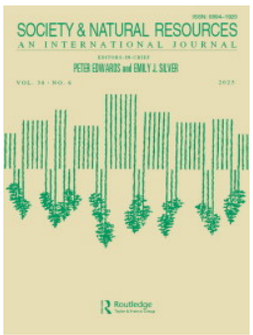

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REPORT

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Community Engagement for Novel Ecosystem Restoration and Assisted Adaptation Interventions: Observations and Lessons from the Australian Reef Restoration and Adaptation Program

Umberto Baresi[a], Rachel Eberhard[b], Karen Vella[a], Margaret Gooch[a], Annah Piggott-McKellar[a], Diletta Luna Calibeo[a], Stewart Lockie[c], Bruce Taylor[d], Erin Bohensky[d], Lokes Brooksbank[e], Matthew Curnock[d], Victoria Graham[f], Taryn Kong[d], Ilisapeci Lyons[d], Kirsten Maclean[d], Gillian Paxton[c], Kelli Schmitt[d], Lintje Siehoyono Sie[g], and Samantha Stone-Jovicich[d]

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ABSTRACT

This paper presents learnings from community engagement and deliberation applied to ecosystem restoration and assisted adaptation in the Reef Restoration and Adaptation Program, a major research and development program identifying and testing novel management interventions for Australia's Great Barrier Reef. Technical, social, and ecological complexities and uncertainties associated with the Program have a major bearing on both the need and character of community engagement and deliberation. Our research used qualitative analysis of documents, interviews, and group discussions to elicit transferable insights from a social research team embedded within the Program. Our findings demonstrate that adaptive and deliberative approaches anticipate and respond to complex and changing contexts by fostering open dialogue, building mutual trust, and integrating community feedback into decision-making. This practice actively recognizes the rights and interests of stakeholders and First Nation peoples, shaping stronger partnerships, supporting inclusive collaboration, and enabling flexible adjustments throughout research and development programs.

3–5 MANAGEMENT IMPLICATIONS OF THE RESEARCH

1. Flexibility and adaptability are essential for addressing dynamic environmental conditions and unforeseen challenges in ecosystem restoration projects.
2. Responding to climate impacts, developing and risk assessing novel management interventions, and facilitating deliberative dialogue about those interventions require different, and at times conflicting, timelines.

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3. Deliberative reflexive practice can facilitate learning and adaptation, enhancing engagement with stakeholders and First Nation peoples.
4. Effective engagement practice can recognize and support the rights and interests of First Nation peoples and stakeholders in the research and deployment of novel technologies that anticipate and respond to complex and changing implementation contexts.

Introduction

Community involvement is widely recognized as critical to the success of ecosystem restoration projects. Meaningful dialogue and opportunities for community members to influence both project processes and outcomes can build public trust and enhance social acceptance, while mitigating resistance, conflict, delays, and potential project failure (McAfee et al. 2022; Provasnek, Sentic, and Schmid 2017). Beyond fostering public trust, incorporating local knowledge and community input helps to ensure restoration and adaptation projects are not only effective but also sustainable (Reed et al. 2009).

Efforts to dramatically upscale restoration and to introduce novel assisted ecosystem adaptation interventions challenge conventional conservation approaches and increase the potential for conflict, making effective community engagement indispensable (Perring, Erickson, and Brancalion 2018). Building on the foundational importance of stakeholder participation in decision-making (Gann et al. 2019), and questioning conventional "good practice" engagement approaches and how they can be tested in a rapidly changing world, this paper addresses the complexities of engaging in difficult conversations about future environmental states. It is the importance of tailoring approaches to social and ecological contexts (Suding et al. 2015), and the need to rethink paradigms such as "stakeholder" engagement, which can oversimplify or overlook the unique perspectives of Indigenous communities, that this paper recognizes and investigates (Reed et al. 2024).

Building on the extensive literature on community engagement (e.g. Reed et al. 2009, Hagendijk and Irwin 2006; Huber, Newig, and Loos 2023), this research is guided by awareness that the two-way communication and relationship-building that is "engagement" can, in practice, be deployed as easily in service of expectation management and liability minimization as it can in service of transparency, social learning, and shared decision-making (Lockie et al. 2008). Deliberation and reflexive practice are thus considered fundamental to achieving community engagement and decision-making that are adaptive and responsive to community inputs. While we acknowledge that power dynamics can be critical to understanding community engagement, this paper focuses on research and development processes and prioritizes practical engagement strategies rather than an in-depth exploration of power relations. For the purposes of this paper:

> Deliberation is here considered as relying on the idea that the legitimacy of any collective decision rests on the right, capacity, and opportunity of those subject to or affected by that decision (or their representatives) to participate in deliberation that is consequential for the content of the decision (Dryzek et al. 2019, 1).

Reflexive practice is considered as a structured approach that combines critical self-examination with open, inclusive dialogue. It requires researchers continuously reflect on their actions, assumptions, and interactions while engaging with stakeholders in a participatory process (Cunliffe 2009).

