn and is centred on a paradigm being a perception or world view that can be shifted to see a same problem or theory from a radically different perspective (Bird, 2014). Massy (2017), building on the work of Mezirow (1997) and Pearce (2002), suggests that for many farmers, the transition to regenerative farming comes from a 'head cracking' paradigm shift often emerging from traumatic experiences such as extreme weather, financial hardship, family changes, or unexpected regulatory changes (Gliessman, 2014).

1.3 Drivers of change

Drivers of change in agriculture can occur at different scales, from local to global (Hazell and Wood, 2008). Farmers may change their practices due to internal or external pressures linked to economic, environmental social, personal and technological factors, as well as policy, politics and regulation (Gliessman, 2014; Pannell et al., 2006). Technological advancements such as genetically modified crops and the Haber-Bosch process have precipitated major changes in agricultural practice (Khush, 2001; Smil, 1999). A farm cost–price squeeze may lead to changing practice (Czyżewski et al., 2019; Giller et al., 2021). Environmental challenges such as water scarcity, climate change and soil degradation may play an important role (Campbell et al., 2017; Pimentel et al., 2004). Social factors, such as consumer behaviour and public awareness campaigns, can also facilitate changes to agricultural policy and practice (Gliessman, 2014) (e.g., Australian Government, 2023).

Socio-psychological factors can play an important role in understanding how farmers make decisions to change (Meade and Islam, 2006, for a review). The Theory of Planned Behaviour (TPB) is a widely used framework that can be applied to understand why new ideas and technologies are introduced and integrated (or not) by individuals, offering a lens to assess behaviour (Fishbein and Ajzen, 2011). A decision or behavioural outcome stems from people's intentions, which are impacted by three key factors: attitude, subjective norm, and perceived behavioural control. This theory provides a useful framework to evaluate the perceived social pressures facing farmers (norms) along with their perceptions of their ability to change (perceived behavioural control) against their goals and attitude (Senger et al., 2017).

In the evolving landscape of agriculture, farmers are confronted with the need for continual knowledge acquisition to ensure their success (Hazell and Wood, 2008). Education has long been proposed to have a strong influence on productivity in situations involving higher levels of technology (Schultz, 1975). Lockheed et al. (1980) found that four years of schooling on average improved agricultural outputs by 7.4% for farms utilising modern technologies. A recent study identified that 44% of farmers implementing a set of best-practices had been university educated, compared to 18% of farmers not implementing those practices (Alexanderson et al., 2023).

Knowledge levels and information-pathways are key to the nature of information accessed by farmers (Alexanderson et al., 2023). Landholders often rely heavily on information obtained from other farmers (Garforth et al., 2003; Ingram, 2008; Prokopy et al., 2015). Schneider et al. (2012) emphasise the importance of networks in knowledge dissemination, as linear transfers of technology from specialists to farmers may no longer be sufficient to solve agricultural problems. While an increasing reliance on agronomists has been identified in recent years, Ingram (2008) points out that there may be a potential disconnect between agronomists and farmers due to differences in goals, motivations and core values. This could also relate to consultants being paid season by season, thereby wishing to generate immediate returns to ensure re-engagement.

Burbi and Hartless Rose (2016) suggest farmers may face time and distance constraints to accessing face to face engagement events run for them. Dipu et al. (2022) propose that farmers interested in farming regeneratively are moving away from conventional knowledge sources and agricultural consultants, and instead turning to social media, workshops, field days, and books. A recent shift has been identified towards the use of online social media networks and messaging apps (Nain et al., 2019; Skaalsveen et al., 2020). Despite these findings, an extensive survey of Australian farmers identified that other farmers and consultants remain leading sources of information in farming communities (Alexanderson et al., 2023).

While there are numerous articles focused on farmer's knowledge of existing approaches and issues (Abang et al., 2014; Grossman, 2003; Ingram, 2008), farmer knowledge of alternative agricultural systems such as regenerative agriculture are less well understood.

1.4 Challenges for regenerative agriculture

Amidst growing interest in regenerative agriculture, critics question the universal applicability of regenerative practices (Giller et al., 2021; McGuire, 2018), arguing that scientific evidence has yet to fully substantiate proponent claims (Giller et al., 2021). Debates over regenerative asset value and profitability persist. LaCanne and Lundgren (2018) suggest that while some regenerative agricultural practices led to reduced yields, farm profitability increased due to reduced inputs. Results from holistic grazing management have showed increased profitability over time (Ogilvy et al., 2018), while Francis (2020) contested profitability claims based on benchmarking data, raising questions about stocking numbers and their implications.

A lack of definition may be impacting widespread adoption and implementation. Alexanderson et al. (2024), highlight barriers to adoption such as mindset, economic considerations, environmental constraints, and the need for clearer terminology. Gosnell et al. (2019) raised concerns about potential alienation among regenerative farmers, finding that many feel less connected to their local communities. Alexanderson et al. (2023) found that many Australian farmers implementing best-practices related to regenerative agriculture were not identifying as regenerative farmers.

