



Extended Peer Communities: Appraising the contributions of tacit knowledges in climate change decision-making

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ABSTRACT

This paper explores the implications of assessing tacit knowledges of climatic change in extended peer communities, as applied in two European research projects on climate action. Post-normal science (PNS) proposes the extension of the peer community to co-produce better quality knowledge for decision-making on issues like climate change, where facts are uncertain, values in dispute, stakes high and decisions urgent. The paper has two aims. The first, more practical, is to explore methods for critically appraising tacit knowledges for climate action, using the example of two ongoing research projects. The second, more conceptual, is to improve practices and discourses surrounding tacit knowledge in current PNS praxis, with close consideration to the implications and challenges involved in including these forms of knowledge in decision making processes. By exploring theoretical perspectives on the topic of tacit knowledge, four challenges facing extended peer communities in engaging with tacit forms of knowledge have been identified: communication, representation, appropriation, and assessment.

1. Introduction

People hold all sorts of tacit knowledge about how the weather should normally be in their locales at certain times of the year. This knowledge builds on their long-standing experiences and skills and shapes the lenses through which they make sense of contemporary climate change (Hulme, 2015; Jasanoff, 2010). As such, it informs the countless decisions and practices that govern individuals' daily routines, like from when to till the garden, up to social choices on setting up infrastructure for instance, or scheduling school vacations. However, rapid climatic and related socio-natural changes may be destabilising and undermining tacit knowledges and practices helping people to organise themselves according to their climate perceptions (Adger, Barnett, Brown, Marshall, & O'Brien, 2013; Bremer, Glavovic, Meisch, Schneider, & Wardekker, 2021). But how can we detect tacit knowledges and critically inquire into their quality for decision-making?

This paper addresses the challenges to mobilizing and appraising tacit knowledge in support of climate action. In this, it is inspired by a post-normal science (PNS) perspective (Funtowicz & Ravetz, 1993a). PNS strives to improve knowledge inputs concerning practical issues when facts are uncertain, values in dispute, stakes high and decisions urgent. Climate change is a paradigmatic case of such a post-normal issue. Faced with climate change, PNS promotes a plurality of knowledges, including *tacit* knowledge, especially when critically engaging with the *explicit* style of scientific knowledge in decision-making. PNS praxis critically addresses, on the one

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hand, the silencing of tacit elements of the scientific knowledge production itself, and on the other, the downgrading of the importance of tacit knowledge, central to traditional, local, and indigenous ways of knowing and humanistic learning (cf. eg., Young, 2017). Instead, PNS advocates the inclusion of a wider spectrum of actors and their knowledge systems in an ‘extended peer community’ (EPC), engaged in the process of mobilising ‘high quality’ knowledge for decision-making (Funtowicz & Ravetz, 1990, 1993a,b, 1994).

We explore quality appraisal of tacit climate knowledges in EPC as a theoretical and methodological challenge for post-normal praxes. This raises issues that PNS scholarship has long been aware of, but which require a renewed methodological engagement. Therefore, our paper has two aims. The first, more practical, is to explore ways for critically appraising tacit knowledges for climate action according to a PNS-inspired approach, using the example of two on-going European research projects. In this, we recognise that tacit knowledges can and should be mobilised in EPCs. The second, more conceptual aim, is to advance post-normal engagement with these tacit forms of knowledge by enquiring about the implications and challenges involved in including tacit knowledge in decision-making processes. As we will see, post-normal praxis shares, with governance and policy literature in general, a tendency to focus attention on explicit forms of knowledge. For this reason, the question of how to approach forms of tacit knowledge remains open, as does the question of how an EPC might be organized to draw upon such sources of expertise in an effective and ethical manner.

We begin by introducing two EU-funded research projects – CALENDARS¹ and CANALS² – aiming to appraise the quality of knowledges used for adapting to climatic change in a variety of institutional settings, from schools to horticulture to water management. CALENDARS and CANALS share post-normal assumptions about extended modes of conducting science but are innovative in that they aim to go beyond existing PNS praxis by focusing on tacit forms of knowledge. Both projects extend their study to implicit forms of knowing weather, seasons and climate as embedded in institutional cultures, including in routine practices, materiality, infrastructures and taken-for-granted logics or worldviews (Bremer et al., 2021). In doing so, both projects are inspired by a cultural conception of climate understood as ‘an idea that humans use to stabilise relationships between weather and their patterned lives. In its various manifestations around the world, the idea of climate enables humans to live with their weather through a widening and changing range of cultural resources, practices, artefacts and rituals.’ (Hulme, 2015, p. 1). With time, though, climate knowledges can become hidden, even to practitioners, or they have been rendered invisible through processes of naturalization by dominant techno-scientific thought collectives. CALENDARS and CANALS seek to reveal tacit knowledges by making them accessible to extended peer review. In doing so, our paper is a conceptual self-reflection of on-going research in both projects and beyond that, a contribution to the wider academic debate for better understanding EPCs.