This paper examines the Reef Restoration and Adaptation Program (RRAP) as the world's largest (in scale and resourcing) active case study of assisted ecosystem adaptation, involving multidisciplinary research and development to develop restoration technologies for the Great Barrier Reef while integrating extensive stakeholder and First Nations engagement. We use the Newig et al. (2019) framework on learning types to analyze RRAP engagement research reports and the perspectives of RRAP researchers and decision-makers through interviews and discussions, as a way to acquire original insights that are relevant to shape guidance for restoration and adaptation research and deployment program managers. This allows us to achieve: flexibility in the deliberative processes within the research team and with externally engaged communities; adaptation in the partnerships with interested community groups; and acceptance of changes in decision-making as emerging from community inputs. We build on this framework due to its emphasis on community engagement strategies supporting bi-directional learning, including deliberation, knowledge exchange, and capacity building, aimed at informing decision-making.

Our aim in this paper is three-fold. First, as authors of this manuscript, who are also the researchers delivering the applied engagement research activities of RRAP (such as community panels, collaborative monitoring and co-design of a biocultural framework, further detailed in the Supplementary material Table 1), we seek to reflect in a structured way on our own participatory research practice and the critical insights and observations that have arisen from that practice. Second, we aim to improve our understanding of both: how the practice itself, of working with stakeholders and First Nations peoples, has influenced the emerging shape and direction of the broader research and development program; and the way communities engage with that program. Third, we consider what the broader insights and lessons from these two points might be for advancing practical guidance to achieve more flexible and adaptive approaches in other initiatives of this kind.

Our findings highlight: the development of adaptive engagement strategies that prioritize iterative learning and responsiveness, enabling more effective handling of uncertainties in complex social and ecological systems; innovative methods for establishing enduring community partnerships, built on reciprocal dialogue and shared objectives rather than transactional interactions; and the use of inclusive decision-making frameworks that dynamically incorporate diverse perspectives, allowing for real-time adjustments in the timing, location, and design of interventions.

Literature Review and Conceptual Framework

The accelerating pace of climate change and uncertainty inherent in large-scale ecosystem restoration and assisted adaptation projects can be productive both of heightening public skepticism toward new technologies (Sovacool, Baum, and Low 2023; Mohr and Metcalf 2018) and support for their development in response to unavoidable environmental change (Bartelet et al. 2025; Lockie et al. 2024; Paxton, Lockie, and

Backhaus 2024). This range of possibilities intensifies challenges associated with community engagement (Vella et al. 2021). While embedding adaptive approaches within institutional frameworks and governance systems enables practitioners to incorporate innovative practices, maintaining the relevance and effectiveness of restoration programs (Higgs et al. 2018), traditional approaches based on the assumption past conditions will be repeated are increasingly unfeasible (Lynch et al. 2022). Yet, guidance on developing flexible, inclusive restoration methods remains limited (Gann et al. 2019).

Because providing information to communities is, alone, insufficient to secure public trust, deeper collaboration is needed to build mutual trust and frame scientific and social responsibilities with impacted communities (Hagendijk and Irwin 2006; Owen, Macnaghten, and Stilgoe 2012; Durrant et al. 2023). Adaptive forms of engagement can facilitate deeper collaboration; however, they require considering context-appropriate communication intensity, and consideration of power delegation, and stakeholder representativeness (Newig et al., 2023). In order to maximize knowledge building together with the engaged communities, successful deliberative processes require reflexive thinking and openness from organizations to adapt key decisions based on community input (Baybay and Hindmarsh 2019; Verkuyten, Adelman, and Yogeeswaran 2022).

In shaping flexible approaches to community engagement in ecosystem restoration and assisted adaptation, it is critical to acknowledge that the integration of First Nations' rights and practices remains limited due to systemic barriers including the dominance of Western scientific paradigms and insufficient recognition of traditional ecological knowledge. Iterative communication and sustained dialogue (see, e.g. Druschke and Hychka 2015; Wehi and Lord 2017) are important elements of equitable and effective restoration efforts that integrate both Western and Indigenous knowledge (Maclean and Lyons 2021). However, barriers persist, including limited capacity for resource mobilization among First Nation leaders, over-engagement of key figures, and power imbalances that constrain influence (Lyons et al. 2019; Day et al. 2020; Dawson et al. 2020).

Research on community-based participatory methods highlights additional preconditions for successful engagement: the necessity of building long-term trust, respecting local governance structures, and acknowledging the sovereignty of First Nation communities (Reo et al. 2017; David-Chavez and Gavin 2018). These principles are echoed in Australian contexts, where First Nations-led approaches emphasize the importance of iterative dialogue, recognition of cultural values, and co-designed decision-making frameworks (Woodward et al., 2020). Together, these findings point to the need for genuine power-sharing, legally recognized rights, and sustained support, moving beyond consultation toward deeper, collaborative partnerships (Huber, Newig, and Loos 2023).

This study adopts Newig et al. (2019) framework to explore engagement strategies, emphasizing the importance of collaborative processes that integrate engagement modes into shared learning and deliberation, facilitating the translation of joint efforts into tangible outcomes. This framework, which identifies three modes of learning (deliberation, knowledge exchange, and capacity building), is well-suited for adaptive management, supporting iterative, bi-directional learning processes that address complex engagement challenges. Deliberation involves inclusive dialogue that incorporates diverse perspectives, aiming for mutual understanding and shared decision-making (Dryzek et al. 2019). This is critical in balancing conflicting interests and integrating stakeholder

input into project decisions. Knowledge exchange between scientific experts and local communities can broaden the knowledge base by including traditional ecological insights. Capacity building strengthens the skills of all participants, ensuring inclusive and effective engagement.