Few other large-scale evaluations of regenerative agriculture industry personnel appear within the literature. Despite these debates and challenges, a comprehensive study focusing on farmers who self-identify as practicing regenerative agriculture is imperative. This study looks to focus on those farmers who self-identify as regenerative, seeking to provide deeper insights into their goals, priorities, challenges, attributes and other drivers of their decision-making. It maps potential practice changes over time and uses the Theory of Planned Behaviour (as per Fishbein and Ajzen, 2011) as a frame to discuss key drivers of practice change and implementation regarding regenerative agricultural practices.

Therefore, the research questions of this paper are:

1 *What are key goals, aspirations and challenges of regenerative farmers?*
2 *What are the perceived benefits and limitations of regenerative transitions?*

2 Methods

An online survey was created using Qualtrics software, and based on a well-established survey structure (Alexanderson et al., 2023; Curtis and Mendham, 2015; Luke et al., 2021). Many of the questions were drawn from the Cooperative Research Centre for High Performance Soils (Soil CRC) Social Benchmarking Survey, with additional questions that were specifically designed for farmers undertaking regenerative agricultural practices.

2.1 Questions

The survey was comprehensive, comprising of a total of 260 data points, including some sub-sections, with one section specifically on perceptions of regenerative agriculture. Past, current and future application and implementation of practices was included for a range of practices linked to regenerative agriculture in the literature (as per: Newton et al., 2020; Schreefel et al., 2020; Alexanderson et al., 2023). The landholder typology developed by Groth et al. (2017) was used to identify landholder types, including full-time, part-time and hobby farmers, as well as non-farmers. The list of information sources and knowledge levels included in the survey were adapted from the work of Luke et al. (2021) and Alexanderson et al. (2023).

For questions on the 'benefits of regenerative agriculture', respondents were asked if they feel confident that adopting regenerative/holistic farming practices is justified by the returns (control beliefs), using a 5-point Likert scale. Those that either 'agree' (4) or 'strongly agree' (5) with the statement were collapsed into a single category. This group were then asked to indicate the return benefits they expected from regenerative agriculture from a list, which included: soil health; farm resilience; landscape health; profitability; risk reduction; family wellbeing; mental health; physical health; natural capital value; asset value and other.

Other survey topics included knowledge on a variety of farming practices (affecting control beliefs); preferred sources of information; and how supported they felt in their communities (normative influences), with response options being a mix of 5-point Likert scale; (also collapsed into binary categories) or yes/no options. Open ended questions were used to provide top of mind associations with regenerative agriculture (Clarke et al., 2015), as well as detail around what they considered to be the most important elements of RA and it's limitations (beliefs and associations regarding regenerative agriculture). They were also asked about their own farming goals and the tools they thought were important for reaching these goals. The relative importance of ideas are visualised in the results using Wordle software, the benefits of which are explored in the works of Viegas et al. (2009).

2.2 Implementation

The survey was promoted through the Facebook pages of two NGOs (Soils for Life and Farming Secrets), as well as Southern Cross University's Regenerative Agriculture Alliance, a deliberate targeting of networks that were already working in the regenerative agriculture space, called targeted snowball sampling (Dosek, 2021). The survey was open for 1 month, with a reminder posted 1 week before the survey closed. Following this period of data collection, the data was downloaded from Qualtrics and analysed in Microsoft Excel using descriptive statistics. A thematic analysis of the qualitative data was applied to provide insights into how regenerative agriculture is perceived by practitioners (Castleberry and Nolen, 2018). The survey received Ethics approval from Southern Cross University, ethics number 2021/142.

2.3 The sample

The survey received 514 views, and 416 total responses (163 full time farmers, 80 part-time farmers, 80 hobby farmers and 91 non-farmers). An additional two respondents failed to answer the farming type question. This resulted in 243 full and part-time farmers being identified for further consideration. Respondents were asked if they considered themselves to be undertaking practices associated with regenerative agriculture, which reduced the pool further, leaving 171 who considered themselves to be undertaking regenerative farming. A further 36 respondents were removed for also being in a teaching/mentoring, extension, management or professional role related to regenerative agriculture. This decision was made so as not to bias the survey towards key influencers in the space, or to skew the knowledge-based data. An additional 11 respondents were removed for not completing the teaching/mentoring question. This left 124 respondents for potential inclusion in this study. Survey respondents were predominantly from Oceania (77% (Australia 76% and New Zealand 1%)), with respondents from North America (14%), Europe (4%), South America (2%), Africa (2%) and Asia (1%) included. Of the Australian respondents utilised in this research (n = 96), 35 were from Victoria, 28 New South Wales, 14 Queensland, 7 Western Australia, 6 South Australia and 4 from Tasmania.

3 Results and discussion

3.1 Attributes of respondents

The majority of respondents were male (73%), with an average age of 58 years old. Fifty-three percent of respondents had a university-level of education, while 19% concluded studies at a vocational college and 16% had completed Year 12. The remaining 12% was broken down between Year 10 (9%) and those trained in life, but with no formal qualifications (3%). Additionally, 72% of respondents indicated that they had participated in training or education related to regenerative agriculture. Regenerative farmers having attended university in over 50% of cases builds on the findings of a study by Alexanderson et al. (2023) in which 44% of farmers undertaking best-practices related to regenerative farming had attended university. The survey results indicated that 66% of regenerative farmers own a single property, while 22% own two or more. A quarter of respondents (25%) manage additional land through lease, share farm or agistment. Results suggest that when making decisions, 79% of regenerative farmers in this study were likely to include others in that process, including their spouse (58%); a parent (15%); a child (13%); and/or agronomist (10%) with 16% claiming 'other'.

