

Article

Trusted Information Sources and Preferred Delivery Methods for Soil Indicator Information Among Farmers, Advisors, and Researchers

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Abstract

Extensive industry efforts have led to the delivery of information supporting farmer production practices, including soil management. Education and extension activities are vital, with wide-ranging information sources being delivered to inform decisions around sustainable food production practices. Despite this, there remain knowledge gaps about actual and preferred delivery of soil indicator information for Australian farmers and supportive stakeholders, including advisors and researchers. This research explored the current and preferred sources for delivering information about soil indicators for farmers and industry stakeholders across different farming enterprises (cattle, grains, and sheep). Data were collected using a 20-item survey. Survey responses ($N = 265$) were received from farmers ($n = 156$), advisors ($n = 72$), and researchers ($n = 37$) to understand how they currently receive soil indicator information, what sources they prefer for receiving this information, and the relationships between sources of soil indicator information to support farming practices. The findings indicate that farmers receive soil information from many sources but prefer to receive it from industry advisors—including researchers; farmer, grower, and producer groups; agronomists; and consultants—and at industry events such as field days, farm walks, and tours, as well as via education and training. The findings demonstrate that information about soil health for farmers must be delivered by trusted individuals and organisations in ways that farmers will find, understand, access, and use. This includes prioritising information delivery through stakeholder engagement and connections, to foster personalised information exchange. In contrast, no preferred information sources were identified for advisors and researchers. While online sources of information delivery are increasing in the digital age, this study did not identify any strong associations between farmers and these approaches. This study highlights the pivotal role that trusted industry intermediaries have in delivering information about soil indicators. This identifies a priority for future support that is directed towards industry advisors and researchers to optimise their delivery of soil health information to farmers.

Keywords: farmers; advisors; researchers; actual and preferred sources of information; trusted and reputable information sources; soil indicators; sustainable agricultural production



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1. Introduction

1.1. Soil Indicators

Soil indicators are globally important measurements for assessing soil health, quality, and function. Soil indicators are “measurable properties of soil or plants that provide clues about how well the soil can function. Indicators can be physical, chemical, and biological properties, processes, or characteristics of soil. They can also be morphological or visual features of plants” [1]. Indicators provide valuable information to assist farmers in their soil management decisions and practices to improve plant and animal production outcomes [2]. Soil is integral to Australia’s economy, environment, and society, and the contribution of the soil ecosystem is estimated to be \$930 billion annually to the national economy [2,3]. In Australia and internationally, soil quality and health are declining, attributed to threats including climate change, intensive agronomic practices, increased urbanisation and large-scale industrialisation [2,4]. As an example, climate change threatens many physico-chemical and biological processes and functions delivered by soil, including reduced fertility due to altered or lost soil organic matter, with drier conditions leaving soils prone to erosion, and waterlogging from extreme events [5]. These challenges have brought soil health and sustainability into sharp focus for land managers and industry stakeholders globally [6].

1.2. Extension Activities for Soil Management

Engagement, extension, and education activities are widely used to deliver information about soil management practices to farmers. As the end users of soil innovations and developments, farmers are vital implementers on the land by translating agricultural research into soil management practices [6–8], leading to improved soil health and quality and resultant sustainable outcomes in farming production [9,10]. Research evidence [11–14] attests to the importance of extension activities leading to changes in farming practices. Information is instrumental in developing farmer knowledge and the adoption of suitable soil practices [15]. Extension activities delivered to farmers are a vital pathway for practice change through innovations that improve soil condition, leading to increased production [13] and resilience (soils less prone to degradation, nutrient loss, compaction) in response to threats including drought, floods, fire, and human impacts.

Deliberative, interactive, and practice-led approaches engage farmers and facilitate the transfer of learning, improving land management outcomes [16]. Engaging farmers through communities of practice generates essential information, which is important for the delivery of, and the impact on, member-focused activities [17]. Social connections involving farmer-to-farmer interactions, and peer observations, often delivered through farmer extension activities, such as demonstration sites, enhance learning outcomes leading to new knowledge for farmers [18,19]. A recent European study [20] found farmers rely heavily on peer-to-peer networks as these were considered “trusted sources” for adopting new practices.

In Australia, grower groups (otherwise known as farming system groups or producer groups) deliver empirical research and extension to farmers supporting the “adoption of new production practices, technologies for locally relevant research and development” [21]. Grower groups are integral to the delivery of information about soil and soil health knowledge through carefully curated design to increase farmers’ knowledge and improve their confidence in managing land and farm practices and increasing soil stewardship [22].

Extension methods for sharing soil information and their effectiveness in changing farmer practices are frequently used to build trust and deliver information that is locally relevant [23]. Farmer trust is an important consideration in communicating information about farming-related practices [24]. Expert advisors and groups, such as grower groups,

are trusted by farmers and considered credible sources for delivering agricultural extension and practices and are viewed as a supportive ally to farmers [25].

Field days and demonstration events remain a key learning and trusted environment for farmers (and advisors) to promote and adopt practice changes [26]. Agricultural demonstrations and field events (e.g., field days) have been a mainstay of extension in Australia for over 150 years, beginning with agricultural shows and field competitions from the late 1850s. Early reporting to the Board of Agriculture in Victoria [27,28] highlights the collaborations between farmers involved in shows and societies and where ploughing competitions involving farmers and the development of experimental farms to support farm management practices were undertaken.

1.3. Digital Extension Activities

Contrasting with more traditional forms of communication that typically rely on face-to-face delivery [29], digital and online information delivery, such as the webinars, videos, and social media platforms [19,30–32], offer convenient, cost-effective methods where information can be shared to a wider farmer-audience across a large geographic area [31]. This case study from Australia highlights the breadth of digital tools utilised by industry/grower groups to supply information and connect with their members, including farmers. Digital tools were valued for their broad audience engagement and communication delivery, particularly e-newsletters, websites, and social media platforms (Facebook, Twitter/X) and mobile apps (such as WhatsApp).

