When salient science is not enough to advance climate change adaptation: lessons from Brazil and Australia

1. Introduction

It is being increasingly recognised that for climate change information to be effectively used there needs to be strong engagement of knowledge users in the knowledge production process (Dilling and Lemos 2011). Some scholars particularly emphasise the need to engage stakeholders for the effective development and implementation of adaptation strategies (Wamsler 2017, Arnott, Moser, and Goodrich 2016). Several approaches and related concepts have emerged in the literature and practice as a means to enable engagement of knowledge users and producers, including transdisciplinary research (Jantsch 1972, Funtowicz and Ravetz 1993), boundary organisations (Star and Griesemer 1989), and knowledge co-production (Jasanoff 2004). We focus on lessons learnt from two projects carried out in Brazil (CiAdapta project) and Australia (Climate Change Adaptation for Natural Resource Management in East Coast Australia) relating to the role of boundary organisations in facilitating knowledge co-production and application for climate change adaptation. Focusing on two differing contexts, urban (Brazil) and natural resource management (Australia), we examine both the conditions under which usable knowledge is produced and those that affect its usefulness, especially in the mid to long-term.

To date, many studies assessing the role of boundary organisations in advancing climate change adaptation focused on issues related to their institutional arrangements (e.g. Offermans and Glasbergen 2015, Graham and Mitchell 2016), and the extent to which these enabled knowledge co-production (e.g. Kirchhoff, Esselman, and Brown 2015, Jasanoff 2010) and knowledge translation (e.g. Kirchhoff, Lemos, and Engle 2013, Gustafsson and Lidskog 2018). Fewer studies discussed the long-lasting effects of boundary organisations (e.g., beyond initial funding availability or project duration such as 2-3 years), including the on-the-ground usability and usefulness of produced knowledge (Dannevig and Aall 2015, Chong et al. 2017). This paper contributes to advancing both lines of research by extracting lessons not only related to the implementation and operationalisation of boundary organisations per se but also the necessary conditions that enable the continual and continuous usefulness of produced knowledge for climate change adaptation. This is particularly relevant when projects are subject to competitive funding schemes, and within political contexts where environmental related initiatives are not considered a priority nor receive the necessary statutory and funding support.

To this end, the paper is structured as follows. The next part provides an overview of the concept of boundary organisations in the climate change adaptation context. This is followed by the research approach, along with the description of the two abovementioned projects. The paper then discusses findings with respect to enablers and barriers for more effective on-the-ground usability and usefulness of climate change information. It concludes with key lessons highlighting necessary conditions for increased impact of boundary organisations for climate change adaptation.

2. Boundary organisations in the climate change adaptation context

The concept of boundary organisations draws on the early works of Star and Griesemer (1989) and Guston (2001). Star and Griesemer's work set how boundary objects

can promote cooperation among differing social worlds. Boundary objects comprise the analytic concept standardised by parties representing differing social worlds (e.g., scientific and non-scientific) to become the intersecting platform for communicating and developing knowledge (Star and Griesemer 1989). Guston (2001) proposed three necessary criteria for boundary organisations both create and use boundary objects at the science-policy interface to solve complex societal problems, namely: (i) providing incentives and opportunities for the usability of boundary objects, (ii) engaging multiple actors from the scientific and professional realms, and (iii) narrowing the science-policy gap. Considering the pressing challenges brought in by climate change (IPCC 2014), there has been a significant number of studies pointing to the role of boundary organisations in addressing these challenges, especially at the science-policy interface (Suni et al. 2016, Arnott, Moser, and Goodrich 2016).

At the centre of the climate change challenge, and beyond mitigation efforts, lies the calls for the generation of information that can assist the implementation of adaptation strategies (Mastrandrea et al. 2010). Notably, boundary organisations are deemed suitable to generate much needed usable and useful information for climate change adaptation because they can bring together multiple knowledge fields allied with their relevance and suitability for decision-making (Kirchhoff, Lemos, and Kalafatis 2015). In particular, boundary organisations can enable the generation of interdisciplinary knowledge which addresses the complexity and uncertainties inherent in climate science (Obermeister 2017). Additionally, they can approximate knowledge producers and knowledge users, therefore maximising information co-production and its subsequent usability for decision-making (Lemos, Kirchhoff, and Ramprasad 2012).

