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Considerations for Research Funders and Managers to Facilitate the Translation of Scientific Knowledge into Practice

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Abstract
Research funders and managers can play a critical role in supporting the translation of knowledge into action by facilitating the brokering of knowledge and partnerships. We use semi-structured interviews with a research funding agency, the Australian Centre for International Agricultural Research (ACIAR), to explore (i) ways that funders can facilitate knowledge brokering, the (ii) barriers to, and (iii) enablers for, facilitating knowledge brokering, and (iv) the individual skills and attributes for research program funders and managers to be effective brokers. Based on these findings, we generate three considerations for research funders elsewhere, in particular R4D funders, seeking to build capacity for knowledge brokering: (i) formalise the process and practice, (ii) develop shared language and understanding, and (iii) build individual competencies and capabilities. Our findings complement the existing literature with a context specific analysis of how research funders can facilitate knowledge brokering, and by identifying the barriers and enablers in doing so.

Keywords Research for development · Knowledge translation · Knowledge broker · Research impact · Science funding

Background

Solving complex socio-environmental challenges such as climate change, resource depletion and biodiversity loss requires the uptake and integration of scientific knowledge and evidence into decision-making processes (Sutherland et al. 2004). This translation of knowledge into action (herein referred to as knowledge translation) sees research findings taken up by users and used appropriately to inform policy, practice or further research (Cvitanovic et al. 2015a; Cooke et al. 2021). However, the routine uptake, integration and application of scientific knowledge - and by extension, the ability of science to address these challenges—remains limited due to a range of persistent and systemic barriers (Graham et al. 2006, Oliver et al. 2014; Rose et al. 2018; Nguyen et al. 2019; Walsh et al. 2019; Bruneel et al. 2010). These barriers stem from cultural differences between scientists and decision-makers, the inaccessibility of science to decision-makers, and institutional dis-incentives (e.g. the 'publish or perish' culture of science which prioritises outputs rather than outcomes) among many others (Roux et al. 2006; Shanley, López (2009); Cvitanovic et al. 2014). These barriers are indeed persistent in research for development (R4D), an approach to conducting scientific enquiry that seeks to generate new knowledge, technologies and innovations which can be used to address the complex socio-environmental challenges faced by those in developing countries (Laws et al. 2013).

To overcome these barriers and support greater research impact, experts are advocating for institutions to build capacity for knowledge translation via the practice of knowledge brokerage. In this regard, we define knowledge translation as the broad practice of supporting the movement of knowledge (in its broadest sense, spanning knowledge systems) into action, and knowledge brokerage as the full suite of activities required to link decision-makers

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with researchers, facilitating their interaction so that they are better able to understand each other's goals and professional cultures, influence each other's work, forge new partnerships and promote evidence-based decision-making (following Lomas 2007; Cvitanovic et al. 2017). In the context of R4D, knowledge brokering plays a critical role in translating research findings into actionable insights that can inform policies and programmes aimed at improving the lives of people in developing countries. It is important to note, also, that in the context of R4D that 'research findings' can take multiple forms, often drawing on inter- or transdisciplinary research approaches that seek to work with and integrate different knowledge systems. As such, the exact approach to knowledge brokerage would be dictated by the specific context in which it is embedded, and must be agile enough to adapt to changing context (Chambers et al. 2021, 2022). Having said this, knowledge brokerage is typically facilitated either by an individual (or team of individuals) within academic research institutions, or in separate boundary organisations (Bielak et al. 2008; Cash et al. 2003). While anyone can engage in knowledge brokering (Ward et al. 2009), typically these activities are undertaken by an expert with the capacity and capabilities necessary to support this agenda (referred to as a knowledge broker). Specifically, a knowledge broker is an intermediary agent who facilitates interaction and engagement among researchers and end-users to enhance knowledge exchange, enable the use of scientific knowledge in decision-making processes, and strengthen research impact (reviewed by Lightowler and Knight 2013).

To date, there has been a focus on the ways in which academic and policy institutions, and the individual actors within them (e.g., researchers, policy makers), must evolve to build capacity for knowledge brokerage and translation (Cook et al. 2013; Laurance et al. 2012). However, it is increasingly recognised that the institutions responsible for managing and funding the research (herein referred to as the research funders) also play a critical role in determining the orientation, conduct and impact of research (e.g., through funding criteria, contractual obligations, and agenda-setting) (Arnott et al. 2020; Lyall et al. 2013; Newig et al. 2019). With calls for actionable science that can address growing socio-environmental challenges, research funders are now increasingly moving away from the 'fund and forget' model of grant-making (Holmes et al. 2012), and instead turning their attention to identifying and implementing strategies that will increase the likelihood their funding leads to tangible and real-world outcomes and impacts (Cvitanovic et al. 2021a; Landrum et al. 2022).

Despite the critical role that research funders can play in supporting the uptake and integration of scientific knowledge, to date there has been little systematic evaluation of the ways in which research funders can actively support such efforts, or the identification of opportunities to enable these practices (Riley et al. 2011; Matso and Becker 2014, Nyboer et al. 2021). Previous studies on the role of research funders have largely been situated in healthcare, medicine, and management sectors (e.g., Armstrong et al. 2013; Thackway et al. 2017; Kerner 2006; Bornbaum et al. 2015). While limited, some studies have explored the role of research funders in supporting knowledge translation mechanisms in the environmental sciences (e.g., Arnott et al. 2020; Cvitanovic et al. 2021a; Nyboer et al. 2021). For example, Arnott et al. (2020) identified opportunities for research funders to improve the generation of actionable science for sustainability through varied approaches to solicitation design, review processes, implementation support and evaluation. However, few studies have evaluated how this role may differ for research funders engaged specifically in R4D. This is particularly pertinent given the additional ethical and cultural challenges in brokering partnerships and knowledge with diverse communities, policy makers and practitioners in this context (Young 2005; Laws et al. 2013). As such, there remains a need for portfolio-scale evaluations of research for development funders to identify ways that agencies can enable and facilitate knowledge brokering to support the generation of knowledge that is relevant, timely and leads to environmental and societal impacts for those who need it most.