There is no clear research consensus about farmers' preferences for receiving this information. Some researchers [33] propose that farmers prefer to receive information about farming practices in the written form, and through face-to-face interactions and event attendance (such as workshops and seminars) with digital delivery (videos, online courses, and podcasts) complementing existing in-person events. Networking and stakeholder engagement facilitates the exchange of soil knowledge and strengthens these relations, regionally, between farmers and advisors [34]. In contrast, some farmers have varied preferences for information delivery, which includes both digital and traditional approaches [24]. Recent research from Australia identified that information delivery to farmers through newspapers, field days, and websites, and sources of knowledge from other farmers and expert advisors, provide important sources of information [35,36]. Varied methods for knowledge-sharing in agriculture must include digital and non-digital methods to accommodate the varied needs of individuals, and their receptiveness (or not) to information delivered digitally [31]. The evidence to date highlights the importance of information-sharing for farmers, consistent with the Information Foraging Theory [37,38]. This theory conceptualises how individuals identify, assess, and generate meaning from information and how they add value for increased knowledge gains that support decision-making processes. The theory provides a framework from which people can make sense of, and adjust to the breadth and complexity of information delivered in multiple and complex ways. The breadth of information available to farmers to aid decision-making is more complex and demanding. Accommodating the preferences of users (farmers) for information delivery must not be overlooked.

The lack of consensus about farmers' preferences for the delivery and receipt of information remains a knowledge gap with implications for those involved in the extension, engagement, and adoption of soil innovations. Understanding the current methods that farmers use to receive soil information, and their preferences for this, are essential for ensuring industry-relevant information is delivered in ways that is required and preferred by farmers [39]. This is essential given the surge in published papers on soil health and quality practiced [40]. Indeed, this plethora of information highlights the need for coordi-

nated communication and engagement efforts. Beyond delivering cost efficiencies, these efforts would streamline and improve (consistent) information delivery, while reducing the potential for information overload among farmers.

Research that explores the current and preferred methods or approaches for delivering information to support decisions about soil indicators, for farmers and industry stakeholders across different farming enterprises (cattle, grains, and sheep), is essential. This will inform and guide strategies for delivering effective practice change. Consideration must also be given to the different sources of information (including technology) used to inform farmers about soil indicators.

1.4. About This Research

This research addresses the knowledge gap by examining the actual and preferred sources of information about soil indicators for farmers. Data were also collected from other industry stakeholders (agronomists, consultants, advisors, extension officers, and researchers/students), enabling comparison between groups. The questions guiding this research are two-fold:

1. What sources of soil information are currently received, and preferred, by farmers, agronomists/advisors, and researchers?
2. What sources of soil information are currently received, and preferred, by different farming enterprises?

2. Materials and Method

2.1. Participants

Data were collected using a self-report survey ($N = 265$). Survey responses were received from farmers involved in cattle, grains, and sheep enterprises ($n = 156$; 59%; to be referred to as “Farmers”), agronomists, consultants, advisors, extension officers ($n = 72$; 27%; to be referred to as “Advisors”), and from researchers and students ($n = 37$; 14%; to be referred to as “Researchers”).

Farmers in the study operated mixed farming systems that combined both cropping and grazing enterprises. Specifically, 61% of grain farmers had livestock enterprises, and 24% of livestock farmers grew grains, with some farmers practicing rotational systems (e.g., a pasture phase within a cropping program). For this study, farmers were categorised according to their primary farming enterprise.

Surveys were received from farmers (Figure 1) in states and territories (Table 1) representing the main agriculture production regions in southern and eastern Australia. Surveys were received from participants in Victoria, Western Australia, New South Wales, and South Australia across a range of ages and roles (Table 2). The largest proportion of surveys were received from farmers aged 35 to 64 years. The composition of participant responses by state and role and state and enterprise (Table 3) highlights the large number of surveys received from participants in Victoria.

Table 1. Responses by location ($N = 265$).

State/Territory	n	%
New South Wales (NSW)	38	14
Queensland (QLD)	18	7
South Australia (SA)	36	14
Tasmania (TAS)	6	2
Victoria (VIC)	109	41
Western Australia (WA)	54	20
Missing/other	4	2

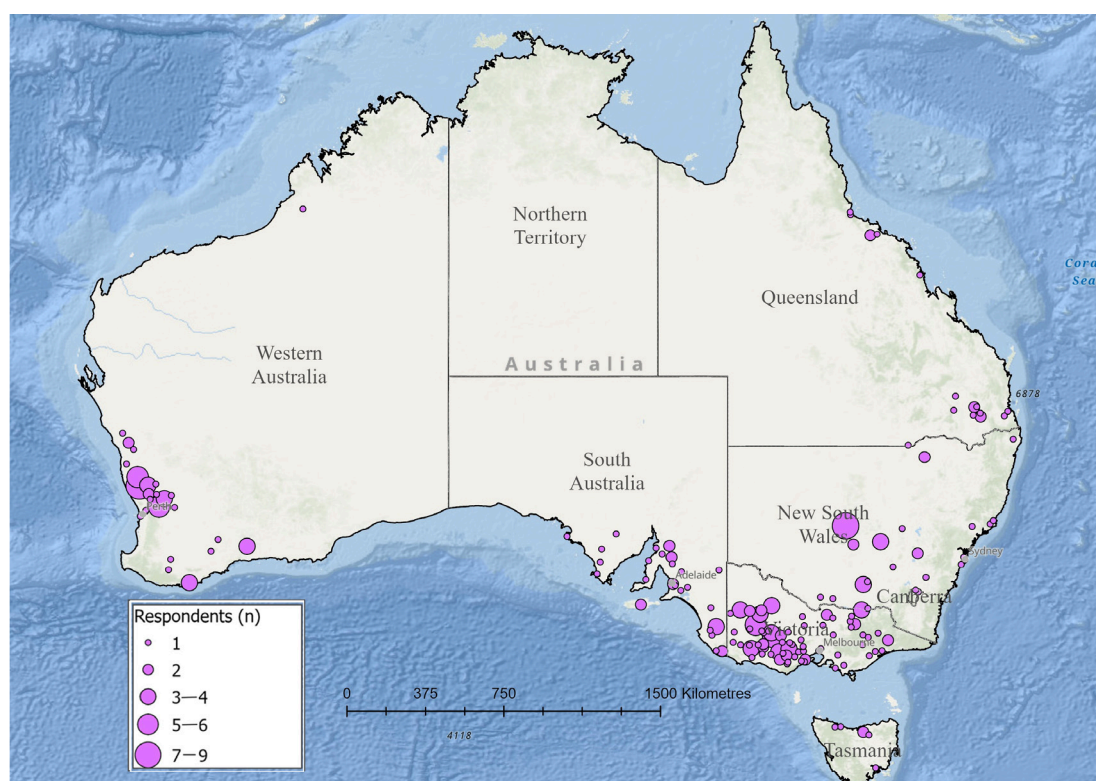


Figure 1. Map of the location of survey participants (N = 265).