Many large-scale initiatives adopted the concept of boundary organisations to support decision-making relating to environmental change and management over the last decade. For example, the concept guided the creation and implementation of a large consortium for dealing with natural hazards and disaster risk reduction in New Zealand (Beaven et al. 2017). It framed the Future Earth global initiative in the European context (Suni et al. 2016), and it was expanded to boundary chains to support climate adaptation in the Great Lakes Region of North America (Kirchhoff, Esselman, and Brown 2015).

These initiatives provide evidence for a large body of scholarly research investigating the on-the-ground application and implementation of the boundary organisation concept in the context of climate change. For instance, Kirchhoff, Esselman, and Brown (2015) investigated how participants' perceptions and actions are affected by the interactions between knowledge producers and users facilitated through boundary organisations. They found that it is instrumental to have 'interest, commitment and investment' from all parties involved for boundary organisations to be effective, and confirmed their role in improving climate literacy among knowledge users. Similarly, Suni et al. (2016) highlighted the need for the establishment of long-term relationships between partners so that disciplinary siloes are overcome. Offermans and Glasbergen (2015) noted the lack of studies that provide in-depth analyses of the knowledge production process, including knowledge operationalisation within the boundary organisation itself. Graham and Mitchell (2016) summarised current scholarship relating to boundary organisations for climate change adaptation by dividing it into two broad categories. The first is concerned with the knowledge generation process itself to ensure knowledge credibility, accuracy and salience, and the second refers to how boundary organisations maximise knowledge application through knowledge transferring and brokering.

Another body of literature provides a critique to the use of the concept to bridge the science and policy interface more broadly. For example, Gustafsson and Lidskog (2018)

criticised the static manner in which the concept has been applied. This includes the assumption that relationships between partners are stationary instead of constantly evolving, that there are no power relations at stake, that there could be multiple boundaries and that boundaries may be blurred at best of times. Using the International Panel on Climate Change as an example of its limited application, Compagnon and Bernstein (2017) argued that the concept of boundary organisations is not more than a fad and that there has always been 'politicisation of science and scientification of politics' in modern times. The authors also claimed that usable knowledge is only enabled if there is political salience in it which in turn requires science to be politicised. Similarly, Dannevig and Aall (2015) highlighted the need to acknowledge the existence of science-politic 'hybrids', and that boundary organisations differ from each other depending on the policy context, their objectives and partners involved.

What can be gleaned from both literature is the need for more empirical evidence that sheds light on what is the usability and usefulness of the information generated through boundary organisations and for whom (Chong et al. 2017). This means that generating knowledge or information that is salient, or useful and relevant (cf. Dannevig and Aall 2015), may not necessarily result in its usability nor in better decision-making (Greyling, Patel, and Davison 2017). It is within this realm of enquiry that we investigate the necessary conditions for knowledge and information co-produced by boundary organisations to be continually and continuously usable and useful in climate change adaptation. The question the paper seeks to answer is: what conditions are required to ensure salient climate change related information and knowledge co-produced through boundary organisations have long-standing effects? The paper adopts the distinction between usable and useful information proposed by Chong et al. (2017) that the former generally refers to the format in which knowledge and information is made available to users (e.g., user friendly, simplified outputs from models etc), and the second not only refers to its salience to decision-making but is also long-lasting in its ability to be useful.

3. Projects description, data collection and analysis

The paper focuses on two independent collaborative research projects carried out in Brazil (Cities, Vulnerability and Climate Change: an integrated and interdisciplinary approach to analyse actions and adaptive capacity - CiAdapta project) and Australia (Climate Change Adaptation for Natural Resource Management in East Coast Australia - NRM project). While both projects were not initially conceived as boundary organisations, they reached this status in the course of their implementation because they brought together a raft of researchers from different knowledge fields and practitioners willing to advance climate change adaptation within their work spheres. Additionally, the research methods adopted by both projects were predicated on multiple interactive sessions between researchers and non-researchers to maximise the uptake of information and application to relevant plans and policies. Table 1 presents an overview of both projects.

[insert Table 1 near here]

The projects adopted differing qualitative mixed-methods approaches as described below.

Project 1: The CiAdapta project

The project adopted an interdisciplinary mixed-methods research approach, combining qualitative and quantitative methods for data collection. It started with the revision

of state-of-the-art climate information, including IPCC reports and climate change datasets, followed by the analysis of current urban policy instruments and legislation (e.g. land use plans and municipal level plans relating to climate change, urban mobility, green infrastructure and management of climate risks).