In this present paper, we use the Australian Centre for International Agricultural Research (ACIAR) as a case study. ACIAR is uniquely placed due to its position as a public science funding agency (i.e., a statutory agency within the Australian federal government) that brokers, funds and manages R4D. Through qualitative interviews with participants who contribute to brokering and managing research programmes at ACIAR, we aim to elucidate a better understanding of the ways in which research funders can facilitate knowledge brokering activities. Specifically, through these interviews we aim to understand (i) the ways that ACIAR currently facilitates knowledge brokerage (i.e., the strategies and activities); the (ii) barriers to, and (iii) enablers for, facilitating knowledge brokering, and (iv) the skills and attributes necessary for individual research programme managers to be effective knowledge brokers. This paper presents an opportunity to learn from one of Australia's foremost public R4D funding agencies, and to contribute to improving the actionability of the scientific knowledge that is generated through ACIAR-funded and managed research.

Methods

Case study

ACIAR was established as a research funding agency with the goal to '*encourage research for the purpose of*

identifying, or finding solutions, to agricultural problems of developing countries' (ACIAR 2018.). Specifically, ACIAR-supported projects produce research outputs that translate to six development objectives—from improving food security and reducing poverty among smallholder farms and rural communities, to improving gender equity and empowerment of women and girls. To date, ACIAR has commissioned and managed more than 1500 research projects in 36 countries, partnering with 150 institutions along with more than 50 Australian research organisations. Currently, ACIAR's research funding portfolio is organised into ten programmes—agribusiness, climate change, crops, fisheries, forestry, horticulture, livestock systems, social systems, soil and land management and water.

ACIAR is uniquely placed as a research funder in that it has a strong and deliberate focus on partnerships, collaboration and relationships in the design and management of the research projects it funds. Specifically, ACIAR's focus is on identifying opportunities and partnerships to fund international agricultural research and capacity building, rather than undertaking the research directly or simply distributing grants to researchers. For example, ACIAR identifies research priorities collaboratively with partner countries (i.e. by undertaking strategic country engagement and horizon scanning with key partners in-country), and brokers research partnerships and projects between Australian scientists and their counterparts in developing countries to tackle those priorities (e.g. by convening workshops and meetings to allow the co-design of research proposals). ACIAR also have a dedicated Capacity Building Program which aims to build capacity within partner countries, to enable them to engage more deeply in these processes.

Once projects are established, ACIAR manages and monitors these investments throughout the research process to maximise impact and return on investment and aims to communicate research findings broadly. ACIAR employs a specific expert to manage each of its ten programmes (known as a research program manager or RPM), who is responsible for supporting and facilitating this agenda. In this way, knowledge brokerage activities are seen to be within the remit of ACIAR as an organisation, as well as of the individuals responsible for the management of ACIAR-supported research projects (i.e., the RPMs). As ACIAR progresses into the latter half of its current 10-year strategy (2018–2027), there is an opportunity to better understand the strategies they employ to facilitate knowledge translation and brokerage, and to identify potential opportunities for ACIAR to increase their support as a research funding agency in the generation of actionable and impactful science (ACIAR 2018).

Research instrument and data collection

Semi-structured interviews were conducted to collect the data for this study. Qualitative methods were selected over quantitative methods to allow for an in-depth understanding of the participants' perspectives. An interview guide was developed and used, but there was a degree of flexibility during the interview to allow for new questions to arise in response to what the interviewee stated (Bryman 2012). Three co-authors (CC, PT and RS) identified relevant participants through 'purposive' and 'snowball' sampling, which are both widely employed methods of sampling in qualitative research (Bryman 2012). Purposive sampling was initially used to sample all relevant employees at ACIAR who are responsible for directly managing the research projects and their associated activities. This initial list of participants was provided by ACIAR and comprised of four people from within the organisation that were considered the most relevant given their roles. These individuals were cross-checked using the publicly available organisational chart to confirm that met the criteria for inclusion in our study, that is, that they (i) worked within ACIAR and (ii) they contributed to management and brokering of ACIAR research projects and knowledge. Interviewees were then asked to identify additional people who they believed would be relevant to the study (i.e., 'snowball' sampling), which identified 11 more potential participants. Ten of these accepted to be interviewed, resulting in a total sample size of 14. Throughout this process, every effort was made to ensure a breadth of experiences, knowledge, career level and demographics among the research participants.

Three co-authors (CC, PT and RS) conducted one-on-one interviews with participants between March and June 2022. Potential participants were invited to participate via email by one of three members of the research team who undertook the interviews (CC, PT and RS). Participants were given the opportunity to be interviewed face-to-face, via a phone call or on Zoom. Interviews ranged from 30 to 45 min, and were audio recorded with the participants consent. Members of the research team (CC, PT and RS) continued to invite participants to the study using the snowball technique until it was deemed that theoretical saturation was reached (as determined by the quality and depth of the information gathered in the interviews). That is, interviews were undertaken to the point where the collection and analysis of data did not yield any new ideas or information in relation to our research aims (i.e., until theoretical saturation was reached; Bryman 2012). This process resulted in a total of 14 interviews being conducted.

The interview guide was developed following the process outlined in previous studies that have also sought to understand the ways in which the scientific knowledge can be translated into tangible impacts and actions work (e.g., Cvitanovic et al. 2021b; Cvitanovic et al. 2015b; Norström et al. 2020). To ensure consistency between interviewers, each interview was conducted following the structure of the

interview guide (interview guide in supplementary materials). After each interviewer had conducted one interview, the interviewers reconvened to discuss the process and make any necessary modifications on the interview guide (following methods described in Cvitanovic et al. 2018). The interview guide was then refined to reflect feedback from this process, including improving the clarity of the wording to ensure that the intent of the guiding questions was clear. For example, after these initial interviews, the term 'knowledge brokerage' was framed more broadly as 'mechanisms for translating knowledge into action, such as knowledge brokerage' in the interview guide in cases where participants were unfamiliar with the concept. As such, the terms 'knowledge brokering' and 'knowledge translation' may be used intermittently here, particularly in the participant quotes from the interviews.