Table 2. Responses by age and role (N = 265).

Age	Role		
	Farmers <i>n</i> (%)	Advisors <i>n</i> (%)	Researchers <i>n</i> (%)
18–24 years	2 (1)	1 (1)	1 (3)
25–34 years	4 (2)	13 (19)	5 (14)
35–44 years	21 (14)	20 (28)	6 (16)
45–54 years	34 (22)	21 (29)	8 (21)
55–64 years	56 (36)	8 (11)	12 (32)
65–74 years	28 (18)	8 (11)	5 (14)
75 years +	9 (6)	1 (1)	-
Prefer not to say/missing	2 (1)	-	-
Subtotals (N)	156	72	37

Table 3. Responses by state and role; state and enterprise.

State	Role			Enterprise		
	Farmers <i>n</i> (%)	Advisors <i>n</i> (%)	Researchers <i>n</i> (%)	Cattle <i>n</i> (%)	Grains <i>n</i> (%)	Sheep <i>n</i> (%)
NSW	15 (10)	10 (16)	9 (26)	10 (19)	15 (12)	3 (8)
QLD	5 (3)	3 (5)	4 (11)	1 (2)	9 (7)	0 (0)
SA	7 (5)	22 (36)	5 (14)	2 (4)	25 (19)	5 (13)
TAS	3 (2)	0 (0)	1 (3)	2 (4)	0 (0)	1 (3)
VIC	80 (55)	15 (25)	10 (29)	29 (55)	45 (35)	24 (62)
WA	35 (24)	11 (18)	6 (17)	9 (17)	35 (27)	6 (15)
Subtotals (N)	145	61	35	53	129	39

2.2. Instrument

The survey (available at <https://figshare.com/s/d17f4a4ade039c94d654> accessed on 20 April 2026) consisted of 20 open- and closed-ended questions about soil indicators and factors that influence and support soil management practices, including farm characteristics: location; farming enterprise; agricultural region; soil type (texture and colour); soil indicators (observation, physical, chemical, biological) used on farm; frequency of use and reasons for use; and consideration of other soil indicator options; other information and influences that may inform future soil indicator decisions. Participants responded to survey questions using Likert scales, multiple choice options, and binary responses (yes/no). Some free text responses were included supporting detailed feedback.

Survey questions explored the factors influencing soil indicator choices (information sources; preferred methods of receiving soil indicator information). These questions included the sources of information that influence choices about soil indicators and the preferred methods for receiving soil indicator information. Fifteen response options were offered, with respondents invited to select all options that applied to their situation. A response option for “other” was included for respondents to provide free text responses about other actual/preferred sources of information.

The survey was created for online completion using the Qualtrics XM Platform (Qualtrics, 2023) computer software, which was hosted by Federation University. The survey was also available for completion as a hard copy and distributed by the researchers upon request. The survey took between 10–15 minutes to complete.

The survey was designed by the researchers, with the questions informed by previous research and survey designs [8,41–43]. The survey instrument was reviewed and refined by members of a small working group consisting of industry stakeholders and grower groups. Internal consistency for the instrument was evaluated using the Kuder–Richardson Formula 20 [44]. The reliability for sources of information was $\alpha = 0.74$ and preferred sources of information was $\alpha = 0.63$.

Participation in the research and completion of the survey was voluntary. Completion of each survey question was optional with respondents choosing to answer some or all of the questions. Eighty-five percent of respondents completed the entire survey questions, 9.1% completed 51–97% of the survey questions, and 6% completed <50% of the survey questions.

2.3. Research Method

An availability sampling approach was used for this study, to increase participation from farmers, advisors, and researchers. Survey data were screened and surveys received from participants residing outside Australia were excluded from the analysis. Multiple recruitment approaches were adopted to increase participation of farmers, advisors, and researchers to this study.

Research information was distributed to organisations at the local, state, and national levels representing the Australian agriculture sector. This included distribution to grower groups, national research organisations, agricultural experts (including agronomists), grains industry organisations, government researchers, universities, and private industry. Organisations were invited to share information about the research with their members and through their networks.

In addition, 10 grower groups from Australia (located in Victoria, Queensland, Western Australia, New South Wales, and South Australia) and representing grains, livestock (sheep, cattle), sugar, cotton, horticulture, and mixed farming enterprises distributed the research invitations, on behalf of the researchers, to their members via email and through their social media channels.

Information about the study was also distributed in industry newsletters, at farming events, research updates, and via industry social media accounts, and through news outlets. Research invitations were distributed electronically and consisted of a letter of invitation, and the Plain Language Information Statement (PLIS).

A YouTube video (hosted on YouTube: <https://www.youtube.com/watch?v=un-AEYpZC8A> accessed on 20 April 2026) was prepared, outlining the research and inviting survey participation. A link to this video was included in the PLIS.

The letter of invitation included a link to the online survey. The homepage for the survey provided information about the research, with a link to the PLIS. Participants commenced the survey from the home page.

Participants were informed in the PLIS that their consent to participate in the research was assumed upon survey commencement.

Survey data were collected between September 2023 and January 2024.

2.4. Ethics

Approval to conduct this research was obtained from Federation University's Human Research Ethics Committee. Project title: Matching soil performance indicators to farming systems (Project reference number: 2022/213)).

