

Effective transfer of scientific information by Integration Forums: The case of land use in New Zealand

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Abstract. Science-based solutions are increasingly recognised as potential game changers for promoting environmentally friendly and sustainable land use policies in New Zealand. Based on the “Moving the Middle” project, we examine how these solutions can be transferred effectively into land use practice. We apply the RIU theory and the concept of Integration Forums to analyse the linkages between research and practice. Our study identifies and categorises 19 Integration Forums with different potentials for transferring science-based solutions. It is based on 20 expert interviews supported and cross-checked by documents and observations. The 19 Integration Forums observed meet significant different effectiveness in transferring scientific information. Furthermore, Integration Forums which activate actors of practice achieve higher effectiveness. The most important conclusion is that transfer of scientific information is a pull process driven by actors of practice in which actors of science can only play a very limited role.

Keywords: knowledge transfer, RIU model, integration forum, New Zealand, agriculture, land use

Introduction

Scientific information fostering change towards environmentally friendly and sustainable land use

Recent research has shown that sustainable land use in New Zealand is facing significant challenges. Land use is dominated by large-scale pastoral agriculture (Caradus et al. 2021), which is shifting from less intensive beef and sheep livestock production toward more intensive dairy farming (Renwick et al. 2022). These changes, driven primarily by market factors due to a low level of policy intervention in New Zealand’s agriculture have contributed to the rapid economic growth of the country’s primary sector (ibid.), which now accounts for nearly 83% of export value (Ministry of Primary Industries 2025). At the same time, the intensification of New Zealand’s agricultural systems has increased multiple risks, foremost for the environment but also regarding the reputation of agricultural production, as consumers today are demanding sustainable practices (Caradus et al. 2021). Consequently, extensive reforms are needed to enhance the system’s sustainability, guarantee water availability and quality, protect soil and biodiversity, and reduce greenhouse gas emissions, among other goals (Renwick et al. 2019; Pannell & Rogers 2022).

Scientific information can foster such reforms in various ways. Natural sciences generate data which, if used for science-based solutions, can effectively contribute to sustainable land use. In addition, social sciences reveal alternative options for collective action driven by particular stakeholders and describe as well as shape the narratives with which these actors participate in discourses on sustainable land use practices (Greenhalgh 2021). Our paper assumes that land use research in New Zealand in general, and the project “Moving the Middle” in particular (which serves as our empirical case), are producing interdisciplinary, innovative scientific information. The central question is how this scientific information can be effectively transferred from scientific actors to land use practitioners. More specifically, we ask where and how these actors encounter innovative scientific knowledge. We are interested in the exact “venues” where land users interact with scientific information, such as internet platforms, scientific seminars, or extension services. Furthermore, we examine which specific actions, carried out by both scientists and land users, facilitate the transfer of scientific information effectively. Accordingly, we investigated both how scientists address land users and how land users assess the relevance of scientific information for their own land use solutions.

To answer our research questions, we first present the theoretical foundation for knowledge transfer: the Research-Integration-Utilisation (RIU) theory. Specifically, we employ the concept of integration forums from the RIU model and focus on the integration activities undertaken by scientists and land users within these forums. We then present the empirical case of New Zealand’s “Moving the Middle” project along with our analytical and empirical approach. Based on the results, we discuss two hypotheses and conclude with two options for strengthening the transfer of scientific information from research into land-use practice.

Theory

RIU-based activities for effective transfer of scientific information from research into land use

