Mobilising Knowledge for Urban Governance: the case of the Gauteng City-Region Observatory

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Abstract

The capacity to derive, analyse and communicate urban knowledge is increasingly essential for decision-makers managing the complex pressures of rapidly expanding cities. This paper examines the importance of transdisciplinary boundary organisations in generating and mobilising this knowledge. It introduces 'urban observatories' as an example of institutions catalysing information that can shape urban governance, considering in detail the experience of the Gauteng City-Region Observatory (GCRO) in South Africa. Insights drawn from GCRO's recent work illustrate key operational considerations for these types of boundary institutions, highlighting opportunities and challenges in shaping the knowledge systems that underpin contemporary policymaking in and for cities.

Keywords: Urban observatories, knowledge systems, co-production, urban governance, boundary organisations

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Introduction

'Urban observatories' – research organisations that work across policymaking and academia – are increasingly flagged as critical in achieving sustainable urban development. In the current context of expanding urban settlements and accelerating global change, there is increasing pressure for cities to play central roles in response to an array of interconnected global, environmental and social challenges (Albertini, 2017; Caprotti et al., 2017). Urban areas are now seen as critical in shifting global development trajectories towards more sustainable and equitable outcomes, but this understanding also begs central questions about what we know of cities and how we mobilise this knowledge effectively towards these goals (Satterthwaite, 2017). As is now well recognised in major United Nations frameworks, the acknowledgement of this role is coupled with widespread calls for cities to develop the capacity to generate, mobilize and access comprehensive knowledge about their environments and to support policymaking and societal action (Acuto and Parnell, 2016; McPhearson, et al., 2016a). Such 'knowledge-for-action' is essential not only for local governments responding to the immediate needs of urban dwellers, but also for national and international stakeholders in developing evidence-based policies and programmes that tackle complex global development challenges (Seto et al. 2017; Robin and Acuto 2018). Importantly, the institutionalization of science-policy connections that can effectively mobilise urban knowledge for urban governance has now taken the centre stage in academia and international policymaking. This is because achieving effective insight into the nature of urban challenges, and addressing them in practice, requires connection and feedback loops between the knowledge produced about these challenges and its application in urban, regional and national policy (Webb, et al., 2017). How these

feedback loops can be institutionalised, and what tangible experiments are out there, is a central concern for many and the subject we would like to address here.

This article focuses on the boundaries across which this knowledge travels and is transformed – what we could term 'knowledge transition zones' - where concepts are reciprocally translated and applied. Effective exchanges across these zones can enable decision-makers to apply academic research, and for research to be informed by insight and data collected within or for decision-making settings (Townsend, 2015). Yet we still know very little about the organisation involved in these boundary crossing processes in urban settings. The contemporary urban science-policy interface is still poorly characterised and under studied. As efforts to create effective interventions within this space increase in number and significance, actionable academic study becomes key to developing novel, critical and enabling insights around its products and processes. Our effort to offer a detailed insight into the operation of an urban observatory, then, responds directly for calls to institutionalize the dynamics of science-policy interaction underpinning urban governance. This is flagged, for instance, by the 'CitiesIPCC' initiative in the Intergovernmental Panel for Climate Change (Bai et al., 2018) and the recent *Nature Sustainability* international expert panel on 'science and the future of cities' (Acuto, Parnell & Seto 2018).

Securing effective collaboration in knowledge generation processes, including data collection, analysis and communication can be difficult, not least because of the divergent purposes, structures, cultures and rhythms of the different institutions involved (Simon, et al., 2016). Given the increasing importance of research to inform decision-making, there are growing calls for organisations that are designed to 'bridge' and navigate this 'knowledge transition zone' between research and decision-making (e.g. Perry and May, 2010). Although the salience of these organisations is now

acknowledged, there is currently only limited analytic reflection on the contemporary institutions that have emerged in this space (Farah, 2011; Acuto et al. 2018; Robin and Acuto 2018). This paper explores the role that such bodies can play in cities and the challenges they have to negotiate in urban governance. Reflexively exploring the practices and dynamics of these institutions offers invaluable opportunities for understanding and shaping the emergence of effective urban knowledge systems. This is achieved through examining a case study to demonstrate the modes, strategies and challenges of building enduring research collaborations around complex urban issues. This paper is addressed to urban researchers, but tells the story relevant to a much wider community of knowledge producers and users, from researchers to universities to local government. It extends a call to all involved for their attention and critical reflection. Some of the key opportunities and challenges at the heart of contemporary urban knowledge systems are illustrated through a detailed examination of an existing institution: the Gauteng City-Region Observatory (GCRO) in South Africa. This examination, written by authors both within and outside of the case study institution, highlights the challenges of critical distance allied with the importance of reflexivity. GCRO stands as an example of a broader class of organizations, referred to as 'urban observatories' ('observatories' from hereon) that represent, in our view, a potentially effective form of institutionalized boundary spanning organization addressing the science-policy links needed for urban governance. In their role of navigating the 'difficult' research space across the urban science-policy interface (Evans and Marvin 2006, Petts et al 2008, Berkes 2009), observatories are well-placed to develop and test innovative means of knowledge production and interaction between academia and decision-makers.