Guided by the need to exchange information between researchers and non-researchers, and promote a dialogic process, the CiAdapta Project comprised a series of interactive workshops with practitioners who worked with urban, climate and environmental issues in six capital cities (see Table 1). All workshops followed the same structure: in the first part, practitioners were invited to explore how their city was responding to climate change, focusing on adaptation strategies and local initiatives already implemented by their departments and by the local public administration. In the second part, the research team presented the current available knowledge of climate change (in terms of projections and local impacts), and discussed with the practitioners what information was still missing for specific regional and local contexts. In the last part, practitioners explored opportunities for improving their local adaptive capacity, highlighting possibilities to overcome some identified barriers and bring adaptation closer to their own professional roles. The interactive mode adopted at the workshops was crucial to engage a variety of practitioners with different experiences, knowledge and expectations, and build a trustful environment to reflect on climate issues and adaptation measures. Empirical data was also collected through semi-structured interviews with 40 practitioners working across different departments (e.g. environment, planning, civil defence, health and transport). The interviews aimed to collect information related to extreme weather events, which have been more frequent in these cities, government strategies to deal with these events, and elements that influence the city's adaptive capacity.

Project 2: NRM project

Guided by the action-research paradigm (Reason and Bradbury 2006), the NRM project comprised a series of five two-day workshops and 11 semi-structured follow-up interviews with practitioners at the completion of the project, both facilitated by the engagement team of the research consortium. All two-day workshops followed the same structure. The first day was dedicated to sharing and discussing research needs and outputs. At the workshops, practitioners from six NRM organisations (see Table 1) had the opportunity to discuss their practice needs with researchers who in turn had the opportunity to explain to practitioners their research activities and outputs. This interactive mode adopted at the first workshop was instrumental to fine tune research outputs to ensure they were usable for practitioners. The second day was specifically designed to provide face-to-face interactions for the existing community of practice (cf. Wenger 2000) involving planners from the six NRM organisations and the engagement team. During these workshops, practitioners had the opportunity to share how their organisations were developing their planning strategies, including how they were using research outputs generated by the research partners and other collaborations being developed within and outside the consortium. Follow-up interviews at the end of the project were carried out over the phone, lasted approximately between thirty minutes to one-hour and were transcribed verbatim. Interviews aimed to collect information related to the applicability of research outputs and sustenance of the community of practice.

3.1 Analytical framework

As outlined in the introduction, the research question this paper seeks to answer is:

"*What conditions are required to ensure salient climate change related information and knowledge co-produced through boundary organisations have long standing effects*?"

While it is difficult to separate what constitutes usable and useful information, to answer the research question we adopted Chong et al. (2017) distinction that usable refers to the format in which knowledge and information is made available to users (e.g., user friendly, simplified outputs from models etc), whereas useful refers to its salience to decision-making and long-lasting effects. We followed this distinction to establish six criteria to guide the data analysis and extract key findings from each project. We advance this distinction by inserting a temporal scale to the effect that usable information refers to more immediate aspects such as issues covered, format of output, and fitness to users' needs. On the other hand, useful information not only departs from the immediacy aspect but also extends over longer time frames. For example, this could include current and future opportunities for including usable information in plan/policy review processes; or changing political context favouring, or not, the use of information. We understand that such distinction is not straightforward because knowledge generation evolves and individual, organisational and institutional/political contexts, and problems requiring solutions also change over time. To this end, two criteria refer directly to information usability from the immediacy stand point, including:

i) The usability of research outputs for planning for climate change adaptation based on issues/ themes addressed. While this relates back to the salience of information, this criterion explored how outputs covered issues that fit immediate or shot-term knowledge needs of practitioners.
ii) The enablers to the application of research outputs based on their format and readiness for use. This criterion explored what output types and formats were more likely to enable their use without the need for practitioners to further process or treat information/data.

Four criteria refer directly to information usefulness from the immediate to short/ log-term stand point, including:

iii) Future opportunities for using research outputs. This criterion explored how practitioners could foresee any future application of outputs, especially relating to known plan/policy review cycles.
iv) Context aspects identified by practitioners. This criterion explored how the context (individual, organisation and/or institutional/political) in which practitioners operated could influence the use of outputs.
v) Project's contribution to improving practitioner's capacity to deal with climate change adaptation in their work. This criterion explored what elements of the projects were instrumental in developing practitioner's knowledge and ability to use information. While this could be an immediate aspect of the project, it is assumed that this would have a long-lasting effect because (i) practitioners could become more proficient in applying climate change information to novel or future situations, and/or (ii) engage with other initiatives to do so.
vi) Support for existing and future collaboration between project partners or other organisations. This criterion explored what elements of the projects were conducive to creating and sustaining collaboration among non-researchers and researchers within and outside project's duration and membership.