Regenerative farmers in this study were found to commonly be involved in mixed farming, with an average 4.1 enterprises on their property. This builds on the work of Alexanderson et al. (2023) where there were 3.6 enterprises on best-practice farms compared with 2.9 on those not undertaking best-practice. Previous studies have identified that farms having a higher number of enterprises may help mitigate the impacts of changes in local and international markets, hence lead to increased resilience against failed crops (Lin, 2011; Singh et al., 2021).

3.2 Key elements of regenerative agriculture

When asked the first four words that come to mind in relation to regenerative agriculture (RA), the following themes were the most prominent across the sample (illustrated in Figure 1):

1. health of soils
2. biodiversity, including microbiology
3. water retention in soils and landscapes
4. taking a holistic approach to management

The top three of these are consistent throughout the literature, however the inclusion of taking a holistic approach demonstrates that ways of thinking about farming remain an important element of regenerative agriculture (Massy, 2017).

Each of these were also present in the goals these farmers outlined for their properties. *Improving* or *increasing* profitability, soil-health, biodiversity and water holding capacity within their farm system, were clear top goals of the regenerative farmers in this study (shown in Figure 2). This highlights an important difference with the concept of the Oxford Dictionary definition of sustainability, which is: *'the ability to be maintained at a certain rate or level'*, or, *'avoidance of the depletion of natural resources in order to maintain an ecological balance.'* While sustainability focuses on maintaining the status quo, regenerative farmers in this study aim to make positive changes and improvements. This raises an important question: what is considered healthy soil in a production system? For instance, a soil supporting a healthy natural ecosystem might have never undergone human intervention, yet it may have limited production capacity. A detailed discussion on the definition of a healthy soil or landscape is beyond the scope of this paper. However, a useful definition from Kopittke et al. (2024, p. 210) describes a healthy soil as '*multifunctional and capable of underpinning human and planetary health*'. According to the International Standards for Ecological Restoration, a '*conversion landscape*' refers to a restored landscape that functions well and is healthy, even if it does not resemble the original or Indigenous ecology of the site (see Luke et al., 2017).

When accessing support to meet these goals, results suggest that RA farmers in this study were not prioritising technologies. Instead, what they are seeking is improved *knowledge about soil health and regenerative farm management,* including *water retention* and how to support *improved soil biology*. This aligns with the findings of Luke et al. (2022), who, after asking farmers what sort of technology, innovations or knowledge would support their farm management goals, found that after basic connectivity (mobile and internet coverage) and accurate weather forecasting, improved knowledge on a broad range of farm and soil management practices was what was most frequently listed as required to support farmer needs and goals.

When assessing the most important elements of RA, *soil health* was again raised as the most common theme, followed by *carbon sequestration* and *increasing biodiversity,* although it is important to note that some farmers were referring to biodiversity within the production system and soil, while others referred to it in relation to natural areas of vegetation and wetlands that were adjacent to the production system. The results align with the findings of a farmer survey by Alexanderson et al. (2023), linking regenerative farming with mitigation of climate change. It also links with the RA objectives identified in an extensive literature review by Schreefel et al. (2020), with many less common objectives also present in our findings (for example improve human health). Additional themes of weighted importance include *taking a holistic approach* and *being sustainable* as well as *profitable*. This highlights some of the competing paradigms within regenerative agriculture as previously identified by Gordon et al. (2023).

FIGURE 1
Wordle™ word frequency diagram showing top of mind associations with regenerative agriculture, for regenerative farmer surveyed in this study.

FIGURE 2
Wordle™ word-frequency diagram using responses to the question on top farmer goals in relation to their farm system.