Data analysis

The audio recordings of the interviews were professionally transcribed to ensure the accuracy of content. The transcripts were then imported into the qualitative data analysis software NVIVO 12 for coding. The analysis of data involved two steps. First, the raw data was broadly coded against the four research objectives. While the four research objectives formed the basis of this initial stage of data coding, analysis was completed following an inductive approach, based on Grounded Theory Analysis (Glaser and Strauss 1967), to allow research findings to emerge from the interview transcripts without the restraints imposed by structured methodologies (Hay 2010). Following this initial stage of data analysis, a second round of coding was undertaken. During this step, data was re-coded following a thematic coding technique to develop a coherent synthesis of key themes (following Blythe and Cvitanovic 2020). 'Thematic coding' refers to the identification and interpretation of patterns, or 'themes,' in qualitative data that are most relevant to the research aims (Saldaña 2015; King et al. 2018). Thematic coding was considered an appropriate approach for the second round of coding given that we wanted to identify common patterns (i.e. themes) among the participants' perspectives.

Several steps were taken throughout this process to ensure the validity and reliability of the coding. First, during step one, three co-authors (CC, DK and PT) each coded 4 transcripts individually, then discussed the pilot coding and any differences that arose. There was a high level of consistency across three authors, as determined by a comparison and group discussion of each author's (CC, DK and PT) pilot coding themes. Thereafter, a single author (PT) then thematically coded all 14 transcripts using NVIVO 12, allowing for codes to emerge within each transcript. During the coding, to ensure themes were relevant and valid, the emerging interpretations were continually checked against the data from which they were derived, following for example, methods described in Marshall et al. (2017) and Shellock et al. (2022). New and emergent themes were also recorded during the analysis of each transcript, and theoretical saturation was reached (i.e. no new ideas, themes and concepts were reported, following Cvitanovic et al. 2016). Four co-authors (CC, DK, PT and JD) then discussed the initial coding, resolved any differences, and developed the higher-level thematic coding.

Study limitations

While there are many strengths of this research, it is important to consider the limitations of the methodology employed in this present study. First, the small sample size may have influenced the nature of the themes derived through the interviews. While there is no universally accepted sample size for qualitative interviews, best practice suggests that meta-themes are often present after six interviews and theoretical saturation tends to be achieved after 12 interviews (Guest et al. 2006; Baker and Edwards 2012). Further, previous studies investigating knowledge translation and brokerage have had similar numbers of study participants while still yielding valid and reliable data (e.g., Cvitanovic et al. 2018), and the homogeneity of the population studied means that saturation is likely to be reached sooner (e.g., review by Hennink and Kaiser 2022). While we were able to elucidate a range of strategies and considerations from ACIAR employees, we were unable to identify the success of these strategies, particularly from the perspectives of different partners, end-users, and beneficiaries. Thus, future research should seek to elucidate these different perspectives to understand the role that ACIAR should play in this landscape, and how effective their current strategies are.

It is also important to note the methodological limitation of using a case-study approach. Although the results presented below are highly context specific to ACIAR, the principles and learnings can also be transferable to other contexts whereby research programme managers and funders are seeking to better support the translation of knowledge from the science they fund (as described in 'Considerations for funders seeking to build capacity for knowledge brokering'). Furthermore, the use of a case-study approach has also been recognised elsewhere within qualitative research in the environmental sciences, allowing for an in-depth understanding of a complex issue (e.g., Cvitanovic et al. 2021b; Starman 2013).

While qualitative interviews allow for an in-depth exploration of the topic, it is important to acknowledge the influence our own (i.e., the interviewers') positionality and biases in the process of interviewing participants (Fazey et al. 2018). For example, factors such as age, gender,

experience, and rapport with the interviewees may have influenced the outcomes. The majority of the authors of this study are researchers in marine social science and/or adjacent fields. Our experiences of knowledge exchange originates mainly from Australia, Europe, North America, and the Pacific. Our experiences, in addition to terminology used within ACIAR, shaped our conceptualisation of knowledge exchange, and hence, the design and analysis of this study. However, we are aware that knowledge exchange and knowledge brokerage are westernised constructs and that there are wider terms and concepts which may be used across other disciplines, cultures and geographies. We are aware that it may be an exclusive and inaccessible term and may not be appropriate communities and contexts. Hence, future research is required to examine knowledge exchange (or more appropriate concepts) with ACIAR staff and project teams who work within the countries where ACIAR fund R4D (i.e. Africa, Asia and the Pacific).

Findings

Overview

Through the analysis of the semi-structured interviews, we identified 19 themes which were coded against 4 research objectives. Table 1 provides an overview of the coding results as an 'analysis hierarchy' (i.e., ordered from most to least frequently mentioned by the participants). Frequency refers to the number of times the theme was mentioned by participants in the interview, not the level of importance that participants placed on any specific theme. The number of sources refers to the number of unique participants who mentioned the theme during their interview (maximum potential is 14). Specific sub-themes are described in further detail in each of the following subsections. A full outline of the themes and a description of each subtheme is provided in supplementary materials to further contextualise the results.