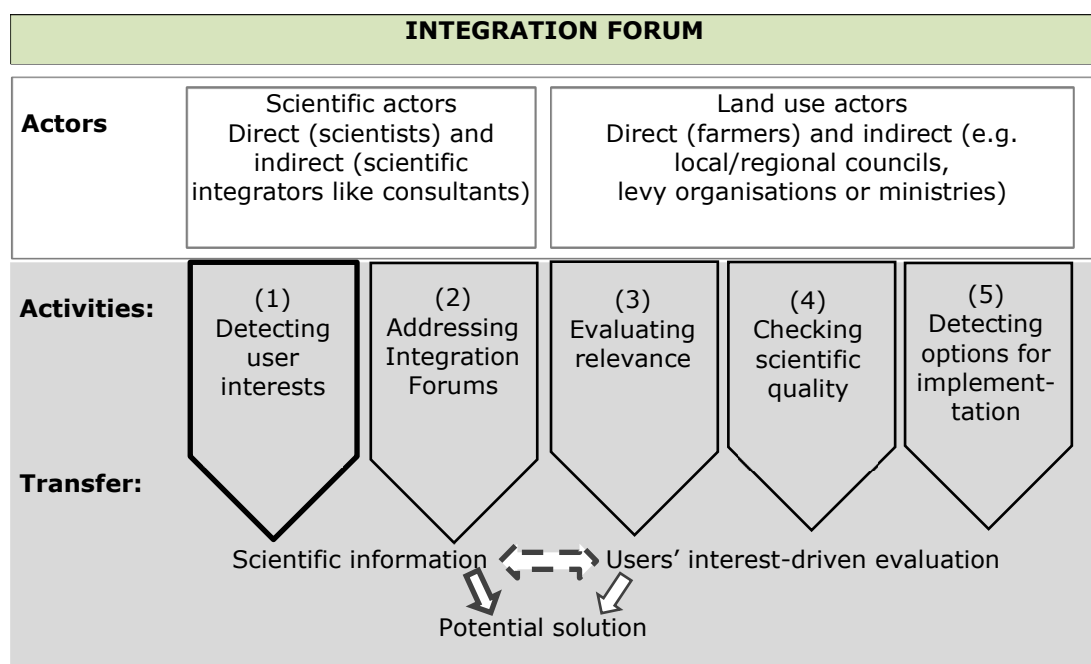
To analyse the transfer of scientific information from research into land use, various theoretical models of knowledge transfer can be applied, from linear (Beck 2011; Durant 2015) through technocratic (Schelsky 1965) over embedded (for an overview see Sokolovska et al. 2019). Whereas linear, technocratic and early embedded mainly emphasise the use of scientific knowledge for legitimisation purposes (Lentsch & Weingart 2009; SAPEA 2019) later embedded models (RIU) look at the embedding of scientific information onto the actor-specific existing knowledge through the lens of interests and power (Böcher & Krott 2016). These factors of knowledge transfer co-exist with the strong requirements of the policy and politics for legitimisation (SAPEA 2019).

The integration of politics and bureaucracy into all scientific activities is being emphasised by co-production models (Turnhout et al. 2019), whereas newer embedded models additionally incorporate explicit formats for societal and economic input. Nevertheless, both approaches carry the risk of diluting the unique potential that scientific information can offer to specific actors, when diverse interests and power resources of different actors are included and combined. Therefore, we follow the RIU model of Böcher and Krott (2016), which takes that into account by distinguishing a research phase from a utilisation phase. In the research phase, scientific information is being produced by scientists adhering to scientific standards. In the utilisation phase scientific information can be utilised by users, who are driven by their interests and power when deciding about activities that initiate land use change. For the efficient transfer of scientific information these two phases (Research and Utilisation) need a bridge called Integration, where users encounter scientific information and potential solutions for practical problems (Stevanov & Krott 2021; Figure 1). In the integration phase users evaluate scientific information from the perspective of their own interests. Based on this evaluation actors may find the scientific information suitable for their science-based solution. The specific “venues” where the process of exchange and evaluation takes place are called Integration Forums (Kirchner et al. 2021a; Figure 1).

Integration Forums are comprised not only of scientists and direct land users (e.g. farmers), but also a wide variety of other actors who regulate and influence land use, such as administrative officers, politicians, journalists and lobbyists. We summarise all these as land use actors (Figure 1). It is often the case that the same actor participates in different Integration Forums. What always holds true is that within each Integration Forum, a land use actor (from the utilisation sphere) comes into contact with scientific information or scientists (from the research sphere). For scientific information to be effectively transferred from research into the utilisation sphere, both sides—scientific actors and land use actors—must engage in specific activities (Kirchner et al. 2021a; Kirchner et al. 2021b; Krott et al. 2024).

In line with a recent study from New Zealand (Kirk et al. 2022), which emphasises the active role of land use actors as “curators” (meaning actors who identify their own needs and weigh the available information before deciding which path to take), our theoretical approach differentiates five key activities (Figure 1), two of which (1–2) are driven by scientific actors and three (3–5) by land use actors (Kirchner et al. 2021a; Kirchner et al. 2021b; Krott & Zavodja 2024):

1. Scientific actors must (1) identify potential users who may be interested in specific scientific information and (2) address the Integration Forums of these users in order to communicate tailored scientific information directly.
2. Land use actors, who receive information from scientists within the Integration Forum, (3) evaluate the relevance of the scientific content in light of their own formal and informal interests. In addition, (4) land use actors must assess the scientific quality, as this is crucial for generating the desired effects on land use. Finally, to effectively apply the scientific information, it is necessary to have a clear understanding of (5) the available options for implementation e.g. where a potential solution can be put into practice and by which resources and/or potential partners (Figure 1). If there are no realistic implementation options, land use actors are unlikely to be motivated to introduce changes related to their ongoing land use practices.