CiAdapta project's data used to inform this paper included workshop reports, document analysis, transcripts of semi-structured interviews, and participant observation in selected interactions (e.g. meetings, forums). Data from the NRM project included workshop reports, NRM organisations' plans/documents, and transcripts of semi-structured interviews. Data were analysed through in-depth content analysis (Zhang and Wildemuth 2009) and NVivo software was used to analyse interview transcripts.

4. Results and Discussion

Applying the abovementioned analytical framework, results of data analysis are summarised in Table 2. Four key lessons can be extracted from our analysis that could inform future implementation of boundary organisations focused on climate change related issues. Two lessons relate directly to usability of information from the immediacy stand point, including salience of information and variety of research outputs. Two lessons relate directly to the usefulness of information, especially from mid to long-term stand points, including capacity building and influence of micro, meso and macro-scale context.

[Insert Table 2 near here]

4.1 Salience of information is well recognised and accepted but not sufficient

Lynch, Tryhorn, and Abramson (2008) highlighted how the boundary object itself is key to bring stakeholders together in a collaborative way, secure attention and interest and facilitate shared understanding. Our findings concurred with Lynch et al.'s remarks and confirmed how the importance of the boundary object guiding both projects (i.e., climate change) helped to maintain participants involvement and interest for the duration of the projects. This occurred despite influence of individual, organisation and institutional/political context (discussed in 4.4 below). However, despite the salience of our boundary object we found that it alone wasn't sufficient to maintain the intense level and type of engagement boundary organisations require to function and co-produce knowledge.

While the literature reports on the barriers to uptake of scientific information by practitioners and decision makers (Cvitanovic et al. 2019, Lemos and Kirchhoff 2018), our findings indicated that, in some locations, practitioners appeared to be more interested in this kind of collaborative work compared with scientists. In particular, the CiAdapta project identified scientists' struggle to communicate and translate their research in a way that it becomes more usable by, and useful for, practitioners. Similarly, scientists from the NRM project referred to the timeframe of the initiative and wide range of knowledge needs from practitioners, and the difficulty to both identify existing and develop new information that could be usable to practitioners (Cox et al. 2013).

There is a normative view that co-production is related to a deliberate choice of researchers and non-researchers to co-produce knowledge, as the process promotes inclusion of different perspectives and increases knowledge use in decision-making (Bremer and Meisch 2017, Lemos et al. 2018). However, on-the-ground implementation of such deliberate choice proves complicated. Our findings noted practitioner's engagement and participation were hindered by a certain level of competition with other initiatives (e.g., ICLEI, C40) (project CiAdapta), and relegation of the project activities in terms of priority (NRM project) amongst participants from scientific and research institutions as opposed to genuine openness and commitment to collaboration for knowledge co-production. As noted by other scholars

(Cvitanovic et al. 2019, Serrao-Neumann et al. 2015) there is a wide range of reasons that undermine the engagement of scientists in these types of collaborative initiatives, including, *inter alia*, lack of understanding of traditional research funding agencies, competition for limited research funds, lack of common language due to interdisciplinarity, and being time consuming.

These findings compromise the usability of information because they hinder the generation of outputs which are both fit to practitioner's needs and readily available for application. They also limit the extent to which knowledge is co-produced because participant's priorities and commitments may affect their full engagement.

4.2 Variety of formats of outputs is essential

Previous studies have recognised the difficulty of translating complex climate change related information to inform policy implementation (Borquez, Aldunce, and Adler 2017, Tàbara, St. Clair, and Hermansen 2017). This includes both the type of research outputs and the inherent uncertainty in climate change projections which require a different approach to policy implementation so as to enable it to deal with non-linearity and shocks. Our findings indicated that research outputs needed to be produced in a variety of formats to suit the needs, ability and capacity of different organisations to process and apply them, including technical and human resource capacity. For example, less resourced, smaller agencies tended to favour more prescriptive approaches to overcome their lack of capacity; whereas larger, well-resourced agencies preferred to 'pick and choose' from a menu of outputs (e.g., data time series, climate storylines) to suit their needs at differing times. While this difference amongst participating agencies may impinge more effort to manage overall activities carried out by the boundary organisation, in both projects such difference did not raise any conflict and participants often shared their experiences and offer support to complement each other's needs. Additionally, in the NRM project such difference resulted in collaboration between participating agencies outside the actual work of the project to jointly fund vulnerability assessments suitable to their location. This finding confirms that for information to be usable it is essential that outputs are generated in a range of format and variety (i.e., in terms of their complexity) to suit different organisation's needs and capacity.

