An Embedded Researcher approach to integrate climate information into decision making in southern African cities: lessons from FRACTAL

Lulu Pretorius, Anna Taylor, Kornelia N Iipinge,
Brenda Mwalukanga, Hecrálito Mucavele, Rudo Mamombe,
Sandra Zenda and Alice McClure

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The Future Resilience for African Cities and Lands (FRACTAL) project aims to address the challenge of providing accessible, timely, applicable and defensible climate information that is needed by decision makers operating at the city-region scale in southern Africa. FRACTAL has been running since June 2015. It is part of the Future Climate for Africa (FCFA) multi-consortia programme. FCFA's major objective is to generate fundamentally new climate science focused on Africa, and to ensure that this science has an impact on human development across the continent. FCFA is funded by the Department for International Development (DFID) and the Natural Environment Research Council (NERC).

These knowledge products have been developed to share findings from the research in the hope of fostering dialogue and eliciting feedback to strengthen the research. The opinions expressed are therefore those of the author(s) and are not necessarily shared by DFID, NERC or other programme partners.

About the authors

Lulu Pretorius | School of Life Sciences, University of KwaZulu-Natal & Environmental Planning and Climate Protection Department, eThekwini Municipality, South Africa

Anna Taylor | The Climate System Analysis Group, University of Cape Town, South Africa

Kornelia N Iipinge | Department of Biological Sciences, University of Namibia & Department of Economic Development & Community Services, City of Windhoek, Namibia

Brenda Mwalukanga | Department of Geography & Environmental Studies, University of Zambia & City Planning Department, Lusaka City Council, Zambia

Hecrálito Mucavele | Department of Physics, Eduardo Mondlane University & Urban Planning and Environment Municipal Directory, Maputo Municipality Council, Mozambique

Rudo Mamombe | Department of Freshwater and Fishery Sciences, Chinhoyi University of Technology & Department of Harare Water, Harare City Council, Zimbabwe

Sandra Zenda | Department of Freshwater and Fishery Sciences, Chinhoyi University of Technology & Department of Harare Water, Harare City Council, Zimbabwe

Alice McClure | The Climate System Analysis Group, University of Cape Town, South Africa

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1. Introduction

There is often a disconnection or gap between scientific knowledge and the implementation of actions aimed at addressing related problems. This gap is especially evident in fields with complex interactions between a multitude of factors and actors, such as sustainability challenges, biodiversity conservation, environmental management and addressing climate change (Moser and Dilling, 2011; Lang et al., 2012; O'Brien, 2013; Cook et al., 2013; Swilling, 2014; Cockburn et al., 2016). Transdisciplinary approaches are increasingly being proposed and attempted to bridge the gap(s) between science and action (Reyers et al., 2010; Cook et al., 2013; Lawrence, 2015). Transdisciplinarity not only bridges and integrates across disciplines and professions, but through this approach science becomes a more inclusive social process of resolving problems through the participation and mutual learning of stakeholders in the government, business and civil society sectors. Making science, or the structured pursuit of improved knowledge, more inclusive is important because the knowledge sought (and the resources invested in it) is more reflective of priorities widely-held in society and the products of research are more widely understood and thereby more readily able to be acted upon.

Building the climate resilience of African cities fits squarely within the category of complex problems that may benefit from taking a transdisciplinary approach to co-producing actionable knowledge between multiple actors and disciplines (Taylor et al., 2017). Yet one of the key challenges in implementing a transdisciplinary approach is building enough trust, familiarity and understanding across various boundaries to engage in meaningful co-production. The Future Resilience for African Cities and Lands (FRACTAL) project[1] employed several strategies to address this challenge, one of which is the establishment of embedded researchers (ERs). This FRACTAL Working Paper presents: the rationale for undertaking embedded research; the aims of embedded research within FRACTAL; the ways in which embedded research is being implemented in each of the city contexts; and the lessons learned to-date from implementing the approach in five cities, focussing on the benefits; and the challenges of the approach. It is written for those in academia, government agencies, NGOs and companies who are interested in potentially conducting embedded research themselves, or in recruiting an embedded researcher (ER) to work with them in their organization and/or in a partner organization (e.g. academic supervisors and managers in the host organizations). It is also written for the colleagues of ERs, particularly our own colleagues in the university and the city government, who wonder and ask us what we are doing, because it is a role that is unusual and unfamiliar to them. In addition, this Working Paper is written for project designers and funders who are interested in incorporating the embedded research approach into projects and for those in other projects already using a version of embedded research, as a basis for comparison and mutual learning.

1 Future Resilience for African CiTies and Lands (FRACTAL) is a four-year project led by the Climate System Analysis Group (CSAG) at the University of Cape Town. FRACTAL aims to provide accessible, defensible and actionable climate information to decision-makers operating at the city-regional scale in southern Africa, by co-producing relevant climate knowledge needed to navigate resilient development pathways.

2. The conceptual underpinnings and rationale of the ER approach

To tackle many of the complex challenges faced globally today knowledge, policy and practice need to be brought closer together such that both theory and practical, contextual experiences and learning shape future choices and actions. While this learning cycle occurs somewhat autonomously at the individual and small scale, having it work within and between large organizations and networks at a system-wide scale, requires conscious design, the creation of and investment in new roles and functions, and sustained processes of engagement and research. Cook et al. (2013) recommend four frameworks that can provide mechanisms for promoting communication, translation, and mediation across the 'knowledge–action boundary'. These are: boundary organizations (organizations that span the boundary between science and management); formal links between decision makers and scientists at research-focused institutions (e.g. advisory committees); training programs for professionals; and research scientists embedded in management agencies. It is this last framework which forms an integral and fundamental part of FRACTAL's approach to integrate climate information into decision making in southern African cities.