In contrast with standardized participatory models (e.g. those described by Reo et al. 2017; David-Chavez and Gavin 2018), our approach embeds iterative, reflexive processes that respond in real time to the complexities of integrating rapid research and development with deep community involvement. The case study highlights the unique challenges of reconciling Western scientific frameworks with the cultural practices of First Nation communities, addressing barriers through sustained dialogue and power-sharing mechanisms often underutilized in conventional projects (Maclean and Lyons 2021; Woodward et al. 2020).

Methods

Case Context: The Reef Restoration and Adaptation Program

The Reef Restoration and Adaptation Program (RRAP) is ostensibly the largest active program (for geographic scope and public investment) examining the efficacy, feasibility and acceptability of novel interventions for coral reef restoration and assisted adaptation (Sovacool, Baum, and Low 2023). This program, focused on supporting Australia's Great Barrier Reef (GBR), features: (1) multi-disciplinary research and development focused on coral reef ecosystems, (2) interventions to enhance coral performance under climate change, and (3) research into socio-cultural perspectives (McLeod et al. 2022). In this paper, we focus on this third feature of RRAP as an exploratory case study (Yin 2018) to highlight learnings about community engagement with respect to novel interventions for reef restoration and adaptation. RRAP interventions include: sea fogging and cloud brightening to limit solar impact in warming marine waters; research to increase coral recruitment; deployment of corals raised in aquaculture or nursery facilities; and enhancement of heat resilience traits through selective breeding of heat-tolerant corals (RRAP, n.d.). Following 18 months of assessing the feasibility of research interventions to be included in the program, the first stage of RRAP began in the second half of 2020. These interventions are researched and developed through 11 subprograms including the Stakeholder and Traditional Owner[1] Engagement Subprogram (hereon referred to as the engagement research team). This paper focuses on key learnings emerging from the activities of engagement researchers within this subprogram (RRAP, n.d.).

The engagement research aimed to understand public perceptions of prospective restoration and adaptation interventions, assess the distribution of associated risks and benefits, develop practices to involve Reef Traditional Owners, stakeholders and communities in intervention research and deployment, and foster learning within the engagement research team. These activities operated across multiple engagement and learning pathways: between GBR communities and the engagement research team; within the team itself; and between the team and other RRAP components, including managers and decision-makers.

Engagement researchers workshopped, through in-person and online meetings (March-May 2022), to refine and clarify a program logic initially developed by Engagement Subprogram leaders that expressed engagement objectives, and intermediate and long-term desired outcomes. Several criteria from the published literature (see Newig et al. 2019) related to monitoring, evaluating, and learning about community engagement were adapted and used to evaluate engagement in RRAP, including how it empowers stakeholders and First Nation peoples and informs RRAP decision-making.

Given the research and development focus of RRAP, this research prioritized facilitating mutual learning with engagement researchers rather than conducting a summative performance assessment of engagement activities. Engagement research activities sought to foster deliberation (encouraging dialogue between researchers and the community), build capacity (enhancing skills and knowledge within community groups), and inform decision outputs (integrating community feedback into the program's decisions). These three modes supported a reciprocal learning process, benefitting both the researchers and the communities engaged (see Newig et al. 2019). Data and information were then sourced via interviews and individual and group discussions that provided collective insights from research activities, as well as document analysis of research reports and individual interviews and group discussions with activity leaders and managers (details in Table 2 of the Supplementary Material).

Methodology for Data Analysis

The three modes of learning by Newig et al. (2019) were considered to acquire insights on three aspects of community engagement: first, insights from RRAP engagement researchers on the results of community engagement; second, insights from RRAP engagement researchers on their own activities; third, insights from RRAP decision-makers on how they responded to engagement research.

Data collection

First, we synthesized key information on engagement from research reports, as they were produced by the engagement researchers, which involved checking the accuracy of data interpretation. Preliminary findings were discussed with engagement researchers who were responsible for primary data collection and reporting. Next, conversations with all engagement researchers revealed information about how their activities contributed to the program logic. These conversations focused on: checking the accuracy of the synthetic messages extrapolated from the reports developed by each researcher; hearing from each researcher what additional lessons they learned throughout the research process; and acquiring insights on how the engagement research could enhance its effectiveness and impact on RRAP. Combining document analysis and researchers' inputs, this first activity generated a baseline for further investigation.

The team held structured group discussions with engagement researchers to conduct a collaborative review of the data, reflecting on emerging themes, collective insights, and challenges encountered across various engagement activities. Using a deliberative reflexive approach, the team systematically analyzed the data sources, interrogated discrepancies and synthesized shared learnings. The outputs were documented and

shared with RRAP decision-makers to inform adjustments in program strategy and decision-making. Third, a round of interviews with RRAP decision-makers provided insights on how the engagement research activities were perceived by the rest of RRAP, and their influence on RRAP decision-making. Managers, mathematical modelers, engineers, marine biologists and Traditional Owners were asked to share their experience working with engagement researchers, in terms of communication, collaboration, and knowledge exchange to shape RRAP interventions that were more accommodating of stakeholders' and Traditional Owners' needs, exposure, benefits, and perceptions.