Figure 1. Transfer of scientific information within Integration Forum

Source: Krott & Zavodja 2024, adapted.

Engaging in these activities requires abilities and capacities on both sides. On one side, scientific actors need to communicate scientific information to land users directly or indirectly (e.g. through a research report on a website) within the identified Integration Forums (Figure 1). A scientific actor may be a researcher producing a research result, but also someone involved in disseminating scientific information ("scientific integrators" such as consultants, journalists, or business advisors). On the other side, land use actors, comprising farmers, local/regional councils, levy organisations, ministries, and others (Kirk et al. 2022), can directly or indirectly influence the introduction of science-based solutions in land use practice. The potential of each Integration Forum to transfer scientific information effectively, that is to embed it into a potential solution, depending on the interest-driven evaluation of land users, is thus determined by the configuration of actors (Kirchner & Krott 2022).

Based on the RIU model and the theoretically outlined key activities of actors participating in Integration Forums, we formulate the following hypotheses:

H1: Different Integration Forums achieve different levels of effectiveness in integrating scientific information into potential solutions.

By facilitating specific key activities of scientific and land use actors, Integration Forums achieve different effectiveness of embedding scientific information into potential solutions.

H2: Integration Forums with strong links to land use actors achieve higher effectiveness in integrating scientific information into potential solutions than Integration Forums with strong links to scientific actors.

Scientific and land use actors undertake different key activities within Integration Forums. We posit that scientific actors face a somewhat simpler task, as they "only" need to present scientific results within the Forum. Land use actors, in addition to communication, must also integrate the acquired scientific information into their land use practices. Therefore, we identify the activities of land use actors as the bottleneck in knowledge transfer. Consequently, we assume that Integration Forums with strong links to land use actors will, overall, achieve better transfer than those with strong links to scientific actors.

Methodology

Case study New Zealand and methods

A suitable empirical case for this study must be a research project that addresses land use problems relevant to users and that aims to have a tangible impact on land use practices. Furthermore, it should involve a large group of scientists from diverse disciplines, including both the natural and social sciences. All these criteria are fulfilled by the "Moving the Middle" project,

which has been running in New Zealand from October 2021, finishing in September 2026. The overarching objective of this interdisciplinary project, involving more than 50 scientists, is to improve the environmental performance of land managers in New Zealand by addressing four powerful leverage points (Greenhalgh 2021). A leverage point, as defined by Greenhalgh (2021), is a place within a complex system where relatively small interventions can lead to significant systemic change; for instance, when an innovative, science-based solution transforms grazing into a sustainable practice. While leverage points may function well in theory, which corresponds to the research sphere of the “Moving the Middle” project, the outcomes can only impact land use if land managers embed scientific information into their existing knowledge and practices within the utilisation sphere (Stevanov & Krott 2021). The transfer of scientific information from research into the utilisation sphere thus forms a crucial additional component of “Moving the Middle,” making it an optimal case study for our analysis.

The aim of our analysis is to assess the effectiveness of different Integration Forums in the transfer of scientific information to land use solutions. Guided by theory and empirical evidence, we identify Integration Forums and analyse how particular actors participate within them. The specific actors and their resources determine the distinctive activities of information transfer, and consequently, the overall effectiveness of specific Integration Forums. Our research design consists of five steps:

1. **Data collection, sampling and reliability check:** First, we collect information about particular Integration Forums relevant to agricultural land use in New Zealand. We applied snowball sampling to identify important Integration Forums. Each actor interviewed recommended to us Integration Forums. In the beginning we got information from the social science work package coordinator of the “Moving the Middle” project (interview 19) who arranged the contact with interviewees in addition. Empirical data were gathered by a team of three senior researchers, who conducted both field and desk research from March 2023 to April 2024. A mix of qualitative research methods was applied, with data sourced from (i) document analysis, (ii) non-participatory observations, and (iii) semi-structured, face-to-face expert interviews (Diekmann 2018). Most documents—such as position papers or legislation—were publicly available (e.g. on actors’ websites), while a minority were obtained upon request. Seventeen interviews with key actors (Table 1) were conducted in person. Main findings were transcribed immediately after each meeting and cross-verified verbally the following day by the team of all three senior scientists. As most interviews were conducted either at the actors’ premises (e.g. ministry offices) or in the field (e.g. with farmers), valuable (non-participatory) observations could also be included in the empirical evidence. The reliability was checked by triangulating these different data sources, minimising interest driven bias of interviewees.
2. **Actor categorisation and coding:** Second, identified actors are grouped into categories. This classification, conducted by the research team, follows those of Schusser et al. (2016): scientists, research organisations, public agencies, organised interest groups, media, and land users. These theory-based actor categories enable us to apply established theories pertinent to particular groups. For example, the observation that New Zealand’s Ministry of Primary Industries uses an “internet platform” for sourcing scientific information is coded as the theory-based Integration Forum “internet-based scientific data platform used by a public agency.” In analysing the effectiveness of this forum, we can draw on well-developed theories of public agencies (Downs 1967; Peters 1995).
3. **Analysis of actor activities:** Third, we examine on a theoretical basis and supported by empirical evidence, how actors conduct their specific activities within identified Integration Forums. For instance, bureaucratic theory suggests that communication between different units of a single public agency is often weak (Downs 1967). Interviews and document analysis enabled us to identify two distinct units within the Ministry of Primary Industries: one unit engaged in searching for scientific information (via the internet-based data platform), and another concerned with developing policy outputs (such as drafting guidelines). Our empirical data indicate that within the Integration Forum “Internet-based scientific data platform used by public agency,” the information-searching unit typically lacks information about either the specific policy product or the specific collaborators the policy unit is working with. Each such shortcoming is recorded as a minus for the corresponding specific activity, which factors into the overall effectiveness assessment in the next step.

Table 1. Sources of empirical evidence

No.	Type of meeting	Date	Duration	Interview ("I") (organisation) / Observation ("O")
1	in person	14.03.23	3:00 to 4:00 pm	I: Wellington City Council
2	in person & online	16.03.23	9:00 to 11:30 am	I: Manaaki Whenua – Landcare Research
3	in person	16.03.23	12:00 to 1:00 pm	I: Science New Zealand
4	in person	17.03.23	1:00 bis 1:45 pm	I: Maori tribe chief
5	in person	17.03.23	2:30 bis 3:45 pm	I: Ministry of Primary Industries
6	field visit	18 & 19.03.23	9:30 am to 19:30 pm	O: Land use observation (sheep & beef, forestry, vineries)
7	online	20.03.23	10:00 to 10:45 am	I: MP (Green Party)
8	online	20.03.23	11:30 am to 12:30 pm	I: Manaaki Whenua – Landcare Research
9	in person	20.03.23	12:30 to 1:15 pm	I: Manaaki Whenua – Landcare Research
10	online	22.03.23	2:00 to 3:00 pm	I: Ministry of Primary Industries
11	online	22.03.23	10:00 to 11:00 am	I: Beef & Lamb New Zealand
12	in person	22.03.23	1:00 to 2:00 pm	I: Fed Farmers New Zealand
13	online	22.03.23	2:30 to 3:30 pm	I: Horticulture Industry New Zealand
14	in person	23.03.23	9:30 to 10:00 am	I: Ministry of Primary Industries
15	in person	23.03.23	1:00 to 2:00 pm	I: Deer Industry New Zealand
16	in person	24.03.23	12:00 to 02:45 pm	I: Farmer O: Land use observation (sheep & beef)
17	in person	29.03.23	9:30 am to 12:00 pm	I: Farmer O: Land use observation (dairy)
18	field visit	14.03.2023 to 05.04.23		O: Various land use observations (sheep & beef, dairy, forestry, vineries, nature conservation)
19	in person	14.3.23	9.00 am to 12.00 am	I: Manaaki Whenua – Landcare Research

4. **Quantification and coding of effectiveness:** Fourth, we quantify the effectiveness of specific activities conducted by scientific actors and land use actors within Integration Forums and coded it into "+, +-, -" (Table 2). The qualitative criteria are defined in Table 1 (Coding Section) in line with methods of qualitative content analysis (Mayring 2014). For example, if scientific actors identify Integration Forums in a way that provides reliable information on the channels land use actors use to access new scientific findings, two credits ("++") are awarded; for a partial fulfilment ("±") one credit is given (partly effective), and for a shortcoming ("--") zero credits (non-effective).