After introducing both projects (Section 2), we turn to exploring different theoretical perspectives on the topic of tacit knowledge and address the challenges confronted by post-normal praxis on quality assessment and EPC (Section 3). We discuss how PNS approaches can better include tacit knowledges, before unpacking some methods being deployed in CALENDARS and CANALS to this end (Section 4).

2. EU projects CALENDARS and CANALS

Research on the social processes of climate adaptation has rapidly expanded since 2000. A ‘cultural turn’ in the past 10 years (Adger et al., 2013; Bremer et al., 2021; Gay-Antaki, 2021; Hulme, 2015) has begun to bring beliefs and practices into focus. The CALENDARS and CANALS projects are a part of this movement to explore how cultures mediate the way we relate and adapt to climate.

2.1. The CALENDARS research project

The CALENDARS (*Co-production of Seasonal Representations for Adaptive Institutions*) project uncovers institutions’ seasonal cultures, and how assess how they influence adaptiveness to seasonal variability and change. There is emerging evidence that institutions’ seasonal adaptation may hinge on their cultures (Bremer et al., 2021; Geoghegan & Leyson, 2012; Sheridan, 2012). On the one hand, where an institution’s culture is well fitted to seasonal rhythms, they can serve as a taken-for-granted resource; cues, scripts, and tools for guiding action (e.g., Birkenholtz, 2014; Hastrup, 2016; Roncoli, 2006; Strauss, 2016). On the other hand, there are signs that rapid climatic, social, and environmental changes may be destabilizing seasonal cultures, and undermining their quality as adaptive resources, sometimes with maladaptive consequences (Adger et al., 2013; Ayal et al., 2015; Bastian, 2012; Bremer et al., 2020; Dixon, Stringer, & Challinor, 2014).

CALENDARS is organised by Scott’s (2014, p. 56) definition of institutions as: ‘the *regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life*’. Specifically, the project sees culture as a ‘toolkit’ of seasonal beliefs and practices (Swidler, 1986) that (consciously or unconsciously) mediate how actors act in different seasonal periods or rhythms. Culture becomes visible in various manifestations, but the project focuses on the *seasonal symbols, practices, values, and materiality* that guide actors in institutions in different periods of the year (Bremer et al., 2021). Arguably, actors’ seasonal routines are mainly taken-for-granted, tacit types of knowledge and practice that are deployed in un-reflexive ways, and are resistant to being made explicit, let alone critically assessed.

The project is organised around a comparison of institutions in two case studies: Bergen city in Norway, and the rural Coromandel Peninsula in New Zealand. On the Coromandel Peninsula, researchers are focusing on seasonality in schools and different ecological restoration and conservation efforts, including ‘coastcare’ groups, and Maori Iwi’s (tribes) traditional knowledge of seasons. In Bergen,

¹ CALENDARS – Co-production of Seasonal Representations for Adaptive Institutions (<https://www.uib.no/en/calendars-project>)

² CANALS – Changing Water Cultures (<https://www.uib.no/en/svt/146488/changing-water-cultures-canal>)

the focus is also on schools and conservation efforts, this time in an arboretum, but also on urban institutions including an artist collective, a café, and a scientific centre working on seasonal forecasts. CALENDARS researchers are embedded as participant observers in these institutions. They conduct observations and narrative interviews over 12–18 months to make seasonal cultures visible through a slow and collaborative process, and stimulate reflexive thinking among institutional actors about their own cultures of practice.

After this ethnographic work, the project brings institutional actors together in focus groups as moments for critically revisiting their own seasonal cultures and discussing their fitness to institutions' functions. These focus groups are organised so that actors can reflect first on their own institution, and then discuss seasonality across diverse institutions, in mixed workshops. This appraisal work is explicitly designed according to a PNS perspective, but it departs from common post-normal praxis in that the focus is on asking participants to subject their own taken-for-granted knowledges to explicit scrutiny.

2.2. The CANALS research project

The CANALS (*Changing Water Cultures*) project asks how a water culture perspective can improve the quality of knowledge production for water infrastructures facing rapid climate change. With this, it pursues two objectives: (a) advancing understanding of how infrastructure knowledge is co-produced in water cultures and (b) mobilizing an extended water cultures peer community for assessing current knowledge of water infrastructures and co-producing new forms better adapted to climate change.