Data sources for this study (see Table 2, Supplementary material) were: documents developed by the engagement researchers; eight individual conversations and four group discussions arranged with engagement researchers; and interviews with 15 RRAP managers and scientists (see the Supplementary material for details). Transcripts from interviews and reports from engagement research were coded and analyzed by 2-4 researchers within the research team. These activities took place between February and June 2023, and were covered by ethics approval provided by Queensland University of Technology (n.3871, 18 January 2021).

Coding structure

Documents and interviews were initially coded to identify information relevant to the program logic (see Supplementary material, Figure 1) and provide feedback to engagement researchers and to other RRAP staff (e.g. managers, modelers). Our process follows established methodologies outlined by Saldaña (2013), incorporating Descriptive, Structural, and Simultaneous Coding techniques. This approach allowed us to systematically capture complex themes, iteratively refine our analysis, and address multi-layered aspects of engagement in the RRAP. The coding structure (detailed in Table 3 of the Supplementary Material) was shaped by combining elements from the program logic and the types of learning advanced by Newig et al. (2019), associated with: deliberation and knowledge exchange, building knowledge and capacity, and knowledge uptake to inform decision outputs.

The documents produced by the engagement subprogram researchers, and the interviews and group discussions were the main data sources relevant to the coding associated to knowledge exchange and capacity building. The interviews with RRAP managers and scientists outside the engagement subprogram were the main data sources relevant to the coding associated to knowledge uptake.

Study Limitations

A key limitation of our study is linked to the positionality of the research team, as we served both as primary data collectors and analysts, which may introduce potential biases. The dual role of conducting engagement activities and analyzing the collected data presented a unique opportunity for comprehensive insights but also carried risks of bias, particularly as participants might have been reluctant to share critical feedback directly with engagement researchers. To address this, we employed several strategies to mitigate potential biases, including reflective practices, triangulation of data sources, and regular team discussions to critically evaluate our interpretations.

The qualitative nature of the study provided valuable depth and understanding; however, we are aware that some findings may not be easily generalizable due to the unique context of RRAP. Additionally, the initial stage of this ecosystem restoration program means that outcomes are still emerging across different levels, such as individual, community, or intervention impacts. Most engagement research activities involved small participant numbers within small-scale pilot studies, limiting the scope of broader conclusions.

We also recognize the importance of a positionality statement to provide transparency regarding our relationship with the research context. As members of the engagement team embedded within RRAP, our perspectives and interpretations were shaped by our direct involvement in the program's activities. This proximity influenced our goals of fostering trust and inclusivity, while also necessitating a reflective approach to acknowledge potential biases in our analysis. Despite these limitations, our early reflexivity about research objectives and engagement strategies helped ensure alignment with community members' stated needs, providing a useful basis for future comparisons and for understanding the broader applicability of the findings.

Results: Learnings to Improve the Engagement Activities and Deliberation

Learnings from community engagement are presented using the Newig et al. (2019) framework, which includes three types of learning in participatory environmental governance: deliberation (dialogue and discussion), knowledge and capacity-building, and informed decision outputs. Our key themes (illustrated below and in Table 4 of the Supplementary Material) aligned well with these types, as they consistently reflected the processes of dialogue, skill enhancement, and the integration of community input into decision-making, reinforcing the applicability of Newig et al.'s framework to our case study. Our analysis differentiates between the implications of deliberation between researchers and community groups (focusing on challenges posed by accelerated timeframes, competing interests and uncertainties), and deliberation that happens within the research team (focusing on reflexive practice to facilitate learning and adaptation). Therefore, our assessment reports results related to (i) deliberation between researchers and the community; (ii) internal deliberative reflexive practice; (iii) knowledge and capacity-building; and (iv) structuring and strategising community engagement to influence decision-making.

Deliberative Process Between Researchers and Community: Challenges of Accelerated Timeframes and Uncertainty

The emergence of novel restoration and adaptation interventions offers hope for environments at risk, but also poses a tension between the urgency for action, timelines for the maturation of technical and ecological research, time required to meaningfully engage with communities, and uncertainty about outcomes.

Our analysis highlights the importance of adaptability and flexibility in delivering effective engagement within RRAP. A key realization was that technically, environmentally, socially, and culturally complex programs like RRAP cannot rely on a linear temporal dynamic. As engagement researchers noted (Group discussion n.3):

> We're dealing with very prospective science… There's a change in understanding of the temporal dynamic here, so it's no longer a technology, followed by management decisions, followed by other things. Everything is sort of happening at once and there's pressure to bring things forward. So, the temporal process is more convoluted, but it's accelerated. Everything's accelerated.

This disruption in the time frames for delivering different project outputs directly influenced how community engagement could be done, in a way that remained meaningful to all engaged and engaging parties (i.e. the community and RRAP). In this sense, sequencing engagement activities to allow meaningful consideration of messages coming from community engagement into RRAP decision-making (and shaping interventions) was challenging. This recognition required a shift from traditional linear project management to a more integrated approach, accommodating overlapping tasks and dynamic timelines. The disruption in standard timeframes for delivering project outputs directly influenced how engagement activities were planned and executed, allowing for more responsive consideration of community feedback in RRAP decision-making. Beyond actively engaging stakeholders and Reef Traditional Owners to shape restoration interventions, ecological researchers did seek social acceptance and regulatory approvals to conduct field trials. For example, Free Prior and Informed Consent (FPIC) protocols (as per the UN Convention on the Rights of Indigenous Peoples – OHCHR 2007) provided a right for Traditional Owners to veto field trials in their area (Interview 6). FPIC activities were undertaken by the Australian Institute of Marine Science (AIMS) Indigenous Partnerships Team, who also collaborated with some of the engagement research That involved Traditional Owners.