The sum of credits across three specific activities gives the score for each key activity, enabling coding of: a) Effectiveness of activities driven by scientific actors, as a percentage out of a possible 12 credits per Integration Forum (12 = six specific activities within two key activities, each with a maximum of 2 credits). b) Effectiveness of activities driven by land use actors, as a percentage out of a possible 18 credits per Integration Forum (18 = nine specific activities within three key activities, each with a maximum of 2 credits). c) Overall effectiveness of Integration Forums, calculated as the average of (a) and (b) (Table 1). d) Effectiveness of key activities driven by scientific and land use actors (across 19 Integration Forums), as a share (in %) of a maximum of 114 credits (3 specific activities × 2 credits × 19 Integration Forums = 114) (Table 1). e) The strength of the links that Integration Forums have established to scientific and land use actors, via key and specific activities (Table 1).

5. **Comparison and synthesis:** Fifth, to compare different types of effectiveness, results from steps 3 and 4 are summarised and related to our hypotheses.

By applying these steps to integrate theoretical considerations with empirical evidence, we are able to rank Integration Forums according to their overall effectiveness (in %) in transferring scientific information to agricultural land use practice and to identify key activities that facilitate this transfer.

Table 2: Conceptual frame for analysing effectiveness of transferring scientific information within Integration Forums and coding it

	Key activities for the transfer of scientific information (each key activity is made of three specific activities (1), (2) and (3) used as indicators to judge effectiveness)					Overall effectiveness of knowledge transfer	Strength of (1), (2), (3) to the actors
	Driven by scientific actors		Driven by land use actors				
	Detecting user interests	Addressing Integration Forums	Evaluating relevance	Checking scientific quality	Detecting options for implementation		
	(1) detecting actors, winners and losers (+ or ± or -)	(1) identifying Integration Forums (+ or ± or -)	(1) evaluating policy product (+ or ± or -)	(1) checking links to science (+ or ± or -)	(1) legal framework (+ or ± or -)	Share (in %) (100% = 30 credits)	5-6 credits (+, +, +) or (+, +, ±) strong
(2) detecting power of actors (+ or ± or -)	(2) accessing Integration Forums (+ or ± or -)	(2) evaluating allies (+ or ± or -)	(2) checking credibility (+ or ± or -)	(2) economic framework (+ or ± or -)	3-4 credits e.g. (+, ±, -) moderate		
(3) detecting conflicts of interests (+ or ± or -)	(3) focusing on relevant scientific information (+ or ± or -)	(3) evaluating public goals (+ or ± or -)	(3) fine-tuning (+ or ± or -)	(3) good governance (+ or ± or -)	0-2 credits e.g. (+, -, -) weak		
Credits	0-6	0-6	0-6	0-6	0-6		
	12 credits		18 credits				
Credits	Coding						
2	+ wide-spread systematic pre-analysis of actors (1), winners and losers (2), conflicts of interests (3)	+ good information about IF (1), strong access to IF (2) and delivering relevant scientific information to IF (3)	+ high relevance for a specific policy product (1), allies (2) and public goals (3)	+ strong link to science (1), independent check of scientific quality (2) and bi-directional fine tuning between science and practice of products (3)	+ excellent knowledge of legal (1) and economic options (2) and requirements of good governance (3)		
1	+/- partly existent	+/- partly existent	+/- partly existent	+/- partly existent	+/- partly existent		
0	- non-existent	- non-existent	- non-existent	- non-existent	- non-existent		
Overall effectiveness of key activity	Share (in %) (100%=114 credits)	Share (in %) (100%=114 credits)	Share (in %) (100%=114 credits)	Share (in %) (100%=114 credits)	Share (in %) (100%=114 credits)		

Results

Different effectiveness of Integration Forums dependent from land users

Integration Forums, comprising various scientific and land use actors, provide the context in which scientific information can be embedded in potential land use solutions. Our empirical analysis identified 19 distinct Integration Forums and evaluated their effectiveness. The results are summarised in Table 3.

Table 3: Effectiveness of transfer of scientific information within Integration Forums