Key to the CANALS project is its *water culture perspective* (Linton & Budds, 2014; Meisch, 2019; Orlove & Caton, 2010; Strang, 2004), which understands cultures as both practices and systems of symbols and meanings (Sewell, 1999). This perspective addresses two challenges which impede a proper understanding of the socio-cultural dimensions of water infrastructures. First, it recognises the hybrid character of water, which exists independently of humans and at the same time is culturally appropriated and enacted through human practices (Perreault, 2014). Second, it sees infrastructures as social practices connecting people and objects in the world in socio-material relations (Bruns, Meisch, Ahmed, Meissner, & Romero-Lankao, 2022; McFarlane & Silver, 2017). A water-cultural perspective aims to capture these complex processes around water and water infrastructures, and better address challenges posed by climate change. At the same time, it means acknowledging the many connections between people and their waters. With this, the multiplicity of institutions and practices emerging with and structuring these connections become visible, many of which are known tacitly.

Empirically studying water infrastructures demands first a robust concept of change, and here CANALS employs a descriptive perspective on 'co-production' (Bremer & Meisch, 2017), as a way of analysing the mutual production of infrastructures, knowledge, social orders, and power relationships. Second, it demands a mixed set of ethnographic methods including narrative interviews, document analysis, participant observation, and techniques for structuring interviews and field-notes. Third, this work requires concepts and methods for actively engaging people in reflexively assessing their water cultures and how well their current knowledge and practices perform for producing water infrastructures that cope with rapid climate change. PNS lends itself here as a promising mode of knowledge production. It attaches particular importance to EPCs, which broadens the spectrum of actors who assess the quality of knowledge for action, and actively co-produces new forms of knowledge and social orders according to these new understandings of quality (Meisch, 2018a), e.g., for climate adaptation. This demands different methods for facilitating creative interaction. While the first perspective requires interpretative methods to unravel formal and tacit understandings of water, climate, and infrastructures; the second demands trans-disciplinary methods of engaging and working with stakeholders.

CANALS explores practices in two case studies by adopting a critical approach to water, climate and infrastructure in order to study places which are considered well-ordered on the one hand, but where, on the other hand, in view of climate change, earlier securities become uncertain and political decisions contested.

2.3. Relevance of tacit knowledge in both projects

Both projects begin from the premiss that it is through cultural practices that people appropriate and give meaning to their natural environments and thus render them manageable. The result is a hybrid 'social nature' blurring the boundaries between 'the social' and 'the natural' (Castree & Brown, 2001). For instance, people hold ideas about how their weather normally behaves at certain times of the year (*seasons*) and they organise themselves accordingly. Climate, understood in this way, is a basis for the institutions and practices by which people culturally appropriate their weather, with all its complexity and unpredictability (Hulme, 2015; Meisch, 2018b). The many conventions, customs, and practices of this cultural appropriation of climate are mostly taken for granted and passed on implicitly.

Such knowledge of one's 'own' weather is increasingly coming under pressure due to the dynamic processes of global climate change. In addition, it is being pushed aside in the search for techno-scientific solutions to the climate and, at worst, defamed as irrelevant and irrational (Funtowicz & Ravetz, 1992; Jasanoff, 2010). In response to these pressures, CALENDARS and CANALS endorse a post-normal perspective that '[when] problems lack neat solutions, when environmental and ethical aspects of the issues are prominent, when the phenomena themselves are ambiguous, and when all research techniques are open to methodological criticism' – as is the case with climate change – then extending the 'peer community is then not merely an ethical or political act; it can positively enrich the processes of scientific investigation. Knowledge of local conditions may determine which data are strong and relevant and can also help to define the policy problems' (Funtowicz & Ravetz, 1993a, p. 752-3).

From a PNS perspective, attempting to critically appraise tacit knowledges for climate action, requires confronting conceptual and methodological challenges concerning the role of tacit knowledge in extended peer communities. Before discussing how CALENDARS

and CANALS address these challenges, it will be necessary to look closer at what is meant by tacit knowledge and examine the problems it gives rise to in decision-making contexts.

3. Tacit knowledge and post-normal science

3.1. Tacit knowledge

Certain forms of knowledge are easy to share because they can be made explicit by being explained or captured in writing or numbers. When we listen to the testimony of experts or consider the information contained in a policy report for example, it is often this kind of knowledge that we acquire. However, the forms of knowledge commonly described as *tacit* resist being shared in this way and are often understood to be acquired only through extended periods of practice. Common examples of this kind of knowledge include practical competencies such as riding a bike, speaking a language fluently, or sometimes even entire systems of practice such as systems of indigenous agriculture or navigation. When asked to communicate this knowledge, skilled practitioners often find themselves at a loss for words. As the philosopher Michael Polyani (1966, p. 4) noted, in such cases we can be said to ‘know more than we can tell’.