2.5. Analysis

The survey data were de-identified and aggregated, and responses were screened using Microsoft Excel™ for Microsoft 365 MSO (Version 2603 Build 16.0.19822.20086). Statistical tests were conducted using the SPSS Statistics for Windows (Version 31, Armonk, NY, USA: IBM Corp.). The chi-square test of independence was selected for this research, enabling exploration of relationships between categorical variables [45]. It is a robust, non-parametric test used to identify group differences across multiple groups, and with nominal data [46]. Two alternative hypotheses were posed: the first, that there is no relationship, association, or significant difference between the variables (H_0); and the second, that a relationship exists between the variables (H_1). Only significant associations at $\alpha = 0.05$, where the alternative hypothesis is accepted, are reported. Cramér's $V(V)$ for significant associations was also conducted. For this research, chi-square analyses were used to describe relationships and associations between actual and preferred sources of information for categorical variables for roles, comprising three groups: farmers, advisors, and researchers, and farming enterprises as three groups: cattle, grains, and sheep.

The results reported in the graphs were calculated based on the number of people who answered yes to each of the options for sources of information and preferred sources of information. Hence, all bars for each option sum to 100% by role or enterprise. The graph shows the relative difference in the percentage of respondents who answered "yes" which indicates that participants use that source of information or prefer to use that source of information.

3. Results

3.1. Knowledge of Soil Indicators

Knowledge of soil indicators is presented in Figure 2. It shows that over half of farmers (61%) have a moderate knowledge of soil indicators, with most advisors and researchers reporting high knowledge of soil indicators. A chi-square analysis identified a significant relationship, $\chi^2(4, N = 228) = 41.14, p < 0.001$, and confirmed that more advisors and researchers self-report a higher knowledge of soil indicators than farmers.

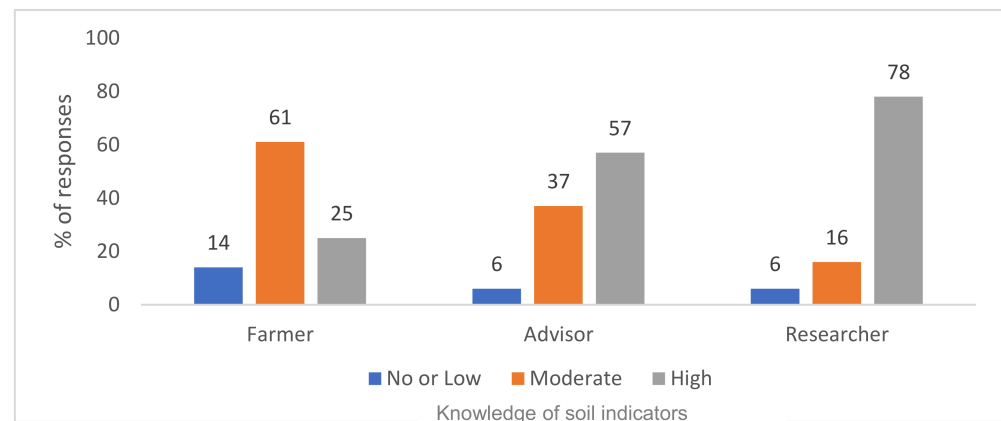


Figure 2. Knowledge (no/low; moderate; high) about soil indicators by role (advisor, farmer, researcher).

3.2. Actual Sources of Information

Multiple sources of information about soil indicators influence farmers, advisors, and researchers (Figure 3). Results from chi-square analysis ($\alpha = 0.05$; $N = 227$) show a significantly higher number of farmers, in contrast to advisors and researchers, receive soil information from local or state government extension officers ($\chi^2 = 27.01$, $p < 0.001$, $V = 0.345$); industry advisors or corporations ($\chi^2 = 26.15$, $p < 0.001$, $V = 0.339$); researchers ($\chi^2 = 25.13$, $p < 0.001$, $V = 0.333$); farmer, grower, or producer group ($\chi^2 = 15.97$, $p < 0.001$, $V = 0.265$); education/training ($\chi^2 = 13.54$, $p = 0.001$, $V = 0.244$); family and friends ($\chi^2 = 12.44$, $p = 0.002$, $V = 0.234$); agronomists, consultants, or stock agents ($\chi^2 = 11.32$, $p = 0.003$, $V = 0.224$); and field days, farm walks, and tours ($\chi^2 = 7.59$, $p = 0.022$, $V = 0.183$). All information sources except field days, farm walks, and tours indicated a medium level of association.

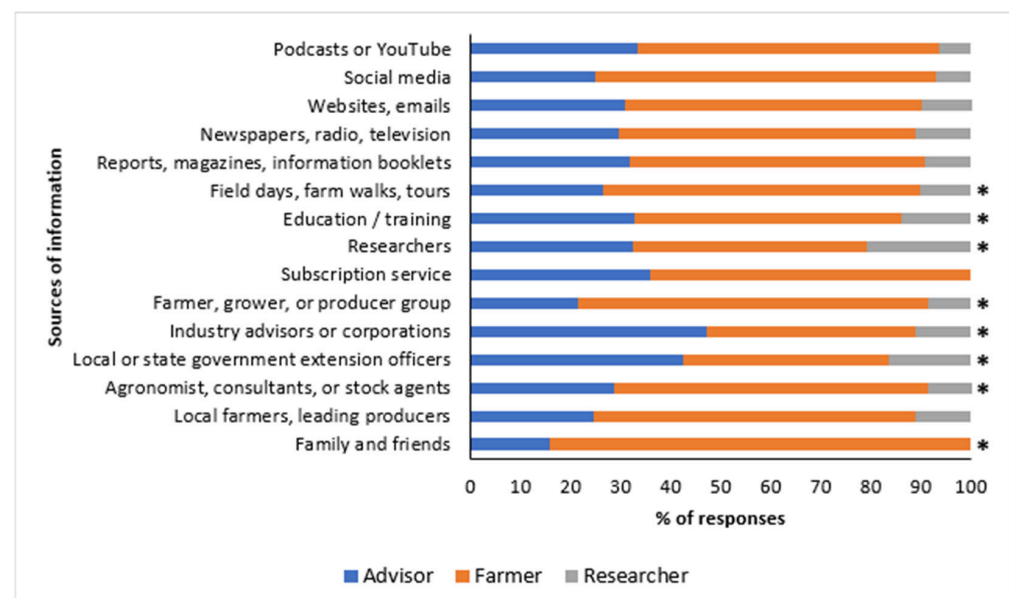


Figure 3. Information sources influencing soil indicators, by role (advisor, farmer, researcher). Note: Bars followed by * are significantly different ($p < 0.05$) for roles tested.