Embedded researchers are individuals or teams who are employed by a research institution and are deployed to work (part of their time) within a host organisation with the purpose of identifying and implementing a collaborative research agenda (McGinity and Salokangas, 2014). According to Jenkins et al. (2012) an embedded researcher can increase research impact - even in domains of high uncertainty - by spending an intensive period enmeshed in the culture and operations of other work communities. The embedded experience, which can range from conducting highly structured research to being a casual participant-observer in another community, gives scientists (both natural and social scientists) opportunities to build personal relationships, facilitate the spread of new ideas, and learn the constraints and initiatives specific to a particular organisation or community – all of which may improve the impact of research on policy and practice, as well as shaping the research agenda based on knowledge needs within the policy and practitioner communities. Vindrola-Padros et al. (2016) describe embedded researchers as knowledge brokers and boundary spanners. They work beyond organisational boundaries and conduct research for knowledge co-production in order to better understand, conceptualize and represent or articulate the phenomenon under study than would be possible through observation and data collection from the outside (Vindrola-Padros et al. 2016). By design, both academic organisations and host organisations should mutually benefit from embeddedness (McGinity and Salokangas 2014). Embedded research has evolved as an innovative way of bridging the research and policy or practice gap in various sectors and disciplines (Oliver et al., 2014). In the health sector for instance, Marshall et al. (2014), Oliver et al. (2014), Ghaffar et al. (2017) and others recognise the value of and need for more embedded research as a way of strengthening health systems.

3. Applying the ER approach in FRACTAL

For cities to develop in ways that are sustainable, climate resilient and equitable, considerations of climate variability and change must factor into planning, investment and management decisions (Bulkeley, 2013; Bai et al., 2018). To do so requires robust, actionable climate information (Hewitson et al., 2017). But it also requires the organizational capabilities and mechanisms to factor climate information into complex technical and political urban decision-making processes. Many fast-growing African cities are only partially serviced and regulated with formal infrastructures and government regulations, and regularly experience a variety of severe cli-

mate impacts on health, mobility, livelihoods and physical assets (Kumssa et al., 2015). At the same time, climate data and scientific expertise are scarce in most African urban contexts. As a result, very little consideration is currently given to climate risks in making development decisions, especially the evolution of climate risks under future scenarios of climate change (Jack, 2017). The question is how to change this situation to better integrate climate considerations and build the climate resilience of cities across Africa and beyond?

3.1 Aim and objectives of the FRACTAL ER approach

The overall aim of the FRACTAL project is to adapt southern African cities to function better and more equitably within both the present and the future climate. One aspect of addressing this aim requires that more and better scientific climate information, which is robust, timely and context relevant, is accessible to urban decision-makers. Ensuring the accessibility, relevance and timeliness in turn requires a much better understanding of where and how the climate information might be used, and thereby what information might be suitable. This surfaces a need to span the boundaries between urban decision-making (both policy and management decisions) and science. One of the approaches to spanning this boundary that has been implemented in the FRACTAL project is the creation of intermediaries, in the form of recruiting ERs in five cities to be employed by the local university and spend time working in government on climate-related matters of mutual interest and concern. The specific objectives of the FRACTAL ERs have been to facilitate and contribute to:

- Co-exploring existing knowledge and co-producing new knowledge on urban climate sensitivities and processes of adapting and building climate resilience in southern African cities between scientists and decision-makers;
- Creating and sustaining learning forums and mechanisms with the long-term goal of shifting the way urban development, resource management and infrastructure investment decisions are made in southern African cities, through advancing the integration of relevant and contextual climate information;
- Strengthening urban governance networks across the public, private and civil society sectors, within and between southern African cities, and building a culture of learning within these networks;
- Sharing lessons about adapting to a highly variable and changing climate across southern African cities in the FRACTAL network and ultimately with other cities globally.

A second approach to spanning the domains of research and urban decision-making used in FRACTAL is the hosting of Learning Labs[2], which are central to the FRACTAL ERs' responsibilities in their cities. This involves gathering a range of stakeholders in a city region to identify and characterize climate-sensitive problems or 'burning issues' in their cities, to explore the decision-making processes and governance around these burning issues, and to develop relevant climate information needed to inform policy choices and management interventions. In addition to Learning Labs, FRACTAL ERs - together with FRACTAL team members - also cultivate linkages and synergies through convening awareness raising, training and leadership workshops, contributing to policy development and planning and budget meetings, preparing policy briefs, working papers, project digests, and facilitating other opportunities as they may arise. These objectives and activities cannot be achieved by the ERs alone. Strong support and commitment is required from all individuals, partner organizations and stakeholders involved in FRACTAL,

2 See companion Working Paper (Koelle et al., 2019) in the FRACTAL series for a detailed description of the Learning Lab process.

within each city, regionally and internationally.

3.2 Partnership approach to ERs

The approach taken in FRACTAL to embedding researchers in numerous cities is illustrated in Figures 1 and 2. There was one ER per city in Durban, Lusaka, Maputo and Windhoek. In the case of Harare there were two junior ERs for a shorter duration. ERs were also trialled in Cape Town and Johannesburg with links to the FRACTAL project, but the arrangements in these two cases were substantially different and so their experiences are not reflected in this paper.

Figure 1 illustrates how each city-based university-government partnership involved in the FRACTAL project engaged with the core FRACTAL coordinating team, which for each of the ERs created a network of ERs in other cities and various project teams or clusters via the lead FRACTAL partner.