The literature on the topic of tacit knowledge is diverse and spans various disciplines such as philosophy, sociology, and psychology. Exactly what tacit knowledge consists of is itself the subject of wide disagreement, as are the reasons that have been proposed for *why* these forms of knowledge resist being made explicit. This extends to debate surrounding the question of whether, or to what extent it may be possible to render such forms of knowledge explicit. Some theorists, for example, use the term tacit to describe forms of knowledge that have not been rendered explicit due to a reluctance or inability on the part of those possessing it to divulge its details. Such theorists therefore accept the possibility that tacit knowledge may be ‘captured’ through different techniques of elicitation and codification (Nonaka & Takeuchi, 1995). Others reserve the term for forms of knowledge that are considered to resist explication due to the nature of what is known and argue accordingly that any attempt to ‘capture’ such knowledge inevitably distorts what is known and renders it unusable (Fischer, 2000, p. 220; Freeman & Sturdy, 2015a).

Though understood to resist codification to differing degrees and for different reasons, tacit knowledge is not considered impossible to share. The institution of apprenticeships, for example, reflects how these forms of knowledge can be transmitted through practice or socialization; processes which require active participation over extended periods of time. While it is commonly assumed that transmission via socialization or practice represents a distinguishing feature of local or indigenous knowledge, longstanding traditions in both the philosophy of science (e.g., Kuhn, 1996; Polyani, 1958; Ravetz, 1971) and sociology (e.g., Collins, 1985; Lynch, 1993; Watson-Verran & Turnbull, 1995) demonstrate how, though utilizing a variety of explicit knowledges, scientific knowledge also possesses irreducible tacit dimensions.

While tacit knowledge resists being made explicit, it is nonetheless possible to learn *about* tacit knowledge by consulting explicit sources. Ethnographic studies of the practice of tacit knowledge in different contexts for example, provide an important resource that enables us to gain some understanding of the nature of these knowledges and the ways in which they differ from the kinds of knowledge that can be gained through reading textbooks or reports. Such studies often draw attention to how these forms of knowledge are based around an intimate and intuitive familiarity or ‘feel’ for specific environments which enables practitioners to discern and interpret the significance of contextual features that are often inaccessible to novices. An ability to draw judgments of quality is also considered central to such abilities (Schön, 1983, p. 50), such as judging what constitutes a good performance, or when a process is developing in the right way according to one’s goals. However, because such capacities emerge by cultivating a receptivity to particular contexts through experience and practice, the logic of these forms of knowledge often appears unintelligible to those who do not possess them. For this reason, the way in which such knowledge is acquired is often characterized as a process of socialization in which an individual comes to inhabit a particular cultural perspective (Collins & Evans, 2007, p. 24).

Yet while they may be difficult to access for outsiders, tacit forms of knowledge are increasingly recognized to hold great value as a resource for supporting decision-making, including for climate adaptation. Given the widespread recognition that scientific knowledge alone is insufficient to address climate impacts, it is now common to find calls to expand the sources of knowledge utilized by decision-makers to also include forms of local knowledge, much of which is known tacitly. In fact, tacit knowledge is often recognized as being especially useful for addressing the kinds of problems described as post-normal. In his account of practical knowledge, Donald Schön for example argues that tacit forms of knowledge are necessary for addressing problems characterized by ‘complexity, uncertainty, instability, uniqueness, and value-conflict(s)’ (Schön, 1983, p. 39). This insight is complemented by other scholarship which highlights the pitfalls resulting from the exclusion of tacit forms of knowledge from decision-making. In his critical analysis of high-modernist planning schemes for example, Scott (1998) provides a variety of case studies demonstrating how attempting to manage complex problems without such forms of knowledge can lead to disaster.

So, considering the importance of tacit knowledges for managing complex problems such as climate adaptation, the question is to what extent can we access these – crucial, but notoriously difficult to pin down – forms of knowledge, and appraise their quality for adaptation?

3.2. Post-normal science and quality assessment

PNS presents itself as a scientific approach for mobilising high quality tacit knowledge for decision-making. One of the original defining insights of PNS was to shift the focus of knowledge inputs for decision-making from ‘truth’ to ‘quality’, on methodological grounds, while recognising that there were also essential social, institutional, and political dimensions in any problem-solving practice

(Benessia, 2021; Funtowicz & Ravetz, 1990, 1992, 1993a,b; Ravetz, 1999). PNS acknowledges the historical and inspirational importance of the ideal of truth but argues that when facing complex ‘post-normal problems’ like climate change, the search for a simplistic truth is futile. Then quality becomes the focus of the creation, deployment, and evaluation of relevant knowledges.