Urban knowledge systems

Urban knowledge and (global) urban governance

Recent international frameworks aimed at improving quality of life and sustainability globally – including the 2030 Agenda for Sustainable Development (Sustainable Development Goals (SDGs)) (UN, 2015), the Paris Agreement on climate change (UNFCCC, 2015), the New Urban Agenda (NUA) (UN, 2016) and the Sendai Framework on disaster risk reduction (UNISDR, 2015) – have all emphasised the central role that cities must play in addressing global challenges and achieving agreed goals. Simultaneously, these frameworks have highlighted the importance of broadly accessible information and data (i.e. 'evidence') for informing decision-making and policy development across all levels of governance. The UN's forum on the 'Global Action Plan for Data' emphasises that effectively implementing the 2030 Agenda for Sustainable Development (SDGs) "requires the collection, processing, analysis and dissemination of an unprecedented amount of data and statistics at local, national, regional and global levels" (UN, 2017). Furthermore, the effectiveness of responses to global challenges, from local initiatives to multilateral processes, depends on detailed and timely knowledge about "demographic, economic, cultural, physical, technological and environmental dynamics" (UN-Habitat GUO, 2015).

'Data', 'information', and 'knowledge' have specific definitions but may overlap in their usage in urban theory and urban studies more generally (Parnell & Robinson 2018). Throughout this paper we use 'data' to refer to collected quantitative variables and statistics (Batty, 2013), 'information' to refer to processed or purpose specific data (Acuto et al., 2018) and 'knowledge' as a sum of data, information and experience (Komninos, 2013). The original formulation is maintained within direct quotations.

Because cities play an important role in the global agreements mentioned above, this places significant pressure on urban systems – particularly those underpinning urban governance – to enable effective generation, analysis and communication of knowledge about the challenges that confront local (and indeed national) governments. From a specifically urban governance perspective, the New Urban Agenda goes further than placing knowledge demands on cities. It also reflects a global appetite to actively support and strengthen "the role and enhanced capacity of national, subnational and local governments in data collection, mapping, analysis and dissemination and in promoting evidence-based governance, building on a shared knowledge base using both globally comparable as well as locally generated data." (UN, 2016, para 159). This sits alongside repeated calls from the urban academic community (e.g. Parnell, 2007; Acuto, Parnell and Seto 2018; Bai et al., 2018) for new modalities for developing applied and policy-relevant urban research with the potential to transform the way in which urban systems are understood, structured, and managed. The challenge is, therefore, to identify appropriate institutional models and practices that enable the realisation of effective urban knowledge systems (e.g. Komninos, 2013). The case presented within this paper emphasises the importance of institutions dedicated to converting urban data into actionable urban knowledge, not only providing data in the manner of statistical repositories (e.g. census) but asking questions about how and why issues arise (Culwick et al., 2017; Parnell and Robinson, 2018). These institutions can play a role in interrogating how research can build better knowledge bases for policy and decision-making, reflecting on the governance of urban areas and practices of urban knowledge generation. They also provide opportunities for city officials to become active in knowledge production rather than merely recipients thereof (Vogel et al., 2016),

encouraging a two-way collaboration that many have highlighted as crucial in cities today (Barnett and Parnell 2016).

Urban Observatories as boundary spanning institutions

Guston (1999, 2001) frames the role of 'boundary organisations' as attempting to navigate the boundary between academia and policy by meeting three criteria: 1) provide opportunities and incentives to create and use boundary objects, 2) involve the participation of actors from both sides of the boundary, and professionals in a mediating role; and 3) exist at the frontier of the two relatively different worlds, but have distinct lines of accountability to each. Academic work has to date offered very limited analysis of these aspects in practice, presenting not only a major literature gap but also a shortcoming in the very science-policy bridging capacity these organisation seek to build.