Table 1 Analysis hierarchy of major themes that were extracted from the interviews with participants in reference to each of the four research objectives ($N = 14$). Frequency refers to the number of times that theme was mentioned across the interviews, while number of sources refers to the number of participants that mentioned that theme (maximum 14). Each theme is explored in greater detail in subsequent sections of this manuscript, with several subthemes identified in each major theme (and described in further detail in the supplementary materials)

Research Objective	Theme	Frequency	Number of Sources
1. Knowledge brokering strategies and activities	Research design and management	21	10
	Communication and awareness	14	7
	Linkage and partnerships	11	5
	Capacity building	6	5
2. Barriers to knowledge brokering	Organisational	46	13
	Practical	31	12
	Political	12	8
	Social	8	7
	Individual	8	5
	Financial	7	5
3. Enablers for knowledge brokering	Practical	15	10
	Organisational	27	9
	Individual	11	9
	Financial	10	6
	Social	9	7
4. Skills and attributes of knowledge brokers	Experiential knowledge	15	11
	Interpersonal skills	23	10
	Personal disposition	15	9
	Professional competence	10	8

Knowledge brokering strategies and activities

The first objective of the study was to understand the ways by which ACIAR currently facilitates knowledge brokering in the research projects it funds and manages. The strategies identified by participants were organised into four themes, (i) research design and management, (ii) communication and awareness, (iii) linkage and partnerships, and (iv) capacity building (Table 1). These themes and associated subthemes are described in further detail below and in supplementary materials.

The largest number of participants referred to knowledge brokering activities which occur in the research design and management (Table 2), with related activities including (i) co-design the research project, (ii) integrate participatory design and management of evaluations, (iii) develop a theory of change for the research project, and (iv) plan knowledge management structures. For example, participants identified early-engagement activities such as developing a portfolio theory of change which is reflected at the project level as well, which *'means understanding who the beneficiaries are, and what the nature of their knowledge need and how the research is going to meet those needs*' (ID01). Additionally, participants identified planning for brokering that occurs post-research, such as design knowledge management structures. Here, one participant stated that '*there is and always has been a fair bit of knowledge management, information management stuff, to make sure that the final reports are externally accessible*' (ID05).

Seven out of 14 participants identified knowledge-brokering strategies relating to communication and

awareness (Table 1). Related activities included (i) creating tailored communication products, (ii) sharing learnings with colleagues and researchers, and (iii) facilitating opportunities for communication and discussion. For example, one participant discussed promoting research uptake through creating tailored communication products for different research users, whereby '*[ACIAR has] had some really creative ways of working with communities, such as incorporating plays, and it was in the Pacific, so it was a lot about storytelling, to communicate the research, but also to create these management plans with the communities*' (ID12). ACIAR also facilitates the sharing of learnings with colleagues and researchers, with one participant stating that '*a lot of what we do is host brown-bag lunches when findings come out, getting people to develop pithy presentations and get our RPMs engaged that way*' (ID03).

Participants also mentioned strategies related to facilitating linkage and partnerships to promote research uptake and integration. Here, specific activities were aimed at (i) brokering relationships with in-country partners, (ii) facilitating collaboration among researchers, and (iii) coordinating multilateral partnerships. Given ACIAR's position as a government agency engaged on a regional level in the Indo-Pacific, one participant on ACIAR's role in coordinating multilateral partnerships, '*Most of the knowledge brokering happens at that peer level with other funders and other organisations trying to make sure that we are governing these multilateral organisations to the best of our abilities. So hoping to get those organisations to achieve value for money and impact, and also working with others to look for synergies where we could co-invest, or we could collaborate, or whether we can build off each other's work that we do*' (ID08). ACIAR also facilitates collaboration among researchers to improve research outcomes in a project, with one participant stating that '*it's part of my job to say, 'I'd really like you guys to work together. Here's the design brief for the proposal I'd like to see you put together. But let me help form that bridge between you, let me help you understand why it is I value you and how I think you're part of a bigger system.'* '*So I do that brokering among the lead scientists that I want to put together to run a project'* (ID14).

Finally, participants identified knowledge brokering activities that ACIAR facilitates relating to capacity building. Specifically, two subthemes were identified here relating to ACIAR supporting (i) individual capacity building, and (ii) institutional capacity building. In reference individual capacity building, one participant stated that '*I think we do fund people to attend conferences, either as a presenter or as a presenter and the delegate, or just as a delegate. So there's opportunities for people to share their information and to be exposed to other people in their sector, and to make those connections and to do those sorts of things through various capacity building programs*' (ID06). Relatedly, participants also discussed opportunities for building capacity for research engagement with policy processes (i.e., institutional capacity building). For example, one participant noted a successful example whereby '*[ACIAR] pulled together community user group members and leaders with different levels of government, and actual policymakers, and put them together in a room and just created space for discussion and talking through the challenges, talking through these expectations*' (ID09).

Barriers to knowledge brokering

The second objective was to identify the barriers for undertaking knowledge brokering activities at ACIAR. Participants identified barriers that were organised into six themes relating to (i) organisational (i.e., relating to the institution responsible for funding and managing research), (ii) practical (i.e., associated with the processes or actions for knowledge brokerage, rather than the ideas and theories), (iii) political (i.e. associated with bureaucratic systems or policies), (iv) individual (i.e. at the personal level), (v) social (i.e. stemming from social interactions and networks) and (vi) financial (i.e. the availability or suitability of funding). These themes and associated subthemes are described in further detail below and in supplementary materials.

Of these, participants most frequently mentioned organisational barriers (Table 1). Organisational barriers included a lack of shared language and understanding; the modality of research projects; the opportunity costs of prioritising these activities; a lack of defined roles and responsibilities; high turnover of staff; insufficient support for capacity-building, and the relatively small size of the organisation (Table 3). For example, one participant referenced barriers to knowledge brokering resulting from the modality of the research projects in the organisation's structure, '*because of the heavy reliance on the project modality, it can be highly dependent on the individual project leader and their capacity to actually manage a team, build the right relationships*' (ID09). In this way, knowledge brokering activities are seen to occur ad-hoc and are dependent across research projects. Five participants referred to the opportunity costs within the organisation that are associated with undertaking knowledge brokerage. For example, one participant stated that '*we can't just keep promoting the research we've already done to maximise adoption or uptake or utilisation because the opportunity cost of that is the inability to fund more research*' (ID01).