In this context, quality is a relational attribute; defined as fitness for purpose (or function). Clearly, its assessment then depends on which and whose purposes are considered as legitimate. On one hand, the range of purposes considered legitimate can stem from a diversity of actors from different knowledge systems in the co-creation of knowledge for decision-making. Or, on the other hand, it may reflect the narrow interests of some actors with the power to control the production or management of knowledge. Quality has some seemingly paradoxical features when, for instance, high quality is linked to evil or corrupt purposes or when it is correlated to high uncertainty.

Quality in PNS is operationalised through EPC. This concept was developed in the context of politicised quality controversies in research used to inform governance policies and decisions in the fields of technological, environmental and health risks. The extension of the concept of a peer community from its original realm of application (disciplinary science) is not only ethically fairer and more democratic but can also serve to enhance the quality of scientific research in areas such as mission-oriented, issue-driven, and forensic science, along with innovation, as well as the provision of science advice. The PNS heuristic diagram (Fig. 1) helps to visualise the extension of the peer community as a function of two non-independent dimensions, systems uncertainty, and decision stakes. As the problem-solving strategies move along these dimensions, new actors are incorporated into the framing of the relevant issue, the creation of pertinent knowledge, the negotiation of purposes and the evaluation of quality.

The work on EPCs builds on precedents set by ‘housewife’ or ‘popular’ epidemiology (for instance, Lois Gibbs and the Love Canal crisis, see, e.g., Fjelland, 2016), and early evidence-based medicine (for instance, the Cochrane collaboration). It deploys insights from Robert Pirsig (in his 1974 book *Zen and the Art of Motorcycle Maintenance*) about quality as complex (ambiguous), holistic and reflexive, and from W. Edwards Deming’s teachings on total quality control, in particular his innovative work on ‘quality circles’ (e.g., Deming, 1986). In this work, the assembly line is transformed into a kind of participatory process. The notion of ‘quality circles’ not only extends the community of quality controllers and evaluators, to benefit from practical knowledge, experience, and commitment, but also encourages whistle blowing. Crucially, any member of the community, including the work force, is encouraged to stop the process if they believe that quality is being violated. In this respect, EPCs have always had some concern for qualities that are implicit to certain knowledges or practices.

PNS emphasises the relationship of tacit knowledge and quality knowledge, especially when critically engaging with the explicit nature of scientific knowledge. On the one hand, it critically addresses how, in the modern European tradition, science became the privileged and unquestioned provider of reliable knowledge for decision-making. In this process, the tacit element of science was silenced, and with it the awareness of value judgements, uncertainties and complexities associated with the production and understanding of scientific knowledge itself (Funtowicz & Ravetz, 1993a,b; Ravetz, 1971). Thus, instead of providing certainty in the mastery of nature as promised, science, unable to deal with the unpredictability and value-ladenness of socio-natural systems, became itself part of the problem – and often the provider of poor or inappropriate knowledge (Benessia et al., 2012; Bremer & Funtowicz, 2015). On the other hand, in this process, tacit forms of knowledge central to traditional, local, indigenous, humanistic or artistic ways of knowing and learning were purposely downgraded to second class knowledge – even though they are highly relevant for understanding and dealing with decision-making problems (Funtowicz & Ravetz, 1992; Young, 2017). Extending the peer community is put forward as one way of providing better quality knowledge to decision-making by including ‘an ever-growing set of legitimate participants in the process of quality assurance of the scientific inputs’ (Funtowicz & Ravetz, 1993a, p. 752).

3.3. Challenges for PNS quality assessment of tacit knowledge

Insofar as it aims to incorporate plural knowledges in the decision-making process (Funtowicz & Ravetz, 1993), EPCs are often

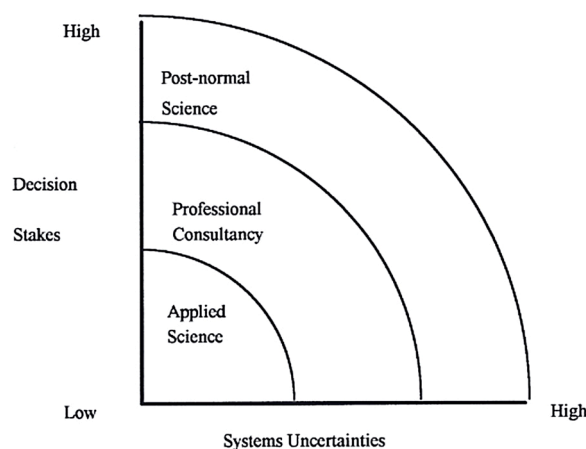


Fig. 1. The PNS heuristic diagram (Funtowicz & Ravetz, 1993a, p. 745).