Observatories have emerged as a broad but important class of institutions within many urban knowledge transition zones. The term 'Urban Observatory' appears explicitly in academic literature in relation to a series of observatories founded in the 1960's in the United States of America to build a robust evidence base for urban decision-making (Williams, 1972). Since then, the establishment of observatories has evolved and proliferated, with clear attention by the United Nations. There are now 187 such bodies listed as part of the Global Urban Observatory Network, set up by UN-Habitat (UN-Habitat GUO) (UN-Habitat GUO, 2018). For the purposes of this paper, the key descriptors for an 'Urban Observatory' are derived from UN-Habitat GUO as the most visible global body in the establishment and management of observatories. UN-Habitat GUO defines observatories as "… governmental agencies, research centres or educational institutions that are designated as the "workshops" where monitoring tools are developed and used for policy-making through consultative processes". UN-Habitat

GUO proposes that all observatories share at least three common aims: 1) to create sustainable urban monitoring systems to support local planning and management processes, linking data to policy; 2) to strengthen local capacity for the development and use of urban indicators that facilitate the collection of disaggregated data at city and sub-city levels; and 3) to promote local ownership of urban indicator systems and a culture of monitoring and assessment in the urban sector (UN-Habitat GUO, 2015, p12). Observatories are thus tasked with the responsibility for sustained data collection and analysis to support public policy in urban contexts. Referring back to Guston (1999, 2001) who frames this as a clear "opportunity… to create and use boundary objects". Despite the existence of many observatories, Siedlok and Hibbert (2014) highlight the paucity of literature that builds an understanding of how long term research collaborations are organised and managed and what has enabled the longevity of these bodies.

Observatories take on a range of forms, which have been summarised by Farah (2011) into four 'archetypes': city-university partnerships, public actor models (based within an existing element of the public sector), global network models (instigated and formed by global bodies such as UN-Habitat GUO) and local initiative models (driven and operated by local, non-government actors). The diversity of forms is also mirrored in the scales of focus. Observatories range in focus from a single city-region (e.g. Vancouver or Melbourne) to the urban form of Europe (e.g. ESPON, the European Spatial Planning Observation Network) (Moore, 2016). Observatories may also have a specific thematic focus (e.g. poverty, gender, housing) or a general remit for the collection of data and formation of knowledge across the city region, where the thematic research priorities are decided by partners, local decision-makers and directly or indirectly influenced by global governance needs (UN-Habitat GUO, 2015). The

individual structure and mandate of the observatories has implications for their day-to-day operation at all levels, including the nature of their partnerships, and the methods and approaches employed to gather and analyse data. The permeable boundaries of knowledge production and transfer place observatory professionals in a mediating role between a range of stakeholders and depending on their formal, institutional structure can generate complex lines of accountability (Guston, 1999, 2001).

Farah (2011) notes that "while urban observatory structures may differ in their scale, mode of operation, objects of interest and outputs, they are all similar in the central thing defining their mode of operation: observation". Irrespective of their 'type', in order for these organisations to research, analyse and present knowledge effectively, they have to negotiate the persistent tensions of being positioned at particular knowledge transition zones. What is 'observed', how, and why - will, therefore, be highly contingent on the respective contextual factors. Yet some generalizations on the operation of observatories might still be of value in charting lessons for the mobilisation of urban knowledge for policymaking.

Spanning boundaries of knowledge

The boundary nature of observatories and their respective capabilities frequently falls within the realms of transdisciplinary research, which is typically problem-oriented and practice driven (Klein, 2008), drawing on knowledge co-production methods such as participatory mapping (Mushongera and Culwick, 2017). These approaches imply a "collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systems-oriented understanding of that problem" (Armitage et al., 2011, pg. 996). Correspondingly, the UN-Habitat GUO guidance for establishing an observatory states that "Urban observatories not only direct specific attention towards urban questions through merging/bridging traditional

disciplines, but they also deliberately attempt to learn from practice and use applied knowledge to inform the scholarly pursuit." (UN-Habitat GUO, 2015). This implies a reflexive positioning for those involved in observatories, which echoes the approach adopted in this analysis of the GCRO.

Here we focus more specifically on the city-university partnership model - Farah's first archetype of observatories (2011) - of which the GCRO is, in our view, an effective and increasingly internationally-recognised example. In considering such a partnership model, some immediate challenges and opportunities present themselves. Public sector decision-makers and academics have very different knowledge practices and these variations can undermine the identification and flow of useful knowledge. In the common caricature of this model, conflicts arise where on the one hand policy-makers consider academic research outputs as too removed from real-world contexts and inaccessible to be meaningfully applicable for governance (Panda and Gupta, 2014), and on the other hand, academics consider knowledge that derives from within government and which has been primarily designed to support pragmatic policy less credible than peer-reviewed academic research (van Kammen et al., 2006). Academic research is also interested in making theoretical advances: these can ultimately form the frameworks of thinking and action which support real-world progress on issues, but in themselves are not always perceived as critical in a decision-making context (Batty, 2012; McPhearson et al., 2016b).