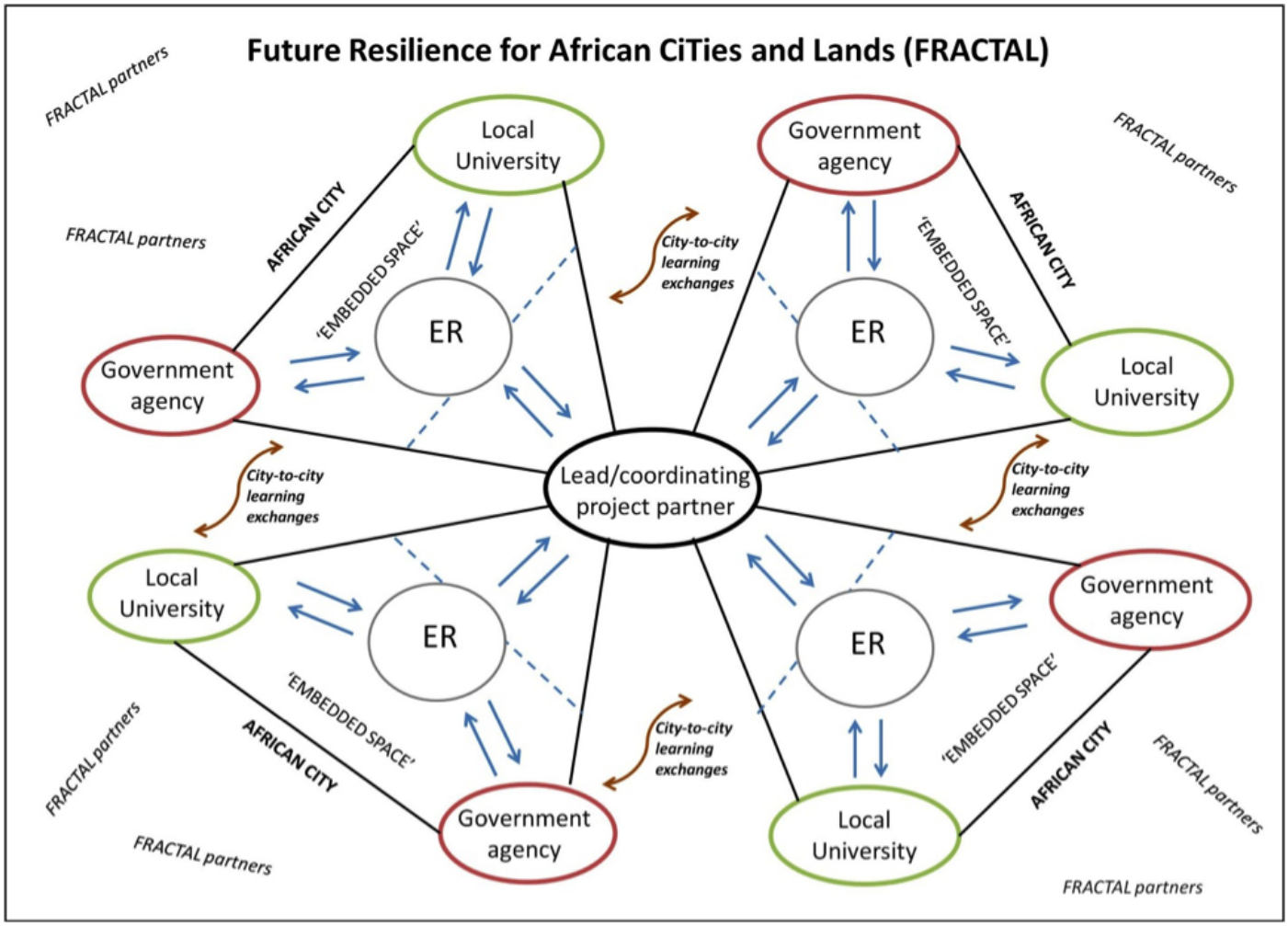

Figure 1: Illustration showing how the various partner cities, each with their own ER, linked together via the core FRACTAL coordinating group. The network of ERs enabled considerable learning to take place between cities, via regular remote engagement and exchange visits. Alongside the FRACTAL partners in each city, various international FRACTAL partners form part of the research and learning activities undertaken in each city.

Figure 2 shows in more detail how the ERs operate within a negotiated space between the local university, local government, and the FRACTAL project lead partner (i.e. CSAG at UCT). This space is governed by formal agreements between the three institutions, a Memorandum of Understanding between all three and a sub-contract between the lead partner and the local university. Each embedded researcher was assigned to two project focal points - one at the local university and one at the local municipality - who act as supervisors. Within the 'embedded space' between the local university and local government, the ERs undertake activities to fulfil their objectives (as set out in Section 3.1. above), which are mainly trust and relationship building and facilitating co-exploration and co-production of knowledge. The pink lines, perpendicular to the red lines in Figure 2, illustrate how the ERs are supported in their engagements in the city by the FRACTAL team, and especially the FRACTAL coordinator (see Section 4). This trilateral partnership in each city is key to the success of the FRACTAL ER approach because the two city-based partners ensure the contextual and conceptual relevance of the ER's work, while the coordinating partner provides structure, guidance, support and learning opportunities relating to the ER approach and the broader themes of the FRACTAL project. Experience from both the FRACTAL project and the preceding Mistra Urban Future project, which informed the FRACTAL project design and approach in numerous ways, suggests that having a cohort of ERs to support and learn from/with each other is beneficial - enabling them to navigate the challenges associated this type of hybrid work.