Integration Forum (IF)		Key activities for the effective transfer of scientific information					Overall effectiveness of knowledge transfer (100% = 30 credits)
		Activities driven by scientific actors (100%=12 credits)		Activities driven by land-use actors (100%=18 credits)			
		Detecting user interests	Addressing Integration Forums	Evaluating relevance	Checking scientific quality	Detecting options for implementation	
Evaluation of effectiveness (absolute/percentage)							
IF1	Scientist within regional or local administration	+-	+	+	+	+	74%
		-	+	+	-	+	
		+-	+-	+	+	+	
		2	5	6	4	6	
		58%		89%			
IF2	Research facility of levy organisation	-	+	+	+-	+	74%
		+-	+	+	-	+	
		+	+	+-	+	+-	
		3	6	5	3	5	
		75%		72%			
IF3	Branding by scientific arguments	-	+	+	+-	+	68%
		+-	+	+-	+-	+	
		-	+	+	+	+-	
		1	6	5	4	5	
		58%		78%			
IF4	Science-based guidelines	+-	+	+	+	+	68%
		+	+-	+-	+-	+	
		-	+-	+-	+	+-	
		3	4	4	5	5	
		58%		78%			
IF5	Scientists addressing task-oriented producer group	+-	+	+	+	+	64%
		+-	+-	+-	+-	+	
		-	+-	+	+	-	
		2	4	5	5	4	
		50%		78%			
IF6	Transdisciplinary innovation hubs	+	+	+	+	+-	63%
		+-	+-	+-	+-	-	
		+-	-	+	+	+-	
		4	3	5	5	2	
		58%		67%			
IF7	Market-driven, applied research organisation	+-	+	+	+	+-	60%
		+-	+-	+	+-	-	
		+-	+-	+-	+	-	
		3	4	5	5	1	
		58%		61%			
IF8	Science based print and internet media for land users	+-	+	+	+-	+-	59%
		+-	+-	+-	-	+-	
		+-	+	+	-	+-	
		3	5	5	1	3	
		67%		50%			
IF9	Scientist directly contacted by state administrator	-	+	+	+-	+	59%
		-	+	+-	-	+-	
		-	+	+	+	+-	
		0	6	5	3	4	
		50%		67%			
IF 10	State-driven, applied research organisation	+-	+	+	+	+-	57%
		+-	-	+-	+-	+-	
		-	+-	+	+	+-	
		2	3	5	5	3	

		42%		72%			
IF 11	Job rotation between science and utilisation	+-	+	+	+	+	56%
		+-	+-	+-	-	+	
		+-	-	-	+	-	
		3	3	3	4	4	
		50%		61%			
IF 12	Asking champion scientist	+-	+	+	+	+-	56%
		-	+	+-	+-	+-	
		-	+-	+-	+-	+-	
		1	5	4	4	3	
		50%		61%			
IF 13	Scientifically informed chief of indigenous group	-	-	+	-	+	55%
		-	+	+-	-	+	
		+	+-	+-	+	+-	
		2	3	4	2	5	
		42%		67%			
IF 14	Research manager as part of extension service	-	+	+	+-	+-	53%
		+-	+-	+	-	+-	
		+-	+-	-	+	+-	
		2	4	4	3	3	
		50%		56%			
IF 15	Scientifically informed trusted producer	-	-	+	-	+	49%
		+-	+	+-	-	+	
		-	+	-	+	+-	
		1	4	3	2	5	
		42%		56%			
IF 16	Scientifically informed business company advisors	-	+	+-	+-	+	39%
		-	+-	-	-	+	
		-	+-	-	+-	-	
		0	4	1	2	5	
		33%		44%			
IF 17	Scientific information seminars	+-	+	-	+	+	38%
		+-	-	-	+-	-	
		-	-	+	-	+-	
		2	2	2	3	3	
		33%		44%			
IF 18	Internet-based scientific data platform used by public agency	+	+-	-	+	+	38%
		-	+	-	-	-	
		-	-	+	-	-	
		2	3	2	2	2	
		42%		33%			
IF 19	Information by anticipating scientific projects	+	-	-	+	-	30%
		+-	-	-	+	-	
		+-	-	+	-	+-	
		4	0	2	4	1	
		33%		28%			
Overall effectiveness of key activity (percentage/absolute-114 maximum credits)		35 % 40	65% 74	66% 75	56% 64	60% 69	