City-university boundary organisations, therefore, deliberately create common 'objects' such as aims and procedures shared or agreed by all parties to ensure genuine engagement and participation across the knowledge transition zone. This practice of co-production between academia and policy-making is essential for the achievement of a productive partnership. Approaches to addressing tensions lie both in increasing the

quality and contextual relevance of policy research and in strengthening the translation of academic research into policy (Sutcliffe and Court, 2005). Observatories, through navigating the perceived 'difficult' co-production and interdisciplinary research space (Brewer, 1999; Campbell, 2005; Evans and Marvin; 2006, Petts, et al., 2008; Berkes, 2009,), can provide insights into developing innovative approaches to knowledge production and interaction that are required. Observatories can create permeable boundaries for knowledge exchange in a way that cultivates the reciprocal absorptive capacities of the partner institutions and generates shared insights that are productive for better-informed public policy.

Despite the acknowledged importance of observatories in facilitating evidence-based policy, and the growing calls for observatories to play a more prominent role in addressing global urban challenges, they remain under-analysed, with the scientific literature on observatories described as "rare and culturally fragmented" (Farah, 2011, Holden, 2006). Towards filling this 'void' the following section explores how our case-study observatory, the Gauteng City-Region Observatory (GCRO) in South Africa, navigates the complex and relatively unreported terrain of applied urban research for decision-making. The GCRO was selected due to its relatively long history as an observatory (10 years) and the existence of detailed, open access records of its foundation and development as well as open information on the example projects reported. The GCRO is also respected as a credible research institute by government, academia and the broader public. It is used in this paper to explore how the theoretical context of observatories and knowledge transition zones is visible in a functional institute. It is also, in our view, a chance to encourage greater learning from the Global South. Our case highlights how some of the most effective forms of urban governance innovation might, in fact, have a long history (10 years in the case of GCRO) rather

than being borne out of a current 'urban' fad. It also highlights the potential for global relevance of models situated, like GCRO, beyond the traditional core cities of urban theorizing, often "off the map" of those Norther-driven geographies of "authoritative knowledge" that for too long have dominated our thinking about cities (Robinson, 2006; Roy, 2011). The operating mode, form, philosophy, skills base and impact of the GCRO reveal both the successes and persistent struggles of being a transdisciplinary boundary organisation. The paper also serves as a means of reflection on practice for the GCRO regarding its data, methods, modes of working and partnerships.

Materials and methods

This case study was developed to investigate some of the key opportunities and challenges for boundary organisations noted in the preceding sections and in the relevant literature. All of the examples noted in the introductory passages highlight critical interactions around the institutional structure of the boundary institution, its mode of operation and some aspect of its ultimate outputs as concrete artefacts and as 'boundary objects' between different stakeholders. The case study was shaped through a close analysis of the history, processes, working experiences and outputs of GCRO, based on a varied corpus of documentation, research materials, direct insight, and interviews more specifically developed for the purpose of this study. The study employed a holistic single case study approach, taking a detailed view across many facets of the study organisation (Mills et al. 2010). It provides a 'critical case' which is intended to explore existing theory around observatories and boundary organisations more broadly. Throughout the discussion we have endeavoured to draw the case back to the literature in the introductory sections, implementing an embedded design approach to connect observations to theory (Mills et al. 2010). Although we acknowledge the limitations of considering GCRO as a 'representative case' within the field of urban

observatories, our intention is to develop a case study approach that can be adopted as a template against which other observatories can reflect on their own practice.

The corpus from which the GCRO case study was developed includes publicly available materials online (www.gcro.ac.za), combined with annual reports, the GCRO constitution, board and internal reporting documents. It also includes quantitative figures on the GCRO, descriptions of materials and interventions generated by the GCRO and autoethnographic reflections from the GCRO co-authors of this manuscript (Christina Culwick and Rob Moore) on their work within the GCRO (Culwick et al. 2016; Moore, 2016). This required a reflexive approach, acknowledging the GCRO authors' close involvement with the case in question and cross-validating their insights through the inclusion of other research inputs (document analysis, interviews) (Thorpe and Holt, 2008; May and Perry, 2018). In the development of the case we acknowledge a particular need for 'introspective reflexivity', promoting a high degree of self-consciousness on the part of the GCRO authors, 'especially in terms of how [their] identity affects the design and process of [their] work' (Thorpe and Holt, 2008). The development of this case could be conceptualised as an example of 'reflection-in-action', as the GCRO authors' reflected on both past and present everyday activities (Schön, 1983). The paper also draws on two semi-structured interviews with longstanding senior GCRO staff members, in which they were asked to reflect on GCRO's form and approach, partnerships, philosophy and impact.