4.3 Enablers and barriers to creating knowledge and developing capacity

The literature noted that when it comes to knowledge co-production the 'level and quality' of interactions between participants is a crucial element (Lemos and Kirchhoff 2018). Our findings indicated that in addition to the variety of formats in delivering and accessing outputs, interactive workshops were clearly recognised as essential enabler to build new knowledge and develop capacity of participants – especially when dealing with complex information and time poor situation of practitioners to 'digest' new information.

Nonetheless, our projects generated a limited amount of new knowledge that was readily available to, and used by, practitioners due to the mismatch of time scales and needs involving research production (e.g., duration of peer review process) and application of research outputs by practice (adoption by practitioners, and informing policy implementation and decision-making). Hence, the application of existing, adapted knowledge by practice seemed to dominate the process. For example, this occurred regardless of the effort made by the NRM project from its outset to carry out conversations to identify the needs of practitioners and what researchers could provide based on, or adapted from, their previous

research outputs. This proved to be a difficult task because practitioners didn't know what was available and researchers didn't know what priorities practitioners had. Perhaps, to some extent, this was a novel situation for some researchers (i.e., being directly engaged with knowledge users); others found it difficult to get out of their depth to rethink how their research outputs could be modified to suit practitioner's needs.

On the one hand, practitioners struggled to balance the amount of work needed to process a considerable amount of potentially usable scientific outputs with other administrative and reporting burdens from their organisations and funding agencies. Government based practitioners (i.e., CiAdapta project) also found it difficult to mobilise colleagues from other departments that have critical responsibility in the effective implementation of climate change related policies (e.g., land use planning, operational procedures). This issue was exacerbated because some practitioners participated in multiple research and non-research related initiatives as they were often considered to be the 'champions', or have the necessary expertise, within their organisations to be involved in such initiatives. This is problematic considering the relatively high-level of staff churn and long-term employment uncertainty in the field (see discussion in item 4.4 below). On the other hand, without being able to pin point exactly how their research expertise and outputs could fulfil practitioners' need, scientists resorted to their familiar way of knowledge production as opposed to co-production. Additionally, there were knowledge gaps relating to scientific expertise and limitation of research outputs (e.g., single response location or variable) to deal with issues practitioners faced. This shows the limitation of available scientific information to address more complex problems practitioners were dealing with in their day-to-day work (e.g., land rehabilitation advice following major flood events, climate projections with finer spatial resolution to guide land use planning, up-to-date state of the environment reporting).

While face-to-face interaction between researchers and non-researchers comprise a key enabler for knowledge co-production, out findings indicate that there are substantial barriers to this from both ends, researchers and non-researchers, with direct implications for information usefulness and corresponding long-lasting effects of boundary organisations. One particular barrier points to the uncertainty with which issues emerge in the day-to-day work practitioners deal with and the time lag it takes science to provide answers that are sound and robust. It appears that the knowledge production process is not able to quickly respond to the dynamic situation experienced by practice, in light of absent information decisions thus may need to rely on tacit knowledge which therefore challenges the actual need for boundary organisations to be created in the first place. While this situation may be more an example of how usable information is considering its immediacy dimension, such information 'deficit' is likely to also influence future situations and compromise long-lasting effects. It also presents considerable challenges to society given the difficulty to predict how, when and where climate change will influence the severity and frequency of extreme weather events.

4.4 Influence of micro, meso and macro-scale context

Recent scholarly research carried out by Flagg and Kirchhoff (2018) discusses the role context plays in the usefulness of climate related information in addition to more traditional usable aspects such as output format. The authors identified three levels at which context can influence the application, or otherwise, of climate information, including individual (micro), organisational (meso) and institutional/political (macro) scales. Our

findings confirm such influence across all levels, including how they can compound and influence each other.

One of the key purposes of boundary organisations is to narrow the science policy gap through improved cooperation between a range of partners (Star and Griesemer 1989, Guston 2001). This is particularly emphasised in the climate change realm where the lack of action is often justified by the complexity and uncertainty inherent in climate science (Mastrandrea et al. 2010). While cooperation between partners was generally successful for the duration of both projects (e.g., interest in partnering in future research projects, joint forums, participation in expert panels), our findings indicated that their long-lasting effects were less evident because of direct meshed influence from both individual and organisational aspects. For example, at the individual scale, we identified that often practitioners had to juggled competing priorities and participation across multiple initiatives which made it difficult for information to be disseminated within their respective organisations (see section 4.3). Long-lasting impacts were also hindered by the high level of staff churn and associated loss of organisational learning and capacity due to long-term employment uncertainty and workplace redundancies. As identified by Lemos et al. (2018), the constant request for participation in co-production may lead to fatigue among stakeholders repeatedly sought out as co-production partners. The authors also reported on how the strong reliance on 'champion' practitioners (who get overloaded by participating across too many projects/ collaborations) also hindered continuity of boundary organisations effects because they tended to maintain internal power and control over information/ knowledge accessed through initiatives. These champions take with them all knowledge/ information/ learning when they leave their organisations.