directly engaged with tacit forms of knowledge. However, the difficulties involved in communicating and explicating tacit knowledge yield a variety of challenges for bringing such forms of knowledge to influence decision processes; challenges that are often given insufficient attention in the current post-normal praxis. For example, it is common to find suggestions that the inclusive nature of EPCs, alongside methods of open dialogue, are by themselves sufficient to ensure that tacit knowledge comes to be included in decision-making processes (Betz, 2006, p. 243; Glavovic, 2014, p. 211). Yet, proposals such as this overlook the variety of challenges facing EPCs in the attempt to access and incorporate tacit forms of knowledge, which we suggest can be grouped into the following four overlapping categories:

The first set of challenges surrounds the *communication* of tacit knowledge, and stems from the difficulties facing those in possession of such knowledge in explaining or showing what they know in a form which is intelligible and accessible to diverse actors in a decision-making setting. Importantly, communication here extends beyond verbal communication. These challenges can be understood to depend, in part, on the way in which the activities of an EPC are organized. As Fischer (2000, p. 253) notes, drawing judgements and deliberating on policy issues often requires relatively longer periods of time for practitioners of local knowledge that are rarely made available in participatory governance schemes.

A second set of challenges concerns the *representation* of tacit knowledge. As Freeman & Sturdy (2015b) note, explicit forms of knowledge, such as transcripts, reports, and records, represent the standard mechanisms of policymaking. It is therefore not surprising to find that attempts to include tacit knowledge in policymaking often involve the use of strategies for ‘capturing’ or ‘eliciting’ such knowledge in explicit form, such as mapping techniques or narrative elicitation. However, the issue of whether these forms of knowledge can be explicated at all is a contested topic and it therefore remains an open question whether such methods can succeed in yielding accurate and useful representations of what is known.

The third set of challenges is related to representation and concerns the *appropriation* of tacit knowledge (Mason, 2011). These problems encompass a range of ethical issues which stem from attempts to extract tacit knowledge via explication in a wider social and political context. Insofar as forms of local knowledge considered valuable for decision-making are very often the possession of marginalized communities or social groups, this set of problems invites us to consider power relations more directly, by enquiring not only into whether representations of tacit knowledge can and should be considered authentic but also into whether the uses of such representations can be considered to remain in line with the interests of those who helped create them.

A final set of challenges we shall consider applies to the *assessment* of tacit knowledge. As Wynne (1996) notes, the difficulties associated with understanding and evaluating evidence that is not presented in one’s cultural style can contribute to a range of problems which themselves threaten the integrity of participatory governance schemes such as breakdowns of dialogue and mutual trust. Indeed, what Healy (1999) describes as the widely documented sceptical attitudes towards lay tacit knowledge inherent to contemporary science can be understood to stem, at least in part, from the way in which the standards by which the quality of such knowledge is assessed often forms an inherent part of that which is known tacitly.

4. Discussion

We have argued so far that cultural knowledges and practices play an important role in how groups act according to climate variability and change, but that they often resist being explicitly discussed and appraised. Through the notion of the EPC, PNS promotes the idea that these forms of tacit knowledge should be included in decision-making processes and considered alongside explicit knowledge in effecting climate actions. However, for this integration to yield meaningful results it must address the four sets of challenges discussed above. This section puts forward some practical methods and conceptual reflections for addressing these challenges. Our findings are represented in Table 1.

4.1. Guiding principles for addressing the challenges of tacit knowledge for EPCs

The four challenges concerning the nature of tacit knowledge demand deeper conceptual reflection in PNS praxis focussing on quality assurance in EPCs. Subsequently, we identify principles in the existing PNS literature which can be understood to address these challenges.

The challenge of communication stems from the somewhat inert resistance of some tacit knowledge forms to being made fully explicit (Collins, 2010). As participants in EPC ‘know more than they can tell’, deliberations about quality will be iterative learning processes of telling and asking back, of showing and imitating. So, knowledge co-produced in EPC will to some degree always be *provisional* – the best approximation at any point in time – and open for revisions in further rounds of deliberations as understandings of a problem evolve. As such, EPC change along the process, and the quality of the knowledge produced is a function of the quality of the

Table 1
Challenges of tacit knowledge for extended peer communities.