Advisors and researchers also receive soil information from a range of sources; however, unlike farmers, no associations were identified.

Sources of soil information that influence the soil indicators for different farming enterprises is presented in Figure 4. Chi-square analysis ($\alpha = 0.05$; $N = 207$) shows a

significantly higher number of grain farmers, in contrast to sheep farmers and cattle farmers, receive soil information from researchers ($\chi^2 = 17.71, p < 0.001, V = 0.292$); industry advisors or corporations ($\chi^2 = 11.27, p = 0.004, V = 0.233$); and agronomists, consultants, or stock agents ($\chi^2 = 8.85, p = 0.012, V = 0.207$).

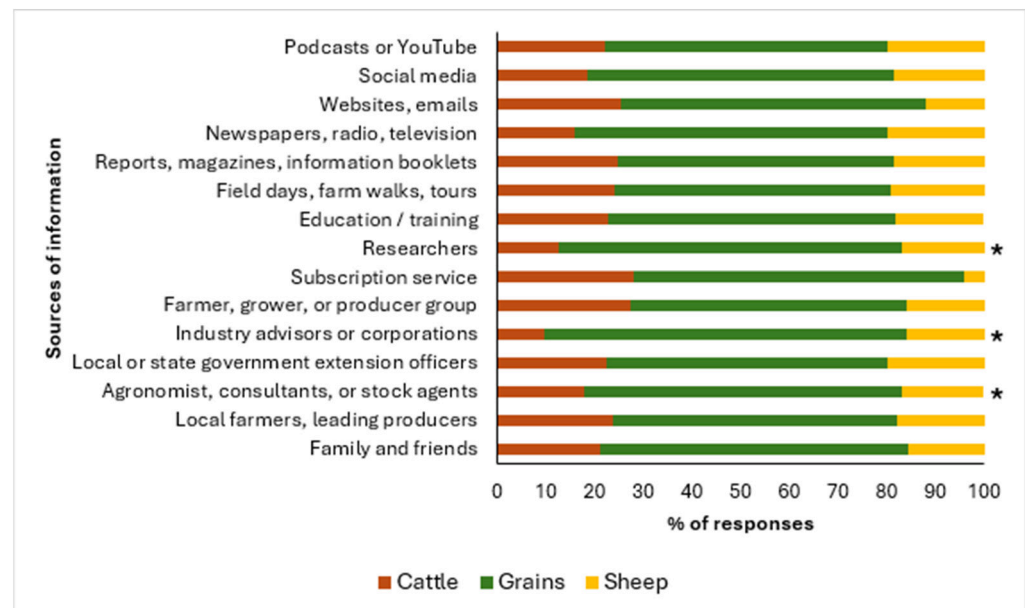


Figure 4. Information sources influencing soil indicators by farming enterprise (cattle, grains, sheep). Note: Bars followed by * are significantly different ($p < 0.05$) for the enterprises tested.

Other sources of information were identified by role (Appendix A). Twelve participants identified receiving “other” sources of information. Farmers ($n = 6$) reported receiving information from other sources including seminars, or from their own knowledge (farmer/agronomist) and training. Advisors and researchers ($n = 6$) received other sources of information from peer reviewed publications and research literature.

3.3. Preferred Sources of Information

The preferred sources for receiving information about soil indicators are presented in Figure 5. Chi-square analysis ($\alpha = 0.05; N = 225$) were conducted to examine the relationship between role and preferred sources of information. The findings show that a significantly higher number of farmers, in contrast to advisors and researchers, prefer receiving soil information from researchers ($\chi^2 = 15.29, p < 0.001, V = 0.261$); farmer, grower, or producer groups ($\chi^2 = 12.96, p = 0.002, V = 0.240$); field days, farm walks, tours ($\chi^2 = 12.30, p = 0.002, V = 0.234$); agronomist, consultants, or stock agents ($\chi^2 = 11.93, p = 0.003, V = 0.230$); education/training ($\chi^2 = 7.03, p = 0.030, V = 0.177$); reports, magazines, information booklets ($\chi^2 = 6.67, p = 0.036, V = 0.172$); and family and friends: ($\chi^2 = 6.02, p = 0.049, V = 0.163$). These effect sizes indicate a small to medium association.

Unlike farmers, no strong relationships for preferred sources of information were identified for advisors and researchers.

The preferred sources for receiving soil indicator information by farming enterprise are presented in Figure 6. The chi-square analysis indicates that significantly more cattle farmers, $\chi^2 (2, N = 205) = 6.17, p = 0.047, V = 0.173$ prefer to receive soil information from farmer, grower, or producer groups. No other significant effects were observed for farming enterprise.