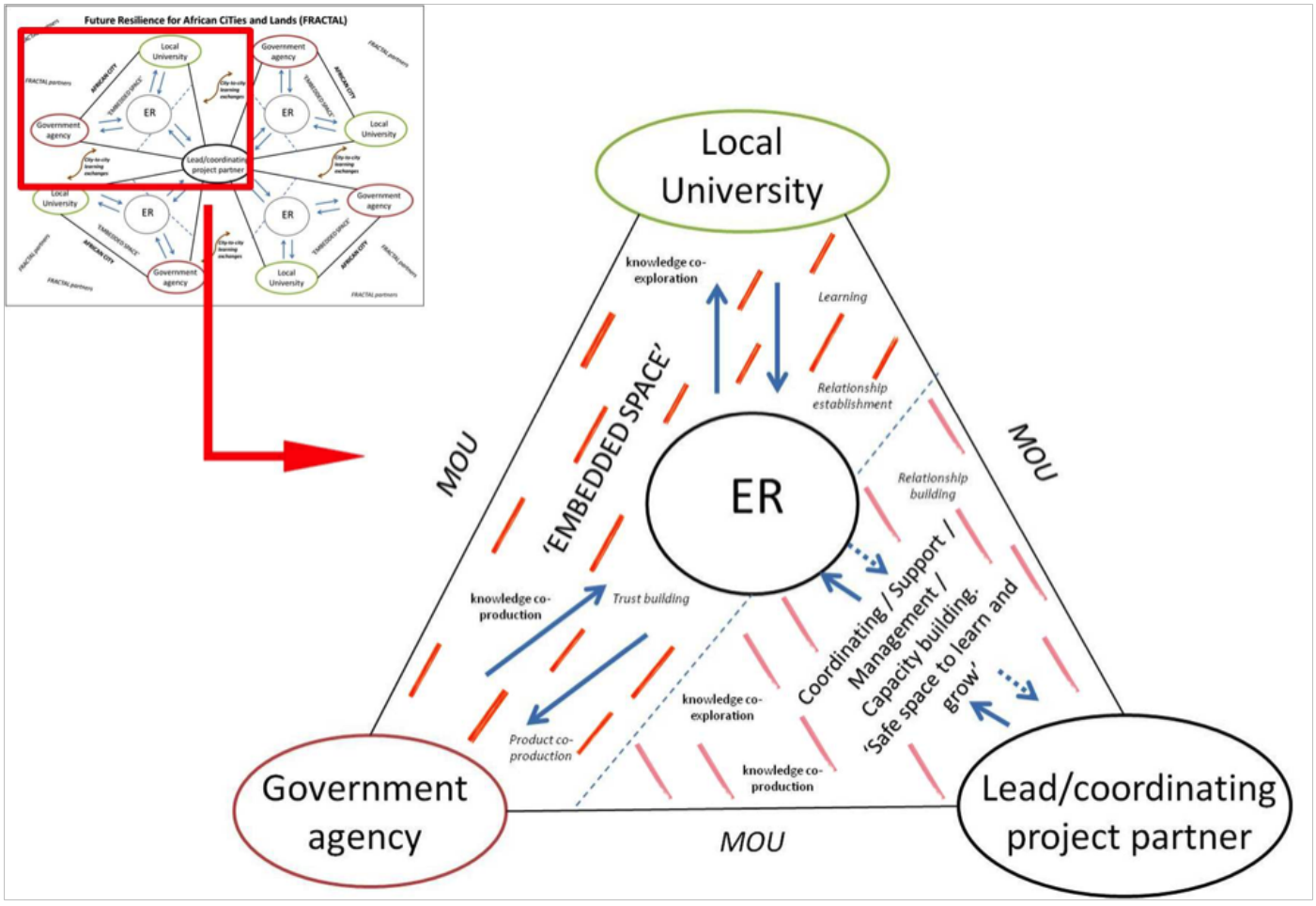

Figure 2: Operational model of one city in the trilateral partnership creating the space within which that city's ER functions. An enlarged illustration of the inset map can be seen in Figure 1.

The design of the ER approach within FRACTAL draws on, and builds upon, the ER model and experiences of the Cape Town Knowledge Transfer Programme, a partnership between the University of Cape Town and the City of Cape Town under the Mistra Urban Futures Programme, see Patel et al. (2015), Miszczak and Patel (2018) and Perry et al. (2018) for details.

3.3 Matching ERs with city contexts

The ERs were instrumental in facilitating the journey of co-exploring and co-defining the climate-related 'burning issues', the governance configurations and climate-relevant decision-making processes within the various city contexts. Based on the climate-related issues, the capacities and organizational entry points in each city, the composition of the FRACTAL project team and the stakeholders involved in the project process were different in each city, bringing different expertise, interests and mandates to the fore in developing the FRACTAL agenda and activities specific to each location. All of these factors played a role in shaping the work-plan and approach of each ER. Durban, for example, identified the integration of climate information into biodiversity planning as a burning issue, while this is not at the forefront of the agenda in other cities. Water emerged as a central issue in most of the other cities, although the exact aspects thereof differed somewhat. Table 1 presents a comparison of the ER arrangements and the climate-related issues focused on in each city. The general approach of FRACTAL towards facilitating co-exploration and co-production of context-relevant climate information was similar across the cities. The outputs of the process, however, differed according to the city context.

	Lusaka	Windhoek	Maputo	Durban	Harare
Duration	Full-time for 3.5 years	Full-time for 3.5 years	Full-time for 3.5 years	Full-time for 2 years	Full-time for 6 months
Government supervision	Director of City Planning, Lusaka City Council	Environmental Management Officer in Department of Economic Development & Community Services, City of Windhoek	City Officer in Environmental Management and Inspection Department, Maputo City Council	Manager of Climate Protection Branch, Environmental Planning and Climate Protection Department, eThekwini Municipality	One attached to Department of Harare Water; another attached to Zimbabwe National Water Authority
University supervision	Senior academic in Department of Geography and Environmental Studies, School of Natural Resources, University of Zambia	Senior academic in Department of Biological Sciences, University of Namibia	Senior academic in Physics Department, Eduardo Mondlane University	Senior academic in School of Life Sciences, University of KwaZulu Natal	Senior academic in Department of Freshwater and Fishery Science, Chinhoyi University of Technology
Expertise of the ER	Masters in Urban Planning and Management; worked as Planner in Lusaka City Council	Masters in Integrated Water Resources Management	Masters in Cartography and Geographic Information Systems (GIS); worked as Senior Technician in Municipality of Maputo	PhD in Environmental Management; consulting and advisory services to industry and government	BSc Honours in Conservation Management; currently enrolled in a Masters programme
Burning issues for FRACTAL in each city	Low/poor water quality, unregulated groundwater abstraction, flooding and inadequate water supply	Water quantity (not quality); and inadequate services provision in informal settlements	Potable water supply, drainage and sanitation	Biodiversity planning and monitoring under climate change	Water supply and management

Table 1: An overview of the ER arrangements and burning issues in each city.

The table shows the diverse expertise and placement of the FRACTAL ERs in each city and how these related to the climate-sensitive issues facing each city that became the focus of FRACTAL work. By its nature, the recruitment process for such a position - with its associated responsibilities and learning opportunities associated with crossing organizational and disciplinary boundaries - draws the type of people who are interested in and willing to think and act outside of their familiar 'home spaces'. Through various supporting activities, training and learning opportunities such a person, no matter their specific background, can then develop and grow into their role as an ER. This implies that, to bring out the best in ERs and maximize the mutual benefit for the organizations involved, those supporting, coordinating, supervising and managing the ERs need to develop a good understanding of the ERs strengths and weaknesses, co-develop a work plan with the ERs at inception phase with a good overview of the expected trajectory of the project and the expectations of the ERs, and then be open and attendant to arising needs to revise, renegotiate and adapt the ERs workflow as the project unfolds, with associated opportunities and hindrances that emerge over the course of the project.