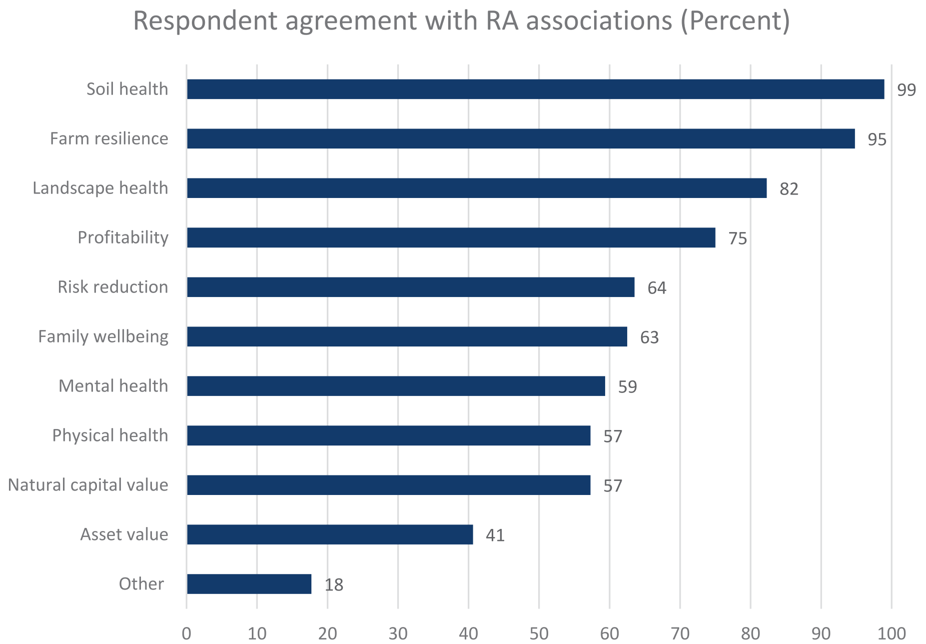

FIGURE 3
Perceived benefits of regenerative agriculture from farmers identifying as regenerative (*n* = 96).

3.3 Perceived benefits

Seventy-eight percent of self-identified regenerative farmers were confident that 'adopting regenerative practices is justified by the returns' (34% of respondents agreed, 44% strongly agreed), against 5% who disagreed (3% disagreed, 2% strongly disagreed), with the remainder uncertain. Those who agreed with this statement were then asked about the benefits of regenerative agriculture (Figure 3). Of this group, 99% viewed soil health as a main benefit of regenerative agriculture, closely followed by farm resilience (95%) and landscape health (82%). These results suggest that the conversation around the environmental benefits of regenerative agriculture is resonating with practitioners, reaffirming the findings of Gosnell et al. (2019), LaCanne and Lundgren (2018) and Rhodes (2012).

Respondents had lower levels of confidence about the benefits of family wellbeing (63%), mental health (59%), and physical health (57%) associated with regenerative agriculture, compared to their environmental counterparts. This suggests that while some literature shows the social benefits of regenerative agriculture in Australia and internationally, (Brown et al., 2021, 2022; Ogilvy et al., 2018; Seymour, 2021), these benefits may not be as evident to regenerative farmers.

Financially, three quarters of respondents felt confident that they had increased their profitability due to implementing regenerative practices, while outcomes of increased natural capital value (57%) and asset value (41%) had lower levels of confidence. An analysis of respondents who were not confident that adopting regenerative practices is justified by the returns (points 1 and 2) was not conducted due to low sampling numbers (n = 5).

3.4 Barriers

While many listed 'none' as a response to a question on barriers to regenerative agricultural uptake, respondents still identified a range of limitations, with a key theme being initial time and financial investments associated with making the transition, described as *'The big short term "bang for the buck"'* temptation of synthetics versus the lower early returns gradually building over seasons to become *a 'sustainably healthier return on investment'.* Lesser but still common themes raised were a need for more knowledge and institutional support, specifically in relation to reducing synthetic inputs, with concerns also raised that *'a plethora of accreditations which ultimately do not serve the grower or consumers'* may hamper rather than support progress or expansion of regenerative agriculture consistent with the findings of Elrick et al. (2022). Other barriers or challenges described by many farmers included: '*Creating a paradigm shift (without a crisis)*'; and *'the many interpretations'* of what regenerative agriculture is perceived or defined to be. These results are comparable yet slightly different to the findings of Alexanderson et al. (2024) in which agricultural consultants identified mindset, economics/governance, environmental factors, time and terminology as limiting factors for RA uptake. For regenerative farmers, the primary limitations were the costs and time required for the transition, along with a recurrent need for knowledge and institutional support. These challenges could potentially be alleviated through enhanced policy and regulatory measures that align with the goals of regenerative farmers and reward good soil stewardship, which, in the Australian context may be through carbon initiatives. The results of this study do, however, indicate that carbon production is not a solo motivator for these farmers, who are interested in the improved health, biodiversity and productivity of their soils and farms more generally (Figures 1, 2).

3.5 Regenerative agricultural practices

When first asked what practices they were undertaking that they considered to be regenerative, the responses fitted quite clearly in to six strongly overlapping areas, being:

1 Improving soil health through keeping the soil covered and with minimal disturbance; and the application of soil amendments that increase soil carbon and water holding capacity, from bacteria and fungi to worms.
2 Maintaining groundcover through no-till or minimum till, cover-cropping and other plantings. Also, allowing weeds to grow as a part of a larger process.
3 Grazing practices, including cell grazing, holistic grazing and integrated livestock.
4 Improving biodiversity (this had the most diverse solutions), including tree-planting; encouraging native grasses and shrubs to grow; expanding fencing including for riparian zones; multi-species pastures and multi-species cropping systems, through to microbiology.
5 Water management, including keeping water in the landscape through keylines, contour swales, and supporting or establishing wetlands.
6 Minimising inputs, for the purposes of both cost-saving and to support biodiversity to flourish.

Once again, increasing biodiversity was discussed both within the production system, and in the adjacent remnant or restored areas of vegetation and riparian zones. Six of the 96 Australian respondents mentioned being under any verification or certification system, five being certified organic with one under the Ecological Outcome Verification (EOV) of the Savory Institute.