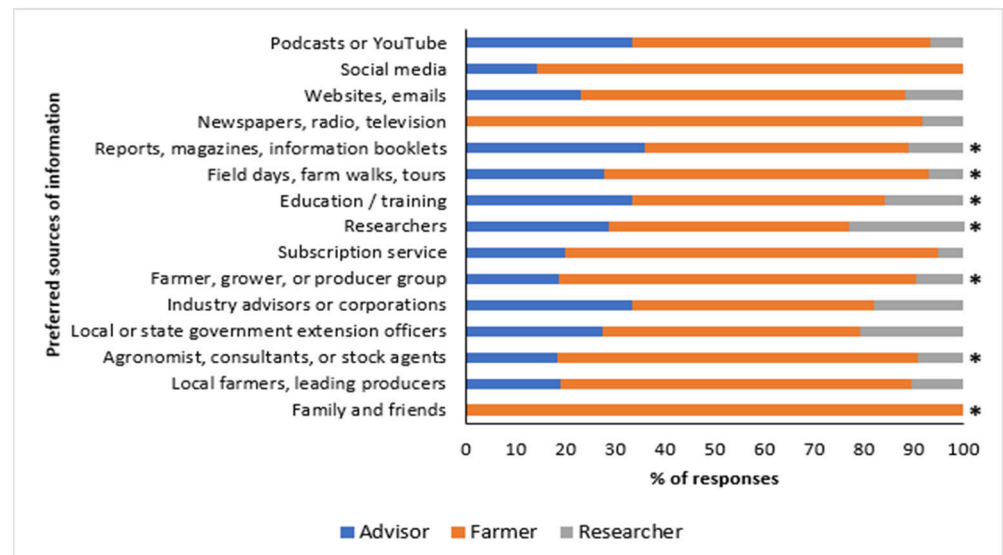


Figure 5. Preferred sources of receiving soil indicator information, by role (advisor, farmer, researcher). Note: Bars followed by * are significantly different ($p < 0.05$) for the enterprises tested.

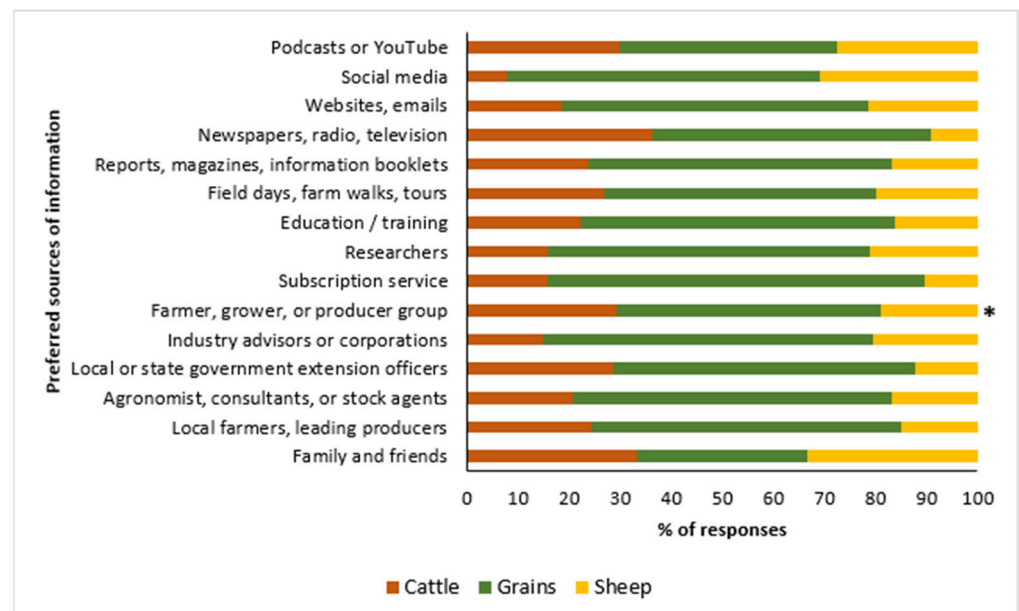


Figure 6. Preferred sources of receiving soil indicator information, by farming enterprise (cattle, grains, sheep). Note: Bars followed by * are significantly different ($p < 0.05$) for the enterprises tested.

Seven participants identified “other” sources of preferred information (Appendix A). For farmers ($n = 3$), this included information delivered through seminars and from Landcare groups, and a combination of sources. Advisors and researchers ($n = 4$) preferred reputable knowledge sources for information, including peer reviewed papers and new information.

A summary of the findings for farmers from the Cramér’s V results (Figure 7) between actual and preferred sources of information is highlighted showing changes in the strength of association.

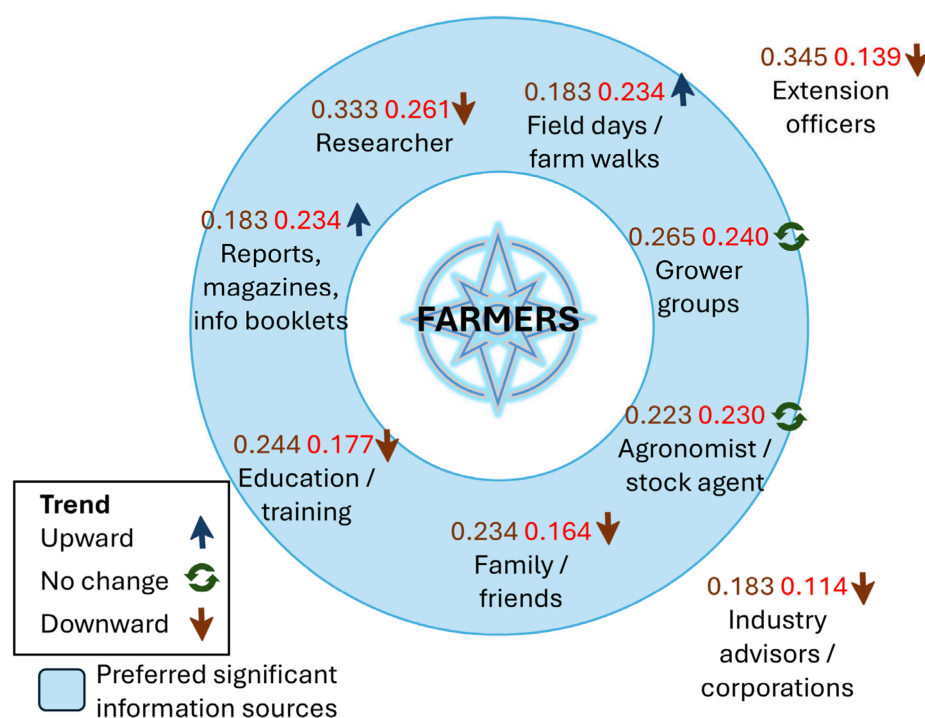


Figure 7. Preferred significant sources of receiving soil indicator information. A comparison of Cramér's V results for actual and preferred information source and the trend between the two is presented (e.g., family/friends actual V = 0.234; preferred = 0.164 and a downward (↓) trend).