The FRACTAL experience suggests that for an ER to be successful there needs to be a good match between the qualifications and experiences of the ER and the skills required to fulfil the duties that those in the organizational partnership require of them, which span from conceptual and analytical skills to logistical, organizational and inter-personal skills and competencies. Because of the diversity of these demands it is unlikely to find them all in a single candidate, which is why ongoing training and support for ERs is so important. After the appointment of a suitable person, it is recommended that the ERs' roles and responsibilities be re-negotiated within the trilateral partnership, with the level of work experience and academic training of the selected person forming the basis of the negotiations, along with the interests and expertise of those designated to supervise the ER, in light of the aim and objectives of the project. Examples from FRACTAL include:

- **DURBAN** | The need from the eThekwini Municipality was for an academically inclined ER, who could lead certain co-produced, research-based initiatives in the City and with various partners. The FRACTAL partners in Durban therefore advertised a post-doctoral position. Appointing a post-doctoral researcher has certain assumptions associated with it, such as academic publication expectations and an extent of intellectual freedom to develop research interests and academic career opportunities. This has to be negotiated and re-negotiated throughout the project to sufficiently align with the more operational needs of the government partner. With existing academic knowledge and research expertise, the ER needed support in navigating and contributing to the policy, planning and implementation work of city government.
- **LUSAKA AND MAPUTO** | The ERs recruited in these two cities have many years of experience working as officials for local government and were encouraged by colleagues in local government to apply for the ER post and arrange a secondment to the university for the duration of the project. Their 'embedding' was therefore more back into academia and they faced the added challenge of extricating themselves from their regular official duties as government employees. With considerable knowledge of and experience in policy, planning and implementation work within local government, as well as Masters level of training in their disciplines, urban planning and cartography respectively, they required support in navigating and contributing to academic research on climate science, urban governance and decision-making, and balancing project demands with ongoing demands form their original role (a particular challenge across many African cities where staff capacity and hu-

man resources within local governments are severely constrained).

The ERs in the three core cities where FRACTAL has been implemented - Lusaka, Maputo and Windhoek - have been employed full-time through the FRACTAL project for the duration of the project. The Durban ER was funded (also full-time) by the eThekwini Municipality through the Research-Action Partnership (D'RAP) with the University of KwaZulu Natal. In Harare and Cape Town, the ERs were funded through supplementary FRACTAL funds (i.e. Global Environmental Change and Small Opportunity Grant funding respectively) for the duration of those subprojects. The ERs on average spent approximately 60% of their time working in the offices of the city government and the remaining 40% based at the local university, although this varied between the cities and over the duration of the project, depending on the main activities being undertaken and outputs being produced. The division of time was kept flexible and negotiated on a needs basis between the ERs and their two supervisors, whose positions are in each city are given in the Table 1. Central to the work and success of the ERs are the project focal points / ER supervisors, their placement in both institutions, their commitment and capacity to host and supervise an ER, and to guide and support the ER to achieve what is set out.

4. Role and value of an ER coordinator

While the ER approaches presented in existing literature mostly function within bilateral agreements, the structure of the FRACTAL project necessitated a trilateral ER approach (as depicted Figure 2). In the case of FRACTAL, the involvement of a third party (the lead partner and coordination function of the international project consortium) enabled the creation of an ER coordinator role that sat outside of, but was the bridge between, the university-government arrangements in each city. This has added significantly to the success of the approach - both in terms of enhancing the benefits to the individuals and organizations involved and in navigating the many challenges inherent in the approach, as discussed in Sections 5 and 6 respectively.

Within the FRACTAL project the ERs have been coordinated by a part-time ER coordinator, with experience of having been an embedded researcher herself (within the Mistra Urban Futures funded Cape Town Knowledge Transfer Programme mentioned above). The role of the FRACTAL ER coordinator has included:

- Supporting recruitment: preparing job adverts, ToR, short listing candidates, preparing interview questions, reviewing employment contracts;
- Preparing/co-producing, reviewing and updating work plans and providing support to set reasonable boundaries on what can be done, working to avoid situations where the ER is involved in too many tasks and activities simply because they hold considerable knowledge of and networks across both the city and the project;
- Processing monthly ER reports to distil and share progress, lessons, challenges and opportunities amongst ERs, within the wider project team, and with the funders;
- Convening monthly calls to discuss progress, experiences, challenges and opportunities;
- Facilitating individual and group reflection on experiences, progress and challenges to identify and share lessons and next steps;
- Developing templates for documents to be produced by the ERs, e.g. work plans, monthly reports, city digests, etc.;
- Planning and facilitating workshops, conference participation and training opportunities for the ERs.

The main added value of the coordinator to the ERs have been: facilitating shared learning between the ERs; iteratively negotiating and articulating the tasks of the ERs within the wider project team (for the ERs in the three core funded cities); technical and socio-emotional support; and helping to identify and resolve problem areas and issues, as well as identifying and harnessing opportunities, as they arise. This has entailed working with the ERs to identify questions about embedded research, jointly articulate what the ER approach is and communicate that to project partners, stakeholders and external audiences, for example via conference presentations, working papers and short videos.

5. The benefits and value of an ER approach

Measuring the quality of the outputs and identifying outcomes of any co-production process is challenging. Often, these processes aim to blend tacit, contextual knowledge with theoretical knowledge and include a variety of contributors engaging in the knowledge co-production process, each of whom have different criteria for measuring success. Furthermore, the engagements between the ERs, colleagues and senior decision-makers in both the local government and the university, and in the international project partners and funders, are often as important as the outputs of the engagements. Both the research community and government agencies do, however, tend to be output-focused, with few effective mechanisms for measuring the quality and benefit of processes and engagements. Ultimately, the benefits and value of the ER approach need to be considered in light of the FRACTAL objectives, which are to contribute new knowledge regarding climate resilient urban development in southern Africa, and to strengthen the capacity of researchers, policy-makers, practitioners and civil society to work together towards developing more climate resilient cities.