This body of materials was interrogated on the basis of three main thematic areas of interest: structure (form, approach), partnerships and outputs. Taking this framework as a point of departure, the following research process was inductive, with some minor themes within these areas surfacing and evolving through the research and analysis, including: philosophy, skills and aptitudes, impact.

Results

The case of the Gauteng City-Region Observatory (GCRO)

The GCRO is a research centre, established in 2008, that supports planning and decision-making in the Gauteng City-Region (GCR). The GCR is a fast growing and dynamic urban area in South Africa's central interior. It consists of a number of municipalities, including three of the country's largest metropolitan municipalities - Johannesburg, Tshwane and Ekurhuleni. Gauteng is the primary economic hub of South Africa and, although it makes up less than 2% of the national landmass, it is home to roughly a quarter of the country's residents and contributes more than a third of the national GDP. It is the most urbanised city-region in the country and has the highest rates of population growth and in-migration. Furthermore, Gauteng is the site of high resource consumption and the most pronounced levels of inequality in the country. Thus, shifting Gauteng towards a more equitable and sustainable space will contribute significantly towards South Africa's progress. The GCRO was established to undertake research to support government in achieving these goals, setting a policy agenda in the background of the knowledge (creation and dissemination) agenda of the GCRO itself.

GCRO as an urban observatory

The GCRO was established to inform the city-region governance agenda and was motivated by calls from within both the government in Gauteng and academic urbanists in South Africa (e.g. Parnell 2007) for policy-relevant research specific to the local urban context. Academics in Gauteng had noted frustration that existing and emerging research was not used within local planning and decision-making, while government stakeholders flagged the inaccessibility of academic research to inform policy.

The GCRO was deliberately set up to address these concerns. This purpose-designed institution undertakes research aimed to address the complex questions of urbanism in the GCR, and to provide insights to inform policies and decision-making (Everatt, 2017; Mushongera and Culwick, 2017). Its formal mandate is to:

- Generate datasets for evaluation and comparison of the settlements of the city-region with one another and with other local and international comparators
- Analyse the data to identify the key opportunities and challenges highlighted by these comparisons
- Assist government and its partners to interpret the trends and forces shaping the city-region
- Support decision-makers through analysis and evaluation

Observation is a defining modality of research adopted by the GCRO and is undertaken through the collection of both quantitative and qualitative data, and the analysis of existing datasets from a range of sources (e.g. Census, GIS and remote sensing data). In line with the UN-Habitat GUO (2015) 'requirement' for observatories to create sustainable urban monitoring systems, and to develop and use indicators at the city-region level, GCRO has developed the Quality of Life (QoL) survey, which serves as a tracking and diagnostic tool, affording a rich information resource about Gauteng, and is deliberately designed to feed in to a knowledge base for supporting decision-making in the GCR.

The GCRO's QoL survey, run every two years, measures the quality of life, socio-economic circumstances, attitudes to service delivery, psycho-social attitudes and opinions, and other characteristics of residents within the GCR. The QoL study is a household-based survey with randomly selected adults (18 years of age and over) as respondents. The sample, which has grown significantly over time, is designed to be

representative of the Gauteng population. The QoL survey has arguably become the largest independent social dynamics and attitudes survey conducted in South Africa. The questionnaire consists of over 200 questions spanning topics including dwellings, services, satisfaction with services and government, migration, transport, public participation, employment, and perceptions about a range of socio-political questions. While approximately 60% of the questionnaire remains constant across all iterations of the survey, the remaining bank of questions has evolved over time. The questionnaire has evolved in response to extensive engagement with both government officials and academic researchers, with the expressed intention of equipping a range of actors with critical, local-level data needed to ensure the effectiveness of their programmes and research.

Analyses arising from the QoL survey, including various multi-dimensional indices (e.g. the Quality of Life index (Everatt, 2017)), have provided perspectives on how the lived experience of residents varies across the spectrum of affluence and poverty, and how these deep inequities in well-being remain differentially distributed across social identities and spatial locations. These analyses provide the government with a set of variables (and thus a conceptual vocabulary) together with trend data on the trajectory of these variables across wards, intended to inform planning and evaluation.

While there has been uneven uptake of the QoL data across departments and agencies, there is growing evidence of increasing traction in various quarters. These concepts, born primarily within academia, have enabled ideas within government to be articulated and crystallised in a way that empowers the government to rethink how it engages with and cares for its residents. The City of Johannesburg, for example, has taken these concepts strongly on board and has used the Quality of Life index, which combines 58 variables from the QoL survey into a single measure of quality of life, as an internal

monitoring tool to assess the municipality's performance in advancing the city and its residents.