4. Discussion

4.1. Sources of Information: Wide-Ranging

This research was conducted to understand the current and preferred sources for delivering soil information for Australian farmers—and other industry stakeholders—across different farming enterprises. This research is critical for informing effective, consistent communication and suitable engagement activities for farmers about soil health information. The findings indicate that farmers, advisors, and researchers receive soil indicator information from an extensive range of sources with a higher proportion of farmers receiving soil indicator information from up to eight sources. These included extension officers; industry advisors; researchers; farmer, grower, or producer groups; education and training; family and friends; agronomists, consultants, or stock agencies; and field days, farm walks, and tours. Farmers receive a wider range of external information sources than advisors and researchers. An explanation for this finding is that advisors and researchers are not usually recipients of information in the same way that farmers are; instead, they are knowledge intermediaries (advisors) or knowledge producers (researchers).

4.2. Preference for Direct and Expert Interactions

Similarly, farmers preferred to receive information about soil indicators from industry advisors and experts at field and farm days, and at education and training sessions. With the exception of (a) and field days, farm walks, and tours, and (b) reports, magazines, and information booklets, the preferred sources for soil indicator information are similar to the current methods they receive soil indicators information. This is consistent with previous research findings that have identified that agronomy and business professionals, farming press, and farmer-friends represent important, trusted sources of information for farmers [47], with preferences for written information [33], including newspapers [35].

Face-to-face interactions, from experts (agronomists/researchers) and event attendance (field days, farm walks, and tours), were preferred by farmers in this study. This is consistent with previous research whereby engagement and extension activities were identified as best practices for supporting farmers to manage their soil [8,34,48], with opportunities for networking and engagement between stakeholders leading to knowledge exchange [33,34,49].

The theoretical framework of the Information Foraging Theory [37,38] proposes that individuals make sense of complex and wide-ranging information for decision-making, and this is no different for farmers. As such, industry organisations supporting farmers (such as grower groups) are essential for providing information that supports farmers to make good decisions about their soil. These industry organisations play a vital role in sharing and shaping information across farming communities and this is aligned with the needs of their farming members.

4.3. Practice-Led Approaches Delivered by Trusted Experts

The current research highlights an important finding about the range of information and extension activities delivered to Australian farmers from legitimate and trusted sources, including advisors and grower groups. This was most pronounced for grain farmers who are highly reliant on information delivered by researchers, industry advisors, and agronomists and consultants. Although this finding supports existing research evidence about best practices using engagement and extension activities to support farmers to manage their soil [8,34,48], the evidence from this study goes further. It emphasises the importance of experts and respected industry advisors in the delivery of information that farmers rely on. Such approaches will be integral for the future delivery of information that supports farmers to adopt best practice around soil indicators. Improving soil health is a critical goal for supporting national and global objectives to address climate change and carbon sequestration.

Practice-led approaches are important for farmers in this study, with the delivery of soil indicator information provided at field days, through education and training, and delivered by grower groups. This finding supports the growing body of evidence about the importance of information delivery for farmers using approaches that are practice-led [49], including demonstration sites [18,19] and peer-to-peer learning [20].

4.4. Personalised Digital Information Delivery

An unexpected finding from this research was the lack of difference between groups or farmers about digital information delivery. Digital information is wide-ranging and considered cost effective for large audience uptake [19,30–32]. Yet this study highlights their potential ambivalence towards digital modes of information delivery. This may be due to lack of farmer trust in the information and in the application and delivery of the information [50]. Instead, farmers receive and prefer their soil information from sources that offer personal connections and face-to-face delivery. Such trusted industry sources could assist farmers by reducing information overload, while concurrently supporting them with other farming business priorities associated with costs, rainfall, animal welfare, and farmer mental health. This study delivers evidence about the importance of personalised delivery and human interaction when delivering information to farmers. Further, it emphasises the importance of personalised information delivery to farmers which should not be compromised in favour of economics or practicalities.

This has implications for online information delivery approaches which are now widely used by the industry. These methods must be created to provide a personalised context, where face-to-face and online interactions, which originate from trusted

sources, support and build the knowledge uptake of soil health information for farmers. This will advance and support farmers to address soil health for sustainable agriculture production [9,10]. This will be essential for an industry responding to external pressures such as climate change, and flux in global markets, that are financially impacting the industry. This will also be important for an industry that is now experiencing a surge in information about soil health and quality [40]. Deciphering information about soil indicators for sustainable practices must be delivered to farmers using their preferred methods (and from sources that are trusted). Prioritising human interaction in information delivery will be essential to achieving successful outcomes and practice change for the industry.

4.5. Information Sources for Advisors and Researchers

Advisors and researchers receive soil information from a range of sources, but unlike farmers, no strong associations or preferences were identified. This is not unexpected given that advisors and researchers reported high soil indicator knowledge. As such, they have an established knowledge of soils and ready access to information sources compared with farmers, thus enabling them to provide informed recommendations to address soil health on farms.

Advisors and researchers are also likely to be content creators of information about soil indicators that is delivered to farmers. As such, they may receive information about soil indicators from other, credible sources (such as academic and industry conferences, primary research, peer-reviewed journals). These insights may not have been fully captured through the survey responses.

This research offers new directions for how soil health information is disseminated to key stakeholder groups, aligned to their preferred methods for receiving information (Figure 8). The research presents opportunities for information delivery to farmers and recognises the importance of targeted engagement and information dissemination about soil health delivered by reputable, trusted, and knowledgeable sources. Advisors and researchers represent the critical expertise required for the delivery of this information. As trusted experts and intermediaries, they are essential in communicating information to farmers that both directs information access and supports farmers with their soil health management practices. It is imperative that these critical industry advisors also receive support to prioritise the effective delivery of soil health information to farmers.