In parallel, researchers struggled to tailor their research to practitioner's need whilst meeting their own professional performance indicators such as generating peer-reviewed outputs. Again, this is a direct effect of the organisational structures within which they have to operate where academic productivity is imperative. Closely allied to this, at the organisational scale there was significant uncertainty regarding employment in this field in both countries for the duration of the projects - that is, the majority of practitioners had temporary work contracts as opposed to being permanent staff members of the organisations they represented (NRM project), or were under constant threat by public administration trends towards redundancies and reduction of permanent staff numbers with technical and administrative knowledge (CiAdapta project). In fact, our findings indicated that staff churn in the field seems to be the norm rather than the exception; thereby, highlighting the need for proper organisational learning structures. This speaks directly to the usefulness of information. In this case, it doesn't matter how usable a research output is if who acquired the information/ knowledge does not, or is unable to, share it, therefore closing the cycle of influence the output could have on future situations.

Additionally, at the organisational – institutional/political interface, our studies noted the difficulties to continued collaboration after funding for the projects ceased, even when communities of practice were previously operating (i.e., NRM project). Porter and Birdi (2018) noted that unsustained participation can undo collaboration processes despite the contribution of effective boundary organisations. Hence, without the necessary funding to support existing networks and create new ones it is unlikely that collaborations will be maintained, and the related impact of boundary organisations will finish with projects that set them up. Many funding mechanisms are being increasingly influenced by the political sphere (e.g., shifts in research funding even when this is secured by statutory mechanisms) which in turn increases competition for the same funding avenue by organisations, rather than collaboration (Vella et al. 2015).

Notably, it is widely acknowledged that unfriendly political conditions negatively affect advancements in urban climate governance and adaptation (Flagg and Kirchhoff 2018, Tangney and Howes 2015). Urban political economic structures (e.g., economic interests, political ideology, social movement that contests planning agendas) have an important role in the climate change adaptation process (Chu, Anguelovski, and Roberts 2017). Worldwide, including in large cities in the global South, political cycles affect the development of urban adaptation processes even where efforts are already underway (Carmin, Anguelovski, and Roberts 2012, Di Giulio et al. 2019). This macro force certainly affects the effectiveness and continuity of boundary organisations, including their long-lasting effects through uptake of knowledge produced, opportunities for collaborations to continue beyond the duration of projects, and appropriate investment in human resources and intra-agency expertise. This was the case of the NRM project which was initially funded by a carbon tax axed with the election of a climate change skeptic federal government.

Furthermore, the literature focusing on urban climate change experiences and environmental governance highlight a distinction between policy adoption and policy implementation. The first tends to be relatively politically palatable; whereas the second requires concrete government actions, including organisational and economic resources, and therefore may trigger latent resistance to emerge (Ryan 2015). Again, such macro scale force is not necessarily related to boundary organisations effectiveness in supporting climate change adaptation but certainly impacts on the extent to which their gains are long-lasting. For example, as seen elsewhere (Serrao-Neumann et al. 2014, Taylor, Harman, and Inman 2013) the practitioners from the CiAdapta confirmed that the implementation of climate change adaptation and mitigation measures involving contested land use planning issues (i.e., property rights, land and property prices) are often delayed because of political pressure from interest groups. These practitioners also identified the limited capacity of local governments in rolling out measures that are tied to metropolitan scale and multiple jurisdiction issues (e.g., land use planning and water resources). Hence, neither the availability nor the amount of scientific evidence relating to climate change guarantee its use in decision-making.

5. Conclusion

This paper aimed to extract lessons from two collaborative projects to distil the necessary conditions for the long-term influence of boundary organisations for advancing climate change adaptation. We found that two key systemic changes are needed for this to occur despite the salience and pressing urgency of climate change adaptation. These include changes in: (i) the science, knowledge production process; and, (ii) political culture.