Form and approach

The GCRO emerged as a formal partnership between the University of Johannesburg (UJ), the University of the Witwatersrand (Wits) and the Gauteng Provincial Government. Organised local government in Gauteng is also now represented on the GCRO's board. The GCRO receives a core grant from the provincial government and the two universities provide significant in-kind support. A senior academic at GCRO noted that "it is in many ways the best possible set of arrangements… [GCRO] is given full academic autonomy to develop its own academic programmes and interests" (Ballard, personal communication 4 February 2019).

While the GCRO's academic partners are formally limited to Wits and UJ, it undertakes collaborative research with individuals and departments across other higher education institutions, research centres, private sector think-tanks, NGOs, and knowledge-exchange and learning-networks that operate both within and beyond the city-region. Partnerships exist at both organisational and individual researcher levels, with local and international organisations and researchers, and take the form of advisory, short-term project-based collaborations, as well as longer-term research initiatives.

As noted in the introductory sections, tensions can derive from the fact that the GCRO is a hybrid, interstitial organisation that straddles the boundaries of very different institutions (university and government) and must mediate and resolve competing priorities, rhythms and cultures. It draws on the resources and methodologies of both academia and government to inform its research and research outputs, and in this way "there can be a productive tension" (Ballard, personal communication 4 February 2019). It is physically located in the academy (to signal and support its independence and

credibility) but takes its cue from the needs of government. Inevitably, both these contexts compete to influence the disposition of the organisation, and the staff of the GCRO must steer an accommodating route between these competing demands. This tension is most obviously reflected in the interplay between different types of research output, illustrated later in this paper.

The GCRO's research focus is directed broadly by government objectives; however, it maintains academic independence and accountability through the two university structures. For example, the chair of the governing board alternates annually between the two academic partners, which means that although the core funding comes from government, the chair of the board (i.e. academia) holds a deciding vote on any evenly contested issue. The GCRO is physically located at Wits University and the organisation links directly into academic structures of both UJ and Wits. The GCRO also draws on the expertise of a 'Research Advisory Committee' with representatives from relevant research fields in academia, the public sector and beyond. Individuals from the research advisory committee help to develop the research agenda, review GCRO outputs and foster relationships between key researchers and counterparts in government.

The GCRO has deliberately built on the opportunities afforded by the organisation's formal partnership structure and fostered relationships across government and academia to build trust across these sectors. Inevitably, this trust is carried largely in the form of personal relationships between researchers and government officers, as well as in established track-records of repeated co-operative initiatives. For example, although the political leadership in one of the metros in Gauteng has changed since the establishment of the GCRO, this metro has continued to provide financial support to key GCRO initiatives, based on the track-record of independent, credible data provided in the past.

Although GCRO has had overall success in building relationships and trust across the knowledge transition zone in Gauteng, it has faced challenges related to external political priorities with regards to university-government interaction. Municipal funding has for example been threatened in one of the GCRO's projects unless a particular university in the province is included on the GCRO's board. Thus, while the GCRO structure and institutional relationships have been relatively stable, this particular form cannot be taken for granted over time.

The relationships of trust, maintained at personal levels, have enabled researchers to gain clearer insight into the contexts of government and for public officers to better understand the methods and time-scales of good-quality research. Together, these reciprocal insights contribute both to the quality of the work and its absorption into the public sector. The GCRO co-authors of this manuscript have frequently noted their appreciation for the levels of political maturity exercised by government leadership that have persistently respected the scholarly independence of the GCRO and have thus far never sought to limit the publication of, or disengage from, (sometimes) uncomfortable research findings. This speaks to the space for dialogue and mutual trust that is fostered by GCRO's core belief that "academia is only relevant to the extent that it talks to the real-world challenges and… you only make progress in government if you are continuously reflecting" (Götz, personal communication 4 February 2019).

Philosophy

In order to establish a coherent and resilient organisation, significant work was required to bring the government and academic partners together and reach consensus among them regarding the role and mandate of the GCRO. In the end, this was achieved in part by a powerful and overarching mobilising vision for an alternative future for the city-region as a whole, as well as mutual acknowledgement of the respective contributions

both government and academia brought to the partnership (Moore 2016). This established not only an organisation that is able to operate between government and academia, but also an organisation that has developed the trust of both government officials and academics.

Although the city-region is roughly co-terminus with the boundaries of the Gauteng Province, the functional footprint of this urban agglomeration sprawls beyond these boundaries into neighbouring provinces. While the Gauteng Provincial Government has taken the steerage of the city-region as its emblematic purpose, this governance ambition is curtailed by the constitutional autonomy of the city-region's metropolitan and district municipalities.