Uncertainty about future reef restoration and adaptation activities (including technical research, field trials, regulatory, management, and engagement activities) also impacted interactions with stakeholders and Traditional Owners. As an example, reconciling the gap between current conversations and future potential restoration initiatives was a significant challenge, due to uncertainty about:

> What does engagement and acceptance mean now and what it actually might mean and look like in the future? So, you (are) constantly holding those two time frames in your hands (Group discussion n.3).

This uncertainty prompted engagement researchers to carefully manage expectations, both theirs and that of stakeholders and Traditional Owners, as noted by an engagement researcher:

> trying to promote enthusiasm through making sure we don't overcommit [and therefore risk creating false expectations] about what can be achieved. It's tricky, especially when things can be a bit out of control for us. So, we need to make sure it doesn't become [our] downfall (Individual conversation 5).

Internal Deliberative Reflexive Practice to Facilitate Learning and Adaptation

Another theme emerging from our analysis was the adoption of a deliberative reflexive practice by engagement researchers to address challenges posed by accelerated timeframes and uncertainty. This approach included developing a collective program logic,

fostering internal reflection and learning, acknowledg stakeholder agency, adapting research and engagement strategies, and building pathways to influence broader program management and policy decisions.

As most research and development programs operating in complex social and ecological ecosystems, RRAP faced significant uncertainty about achieving efficacy and feasibility, which only became clearer over years of research and community engagement. While uncertainty did not stem primarily from the research program itself—as the objectives, activities, and resources were clearly defined—it centered on whether the program's outcomes would effectively support large-scale reef interventions, and to what extent. Additional socio-political uncertainty arose from whether these interventions would gain support from managers and other decision-makers and how they might be implemented at scale in a rapidly changing ecosystem.

Engagement researchers, aware of these uncertainties, adopted deliberative processes to facilitate mutual learning between researchers and the community. This opened the possibility to acknowledging and supporting the agency of the stakeholders and Traditional Owners, while accounting for technical constraints posed by scientific evidence and action ability. As one engagement researcher highlighted, there was openness in discussing how interventions could be modified to incorporate the community's inputs (Individual conversation 7).

Another researcher also stressed the nature of the mutual learning:

> This activity gives them [stakeholders and First Nation peoples] direct exposure to RRAP subprograms… so they're learning about these devices, what they do, their purpose… and by contributing to their monitoring … they're learning the same thing as RRAP is, about those devices (Individual conversation 5).

Notably, mutual learning and engagement happened not only between researchers and community members, but also amongst community members involved in activities with the engagement research team. As an engaged community, members had "to work with each other and negotiate and deliberate, contributing to a broader level stakeholders and First Nation peoples' understanding" (Group discussion 2). This enriched the capacity of local networks across different fields by bringing closer profiles such as tourism operators, Traditional Owners, public administrators and environmental activists. An example of this was the Advisory Group activity, which saw participants appreciate "the networking that's happening within the group" (Individual conversation 4). This networking evolved to a point that the group "developed its own community and that's just been strengthened the more it goes along" (Individual conversation 4).

Engagement researchers were adaptive and flexible in adjusting their schedules and project objectives to better meet the needs of project participants (Group discussion n.3). This was reflected in shifts in their long-term goals, as well as in the steps necessary to achieve them. A focus on monitoring and evaluation activities also allowed projects to respond to emerging problems, needs, and aspirations, such as adjusting intervention timelines based on feedback from Reef Traditional Owners, modifying deployment locations to respect community concerns, and incorporating real-time feedback into the design of restoration trials.

The monitoring and evaluation activities across the engagement research team triggered interest across RRAP managers and decision-makers with one person remarking:

> we should do it in terms of leadership of the program as well. We've had some different layers of feedback in terms of our processes and structure, but I think maybe a lens or some advice on continuous improvement as leaders could be really useful as well (Interview 4).

Another noted the importance of an "examination of how the program's going socially or organizational[ly]" (Interview 12).

Within the engagement research team, strong face-to-face interactions among researchers (based at different institutions spread across and outside the GBR catchment) were considered essential to get a sense of connections between specific activities, and how all engagement research activities coherently fit together (Group discussion 1, 2). Internal coherence and the degree of collaboration within the engagement research team helped to overcome a sense of fragmentation of physically and institutionally dispersed activities. At the same time, having multiple engagement research coordinators enhanced the capacity to attend regional meetings and gather diverse inputs, which facilitated timely integration of social research findings into

Knowledge and Capacity-Building by Strengthening Partnerships with Stakeholders, First Nation Peoples and Decision-Makers

Our analysis also highlighted the necessity to account for the differentiated expectations by: government officers focused on the implementation of policy and regulations; general community members and their growing interest in RRAP as well as their underlying social, cultural, and economic concerns and hopes; and Reef Traditional Owners who have rights and aspiration for the management of sea Country. As highlighted by an RRAP decision-maker (Interview 14), it made "absolute sense to get a rapid but carefully considered structure around how we engage".