Twelve out of 14 participants referred to practical barriers that impacted their ability to translate knowledge generated through their projects (Table 1). Of this, four sub themes were identified, including a lack of expertise, lack of

Table 2 Themes and subthemes derived from interviews with research participants to address Research Objective 1: Knowledge brokering strategies and activities ($N = 14$)

Theme	Subtheme	Frequency	Number of Sources
Research design and management	Co-design the research project with researchers, in-country partners, and users	9	8
	Integrate participatory design and management of evaluations	6	4
	Develop a theory of change for the research project	4	4
	Plan knowledge management structures	2	2
Communication and awareness	Create tailored communication products	7	4
	Share learnings with colleagues and researchers	4	3
	Facilitate opportunities for communication and discussion	3	2
Linkage and partnerships	Broker relationships with in-country networks	5	4
	Facilitate collaboration among researchers	4	3
	Coordinate multilateral partnerships	2	2
Capacity building	Support individual capacity building	4	3
	Support institutional capacity building	2	2

Table 3 Themes and subthemes derived from interviews with research participants to address Research Objective 2: Barriers to effective knowledge brokering ($N = 14$)

Theme	Subtheme	Frequency	Number of sources
Organisational	Lack of shared language and understanding of knowledge brokerage	15	10
	Research project modality	12	7
	Opportunity cost of undertaking knowledge brokering	8	5
	Lack of defined roles and responsibilities for knowledge translation	5	5
	High turnover of staff	4	4
	Insufficient support for capacity building	1	1
	Small size of organisation	1	1
Practical	Lack of expertise	14	9
	Lack of time	11	9
	Lack of contextual knowledge	4	4
	Insufficient monitoring, evaluation and learning processes	2	2
Political	Complexity of research system	7	5
	Bureaucratic processes	4	3
	Illegal activities	1	1
Individual	Negative attitudes towards knowledge brokering	6	4
	Negative attitudes towards training for knowledge brokering	2	2
Social	Unable to engage in-person due to COVID-19	8	7
Financial	Lack of funding	7	5

time, lack of context-specific understanding, and insufficient monitoring, evaluation and learning (MEL) processes (Table 3). For example, one participant mentioned a '*lack of social science, capability and ability*' in reference to the lack of social sciences expertise within the organisation to support knowledge brokerage and policy adoption (ID02); while another referred to the lack of knowledge brokering expertise in particular, *'I think it's a gap in the organisational structure—a team of people that focus on brokering'* (ID06). Another participant referred to time availability as a practical barrier to undertaking knowledge translation strategies, sharing their uncertainty in *'how much time people*

have to engage in processes that are a bit tangential to their day to day responsibilities, and also availability to participate post-project' (ID03).

Participants also mentioned several political barriers to undertaking knowledge translation in their work. Specifically, three sub themes were identified, including barriers stemming from the complex system of R4D, bureaucratic processes, and illegal activities occurring in-country which can make undertaking research more difficult (Table 3). For example, in reference to the complexity of the system that they work in as an inhibitor to planning knowledge brokering activities, one participant stated that *'of course, you don't know how it's going to be brokered, because you don't know what the results are going to be and research tech can take many years'* (ID06).

Barriers relating to individuals were identified by five participants (Table 1). Participants discussed that some people (e.g., colleagues) have negative attitudes towards knowledge brokerage, as well as negative attitudes towards training for knowledge brokerage (Table 3). For example, one participant mentioned that *'some of us are much more engaged than others…they're more really passionate about it, whereas others, they'll do it, but it's not – they don't see it as we do, as absolutely critical to achieving success'* (ID02).

One social barrier was identified by participants in their efforts to translate knowledge into action. Specifically, an inability to travel in-country (due to COVID-19 restrictions) was referred to by seven participants (Table 3). For example, one participant stated that *'I think the lack of travel has obviously been huge, so it's one thing to ask someone and talk with them online, but actually being face-to-face… and then I think beyond that, actually getting a sense of place and having those backroom conversations with people that you actually get a richer view of the context has also been absent as a result of that'* (ID09).

Finally, financial barriers to knowledge translation were mentioned by five participants (Table 1). Participants mentioned a specific lack of funding for knowledge brokering activities, and in particular the lack of funding support for knowledge brokering post-research. For example, in reference to the lack of knowledge brokering post-project, one participant stated that *'I think the nature of the way we fund stuff means that it generally does. People lose interest when there's no money involved, or they get funding for the next thing and move onto that and tend to leave stuff [knowledge management and translation] behind'* (ID13).

Enablers for knowledge brokering

In this section, we describe the opportunities that could enable ACIAR to overcome these challenges and to better support knowledge brokerage. These enablers describe things that ACIAR is currently trying to do, or should be doing, to overcome the challenges and barriers described in '*Barriers to knowledge brokering*'. Five overarching themes were identified through interviews with the participants, with enablers categorised into (i) practical, (ii) organisational, (iii) individual, (iv) financial, and (v) social. These themes and associated subthemes are described in further detail below and in supplementary materials.

Of these, practical enablers were identified by the greatest number of participants (Table 1). Five subthemes were identified here relating to practical enablers, including (i) in-house expertise, (ii) adequate training, (iii) formalised practice and process for knowledge brokerage, (iv) ongoing monitoring and evaluation, and (v) allocated staff resources (Table 4). For example, in reference to in-house expertise, one participant identified a need for a knowledge broker to be embedded within ACIAR, *'because just expecting that it'll be an add-on to someone else's role is probably not a very good way of looking at it' (ID12)*. This was supported by another participant, who stated that '*having some guidance upfront on how we should think about designing these things into projects would be really very useful*' (ID13).