Our findings indicate that practitioners alone, and their relentless workloads, employment conditions and political impediments, will not be able to advance adaptation without the support from the scientific community. Our findings also confirmed that face-to-face interactions are more likely to result in research having the societal impact that is being increasingly required by research and funding bodies. Producing fit for purpose scientific outputs on a variety of formats takes time, as does their translation and application by practice. This points to the key role of transdisciplinary research (including co-design, co-production and co-dissemination of knowledge/information) in achieving transformative pathways for sustainability and sustainable climate adaptation. Hence, the first systemic change needs to challenge the notion that co-production of knowledge, collaboration with non-researchers and applied research are a burden on individual scientific careers. While transdisciplinary research has short falls, it is highly unlike that there will be a return to pre post-normal science (Funtowicz and Ravetz 1993), especially under the current emergency

called into the climate change crisis. The only way forward is to improve how we carry out transdisciplinary research, or any other potential paradigm that might replace this. Our findings, however, noted that from an epistemological viewpoint transdisciplinary is still a challenge for many researchers. Some who embarked on our projects were confronted for the first time with the usability and usefulness aspect of their research; others had more experience but each transdisciplinary project is unique with respect to the mix of people, expertise, research topics, and context. This points to the evolving aspect of transdisciplinary research itself – that is, we are still doing-by-learning and learning-by-doing (Loorbach and Rotmans 2006). Unsurprisingly, when coupled with another evolving science (i.e., climate change) it is expected that there won't be a straightforward solution to how to do transdisciplinary research more efficiently.

Our findings, however, also identified that changes to the interactive, interdisciplinary mode of knowledge co-design, co-production and co-dissemination may not be sufficient to increase information usefulness because there are other factors influencing this at meso and macro scales. Perhaps the key barrier that needs be overturned lies within the political sphere. The shift in the political culture is closely allied to this situation because it not only would (re)value work relating to environmental issues by providing much needed stability to practitioners and funding for transdisciplinary research, but also could at least attempt to create safe spaces for experimentation to occur. Perhaps the way forward here might be to expand the 'safe-to-fail' concept (Ahern 2011) to decision-making spheres by creating safe spaces where both researchers and non-researchers can break free from political and professional entrapment (Brown, Ashley, and Farrelly 2011). In particular, there needs to be a political shift towards accepting that environmental and inherent climate change issues are important and real. While we continue to see a devaluation of professional (staff churn, technical and scientific dismantling in public administration) and scientific expertise (scepticism, lack of trust in science), and their role in informing decision-making, there will be limited scope for having more comprehensive climate change adaptation response. Additionally, because climate change impacts will be occurring in a non-linear mode well into the future, the biggest challenge facing decision-making is the alignment of short-term plans and visions produced by short-term electoral cycles with the long-term perspective that is required to enable society to deal with future environmental and social change. This endeavour is further compounded by increasing social inequalities (especially in the global South), budget constraints and loss of corporate knowledge. These changes are not easy to be achieved, but we cannot pretend that they don't exist and continue our business-as-usual approach to knowledge production and decision-making.

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Table 1. Overview of projects

Overview	CiAdapta	NRM project
Project aims	To understand how the governments of six large Brazilian cities are coping with public policies for climate adaptation, and engage local practitioners in deliberation to identify effective practices for adaptation (reflecting on some barriers and opportunities).	To foster and support an effective community of practice for climate change adaptation within the East Coast Cluster (six regional organisations engaged in natural resource management).
Project duration	2015-2018	2012-2016
Structure of boundary organisation	Research consortium involving eight Brazilian research institutions (in collaboration with an international university), and support from local practitioners. One member of the research consortium had the primary role of facilitating the engagement activities for the project.	Research consortium involving four research institutions, two state government agencies, and the East Coast Cluster (six natural resource management regional organisations). One member of the research consortium had the primary role of facilitating the engagement activities for the project.
Project outcomes	State-of-the-art climate information review (e.g. regional climate change projections, development of socioclimatic vulnerability index for these six cities); analysis of local governance arrangements to achieve climate adaptation policy-making; exchange information between researchers and end-users (advancing dialogic processes); production of technical reports (focused on climate adaptation, identified barriers and opportunities).	Incorporation of research outputs in natural resource management regional plans (e.g. climate change projections, coastal vulnerability analysis, carbon farming framework); expert panels provided support to natural resource management organisations; ongoing inter-regional connections to share learnings; and development of new initiatives (e.g. website chapter on biodiversity adaptation, spatial analysis tool for carbon farming).
Location	São Paulo, Vitória – Southeast region; Porto Alegre, Curitiba – South region; Natal – Northeast region; Manaus – North region. These cities have different levels of vulnerability to climatic risks (Darela Filho et al. 2016), are located in different regions and biomes, are the centres of six important Brazilian metropolitan regions, and where both the resources and problems that affect urban systems are concentrated, making them critical cases for understanding opportunities and constraints for mitigating and adapting to climate impacts. 	East Coast of Australia – New South Wales: North Coast, Hunter and Greater Sydney Local Land Services Queensland: Fitzroin Basin Association, Burnett Mary Regional Group and former SEQ Catchments. 