For example, this approach recognized the importance of Reef Traditional Owners' aspirations to contribute to current activities while working on partnerships going forward (Group discussion 4). Reef Traditional Owners emphasized the importance to both recognize and respect cultural intellectual property, including via negotiated benefit sharing, with "the understanding that there will be benefits for the group when individuals share information and knowledge" (Maclean et al. 2022a). Reef Traditional Owners also highlighted the need for "a cultural training program (run by Traditional Owners of country) before research staff go on sea Country" (Maclean et al. 2022a), to ensure that RRAP staff be prepared to operate in a way that is culturally appropriate. At the same time, securing Free Prior Informed Consent from Reef Traditional Owners groups was a high priority for field-based R&D.

Addressing issues of limited trust and inequity in community engagement was essential to set the groundwork for genuine and successful collaboration. It was not surprising that the request for adequate resources to be allocated to the establishment of meaningful partnerships emerged as a high priority, including time and resources to support participation.

The potential benefits of successful partnerships with stakeholders and Reef Traditional Owners can expand beyond the life and scope of the restoration R&D program. As well as contributing to environmental outcomes, capacity building to support collaboration between scientists, managers, stakeholders, and Traditional Owners

can generate significant co-benefits through, for example, include training, education, and employment pathways, as well as through the future co-development and co-conduct of research. Such approaches move this kind of program well beyond only seeking Free Prior and Informed Consent (FPIC) for interventions on sea Country (Group discussion 3) to something much larger and more sustainable. In the process of strengthening partnerships with Reef Traditional Owners, RRAP engagement researchers acknowledged the importance of managing potentially emerging expectations for ongoing and deepening engagement with researchers and the capacity of research teams (particularly those located in the Reef catchment). If not properly managed, this can raise two potential issues: one being the potentially different expectations and engagement "workload" that different engagement researchers might be asked to commit to by the engaged Traditional Owner groups; and another being the eventual need to accommodate emerging requests for engagement by specific engagement researchers, and hence to provide them with adequate resources that may exceed initially allocated resources.

RRAP adopted an approach based on FPIC which recognizes Reef Traditional Owners' rights of veto for research or deployment on their own sea Country. The strong appetite for collaboration and inclusiveness in decision-making by both Traditional Owner groups and RRAP resulted in the development of a draft biocultural framework[2]. The aim of this work was to develop a decision-making tool that Reef Traditional Owners could use to consider the deployment of technologies on their sea Country. The framework was co-developed by researchers and Traditional Owners across the Great Barrier Reef. This activity provided good learnings for RRAP; for example, engagement researchers highlighted that:

> some Traditional Owners have discussed how the outward facing part of the draft framework could be used in the future by RRAP scientists or others to get a better understanding of the important protocols and approaches they need to use if they wish to discuss the option for future partnerships (Group discussion 4).

Further, there was recognition of the time required to build relationships with Reef Traditional Owners to enable effective collaboration (including via FPIC processes), and this was noted as a high priority for future partnership development. As a last point on capacity-building, Reef Traditional Owners showed interest to become active partners in the program, with calls for:

> Traditional Owner businesses/enterprises and rangers to be the first port of call for deployment work (rather than non-Indigenous entrepreneurs), and for employ[ing] Traditional Owners on research vessels and/or hire Traditional Owner vessels for research (Maclean et al. 2022a).

Flexibility in the approach to partnering also required adapting to both formal permissions (through the FPIC process) and more general community feedback on preferences and/or concerns. At time Traditional Owners have declined to permit research and deployment at specific sites or using particular interventions.

> the social risk is [going to] be a big one that needs to be addressed because it might be the best science in the world, but if the Traditional Owners don't believe in it or don't want it to occur, it won't occur. I don't think AIMS [wants to] be throwing the whole Indigenous

> engagement process out the window just to try and have the best biodiversity science in the world. And probably some scientists will need to realize that no, that's actually NOT what the community wants (Interview 11).

In other cases, community feedback has guided cross-cultural approaches to growing corals in labs (see, e.g. the Woppaburra cross-cultural approach to biobanking as in Daly et al. 2024) the fine scale selection of deployment sites. For example, the program has had to "pick up and move a couple of deployment sites from where they were originally" to accommodate community concerns (Group discussion 2). Some deployment trials and collaborative monitoring activities have benefited from the support of tourism operators. As remarked by engagement researchers, this could have costed up to "tens of thousands of dollars a day [whereas] if you get partners to do it when they're just going out on a tourism platform… it's only hundreds of dollars" (Group discussion 2).

Influence Decision-Making and Decision Outcomes by Structuring and Strategising Community Engagement

As the RRAP research and engagement activities progressed, differences in time frames for delivery of different components of the program, and their needs for information exchange materialized. As one RRAP decision-maker observed: "There is almost like this two-way pressure where we need to go out and get this information, but we also have this pressure back saying you need to do it properly" (Interview 12). This materialized as attempts to reconcile internal expectations with stakeholder and Traditional Owner expectations of the engagement process. Acknowledging and accounting for this potential mismatch needs to be ingrained in the logic of the program, because this potential issue:

> doesn't come necessarily from the stakeholder engagement team, doesn't necessarily come from the managing entity, it doesn't necessarily come from those that were trying to engage with the Reef industry. But there's some combination of that message which is essentially the message of being frozen or moving very slowly or moving carefully – which is understandable (Interview 12).