Organisational enablers were also frequently identified by participants (Table 1). Five sub themes were identified within the organisational enablers, including (i) shared language and understanding of knowledge brokering (ii) cohesion of knowledge brokering activities, (ii) clear organisational direction and strategy, (iii) prioritise and support for capacity building, and (iv) integrated knowledge management system (Table 4). For example, in reference to the need for more shared language and understanding between the different organisational functions of ACIAR (e.g., capacity building, research management, outreach) one participant mentioned that *'having a common definition and understanding of what knowledge brokering actually is and how each of those functions connect with it and are building towards the same goal will be really important'* (ID03). Furthermore, four participants also mentioned the need for knowledge brokering to be managed and undertaken at the portfolio level to overcome challenges associated with project modality (i.e., better cross-organisational cohesion of knowledge brokering activities), *'we produce so much knowledge and do all of these projects, and it could be really good to gather it up and have ACIAR people, rather than just the project teams, be doing these knowledge brokering activities'* (ID12).

Two opportunities were identified under the theme of individual. These included the need for individuals to have (i) on-the-job experience, and (ii) positive attitudes towards knowledge translation (Table 4). For example, in reference to the need to improve attitudes of RPMs within the

organisation towards knowledge brokering, one participant suggested that *'if it* [knowledge brokerage] *is something that they* [the RPMs] *see as relevant to solving the problems that they're struggling with rather than being told how to do another part of their job or being told that they have to do a new thing'* (ID03).

Six out of 14 participants referenced opportunities to improve the translation of knowledge into action through financial enablers (Table 1). Two sub themes were identified by participants, relating to opportunities for (i) recognition of knowledge brokering activities in ACIAR, and (ii) recognition of knowledge brokering activities in ACIAR-funded project budgets (Table 4). For example, in reference to the need to recognise knowledge translation within the organisation's budgets, one participant commented on a need for the KB activities to be *'actually recognised and resourced, both within [project] teams and within the broader agency' (ID09).'*

Finally, several opportunities were categorised into the overarching theme of social enablers. Social enablers included (i) engaging with research partners and users, (ii) travel resuming (post COVID-19 pandemic), and (iii) cross-disciplinary collaboration (Table 4). For example, in reference to the need for meaningful engagement with research partners and users in order to effectively translate knowledge into action, one participant stated that there is a *'… higher order of brokering that needs to happen so that we're really understanding their goals and their priorities and their understanding of what we can do for them'* (ID14).

Skills and attributes of effective knowledge brokers

The fourth objective of this study was to identify the key skills and attributes that are required for RPMs to be successful knowledge brokers. Key skills and attributes were grouped into four overarching themes: (i) experiential knowledge, (ii) interpersonal skills, (iii) personal disposition and (iv) professional competence (retrofitted from framework outlined in Jessani et al. 2016). These themes and associated subthemes are described in further detail below and in supplementary materials (as summarised in Fig 1).

Of these four overarching themes, experiential knowledge was mentioned by the greatest number of participants and was seen to be an important attribute that helped RPMs to be successful knowledge brokers (Table 1). Two subthemes were identified by participants and related to RPMs having (i) contextual knowledge and an (ii) understanding of social systems (Table 5). For example, one participant noted that *'you need to understand the social systems for what it is that will lead to adoption by the end user*. (ID02). Interpersonal skills were also highlighted as important for being an effective knowledge translator (Table 1). Interpersonal skills included being an effective (i) networker, (ii) communicator, and (iii) listener (Table 5). For example, in reference to being a good networker (i.e., the ability to build

Table 4 Themes and subthemes derived from interviews with research participants to address Research Objective 3: Enablers for effective knowledge brokerage ($N = 14$)

Theme	Subtheme	Frequency	Number of sources
Practical	In-house expertise	6	5
	Adequate training	4	3
	Formalise practice and process for knowledge brokering	3	2
	Ongoing monitoring and evaluation	1	1
	Allocate staff resources	1	1
Organisational	Shared language and understanding of knowledge brokering	12	7
	Cohesion of knowledge brokering activities	6	4
	Clear strategic objectives and direction	5	4
	Prioritise and support capacity building	2	2
	Integrate knowledge management systems	1	1
Individual	On-the-job experience	6	6
	Positive attitudes towards knowledge brokerage	5	4
Financial	Recognition of knowledge brokering activities in ACIAR budgets	6	4
	Recognition of knowledge brokering activities in funded project budgets	4	3
Social	Engage with research partners and users	4	4
	Travel resuming (post COVID-19 pandemic)	3	3
	Cross-disciplinary collaboration	2	1

Table 5 Themes and subthemes derived from interviews with research participants to address Research Objective 4: Skills and attributes necessary to be an effective knowledge broker ($N = 14$)

Theme	Subtheme	Frequency	No. of sources
Experiential knowledge	Contextual knowledge	12	10
	Understanding of social systems	3	3
Interpersonal skills	Good networker	11	9
	Good communicator	9	6
	Good listener	3	3
Personal disposition	Big picture thinker	7	6
	Humble	3	3
	Open-minded	3	2
	Knowing your limitations	1	1
	Patient	1	1
Professional competence	Subject matter knowledge	6	6
	Understanding of policy	1	1
	Guided by theory	1	1
	Research management skills	1	1
	Ability to design effective theory of change	1	1

strong connections, relationships and networks), one participant remarked that *'a lot of their [RPMs] capacity to broker anything is really about the extent to which they have networks of people in particular places'* (ID13).

Nine out of 14 participants stated that an RPM's personal disposition was also pivotal for effective knowledge translation rather than having a particular skillset or knowledge base (Table 1). These personal attributes included being (i) a big picture thinker, (ii) humble, (iii) open-minded, (iv) knowing their limitations, and (v) being patient (Table 5). For example, in reference to the need for RPMs to be open-minded, one participant noted that RPMs need to support *'…open, adaptive management, be open to change that comes out of areas that might be non-scientific, but it might better cater to the needs of the end user. It's more of an attitude towards knowledge brokering rather than specific tricks of the trade or something like that'* (ID04).