4.6. Study Limitations

Limitations associated with study participation and sampling techniques are noted. The sampling techniques in this study may have contributed to survey response bias, and a lack of representation from the participant groups under investigation has contributed to varied participation numbers across the different roles and farming enterprises. Despite these potential limitations, the method and sampling techniques were chosen for their suitability to engage a wide number of farmers, and other stakeholders, across a vast geographical spread. The larger number of farmers in the study, in contrast to the smaller numbers of advisors and researchers, reflects the study's primary focus on farmers and the practical challenges of recruiting evenly across stakeholder groups. Irrespective of this, the current research offers new insights about information sources and preferences about soil indicators within the Australian context.

Surveys were chosen for their suitability to collect data from a range of different industry participants across Australia. There is an opportunity for future research methods to be expanded, to incorporate qualitative data collection methods.

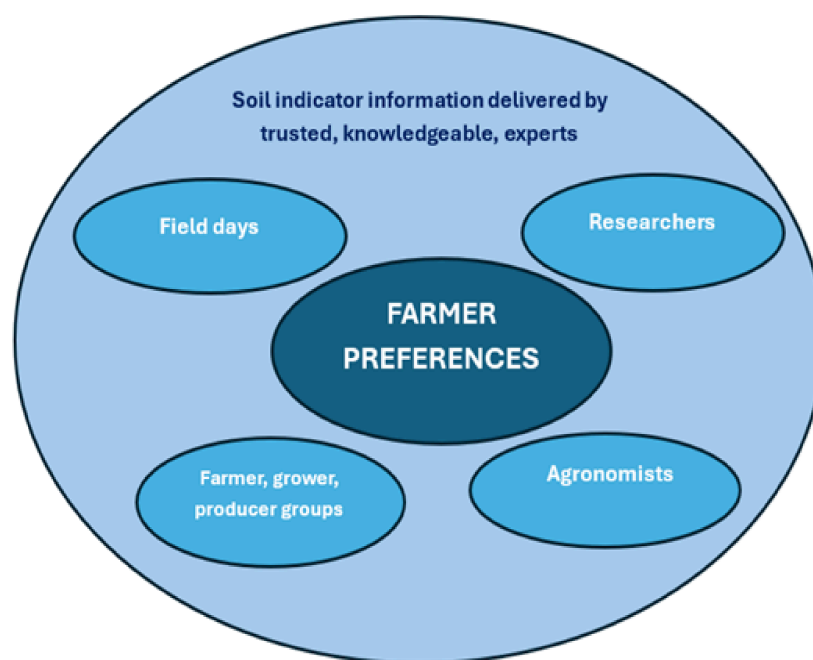


Figure 8. Preferred sources of receiving soil indicator information for farmers.

4.7. Future Directions

Future research must be extended to understand the application of soil information by farmers in relation to their decision-making about soil health. It is important that future research examines farmers' decision-making processes around how, when, what, and from whom they prefer to receive soil information. This will assist in prioritising support to farmers to inform their decisions to improve viability, profitability, productivity, and sustainability on farms.

Further research examining the actual and preferred sources of information, and how these are used, accessed, and adopted by farmers, is also essential. Delivering soil information to farmers using digital information delivery methods must be investigated. This is essential given the increasing reliance on digital tools and technologies for information-sharing to farmers [31].

Research is underway to consolidate activities around soil indicators that support better management practices. Establishing cooperative opportunities through workshops to deliver empirical soil indicator information around biological soil health to farmers is currently being developed. In-person and face-to-face delivery—thereby establishing a relationship with end users, specifically farmers—is being fostered through collaboration and implemented using preferred information sources for farmers.

5. Conclusions

This research explored the actual and preferred sources of information about soil indicators for farmers, advisors, and researchers. The findings highlight that Australian farmers are receiving soil information from a range of highly reputable and valued sources, many of which are also preferred sources of information by farmers. Trusted sources and methods of delivery are important for farmers who rely heavily on professional support and the delivery of timely information provided by experienced professionals and industry organisations. Personal interactions, through the delivery of information from advisors and through field days, farm walks, and similar events, are important. This finding is essential in guiding future methods of information delivery, necessitating greater effort and consideration, not just around the content of the information shared, but, importantly, in the

way it is delivered and by whom. Stakeholder connection with the information delivered, through personalised engagement, is important for Australian farmers and highlights where future delivery of soil indicator information to farmers must be focused. Additionally, sources of information that are delivered digitally must ensure closer alignment to preferred information sources where emphasis is on those sources that are trusted, experienced, and personalised. While advisors and researchers also receive soil information from a range of sources, this research did not identify an association with specific information delivery sources or methods. Given their important role as trusted intermediaries of information and knowledge, efforts to support advisors and researchers in optimising the delivery to soil health information to farmers is essential. Emerging technologies, including artificial intelligence (AI), offer opportunities for streamlining information access that support the translation of soil health information for on farm practices.

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Appendix A

Table A1. Role and “other” sources of information ($n = 12$).

Role	Others Sources of Information
Farmer, producer, grower ($n = 6$)	Seminars ($n = 1$)
	Own research ($n = 1$)
	Studied Soil Science at University ($n = 1$)
	Landcare Groups ($n = 2$)
	I am a farmer and an Agronomist ($n = 1$)
Agronomist, consultant, advisor, extension officer ($n = 3$)	Industry’s researchers, commercial soil test providers ($n = 1$)
	Career and FACTS syllabus (UK) ($n = 1$)
	Experience with crops ($n = 1$)

Table A1. Cont.

Role	Others Sources of Information
Researcher, student (<i>n</i> = 3)	Peer reviewed; publications, research literature, journal papers

Table A2. Role and “other” sources of preferred information (*n* = 7).

Role	Other Preferred Sources of Information
Farmer, producer, grower (<i>n</i> = 3)	Seminars (<i>n</i> = 1) Landcare Group (<i>n</i> = 1) No primary source, a combination of all that I have listed (<i>n</i> = 1)
Agronomist, consultant, advisor, extension officer (<i>n</i> = 1)	Available new information
Researcher, student (<i>n</i> = 3)	Peer reviewed; publications, research literature, journal papers

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