Challenges posed by tacit knowledge for EPC	Guiding principles for addressing these challenges in EPC	Ways of applying these principles in the CALENDARS & CANALS projects
Communication	Provisionality	Long term participant observation & mixed methods
Representation	Hybridisation	Co-existing representations, culturally transmitted
Appropriation	Epistemic Justice, democratisation	Co-production of research with participants
Assessment	Relationality, responsibility	Participant-led assessment, combining disparate quality criteria

process. If action is taken based on this knowledge, errors and failure will inevitably occur, and opportunities for genuine correction must remain possible. Such failures and errors are inevitable once we realise that there is no predictability or control over post-normal problems. The political issue is then the acceptance of this fact, and how to adapt institutions and constitutions to this situation.

When tacit forms of knowledge can be elicited, the challenge of representation arises: What are appropriate ways of representing tacit knowledge without distorting it? Previous studies strongly caution against (simplistic ideas of) translating tacit forms of knowledge, which are central to traditional, local, indigenous, or artistic ways of knowing, into scientific language and representations ('collecting data') (Bremer & Funtowicz, 2015; Yates, Harris, & Wilson, 2017) and call for new and *hybrid* forms of knowledge (Benessia et al., 2012; O'Connor, 1999). While current post-normal praxis acknowledges this challenge, further research is needed to develop methods for knowledge hybridization.

The challenge of appropriation raises the question of control and ownership over tacit knowledge – and hence the question of *epistemic justice*, i.e., the "universal participation on terms of equality of all inquirers" (Anderson, 2012, p. 172; see also Mason, 2011): Who gets a say in producing knowledge and how it is represented and used for decision-making? From the beginning, the rationale of EPC was the democratisation of knowledge production. While extending the peer community is about better-quality knowledge, it is also 'an ethical or political act' (Funtowicz & Ravetz, 1993s, p. 753). For post-normal praxis, this implies addressing the power elements of EPC more explicitly as it might corrupt the process of knowledge production and quality assurance (danger of 'good quality for bad purposes').

The challenge of assessment refers to understanding and evaluating evidence that is not presented in one's cultural style. This makes assurance very much a *relational* issue – a learning process (as described above) driven by dialogue and mutual trust. Participants in EPCs need to get to know about each other's evaluative languages which they refer to when judging something as good or bad, better or worse, relevant or irrelevant. They might even learn to speak in the other language, showing appreciation and good faith (Bremer, 2014). In this process, participants of EPC might find shared – even to some degree tacit – quality criteria. In addition, and as described above, assurance is as much about interaction as it is about shared *responsibility* for knowledge production during application (see the example of 'quality circles'). In this way, knowledge production and quality assurance merge in practical contexts to a certain degree.

Even though we discussed the four challenges separately, we are fully aware of the multiple interactions between them. For instance, ambiguities can arise in terms of representation when new tacit knowledge emerges in the interaction of participants in an EPC, leading to a situation when the quality criteria arrived at cannot be adequately communicated to non-participants. Or else, making tacit knowledges explicit (communication, representation) has the potential of transforming these knowledges as well as the relations amongst participants and even their perception and experience of themselves. Hence, EPCs are conceptualised as spaces where participants have control of their affairs (justice) and where they build trust in, and share responsibility for, the process of producing better knowledge. Moreover, this responsibility for the process plays a crucial role regarding the provisionality of the knowledge produced and the ability to correct errors that will inevitably occur. This means, all actors with a stake in the issue need to be included in the process (justice). Yet, it is precisely because the challenges posed by tacit knowledge for EPCs are both complex and entangled, that conceptualizing them in terms of discrete categories represents a useful tool for enabling us to comprehend and address them in a systematic way. In the next section, we will illustrate how this framework can be usefully applied by focusing on the examples of the two research projects CALENDARS & CANALS.

4.2. Applying these guiding principles in the CALENDARS & CANALS projects

CALENDARS and CANALS identified the issue of appraising tacit forms of knowledge as a challenge to their research as well as an as-yet unexplored aspect in post-normal practice. Thus, this paper is a conceptual and methodological reflexion of their on-going work and a contribution to the wider field of post-normal practice. Due to the Covid pandemic of the years 2020–21, both projects are in their early stages of empirical work, yet first insights can be shared.

Relative to *communication*, both projects begin from the assumption that it is possible to build long-term relationships with groups of actors, to collaboratively make tacit knowledges visible and accessible. This recognises tacit knowledge as implicit to daily practices, showing itself over time as it is deployed for different situations, and always provisional to the current level of understanding. The overarching method is participant observation, with researchers regularly (weekly) working within institutions over a year or more, keeping detailed field-notes and photographs of what they observe and discuss. For instance, at the arboretum the researcher keeps detailed notes of locations and seasons when the gardeners conduct drainage works and how they time this between the frost and the thaw. Within this ethnographic framework, a set of methods illuminate tacit knowledges from different viewpoints. Narrative interviews are proving successful for eliciting anecdotes of actors' daily lives, and are augmented by analysis of written texts, completed calendar templates, and data from weather stations. Film can record dynamic practices, like how to sow seeds and water them. And blogs are a way for the researcher to show back to actors what she is seeing and bring tacit knowledge to their attention. Finally, the projects accept that some knowledges and practices will defy communication in any way, but that enough is made visible to enable a meaningful discussion of tacit elements.