Achieving coherence and co-ordination across this city-region is obviously in both the regional and national interests and, municipal autonomies notwithstanding, it falls to provincial government to achieve a synoptic view across the region and to plan for its collective future. A challenge in this regard is the disconnectedness of available data, particularly spatial data. Although many of the municipalities in the province gather spatial and other data, securing access to this data can be difficult, even for the GCRO, a government-funded research institute. Furthermore, even when data is accessible, different departments and levels of government have adopted different approaches to its gathering and storage (Schäffler et al. 2013). This can make it difficult and sometimes impossible to analyse the data at a city-region scale. The GCRO itself has found it difficult to collect data beyond the provincial boundary – only the 2009 QoL survey was successful in conducting interviews in the provinces adjacent to Gauteng.

Because the GCR is a heterogeneous city-region made up of a number of urban nodes, rather than a single constrained urban core, the GCRO not only navigates the government-academic divide, but also the complex terrain of multiple municipalities in

500 the city-region and different levels of government (primarily local and provincial, but
501 sometimes national too). This is particularly difficult when conflicts exist between or
502 within different government spheres. The GCRO has adopted an approach where,
503 instead of taking a particular side (between academia and government, or between
504 different government spheres) the researchers deliberately find ways to open up debate
505 and discussion around contentious issues.
506 An example of where this approach has proved valuable is the May 2015 Map of the
507 Month (Figure 1). The map plotted the location of government funded human
508 settlements proposed by the provincial government, together with the concentration of
509 businesses and unemployed people in Gauteng. The map made the argument that there
510 is an apparent disconnect between the location of proposed housing and work
511 opportunities. Subsequent to the release of the map GCRO received a plethora of
512 requests for presentations and engagement from all spheres of government. These initial
513 engagements mushroomed into numerous seminars and facilitated discussions between
514 government officials and academics, special sessions at academic conferences and a
515 journal special issue focused on Megaprojects for South Africa's settlements (Ballard,
516 2017).
517 **[Figure 1 about here]**

518 *Skills and aptitudes*
519 GCRO's core research includes a range of urban themes: 'changing social fabric',
520 'government and governance', 'histories and futures', 'landscapes in transition', 'new
521 regional economies', and 'sustainability transitions', with the crosscutting theme
522 'analytics and visualisations'. These themes are deliberately designed to transcend
523 traditional disciplinary boundaries to provide integrated insights into complex urban
524 trends and processes. GCRO explicitly tries to draw on the strengths of both

525 government and academia, to help produce and translate knowledge to inform
526 government decision-making. One of the main purposes of GCRO's research is in
527 providing different perspectives and thus shifting understandings of the GCR to
528 influence governance in the city-region. This requires researchers who are willing and
529 able to interrogate current approaches and understandings to explore where a particular
530 reading or theorisation of a problem needs to be interrogated.
531 The GCRO presents its research in a range of outputs (see Figure 2) including
532 infographic style vignettes, Maps of the Month, interactive websites, research reports,
533 data briefs, and academic publications. The balance between academic outputs (journal
534 articles and books) and materials for other audiences is about 47% academic to 53%
535 other. In addition to raw and analysed QoL data, the GCRO develops innovative web-
536 based applications to ensure that the QoL data and other spatial datasets are available
537 and widely accessible even to people without data or spatial analysis capabilities. Data
538 analytics and visualisation is a key focus that cuts across all of GCRO's research themes
539 coupling data generation, analysis and visualisation to increase the accessibility of the
540 research to a range of audiences.
541 **[Figure 2 about here]**
542 One of the GCRO's ongoing projects, Green Assets and Infrastructure (GAI), provides
543 an example of how the GCRO has utilised a range of data, methods and output types to
544 systematically build the argument for rethinking the current approach to urban
545 development and infrastructure provision in Gauteng. The project explores how green
546 infrastructure (the interconnected network of ecological systems) can be mainstreamed
547 into urban infrastructure planning and management.
548 This project has brought together qualitative and quantitative methodologies and
549 approaches including GIS (Geographical Information Systems), data visualisation and
550 photography. While few of the concepts adopted in this project are novel