Because this study is interested in the evolution of practices implemented over time, respondents were asked about the practices they had been implementing on their farm 5 years prior; what they were doing presently at time of study; and what they planned to be doing in 5 years' time (Figure 4). There is a clear trend that the farmers who responded to the study are increasing their regenerative farm and land management practices over time, with the biggest shift having occurred in the previous 5 years. This shift continues into the future in most categories. Exceptions include an intended reduction in soil testing; supplementary feeding to maintain stock levels (as expected in regenerative systems where early de-stocking is encouraged); and deep ripping, which is usually applied as an infrequent tool to create deep mixing of soil profile. Increases of 10 % or more occur in on-farm composting (14%), and carbon farming (23%). Carbon farming (aimed at increasing carbon stores on-farm) had the greatest anticipated rise, although reported low knowledge-levels about carbon markets remain a challenge to adoption.

3.6 Support and information networks

When asked if they felt supported by their local community to be implementing regenerative practices, just 8% of farmers strongly agreed with this statement, while 24% agreed. Conversely, 15% disagreed, while 7% strongly disagreed. Having just under a third of regenerative farmers agreeing that they feel supported within the community aligns with the findings of Gosnell et al. (2019), who found that regenerative farmers may not feel supported in their 'communities of place' and instead need to build their own peer support network. Similar processes of social identification has been identified in research on controversial topics (Luke et al., 2018; Tajfel and Turner, 2004). Previous research on early adopters has suggested that early adopters of new innovations often feel somewhat outside of the 'norm' of their local communities, and are therefore likely to draw on external or online networks (Padel, 2001; Valente, 1996). This finding also suggest that regenerative farmers are dispersed within farming communities, and not necessarily learning from their neighbours.

Results indicate that many farmers adopting regenerative practices are moving away from the traditional sources such as

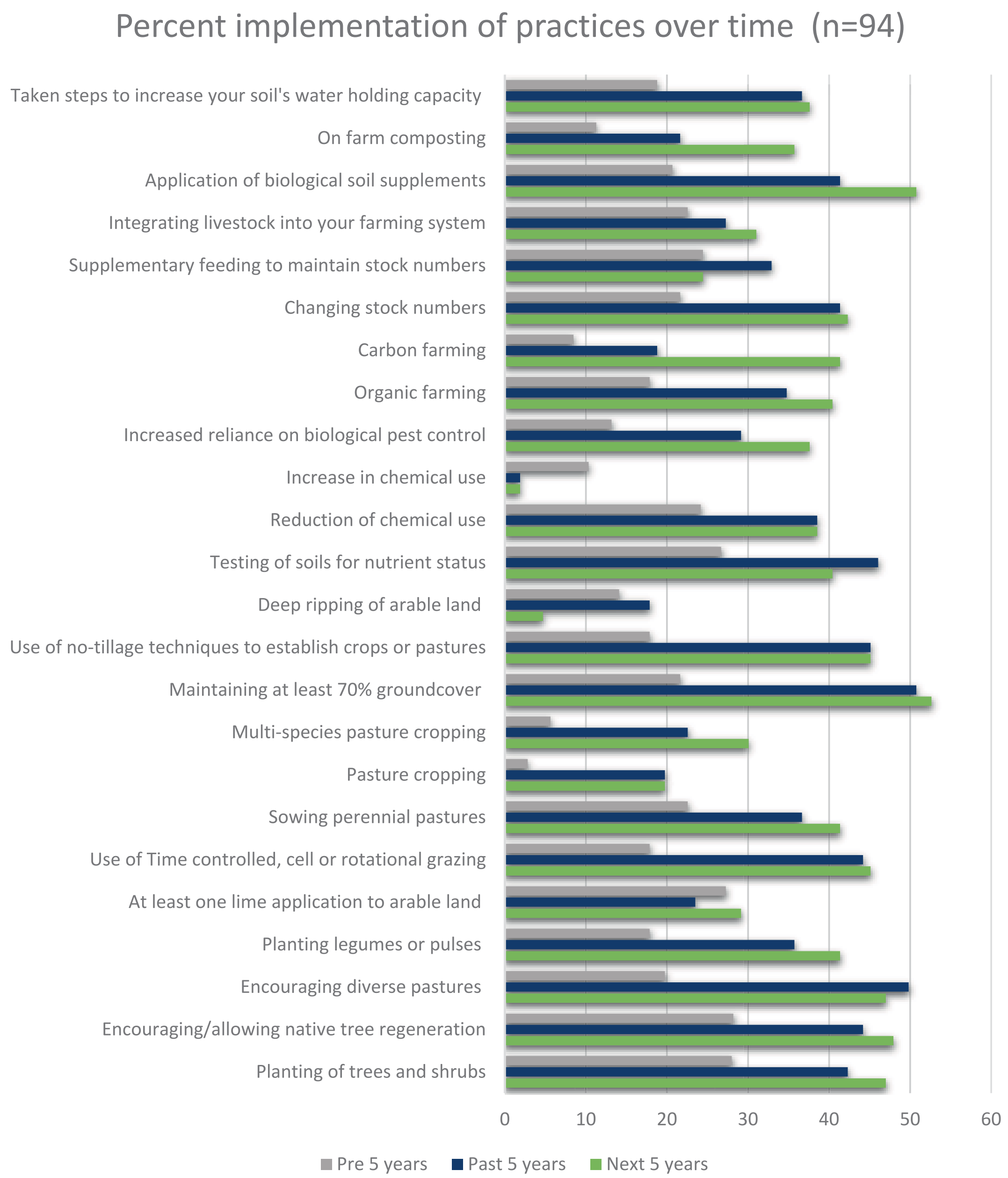

FIGURE 4
Farmers who identify as "regenerative" self-reported practice changes over time (*n* = 94).