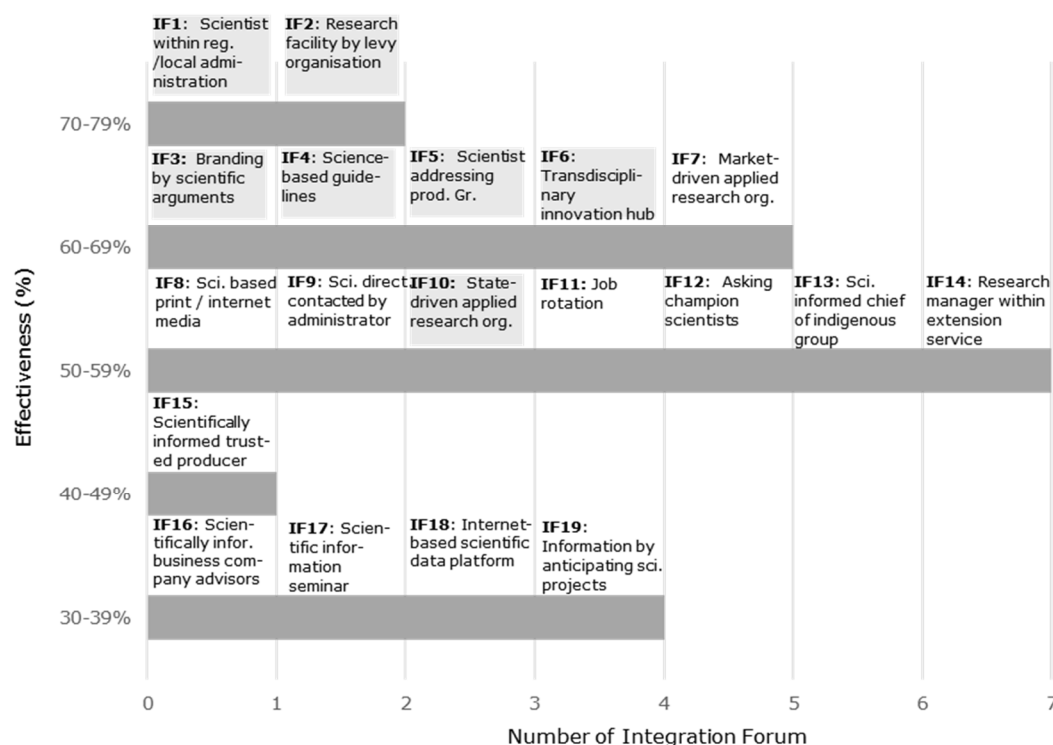
These Integration Forums (IF) are briefly characterized below, following an order from those situated closer to research to those closer to practice, based on whether the key actor in the Forum is primarily positioned within the research or utilisation sphere:

- IF1: **Scientists directly employed by regional or local administrations**, embedding scientific knowledge in day-to-day administrative work (*Regional council employing scientific staff*)
- IF2: **Levy organisations running or financing research facilities**, which generate scientific information tailored to the organisation's needs (*Research tasks of public organisations financed by levy, e.g. monitoring by Beef & Lamb*)
- IF3: **Branding by scientific arguments**, where scientific arguments strengthen public acceptance (*Climate footprint by big industry*)

- IF4: **Public policy organisations producing science-based guidelines** drawn on research results as foundation of proposed solutions (*Guidelines for certified export*)
- IF5: **Scientists addressing producer groups directly** by capitalising on the group's task orientation (*Catchment groups, agricultural greenhouse gas consortium*)
- IF6: **Transdisciplinary innovation hubs** integrating users, politicians, and farmers to combine diverse interests and experiences (*Local policy/science/farmer discussion groups, e.g. Margret Brown local initiatives*)
- IF7: **Market-driven research organisation for applied research**, oriented toward projects that respond directly to market demands (*Crown Research institutes*)
- IF8: **Science-based print and internet media** disseminating research findings to broader user groups by framing messages to attract target audiences (www.sciencemediacentre.co.nz; www.apen.org.au)
- IF9: **Scientists contacted directly by public administrators** tend to be informal forums grounded in mutual trust (*Informal request to scientist by administrators*)
- IF10: **State-driven organisation for applied research** consists of research units conducting applied projects for land users, guided by one or more state agencies (*Foundation for Arable Research*)
- IF11: **Job rotation** between research organisation and utilisation entails individuals switching from the role of scientist to practitioner (or vice versa), which facilitates transfer of tacit knowledge (*Observed as a frequent practice in NZ land use sector*)
- IF12: **Asking champion scientists** is a more formal approach, with land users seeking expertise from recognised leaders in specific fields. (*Informal list of national champion researchers*)
- IF13: **Agricultural land use by indigenous groups**, such as the Māori, often involve a chief acting as a gatekeeper to scientific information, with interests shaped by tribal experience (*Regional Maori Chief*)
- IF14: **Extension services engaging research manager** who Acts as gatekeeper when introducing scientific content into extension activities (*On Farm Support services for farmers and growers*)
- IF15: **Trusted producers who are scientifically informed** plays a similar gatekeeping role (as research manager, IF14) for others in the sector (*Trusted Farmer*)
- IF16: **Business company advisors** as gatekeepers for scientific information, having organisational needs and a business model as a guide (*Agribusiness advisor*)
- IF17: **Scientific information seminars** organised flexibly by research institutions to communicate research findings to selected land use actors (*Seminars by MtM researchers*)
- IF18: **Internet-based scientific data platforms** making scientific data widely accessible to land use actors (we observed a public agency using such platforms to search for relevant information: *Internet evaluation by Ministerial science/policy team*)
- IF19: In the Forum "Information by anticipating scientific projects" (IF19), scientific actors aim to anticipate future land user demands by orienting research questions and outputs toward long-term needs; this approach reveals future requirements but may not address immediate demands. (*Anticipating research projects on flooding*)