Finally, 8 out of 14 participants referred to having professional competence in order to be effective knowledge translators. Several skills and attributes were identified here, including (i) subject matter knowledge, (ii) an understanding of policy, (iii) being guided by theory, (iv) research management skills, and (v) an ability to design an effective theory of change. Of these skills and attributes, having subject matter knowledge was referred to most frequently by participants (i.e., discipline specific knowledge) (Table 5). Participants also referred to the ability to be guided by theory as critical for RPMs, *'I would say being guided in your work by theory is actually an important skill [and] it's an important approach to being a successful program manager. Even if that theory is not necessarily enacted in each and every project but in general to know what the general direction is'* (ID04). Furthermore, participants saw research management skills and experience to be important for RPMs, *'increasingly more of us have actually been in a research management role before coming to ACIAR and maybe particularly domestically, but it's honed that skill of being in that intermediate space'* (ID14). That is, participants referred to the importance of not only having previous experience and skills undertaking and facilitating research projects (i.e. as a scientist), but also competency in managing research projects (Fig. 1).

Discussion

Research funders can play a key role in promoting evidence-informed decision-making and improving the impact of research (Arnott et al. 2020). Knowledge brokering is one mechanism that can be used to create more relevant, timely, and impactful research by facilitating the transfer and translation of knowledge between researchers, practitioners, and users. While much of the focus is on how policy and academic institutions can build capacity for knowledge brokerage, few studies have explored how research funders themselves can facilitate and engage in knowledge brokering (Cummings et al. 2019; Klerkx et al. 2012). By eliciting the perceptions of individuals working within a research funding and managing agency (ACIAR), we can expand our understanding of how research funders can support this agenda. We use ACIAR as a case study given its unique position as a research funder engaged in R4D, and with an existing mandate for brokering relationships and knowledge. Here, we: (i) discuss our results within the context of the broader literature and (ii) conclude with a synthesis on considerations for research funders elsewhere seeking to build capacity for knowledge brokerage.

Much of the existing literature focuses on the need for research funders to recognise the value of co-created, transdisciplinary approaches through funding criterion and contractual obligations for researchers, however few studies evaluate how a research funding agency themselves can facilitate knowledge brokering activities (McGonigle et al. 2020; Klerkx et al. 2012). In this study, we identified several knowledge-brokering strategies and activities that ACIAR currently use to translate knowledge into action. Example activities related to communication and awareness (e.g., traditional communication products such as social

Fig. 1 Skills and attributes necessary for research programme managers to be effective knowledge brokers

media posts and policy briefs, as well as more novel approaches such as developing plays to communicate the research with local communities), linkage and partnerships (e.g., coordinating the donors and development banks that operate in the region, as well as fostering collaboration between researchers), capacity building (e.g., funding individuals in country to attend conferences), and research design and management (e.g., co-design the project, develop theories of change and impact pathways).

While knowledge brokering is typically seen to occur through post-research synthesis, dissemination, exchange, and application (e.g., Cvitanovic et al. 2016), here the largest number of participants identified activities and strategies that are facilitated through research design and management. For example, participants identified activities such as co-designing the research project alongside researchers, country partners and users, and developing an effective theory of change, both of which have been proven to support the translation of knowledge into action (e.g., Lindahl Rajala et al. 2020). As part of this co-design process, it was identified as important to plan for, and integrate monitoring and evaluation as key components of knowledge brokering from the very start (as identified elsewhere, e.g., El-Jardali and Fadlallah, 2015). Such mechanisms are key to effective engagement and collaboration between research producers and users and has been reflected in previous studies (Huzair et al. 2013; Karcher et al. 2022).

While participants described a range of knowledge brokerage strategies and activities that are also documented in the literature, we note that a quick glance of ACIAR's reports identifies broader activities or strategies used by ACIAR that were not mentioned in these interviews (e.g., providing opportunities for individuals in partner countries to undertake PhD and master's degrees to boost technical, policy and management skills). One potential reason for this gap may be the lack of shared language and understanding of knowledge brokering (as identified by participants in this study), and as such difficulty identifying which activities are considered 'knowledge brokering'. Furthermore, participants indicated that there is a lack of defined roles and responsibilities for knowledge brokering, which may have resulted in participants having difficulty defining or recalling activities that they have undertaken. This is supported elsewhere in the literature, whereby brokering activities are often difficult to standardise or define because of the flexibility of the role, the fact they often happen in the background of an individual's roles and responsibilities (Moss 2013; Meyer 2010), and as a result many knowledge practitioners often do not claim responsibility for their achievements (Bornbaum et al. 2015). As such, the findings presented here may be an underestimation of the diversity and quantity of activities undertaken by the research funding agency to actively broker research and partnerships.

While the need to ensure the uptake and integration of research is recognised within ACIAR's internal strategies (e.g., ACIAR Ten Year Strategy, 2018), participants reported resource constraints which have created obstacles in undertaking these knowledge brokering activities. Here, resources include allocated time, staffing and funding for knowledge brokering activities. A lack of resources allocated for ACIAR staff to facilitate and support knowledge brokering could mean, for example, the end of a project funding cycle is misaligned with the maintenance of post-project knowledge management and brokering. To overcome this, participants identified a need to formalise knowledge brokering during research design by planning, and budgeting for, knowledge brokering activities. In doing so, ACIAR can invest pre-project effort to support knowledge brokering (e.g., building relationships, stakeholder mapping to avoid exclusion of key partners, including stakeholders with relevant expertise). Furthermore, ACIAR could ensure that they acknowledge the resources required for research program managers, commissioned organisations and implementing partners to effectively facilitate knowledge-brokering activities.

Given the mandate for RPMs in ACIAR to engage with knowledge brokering activities, in this study we aimed to explore what skills and attributes are necessary for individual RPMs to effectively facilitate knowledge brokering

activities. Participants emphasise that there are four main skills and personal attributes that are required by individual research funders and managers to be an effective knowledge broker, with experiential knowledge the most frequently mentioned. While this appears in the literature elsewhere on skills and attributes of knowledge brokers (e.g., Shaxson et al. 2012; Hering, 2016; Cvitanovic et al. 2021b), we stipulate that there may be a stronger need for experiential knowledge when brokering knowledge and partnerships in research for development. This is because engaging with dynamic and culturally diverse communities, as is prominent in R4D, requires an experiential understanding of the social systems, context, and cultures of the operating environment (e.g., Cummings et al. 2019). As supported by research elsewhere (Evans and Cvitanovic 2018), interpersonal skills were also frequently mentioned by participants as essential for being an effective knowledge broker (e.g., being a good networker, communicator, and listener).