other farmers or agronomists, and moving online (Figure 5). It's possible the online resources are hosted by farmers or feature farmers' stories, but regenerative farmers appear to be moving away from communities of place towards online communities of interest (Dare et al., 2014). 'Other farmers' were identified by just 39% of respondents as an important source of information, significantly different to the 76% reported in an Australian social benchmarking survey (Luke et al., 2021). Farmers in our study are more likely to source information from outside of their region, with websites (60%) and books (54%) being the most popular information sources used by regenerative practitioners. YouTube (37%), Emails (38%) and podcasts (36%) also emerged as more important than for farmers more generally (Luke et al., 2020; Luke et al., 2021), whereas independent consultants (26%), commercial consultants (17%) and extension officers (9%) were less likely to be used.

This is somewhat expected as the survey was deployed online, through regenerative focused networks, so it's logical that respondents are commonly using the internet to gain knowledge on regenerative agriculture. It is also important to note that many popular regenerative ag resources are freely available online. However, these findings are also consistent with the findings of Alexanderson et al. (2023), that farmers applying best-practices for soil and farm health were also more likely to source their information from books, and the internet. The findings highlight the importance of less traditional ways of disseminating knowledge amongst farming communities, and reiterates the benefits and importance of technology for knowledge-sharing

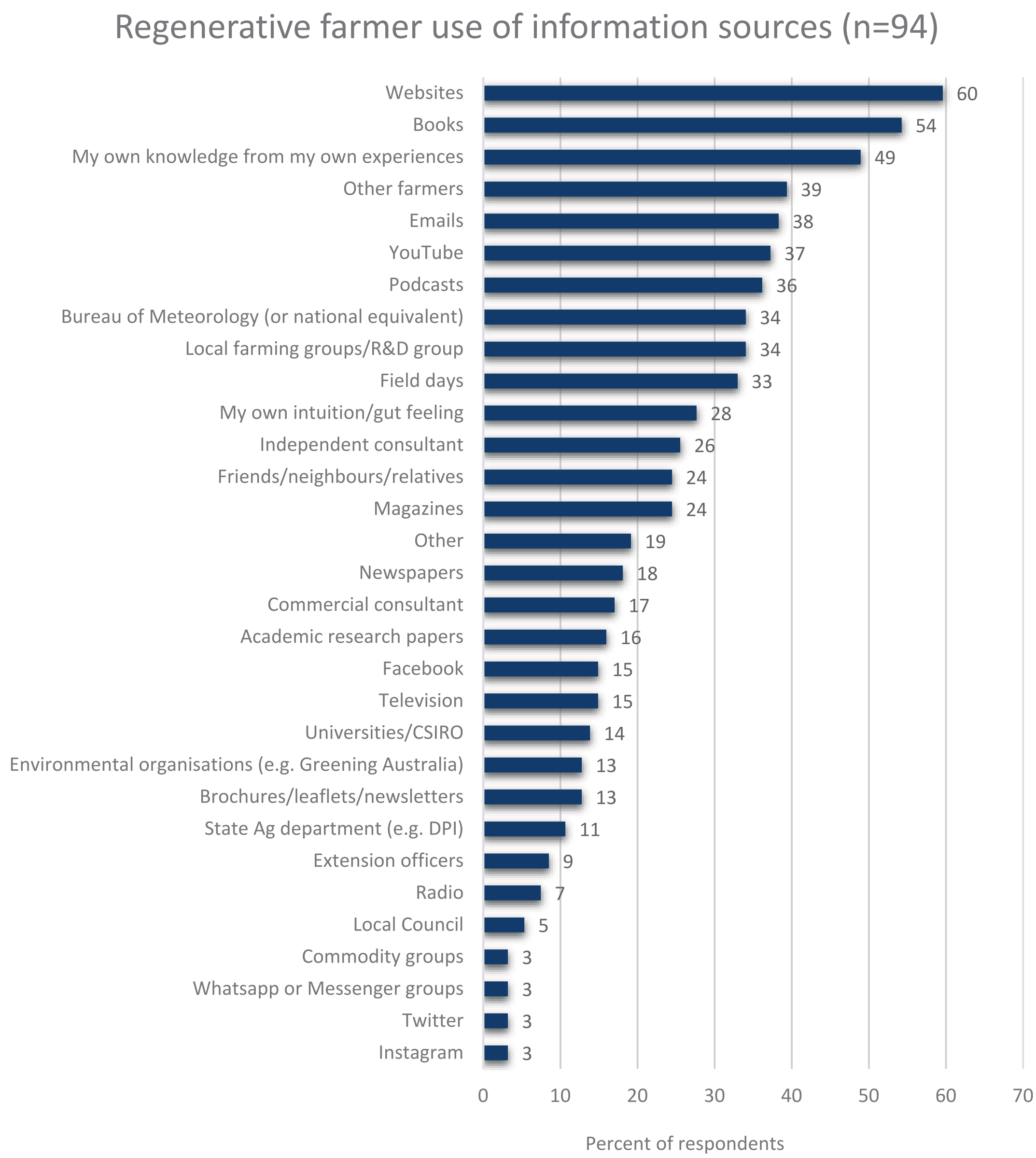

FIGURE 5
Information sources used by farmers identifying as regenerative.