Hypothesis 1 proved different effectiveness of examined Integration Forums (IF1-IF19). Figure 2 indicates that the overall effectiveness ranges from 30% to 74% of the maximum (100%). Among all Forums, two (IF1, IF2) achieve 70–79% effectiveness, whereas five (IF15 to IF19) fall below 50% (Figure 2, Table 2). Thus, the extent to which relevant scientific information is transferred and utilised by land users is determined by the specific Integration Forum.

Hypothesis 2 stated that Integration Forums in which land users play a stronger role than scientists achieve higher effectiveness in knowledge transfer. Those Integration Forums are marked with shading in Figure 2, showing that IF1, IF2, IF3-IF6 and IF10 (with stronger links to land users) are in the upper part. They constitute the Integration Forums with top effectiveness and support H2.

Figure 2. Different effectiveness in transfer of scientific information of Integration Forums (IF1 – IF19)

The shades in IF1, IF2, IF3-IF6, and IF10 indicate integration forums with strong links to land users.

Discussion

Key activities determining knowledge transfer

Our analysis focused on specific Integration Forums in which both scientific and specific land use actors are active. In this regard, our empirical study of 19 Integration Forums offers a more nuanced and specific assessment than much of the current literature on knowledge transfer and its environmental impacts in New Zealand's land use sector (Pinxterhuis et al. 2019; Eastwood et al. 2022; MacLeod et al. 2022). While this literature rightly emphasises multidisciplinary as well as the centrality of actor participation and communication (e.g. through co-design and co-production), it frequently generalises the key to successful knowledge transfer as merely the broader involvement and improved communication among actors to address complex agricultural problems.

The co-production perspective, prominent in much recent literature (Djenontin et al. 2018; Gerlak et al. 2023), frequently points to deficits in land user activities or engagement as critical to integration effectiveness. Our findings strongly support this focus. However, taking land use actors seriously also entails taking their interests and conflicts seriously. Unlike scientists, land use actors are not driven by academic curiosity; they must manage the risks associated with new solutions and advocate for their position in the face of competing interests. These actors do not search for the most innovative solution per se but rather favour solutions that advance their specific interests (Kirchner & Krott 2020, 2022).

The differentiation of knowledge transfer into specific Integration Forums shows that science-based extension services and the transfer of scientific information into innovative solutions for practice depend mainly on the activities of the land use actors. If the land use actors get active within Integration Forums (by evaluating the relevance, checking the quality of scientific information and by designing realistic options for implementation) then scientific information will be effectively embedded into innovative solutions. But scientific actors cannot activate or substitute land use actors. Scientific information can successfully overcome the bottle neck of knowledge transfer by the "pull" of land use actors willing and able to transform potential solutions into the real science-based solution.

Conclusion

Effective transfer by active practice actors

By using the case of sustainable and environmentally friendly land use in New Zealand, we could show the specific ways in which scientific information gets transferred and embedded into innovative land use solutions: by 19 Integration Forums, within which the actors from practice meet scientific information delivered mostly directly by scientists. It turned out that:

- The effectiveness of transferring scientific information differs widely between analysed Integration Forums. Meaning the more active the role of land use actors is within the Forum the higher the effectiveness.
- Scientists and research projects have limited opportunities when it comes to transferring scientific information into practice and involving multiple stakeholders. The bottle necks are in already existing Integration Forums, which are closely linked to specific (strong) actors of land use. It is in the hands of these actors to pull for scientific information and handle the multiple supply of scientific information in a professional manner. Activating land use actors within existing Integration Forums means their active checking of relevant and high-quality scientific information as well as fine tuning it into realistic solutions for implementation in the land use practice. Professionalisation of existing Integration Forums might therefore be a more promising strategy for increasing effectiveness of knowledge transfer than creation of new Integration Forums or pushing for new research projects (which are not the limiting factor for providing the desired (and often promised) transfer of scientific information).

For further research the results show the fruitfulness of looking more closely into the specific Integration Forums and their particular activities in order to identify bottle necks of transfer of scientific information. Our investigation only scratches the surface but selecting specific effective Integration Forums and analysing their progress in the last decade, would be a most promising research strategy in the future to strengthen the transfer of scientific information into innovative land use practices.

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