5.1 Benefits to the ER

The FRACTAL ER approach has focused on early career researchers and professionals, within the first 10 years of their careers, with the aim of building their capacity to undertake collaborative and impactful research on climate-related issues that is guided by and feeds directly into urban policy and -practice. For the individual ERs, the skills and benefits they have accrued by working as ERs, have included:

- Increased knowledge of regional climate modelling and analysis;
- Increased knowledge of the policies, plans and programs operating in the city, as well as other cities in the region;
- Improved knowledge on how climate science can be used in decision-making and skills in how to effectively communicate climate science to decision-makers;
- Improved teamwork skills and transdisciplinary research skills, through long-term, in-depth engagements with government officials, politicians and researchers in the natural and social science disciplines across the city, the region and internationally;
- Academic skills in various methods of data collection and analysis and in writing, publishing and presenting;
- Skills in workshop design, logistics and facilitation;
- Networking and negotiation skills;
- Improved regional and international networks with contacts from the public, private, civil society and academic arenas;
- Satisfaction and personal growth from being part of a transdisciplinary team bridging research and city government needs with the shared goal of building the resilience of African cities in the face of climate change.

FRACTAL's capacity building approach has prepared the ERs for other opportunities in the climate change field and to become climate leaders within their existing fields (e.g. urban planning, water management, cartography and GIS, ecology and biodiversity conservation).

5.2 Benefits to the project participants and wider stakeholder groups

With the initiative and support of FRACTAL the ERs create opportunities to connect with and connect up a diversity of people, projects, information and knowledge across organizations, cities, sectors and scales. The ERs have a pivotal role in establishing, facilitating and sustaining a variety of co-exploration and co-development platforms, approaches and networks. Benefitting from their integral involvement and hands-on approach, a range of professional and personal learning opportunities for those involved in the project (direct or peripheral) were unlocked through the FRACTAL project. These have included, but are not limited to:

- Increased access to government data and information for researchers, and increased access to research results and scientific knowledge for government and other actors;
- Gaining access to spaces and people of influence shaping policy and research agendas and thereby contributing to increasing the relevance, robustness and defensibility of both;
- Creating spaces of inquiry, exploration and reflection across departments, organizations, professional fields and disciplines;
- Doing exchange visits with other cities and residencies with research partners in the FRACTAL network as a way of learning from each other's best practices;
- Having access to funding that promotes the learning of city officials, that city governments would otherwise be unable to afford or would not prioritise (for example funding to attend a Winter School at the University of Cape Town on the use of climate information);
- Interactions with senior academics and high-level key decision-makers through the Learning Labs which otherwise would not have happened;
- Benefitting from the flow of existing and new information between partners, since an ER networking between various university researchers and municipal officials is increasingly aware of the various projects going on in the City and the university, and can make linkages between valuable and relevant projects and people;
- Having an intermediary mediate expectations and mandate differences, since researchers and city officials working from different mandates may experience dissatisfaction in project expectations, work approaches, definitions and outcomes. An ER who is familiar with the processes and limitations at both organizations can help to mediate the expectations, and find ways to facilitate the working relationships between researchers and municipal staff;
- Exposure to international platforms at conferences and workshops, which helps to build and boost confidence to speak before renowned experts in various fields of expertise;
- Build relationships of trust, understanding and value for further collaboration.

5.3 Value within the wider city contexts

Across the cities there are signs of the ERs and FRACTAL as a whole adding value beyond only the individuals and organizations directly involved to the wider city context. These outcomes are more extensively documented in the FRACTAL impact stories but are briefly described below.

LUSAKA | In Lusaka institutions have come to recognize the need to include climate information in the city strategic plan and the action and investment plan for water security. The plat-

forms that were facilitated by the ER nurtured improved collaboration across sectors to share information and bridge the large bureaucratic barriers that exist. Climate narratives describing the possible evolution of Lusaka's climate into the future have been integrated into city decision-making. Policy briefs have been co-produced by stakeholders on four climate-related burning issues, and some of the recommendations from these policy briefs are being implemented. There is increased awareness of the impact of climate on water supply, a request for climate narratives, the creation of networks and training opportunities for municipal and university stakeholders. The uptake of the ER approach by the Lusaka Water Security Initiative, a multi-stakeholder initiative that FRACTAL has partnered with, indicates that the approach is seen to be successful and useful by others seeking to bring about systemic change in cities.

WINDHOEK | The main contribution of FRACTAL in Windhoek has been supporting the collaborative development of the City of Windhoek Integrated Climate Change Strategy and Action Plan (CoW-ICCSAP), by convening diverse stakeholders, providing training, strengthening knowledge of and leadership on climate issues, and facilitating an iterative and evidence-based approach to policy development. The work of the Windhoek ER and the FRACTAL team has increased the attention given by the National Climate Change Committee (NCCC) to the role of cities and towns in building the climate resilience of Namibia. The University of Namibia has increased their engagement with the local authority and their research focus on climate issues, for example through the Windhoek START GEC Project focusing on Water Security in Windhoek. There has been political involvement and participation of leadership in these processes - councillors have been sensitized to climate risks, opportunities and capacity needs through training and buy-in from senior officials has increased over the lifetime of the project. Windhoek has also made connections with other Namibian municipalities, acting as a local leader in building awareness and sharing lessons about acting on climate change across Namibia. Climate risk has been integrated into strategic plans using narratives and infographics developed in FRACTAL. Planning is underway to create a City of Windhoek climate change steering committee that will guide and oversee the implementation and updating of the CoW-ICCSAP. Through FRACTAL, with logistical support provided by the ERs, researchers and officials from Windhoek, Lusaka, Harare, Gabarone and Maputo were able to undertake exchange visits between the cities, which further contributed to sharing knowledge of common challenges faced across the cities and various ways they were being tackled.