Table 2. Summary of findings across the two projects related to six assessment criteria

Assessment Criteria		CiAdapta project findings	Examples	NRM project findings	Examples
Information / output usability	**Usability of research outputs for planning for climate change adaptation based on issues/ themes addressed.**	• Technical reports focused on review of regional climate information and critical elements for improving the local adaptive capacity • Information that could be used for planning efforts for climate adaptation	• Downscaled climate projections, assessment of barriers and opportunities for local climate adaptation • Socioclimatic vulnerability assessments	• The provision of research summary reports that clarified and/or generated new information were welcome by practitioners. • Practitioners appreciated the sharing/ availability of tools/information that could be readily used for planning for climate change and stakeholder engagement.	• Social and economic vulnerability assessment, coastal vulnerability analysis • Downscaled climate projections, carbon farming mapping and assessment framework, scenario planning exercise/ training
	Enablers to the application of research outputs application based on their format and readiness for use.	• Ability of research outputs to be incorporated in the local agenda depends on the information availability, resources, and mostly important, support among local governments and from part of the municipal staff	• Vulnerability assessments, technical reports, face-to-face workshops, interviews to the local media	• Ability of research outputs to be interrogated and applied by different tools was essential • Mix of formats of outputs was advantageous	• Vulnerability assessments • GIS data/ spatial layers, synthesis reports, web-based platforms, face-to-face workshops
Information / output usefulness	**Future opportunities for using research outputs.**	• Addressing planning efforts and urban policy instruments connected to climate change, stimulating non-regret measures	• Downscaled climate projections, land use planning (review of Master Plans), stakeholder communication	• Outputs that were complementary to existing planning mechanisms were more likely to be used in the future	• Downscaled climate projections and future land use planning, stakeholder communication, and NRM plan development
	Context aspects identified by practitioners.	• There is a close connection between development, adaptation and sustainability • Urban planning dynamics affect climate change policies and concrete interventions • There is a need for engagement of civil society, economic actors and private sector groups	• Better understanding about non-regrets policy is crucial to align adaptation to urban sustainability, and mobilize local governments • Bureaucratic and political utilitarian perspective strongly influences political trends and will, and concentrations of financial and human resources at the municipal level	• Mismatch in funding opportunities and planning stage and timing and availability of released outputs were challenging to manage • Understanding differing capacity among organisations in how they planned and implemented initiatives was critical	• Organisations were at differing stages in their plan review and implementation cycle, and corresponding funding availability • Engagement workshops and needs analysis with all consortium members

Assessment Criteria		CiAdapta project findings	Examples	NRM project findings	Examples
			• Engagement workshops and meetings/forums of climate adaptation; interviews for the local media		
	Contribution improving to practitioner's capacity to deal with climate change adaptation in their work.	• Capacity to bring their different experiences, knowledge and expectations to reflect on climate issues and propose adaptation measures	• Face-to-face workshops and meetings	• Increased capacity to plan for climate change was especially supported by expanded networks that can be accessed in the future • Face-to-face demonstration on how to use outputs • Engagement of NRM planners from the project outset enabled them to enhance their capacity to apply new knowledge and monitor it over time	• Participation in expert panels and steering group during plan review process • Development of spatial analysis tool (tri-cluster modelling and carbon farming) • Regular engagement workshops facilitated inter-regional connections and learning about research outputs
	Support for existing and future collaboration between project partners and other organisations.	• There is a need to improve the collaboration between municipal departments and local public universities	• Meetings/forums of climate adaptation and urban sustainability • Interest in partnering in future research projects (e.g. nexus water-energy-food)	• Limited support for existing collaboration between organisations, with exception of some collaboration with government and research agencies, and interpersonal collaboration (albeit this was limited due to high staff turnover) • Limited contribution to establishing new collaborations post-project, with only some ad hoc engagement of consortium partners	• Participation in expert panels and steering group during plan review process • Interest in partnering in future research projects (e.g. blue carbon farming)

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