Misaligned expectations can disrupt decision-making, leading to delays and conflicts among stakeholders. Engagement researchers observed how community engagement can mobilize broader community support, align efforts with socio-institutional contexts, and influence not only RRAP but also other institutions involved in Reef management. This came as a natural consequence of engaging with community groups in the original and adaptive ways discussed above, as noted by engagement researchers:

> It's a different proposition when it comes to citizen science activities and Traditional Owner involvement and other stakeholder involvement… it's different from top-down, government agency-driven decision-making (Group discussion 3).

The activities of the Stakeholder and Traditional Owner Advisory Group highlighted how members of different organizations involved in Reef management embraced the opportunity to be part of shaping RRAP, due to its potential ramifications. This includes: government-led management of the Great Barrier Reef (e.g. meeting regulative

frameworks more effectively); citizen science initiatives combining tourism, recreational, and educational activities with contributions to scientific processes (e.g. monitoring of coral adaptation in real-world sites); and potential collaborations with government-funded initiatives for aquaculture projects supporting research and development as well as deployment of novel interventions (e.g. growing corals in controlled environments). For all these reasons, a final learning that emerged was the necessity to design and follow an engagement plan that applied not only to the specific engagement research activities, but to the whole of RRAP. Engagement researchers (and the Engagement Advisory Group) argued for the need of an engagement plan that could drive public consultation and engagement in the next phase of RRAP, to enable communities and the public to have opportunities to participate and avenues for voicing their perspectives, needs, and concerns about the potential risks and benefits of RRAP interventions.

Key Learnings for Social Science in Ecosystem Restoration and Assisted Adaptation

Our findings align with broader trends in knowledge co-production, where early integration of diverse perspectives is emphasized in conservation and climate change initiatives (Buschman 2022; Norström et al. 2020; Chambers et al. 2021). Reflecting Norström et al. (2020), our study highlights the value of building trust and adaptive capacity among stakeholders, consistent with co-production frameworks in Australia (Hill et al. 2020) and Canada (Petriello et al. 2022). Yet, our findings reveal distinct challenges in balancing accelerated timelines with meaningful stakeholder engagement, underscoring the need for flexible co-production processes that address both strengths and limitations.

Balancing Act: Managing Accelerated Timelines and Diverse Community Interests

Our study highlights the importance of flexibility and adaptability in engagement processes to navigate the accelerated dynamics of ecosystem restoration and adaptation. By moving from linear, conventional approaches, we advocate for integrated strategies that address rapid changes and uncertainties, fostering deeper engagement, trust, and effective incorporation of diverse community inputs. Engagement researchers observed that "everything is sort of happening at once and there's pressure to bring things forward" (Group discussion 3), reflecting the complexities noted by Sovacool, Baum, and Low (2023). This deviation from conventional approaches, where stages are clearly delineated, suits more integrated and adaptive management strategies (Higgs et al. 2018).

To address the gap in managing community expectations and future uncertainties, our study highlights the necessity of deep engagement and meaningful dialogue to build trust and ensure program success. This aligns with Hagendijk and Irwin (2006) assertion that information dissemination alone is insufficient for public endorsement, and Owen, Macnaghten, and Stilgoe (2012) emphasis on engagement's critical role in fostering trust and collaboration.

Contrary to that literature depicting community engagement as a linear path to success, our results reveal significant challenges, particularly in sequencing engagement

activities. Aligning research timelines with engagement processes to incorporate community feedback meaningfully into decision-making proved difficult in this case study. This aligns with Druschke and Hychka (2015) and Wehi and Lord (2017), who stress the considerable time and trust required to integrate Traditional Owners' knowledge and practices. For example, adherence to the FPIC protocol posed challenges, including demands on time and resources for meaningful engagement with Traditional Owners.

Recommendation: Programs need to navigate the tension between timelines for engagement, urgency of action and uncertainty. Engagement should have clear goals and evaluative criteria, but also needs sufficient time and flexibility to navigate unpredictable changes.

Mutual Learning and Reflexivity: Embedding Deliberation in Research and Management

Our study addresses the limited guidance for practitioners by emphasizing deliberative reflexive practice as key to facilitating learning and adaptation in ecosystem restoration projects, aligning with Newig et al. (2019) and Dryzek et al. (2019) calls to embed engagement into collaborative learning and deliberation. Engagement researchers embraced mutual learning and shared leadership with community groups, enabling stakeholders and Traditional Owners to actively contribute to and learn about RRAP interventions (Individual conversation 5). However, the dynamic and accelerated timelines complicated the sequencing of engagement activities, challenging the integration of community feedback into decision-making (Group discussion n.3). These challenges underscore the importance of trust and equity in collective learning processes, as highlighted by Garavan and McCarthy (2008), to help address procedural issues and enhance transparency amid uncertainties inherent in complex ecosystem restoration and adaptation efforts.

Continuous monitoring and internal learning within the RRAP subprograms (Interviews 4 and 12) demonstrated the importance of deliberative reflexive practice in driving improvement and effective community engagement. This approach allows programs to adapt strategies based on internal feedback and evolving conditions, enhancing the relevance and impact of interventions. By incorporating reflections from diverse participants, RRAP fosters trust and collaboration while strengthening community partnerships. However, managing ongoing dialogue amid project complexity is essential to prevent engagement fatigue among participants and communities.