MAPUTO | A main achievement was the development of an improved early warning tool for climate-induced vector- and water-borne diseases. A web-based tool was developed for estimating risk of vector-/water-borne diseases as a function of climate variables, which will help enhance understanding for stakeholders of how vector-/water-borne diseases relate to climate variables, and how to trigger adequate actions that favour early adaptation to climate risk within the Municipality. The design of the tool was informed by engagement between researchers and various city and national stakeholders, supported by the ER. Also a more coordinated response to early warnings has been supported through city dialogues and Learning Labs convened by FRACTAL, enabled by the ER, which has helped in increasing communication and understanding between various departments and agencies that mostly work in isolation.

DURBAN | The ER co-developed climate and biodiversity information to support the implementation of the Biodiversity Theme of the Durban Climate Change Strategy (DCCS). The extensive engagement, network building and data sourcing involved in this process has led to increased recognition of the need for improved data management and data sharing within and between

branches and departments of the municipality, as well as external sources, which contributed to creating a new post for a data manager. The work of the ER and the FRACTAL project also contributed to strengthening the capacity of various city actors to integrate climate information into their work, for example through coordinating climate change awareness training for city planning staff of the municipality.

HARARE | There has been a mind-set change about the importance of collaboration between practitioners and researchers when undertaking projects. There has also been an increase of invitation for input and engagement, as well as for sharing outputs, in projects to do with climate change in both formal and informal spaces, so they could be presented to different relevant ministries. There has also been improved awareness among local government officials on the importance of incorporating climate change issues in planning for the city.

It is difficult to anticipate what the knock-on effects of all these activities, interactions, learning opportunities and outputs will be, but they have created fertile ground for progressing the climate agenda within and between the cities and others in the southern African region. While these developments cannot be solely attributed to the ERs, the persistence and skills of the ERs in building relationships, opening and sustaining communication across organizations, disciplines and sectors, and translating relevant information, needs and opportunities clearly played a key role.

6. Challenges and inhibitors to the ER approach

While the benefits and values of undertaking an ER approach are many, the approach also presents some challenges that are important to acknowledge and actively address, many on an ongoing basis.

6.1 Being an anomaly and a hybrid

There are several challenges that emerge from operating across two domains: being a researcher in a public policy and operational public service environment and being a highly applied person in a largely natural sciences research environment. The fact that universities and governments are both large hierarchical bureaucracies make operating across them particularly challenging because they are constrained by many rules and protocols that are not always compatible with one another. The initial 'settling in' time period is lengthy, since it is a new way of doing things - not only for the ER, but also for both the university and government departments hosting and supporting the ER. A lot of time is required to become familiar with new people, terms, concepts, documents, procedures and protocols.

The initiation of activities is always the difficult part of the project and establishing formal engagements and partnerships can be an unexpectedly long process that requires constant follow-up. This lengthy process had an effect of prolonging the set time for initiating project activities such as workshops, fieldwork and data analyses. Establishing contacts, getting access to relevant government data and documents, organizing and hosting multi-stakeholder events in the city was challenging to those ERs with a mostly academic background. It was somewhat easier for the ERs who had been working in the municipalities before getting recruited as ERs, but even for them reaching beyond their departments and directorates proved difficult. For all the ERs, especially the ones who had been working as professional officers in the municipality, coming to grips with new concepts, technical and disciplinary terms (for example from climatology), and academic styles of writing and presenting was a challenge. In the government

and the university, the formats and procedures of reporting are vastly different but equally challenging, but both must be understood and adhered to for the ERs to report their progress into both organizations and get information circulating within each domain. Because the ER position and role is a novel and thereby unfamiliar one, it is difficult for the individuals involved to get clarity on each organization's expectations of them and on how their performance is evaluated. ERs are effectively insider-outsiders in both organizations. While this unusual status poses many challenges, it is also a great strength and source of agency for the ERs because they have (or can cultivate) more flexibility and access across silos and levels in the hierarchy than many within either one of the organizations. However, because an ER moves between organizations, spending some time working at the government offices and other time at the university campus, it is at times challenging to keep the stakeholders committed and active on the project. Conversely, it is also easy to overburden colleagues and stakeholders with information or activities that are not (seen as) core to their mandate, and thereby face a form of stakeholder fatigue.

6.2 Competing logics and demands

It is challenging to merge and comply with the different codes of conduct and expectations from the two different organisations, especially when various outputs had to be delivered within the same period. In such instances prioritising one output over the other, for example a research output over a city policy- or planning-related output, was sometimes negatively perceived as one organisation being prioritized above the other - a situation which occasionally led to organisations feeling short-changed from the ER working arrangement, especially in the early phase when the ER role was still new and being formulated in practice. It quickly became clear that research work and government work happen at different paces. For ERs trying to straddle the two and being held accountable for delivering products and adding value into both domains these differences in timing prove challenging. Timing is one aspect, but more fundamental is the different ways in which problems are framed and what knowledge is valued. The policy and operational framings of problems are often very different from the theoretical framing of research problems. Within government practical knowledge of how to proceed in a particular context is valued more highly than the abstracted and generalizable knowledge mostly sought within academia. Spanning these logics and demands as an ER to be valued within both organizations is very challenging. ERs therefore require unique support from managers, supervisors and coordinators, which is not always easy for them to provide because they themselves are grappling with the challenges of working beyond their own organizations and thereby also facing conflicting priorities, different framings and difficulties understanding and being understood.

6.3 Working beyond one's discipline or profession

The nature of the information an ER must work with can be an inhibitor, although how and to what extent depends somewhat on the background of the ER. In FRACTAL the technical nature of biophysical climate information and the conceptual complexity of understanding city regional systems, governance arrangements and notions of transdisciplinarity proved challenging for many, including the ERs. The ERs experienced first-hand the challenges of communicating issues of uncertainty and confidence in the climate information and facing questions of reliability, relevance and actionability from city stakeholders. The ERs had a diversity of backgrounds, including urban planning, cartography, environmental management and ecology, and so had much to learn about climate issues and how they interconnect with various urban issues. Having a network of other ERs to learn with helped considerably in dealing with these challenges.