across like-minding farming communities of interest (Dare et al., 2014).

3.7 Knowledge of relevant topics

Respondents were asked a variety of knowledge-based questions to gauge their understanding of a range of farming topics (Figure 6). Results indicate that using groundcover to minimise erosion had the highest rate of understanding (87%), which correlated closely with the most implemented practice (Figure 4); while six other topics over 75% agreement related to practices aimed at improving soil health and water holding capacity. Just under half of respondents understood '*how to support the persistence of native grasses*' (49%), indicating an opportunity for further increasing knowledge in this space (Birch et al., 2023). When assessed against the findings of Alexanderson et al. (2023), who used best-practice farmers as a proxy for regenerative, results indicate that the self-identified regenerative farmers report higher knowledge-levels in eight of the eleven comparable categories (Table 1). The results suggest strengths and weaknesses in the capacity of this group of self-identified regenerative farmers, and may offer insight into future research and development strategies to address knowledge limitations.

4 Summary

This study has been conducted with a group of farmers who are adopting a suite of regenerative agricultural practices. For these farmers, a substantial transition had occurred over the previous five

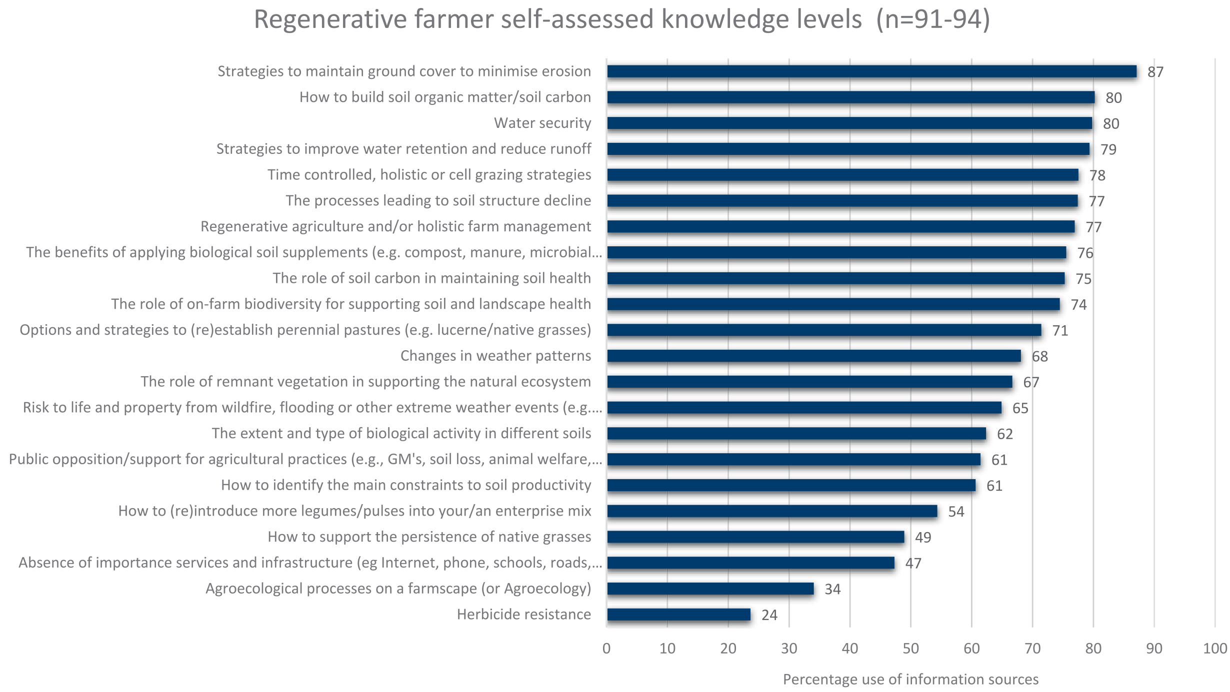

FIGURE 6
Self-assessed knowledge levels of regenerative farmers.

TABLE 1 A comparison of results against Alexanderson et al. (2023) indicating a difference in self assessed knowledge levels for self-identified regenerative farmers when compared with the figures for best-practice farmers.