While our results highlight a broad range of skills and dispositions needed, we acknowledge that it is unlikely that an individual RPM possesses all these skills (i.e., a technical research expert as well as an effective knowledge broker). Furthermore, participants in this study identified challenges associated with the opportunity cost of RPMs engaging in knowledge brokering activities, whereby the more time RPMs attribute to knowledge brokering activities, the less that can be allocated to managing and facilitating the technical aspect of the research itself. Previous studies have reiterated this, with conflicting demands on time and/or clashes with other organisational goals being a constraint for individuals taking on knowledge-brokering responsibilities (Schailee et al. 2019; Holmes et al. 2012). For these reasons, further consideration must be given to how to support knowledge brokering across the organisation, including how to nurture and connect individuals engaging in these activities. A recurrent theme throughout the literature emphasises the importance of conceptualising knowledge brokerage as a distinct role. While knowledge brokerage is often confused with complementary roles such as communications officers, there are unique features which in turn require a unique skill set (Hering 2016). Enablers mentioned by participants here included opportunities for hiring credible in-house expertise. In doing so, it could ensure there is accountability and responsibility within the organisation for leading knowledge brokering activities, as well as ensuring that individual RPMs themselves are not relied upon to undertake these activities alone.

Considerations for funders seeking to build capacity for knowledge brokering

Much has been written about the potential for science to contribute to development. With this comes the need to identify how to support the translation of research into action, what is needed to navigate the challenges and barriers in doing so, and what capacities and capabilities are necessary for facilitating this. While the results of this study are localised and context-specific, we see purpose in synthesising the key learnings on the role of research funders in supporting this agenda. In this section, we summarise three broad considerations for research for development funders seeking to build capacity for knowledge brokering based on the findings of this study and the broader literature.

Formalise the process and practice of knowledge brokering

The ways that knowledge brokering is structurally positioned and supported within a funding agency can impact the rate and scale at which knowledge brokering can occur. If research funders are seeking to build internal capacity for knowledge brokering (i.e., as is the case with ACIAR), there is an explicit need to formalise the process and practise of knowledge brokering. Knowledge brokering efforts should be developed and implemented with a clear and tangible long-term organisational strategy that is underpinned by goals that are representative of, and shared by, all team members. This includes identifying, recognising, and supporting the practice of knowledge brokerage at an organisational level, and formalising a process for facilitating knowledge brokering across all stages of research (i.e., pre-research as well as post-research). These efforts should also be accompanied by specific mechanisms for linking knowledge to action, for example, through the employment of a dedicated knowledge broker (Cvitanovic et al. 2017) or a similar boundary-spanning initiative (Bednarek et al. 2015, 2018), or through a coordinated and supported assignment of responsibilities to RPMs.

Develop shared language and understanding of knowledge brokering

It is well established that promoting a culture of shared values fostering the exchange of ideas and learnings is instrumental in supporting knowledge brokerage (Provvidenza et al. 2020; Kislov et al. 2014; Cherney and Head 2011). However, it remains that while many agencies have committed to knowledge brokering activities (albeit in varying degrees), there are differences in the definition and understanding of knowledge brokering both within and between agencies (as evidenced by this study, and the broader literature e.g., Cordero et al. 2008). Agencies seeking to resource, support and build capacity for knowledge brokering may benefit from an organisational evaluation of agendas, norms, and values associated with knowledge brokering (Pearman and Cravens 2022; Karcher et al. 2022b; Lacey et al. 2015). By developing this shared understanding across the research funding agency (e.g., through a participatory approach), it could help to improve

attitudes towards knowledge brokering as well as foster social learning (i.e., peer-to-peer learning).

Build individual competency and capability

Building individual capacity (e.g., skills and capabilities) is also key to facilitating knowledge brokering (as described elsewhere e.g., Provvidenza et al. 2020). Many of the skills and attributes indicated in this study and the broader literature link to the need for research program managers to have experiential knowledge, be interdisciplinary, and well-equipped with 'soft skills' (i.e., being a good communicator) in order to be effective knowledge brokers. Although many of these attributes cannot be 'taught' or 'trained' (e.g., personal disposition and attributes, or skills gained from on-the-job experience), there are some opportunities for training and guidance in knowledge brokering and effective communication which should be supported by research funding agencies (e.g., through professional development courses or internal training) (e.g., Provvidenza et al. 2020). However, given the challenge in finding a 'jack of all trades' (i.e., technical experts with strong knowledge brokering skills), it is recommended that agencies reflect on the broader needs of the organisation and consider recruiting for specialised knowledge brokers to support research programme staff. In doing so, this mechanism could be a source of expertise and guidance for staff, while also supporting individual competency and capability building (e.g., through training for RPMs).

Conclusion

Solving the complex socio-environmental challenges faced by developing countries, in particular, requires the translation of research into practice. In this paper, we explored how knowledge brokering activities are facilitated by an Australian research for development funding agency (i.e., ACIAR). ACIAR takes an active role in the translation of the research it funds through supporting research design and management, communication and awareness, linkage and partnerships, and capacity building. While participants identified several challenges to facilitating these activities (e.g., organisational and practical barriers), they also identified corresponding enablers for overcoming them. Based on these findings, we have generated three considerations for funders elsewhere seeking to build capacity for knowledge brokering, including: (i) formalise the process and practice of knowledge brokering, (ii) develop a shared language and understanding of knowledge brokering, and (iii) build individual competencies and capabilities. These lessons can be transferable to other contexts whereby research programme managers and funders are seeking to support the uptake and integration of research it funds.

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Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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