A challenge is to *represent* tacit knowledges in a format that knowledge holders themselves recognise, but which can also be discussed across different knowledge systems or cultures. Three methodological considerations are relevant here. First, in recognising institutions' hybrid knowledges, the projects deploy mixed methods for collecting and representing knowledges in appropriate formats; from blogs to weather data, narratives to photographs, field-notes to film. The intention is not to integrate these representations but to consider them alongside each other. Second, CALENDARS engages with cultural modes of transmitting tacit practices. Artists in Bergen are creating a virtual reality simulation for an audio-visual and tactile experience of Bergen's seasons. A filmmaker is

presenting seasonal experience on the Coromandel Peninsula. Amateur writer groups in Bergen and the Coromandel are encouraged to write about their seasonal experiences and a graphic designer developed a circular calendar template for collecting actors' seasonal depictions. Third, representations of tacit knowledge are presented back to knowledge-holders and discussed, as a way of testing their correspondence to groups cultural norms.

Care is taken in both projects that tacit knowledges are not *appropriated* for the research but remain in the ownership and under the control of knowledge-holders. Both projects espouse a 'co-production' ethic, with 'subjects' invited to participate in designing, conducting, and communicating the research. For instance, CALENDARS researchers study the artists working on the VR simulation for the project. And CALENDARS researchers have started collaborating with a Maori Iwi (tribe) on the Coromandel Peninsula, through working with local carvers. Conscious of decades of colonial appropriation of Maori resources, knowledge and culture, the project is negotiating the hiring of a research assistant from the Iwi, ensuring research adheres to agreed principles and protocols, and that the Iwi retains control over what findings are communicated and how, as stewards of their indigenous knowledge.

Assessment remains the most difficult challenge for the projects. The projects focus on groups in particular institutions that aim to affect an EPC to critically reflect on tacit knowledges. In this way, assessment is conducted by knowledge-holders themselves, deploying their own institutionally meaningful quality criteria in more or less formal ways as befits the knowledge discussed. This assessment itself is a long-term endeavour, not limited to a few workshops or focus groups, but spread out over the ethnographic work where researchers mirror their observations of tacit knowledge back to actors through on-going questioning and keeping blog entries for example. In these cases, facilitating assessment will mean acquainting actors with different quality criteria over an extended period, in the hope that actors become accustomed to drawing on criteria of quality from across different knowledge systems.

5. Conclusion

How can we extend the peer community in practice, to critically appraise tacit knowledges and practices for climate action? CALENDARS and CANALS both go beyond descriptive study to intervene in institutions and stimulate reflection and discussion about groups' tacit knowledges, with aspirations for affecting their climate action. Both projects identified this question as a conceptual and methodological challenge for their own research as well as for the wider post-normal praxis. For different reasons, such knowledge resists being made explicit by words or numbers. This observation does not imply though, that they cannot be shared at all, but rather that this sharing requires other ways of transfer such as participating in a field, observing, and learning like an apprentice. We identified four challenges (communication, representation, appropriation, and assessment) that arise when extending peer communities to include tacit forms of knowing into knowledge production processes and to co-create better-quality knowledge for decision-making. Based on the two EU-funded projects on climate action, CALENDARS and CANALS, we discussed methodological approaches how these challenges might be addressed.

By exploring post-normal praxis through the lens of tacit knowledge, issues emerged that PNS has long been aware of, but which require a renewed methodological engagement: One is about how to deal with the tacit elements of the scientific research practice itself and how they impact the quality of knowledge for decision-making contexts. Another is about the implications when dealing with tacit knowledge appropriately as part of quality appraisal in EPC.

We have explored different ways in which these challenges can be addressed by EPC in decision-making contexts. As we have seen, this requires reframing not only the process of knowledge production, but also the institutional contexts in which and with which this knowledge is produced, and thus the social fabric of our societies. The value of such a renewed methodological engagement is becoming increasingly obvious with our example of climate change which requires a completely different regime of knowledge production. Because this kind of issue can never be resolved once and for all – and certainly not with traditional scientific knowledge alone, tacit forms of knowledge must play a fundamental role.

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