Topic	Difference (%)
Regenerative agriculture and/or holistic farm management	+34
The extent and type of biological activity in different soils	+28
Time controlled, holistic or cell grazing strategies	+24
The benefits of applying biological soil supplements (e.g., compost, manure, microbial inoculants)	+21
How to build soil organic matter/soil carbon	+19
How to support the persistence of native grasses	+19
The role of remnant vegetation in supporting the natural ecosystem	+14
The processes leading to soil structure decline	+9
Strategies to maintain ground cover to minimise erosion	−2
Options and strategies to (re)establish perennial pastures (e.g., lucerne/native grasses)	−6
How to identify the main constraints to soil productivity	−14

years, with more change intended. While their age and gender are consistent with many Australian farming regions, this group does appear to have higher rates of tertiary study, with a slightly higher proportion of female farmers responding. While there are few farmers currently engaged in certification, it does appear that there are shared goals and a continuum of practices being undertaken with a clear line of sight towards those goals.

This study demonstrates a very clear link for regenerative farmers between regenerative agriculture, profitability and environmental health, aligning with much of the literature (Colley et al., 2019; Newton et al., 2020; Rhodes, 2017; Schreefel et al., 2020). While various debates may be underway about the underlying philosophies of regenerative agriculture, there is much that this group agree on in regards to associations, goals and practices, which are evident as important drivers of change (Vanclay, 2004). Soil health, carbon sequestration, holistic thinking, and improving biodiversity were top of mind associations with regenerative agriculture, which also flowed through to farmer goals, priorities and practices.

By self-definition, all of the farmers in this study were implementing regenerative farming practices. The Theory of Planned Behaviour is a useful tool here for considering the influence of social norms on this behaviour. Strong perceived benefits to soil health and farm resilience appear to be important drivers of attitudes towards implementing regenerative agricultural practices. For this group, 78%

held a strong control belief that implementing regenerative practices was justified by the returns (with 5% disagreeing and the rest unsure).

While it was acknowledged that capacity to implement may also be hampered by the time, money and knowledge required to make a transition, the findings suggests that another barrier in the adoption of RA is normative, with many Australian regenerative farmers not feeling supported within their community in regards to their implementation of innovative and regenerative practices (as suggested in Gosnell et al. (2019)). Regenerative farmers in this 2022 study may therefore be less likely to connect with other local farmers or more conventional agricultural consultants, with similar trends identified in other studies (Alexanderson et al., 2023).

While this group is looking beyond the fence to find their community of interest, this localised lack of support for their trialling alternative farming practices may present a normative barrier for change that may also impede other farmers who might be considering a change in approach. This is more likely to be the case for those who may not yet be connected with alternative information networks. Knowledge was identified as both a limiting factor in regenerative agricultural uptake, and for farmers in meeting their farming goals. Thus, an opportunity to support practice change appears to be linked to improved education in relation to practice implementation. Substantial differences in self-reported knowledge reflect an increased interest in soil biology and time-controlled grazing, but slightly lower knowledge of how to establish native ground cover and how to identify soil constraints, offers opportunities for improved education for farmers undertaking regenerative agriculture.

5 Conclusion

For the farmers surveyed, a clear link between regenerative agriculture, profitability, farm resilience and environmental health is evident. *Improving* the health and resilience of their farm system was a major motivating factor, alongside reducing inputs. Farmers were working towards achieving this through implementing practices related to improving soil health, biodiversity and water retention, with a strong emphasis on ground cover and grazing practices, although not all knowledge-levels directly reflected these areas of interest. Practices promoting biodiversity were discussed in two different contexts—one being supporting natural function on the property through adjacent remnant or restored areas of vegetation or wetland, and the other was through biodiversity integrated into the production system; into the soils and through multi-species plantings, or the encouragement of native species in the pasture or cropping mix.

With farmers goals and aspirations strongly aligning with environmental values, this provides an opportunity for farming and natural resource management organisations to orient education programs towards both productivity and environmental goals, that are not perceived as mutually exclusive. The survey results reveal that three-quarters of Australian regenerative farmers see regenerative agriculture as a means to enhance profitability, and nearly two-thirds view it as a strategy for risk reduction. However, the challenge of linking regenerative practices and changes in natural capital remain, highlighting the need for further investigation, especially in the context of a shifting policy environment, with growing interest in asset evaluations of regenerative farms. While, 59% of respondents believe regenerative agriculture is crucial for mental health and personal resilience, the understanding of broader social impacts, including mental and physical health benefits and family wellbeing, is less pronounced. This gap underscores the potential for additional research to explore these areas further. From this study and building on the work of others, clear consistencies in farmer goals and approaches inspire a goals-driven definition of regenerative agriculture, which is:

> "The application of management approaches aimed at actively improving holistic farm system resilience through increasing profitability, soil health, landscape health, biodiversity and farmer wellbeing."

Data availability statement

The datasets presented in this article are not readily available because they contain the personal data of farmers, and sharing of the raw data was not agreed to in the participant consent form. Requests to access the datasets should be directed to Mathew Alexanderson, mat.alexanderson@scu.edu.au.

Ethics statement

The studies involving humans were approved by Southern Cross University Human Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. HL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. DL: Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2024.1402849/full#supplementary-material

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