Recommendation: If programs embed deliberation into research and management processes, fostering mutual learning among program leaders, scientists, and community groups, then diverse voices can actively influence decision-making. This approach enhances inclusivity, builds trust, and improves the adaptability and effectiveness of project outcomes by aligning them with community priorities and knowledge.

Integrating Knowledge: Strengthening Capacity and Partnerships with First Nation Peoples

To address the gap in practical guidance for practitioners, our study builds on the literature in highlighting the importance of recognizing and respecting Indigenous

Cultural Intellectual Property as central to partnership development. Reef Traditional Owners emphasized that sharing knowledge must come with benefits for their communities and insisted on cultural training for researchers to ensure culturally appropriate operations (Maclean et al. 2022a, Maclean, Greenaway, and Grünbühel 2022b). The RRAP experience demonstrates some approaches to better recognize and integrate First Nation knowledge and practices into ecological restoration, such as the adoption of group specific customary protocols and cultural processes in the collection and translocation of specimens, and the prioritization of a partnership in research than just the execution of research activities (Maclean, Greenaway, and Grünbühel 2022b).

By implementing the FPIC protocol, our research addresses the need for foundational trust and equitable partnerships. This approach resonates with calls in the literature to recognize the agency of First Nation leaders and to acknowledging the agency of First Nation communities in decision-making processes (Lyons et al. 2019). The co-development of a draft biocultural framework (discussed above), as well as the actual artifact itself is an example of how the engagement researchers successfully worked with Reef Traditional Owners. This experience highlights future partnership opportunities including for co-developed research, enterprise development (for deployment of technologies on sea Country), to identify on-country training needs and more.

Recommendation: Early and close engagement with First Nations peoples can build relationships that support the negotiation of permissions (FPIC), integration of Indigenous knowledge and protocols in research and deployment and provides a foundation for future partnership opportunities.

Strategic Engagement: Influencing Decision-Making through Community Collaboration

Our results demonstrate that incorporating diverse community perspectives influences decision-making within RRAP but reveals tensions between the urgency for action and the time required for deep engagement. Early and adaptive engagement emerges as a crucial consideration. A RRAP decision-maker (Interview 12) emphasized the challenge of balancing the need for rapid information gathering and action with thorough, inclusive engagement, as highlighted by Baybay and Hindmarsh (2019).

Moreover, our findings underline the role of trust and equitable involvement in the decision-making process. As one stakeholder expressed frustration, "we are sick of coming to your table, you come to our table and listen to us" (Individual conversation 3). This sentiment underscores the importance of genuine consideration of community inputs, fostering an environment where all contributions are valued (Garavan and McCarthy 2008).

Balancing the urgency of research and development with the necessary engagement time and processes for stakeholders presents significant tensions. Accelerated timelines, driven by the pressing need for climate adaptation, often clash with the deliberative pace required for meaningful stakeholder engagement (Group discussion 3). This dual pressure necessitates careful planning and a nuanced understanding of these dynamics. As previously highlighted, the limited guidance available to practitioners on effective community engagement and deliberation in ecosystem restoration and assisted adaptation programs can exacerbate these challenges (Higgs et al. 2018). Our findings, supported by literature (see, e.g. Baybay and Hindmarsh 2019; Reed et al. 2009),

suggest that integrating rapid R&D with deep community involvement requires adaptive strategies and clear communication about the scope and influence pathways to address risks effectively.

Recommendation: If early collective efforts, eventually building on pre-established relationships, are made to design strategic engagement plans that clearly define the scope and pathways for community and First Nations peoples' involvement in decision-making, then practitioners can establish a framework that redistributes power, allowing community collaboration to meaningfully influence restoration and adaptation decisions.

Implications

This research provides crucial guidance for researchers, ecosystem restoration practitioners, stakeholders, and First Nation rights-holders, involved in or affected by ecosystem restoration and assisted adaptation projects. The findings highlight the need for adaptability and flexibility in engagement processes, early and inclusive engagement, and managing expectations to strengthen partnerships with diverse groups. Practitioners can leverage these insights to guide their work by embedding deliberative reflexive practices, respecting Indigenous Cultural Intellectual Property, and crafting strategic engagement plans that consider the multiplicity of perspectives within communities. Emphasizing early involvement and clear pathways for engaging with stakeholders and First Nation people ensures meaningful contributions to decision-making. In particular, this research is novel in highlighting the importance of continuous monitoring and learning for effective engagement and deliberation in complex ecological restoration efforts. It also underscores how compressed timeframes and magnified uncertainty make this context both unique and significant, especially as similar programs are increasingly established worldwide.

Notes

1. In the Australian context, some First Nations people "of Aboriginal and Torres Strait Islander descent who have spiritual or cultural affiliations with a site or area […] or are holders of native title with that site or area, and are entitled to undertake activities under custom or tradition, are termed Traditional Owners" (GBRMPA n.d.).
2. Biocultural resources comprise the knowledge and customary practices, associated biological resources and ecological systems, extending to the cultural land and seascapes, as well as the heritage and memories of societies in those places (Eckert et al. 2018).

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