6.4 Dynamic and constrained organizational environments

Securing and sustaining a working relationship with stakeholders who see the potential value of the project, provide time to engage with the ER, and open doors for the ER to do their work and have most impact can be challenging. Often the time of such key, informed and influential people are in high demand, especially in under-resourced and under-staffed settings as is the case in many government departments in southern African cities, so access to and commitment from them is not easily obtained by the ER. This can in turn make it difficult for the ER to get project requests for information, and for attendance and participation by city officials in project events, approved. A related challenge is the high turnover rate in city governments, which require of the ER to re-establish relationships and trust each time key positions are replaced. The reassignment, promotion and departure of staff, especially senior managers and political leaders in city governments, pose a significant challenge to the work of the ERs. This was experienced in all the cities involved in the FRACTAL project. It is particularly difficult when much time and energy has been invested in getting key people aware and in support of the project and meaningfully participating in engagements, and then they are replaced and a new person comes in with different priorities, no knowledge of the preceding work, and often without relationships that enable them to feel comfortable engaging outside of their domain and position in the organizational hierarchy. Also particularly challenging is when positions are left vacant for some time during a large-scale organizational redesign and political reshuffle, or when others are acting in the role. This can cause significant delays in getting permissions granted, documents approved and enabling staff at lower levels to participate in events and deliberations.

The chronic capacity and resource constraints facing both city governments and local universities in many southern African cities further result in people prioritizing their core tasks and being reticent to participate in and commit to activities, processes and outputs that are outside of their mandate, making the kind of transdisciplinary co-production work that ERs are tasked with facilitating very difficult. Because many of these cities are operating in near crisis mode much of the time, agendas and schedules are highly fluid, with people being called into unforeseen meetings on a regular basis. This makes scheduling and organizing project activities between multiple stakeholders and ensuring that the relevant people are present very difficult indeed for the ERs who are tasked with acting as the intermediaries. On a very practical level, some city government departments and local universities struggled to provide the ER with a desk and computer needed to conduct their work because of the resource constraints facing these organizations. Also, internet access is very poor and unreliable in many of these cities, especially in the local government offices, making the research work and the participation of the ERs in project meetings with the wider team very difficult. Within all of these constraints, many if not most of the government and university staff that the ERs have engaged with have been as supportive and helpful as possible.

7. Lessons learned from implementing the ER approach in FRACTAL

Through implementing the ER approach in a variety of city and organizational contexts, several lessons have been drawn to guide future efforts at undertaking embedded research. Key lessons are:

1. Considerable time needs to be given to **the startup phase** of negotiating a shared problem space and getting the organizational partnership agreements and contracts in place to enable the recruitment of an ER. This takes at least 6 months, if not longer, because of its novel nature (outside of the regular procurement processes) and thereby needing to pass through various committees and sign-off procedures within the government and the university. Funders and project timelines need to account for this. The knowledge partnership must be wanted and valued by both the university and the city government, or host organization, otherwise the project and the ER effectively get orphaned and are then not able to achieve their objectives. Once the organizational agreements are in place then time is needed for the recruitment process, to find a good fit between the research and policy/practice needs of all partners and the skills and competencies of ER candidates.

2. **Both organizations must be open to some innovation and change** to be able to get full value out of an ER arrangement. Treating the ER as a traditional researcher and/or a regular government official risks missing the potential for doing things differently to blend research, policy-making and practice in novel and productive ways that can generate new insights and spark alternative courses of action. There is a real need to create spaces in city governments for longer-term, slow work of research and in universities for quicker turnaround outputs that can be produced in a timely manner when needed during public policy-making and planning processes. ERs can be part of opening up such spaces and producing such outputs, but only if the organizations they are operating in create an enabling environment to do so.

3. ERs need to have **excellent interpersonal, communication and organizational skills**, a willingness to be outside of their comfort zones, a strong desire to learn and an ability to be reflexive. These 'soft skills' have proven to be as important, if not more so, than the technical expertise they bring.

4. ERs can learn more and work more effectively, thereby providing more value to the organizational partners, if they are **networked with other ERs and are well supported** by supervisors and project coordinators. Because the role is novel and unfamiliar to most it requires considerable negotiation and learning through trial-and-error. Having contact with others going through a similar process, as well as with experienced academics and officials, helps greatly in navigating these challenges.

5. The success and impact of the ERs work is based on **balancing between a clear scope of work relating to the shared problem space and a level of flexibility** that enables emergent, unforeseen opportunities to be leveraged. The duration that an ER works within the government context, the level of familiarity they build with the people and work of the government and the level of flexibility they have to identify and pursue new leads and opportunities is what sets ERs apart from consultants that are usually contracted to do research work for government agencies, often on a short-term basis (with severe budget constraints) and with tightly pre-defined terms of reference.

6. **New metrics and forms of assessing performance** are needed to account for the hybrid role that ERs play. These need to capture the building of trust, relationships, understanding and collaboration, as much as measuring substantive outputs.

7. ERs cannot achieve the ultimate objectives of increasing the evidence base of policy-making and planning and the relevance of research without **a network of internal champions in government and academia** that create windows of opportunity for change within ongoing policy, planning and research processes. Often the 'glue' or ties that bind such networks are a common or shared question, problem or objective that cannot be addressed in isolation within a single department, sector or profession. This highlights that the ER approach is **well suited to complex or wicked problems requiring transdisciplinary initiatives**, such as how to address climate risks in contexts of urbanization, poverty and informality.

8. Conclusion

Within the FRACTAL project, the ER approach has proven to be an effective means of bringing the worlds of climate science and urban decision-making closer together in the pursuit of building more climate resilient cities. Recognizing the shortcomings of the traditional academic and consulting models - the former being too abstract and slow for policy processes and the latter being too constrained by narrow terms of reference and short-term contracts - the ER approach offers an alternative based on creating an intermediary between academics, policy-makers and practitioners to build relationships and understanding across organizational and disciplinary boundaries. Despite the ERs being from a variety of backgrounds and placed within different city contexts, many of the benefits, opportunities and challenges of the ER approach were similar across the cities. This indicates that the approach is transferable to other contexts and other problem spaces. The ER approach goes beyond a focus on what knowledge is needed, in the FRACTAL case to act on climate risks and vulnerabilities in cities, to attend to how knowledge is generated and who is involved. The ER approach contributes to making both academic research and public decision-making more legible and thereby more accessible and accountable.

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