551 internationally, its significance is that it articulates arguments and translates academic
552 theories in a way that is relevant to government in Gauteng. In reporting on this project,
553 the GCRO has deliberately adopted the language of infrastructure planning and service
554 delivery, rather than that of environmental conservation and biodiversity, in order to
555 open up the research to a wider range of people.
556 The GAI project firstly drew on experience from elsewhere in providing detailed case
557 studies and experiential reflections, and secondly developed strategic conversations and
558 spaces where both practitioners and academics could together explore these concepts for
559 the Gauteng context, in a platform dubbed the 'Green Infrastructure CityLab'.
560 The Green Infrastructure CityLab initiated a space for sharing and co-producing
561 knowledge between provincial and municipal officials, academics and other
562 stakeholders from a range of backgrounds. Modelled on the methodology developed by
563 the African Centre for Cities (Anderson et al., 2013), it was designed as a platform for
564 exploring existing green infrastructure plans and projects and for considering what is
565 required collectively to build the knowledge base to support a green infrastructure
566 approach in government planning processes in the GCR. This method provided a space
567 for people to step away from their day-to-day demands and offered opportunities to
568 think beyond the existing structures and practices (Vogel et al., 2016).
569 In attempting to enhance the traction and uptake of the research the project has used a
570 range of outputs types and methodologies (see
571) to translate concepts in an accessible way. The GAI project has been successful in
572 providing external validation for officials attempting to shift stubborn policy approaches
573 and created 'safe' spaces where the insights from both government and academia
574 contribute to and guide the direction of future research. The project has systematically
575 and logically established an argument that speaks directly to local challenges, draws

insights from other cases and provides officials with the tools, vocabulary and support to change approaches in the face of deep resistance. This has required a range of additional skills, beyond traditional academic research skills, such as facilitation, creative visualisation, co-production methods and diplomacy.

[Table 1 about here]

Over time, the project has developed partnerships and collaborations with government, academia and private sector stakeholders. Furthermore, it has supported a number of government projects and processes, including helping different government departments to think through how green infrastructure can be incorporated into integrated infrastructure planning, natural resource planning and responding to climate change. The GAI project and the CityLab demonstrate the importance of developing a trusted platform for engagement that allows people to come together in sustained deliberation. The relative independence of the GCRO, while concurrently holding the interests of both academia and government, was able to create a space where different actors could be engaged and united towards a combined purpose, even though outside of this space they would not necessarily have been easily aligned. However, the project has also highlighted the time-consuming nature of this type of work, and the additional emotional and administrative burden taken on by the researchers.

This is an example of where GCRO's research approach (outputs and research process) has promoted local ownership of the research and informed change. However, achieving influence in this way is far from a guaranteed outcome, and patterns of uptake are very uneven, with examples where the GCRO research seems not to have gained visible traction.

Impact

The GCRO is predicated on the ideal that systematic data generation and analysis, when presented publicly in ways that enable debate, can both contribute to society's understanding of development opportunities and challenges, and support government's strategic decision-making. An important component of ensuring accessibility is GCRO's commitment to making all research outputs freely and publicly available, and data repositories are available for any non-commercial purposes.

The QoL survey provides the basis for research within and beyond the GCRO. The raw data is freely available for research purposes and can be requested directly from the GCRO or accessed via an open-source data repository. Figure 3 shows the number of direct data requests for the QoL survey data from the GCRO. Although the QoL survey is deliberately designed to support government decision-making, by far the majority of requests come from academia. This demonstrates the limited uptake of data within government for internal analysis and use, and emphasises the continuing importance of ensuring that the QoL results are presented to government in various other formats to ensure the application of the data into government decision-making. QoL related outputs take on many forms including written and visual outputs in physical and digital formats, as well as many presentations to executive groupings, committees, strategic planning workshops and government-hosted conferences.

[Figure 3 about here]

As noted previously, the GCRO produces conventional academic research outputs (e.g. books and journal articles) as well as a wider range of reports and data visualisations. The relative distribution of output across academic and other 'more accessible' categories reflects an approach that ensures the scholarly rigour of the research before the insights are made available in more digestible and applicable policy-friendly formats. In terms of the latter, the GCRO is widely known for its Map of the Month

series, where every month a new map is published using innovative mapping techniques and data, to reveal new and interesting dynamics in the city-region and encourage debate.

The range of GCRO's outputs has broadened over time as staff have pushed boundaries of data analysis, visualisation and dissemination. This is motivated by the concurrent desire to broaden the reach of GCRO's data and research among a wide range of audiences and to explore methodologies that open fresh avenues of enquiry and insight. For example, the GCRO's strong track-record in wide-scale survey methods (e.g. its biennial Quality of Life survey) is currently being complemented by ethnographic enquiry into governmental decision-making cultures on the one hand, and into the social fabric of street-level communities on the other.

GCRO also seeks a broader sense of impact, beyond the number of publications, data requests or citations. As the research director notes, "we would be doing ourselves a disservice if we dwell on those kind of metrics" (Götz, personal communication 4 February 2019). GCRO's greater success has been in "expanding the space of debate within government" (Ballard, personal communication, 4 February 2019) and "there is a huge amount that we have done that has shifted the nature of the conversation and continues to do so" (Götz, personal communication 4 February 2019).

Discussion and conclusion

Challenges and opportunities

The aspirations of an observatory can be specified from the outset but will evolve with time and the changing demands to which it is exposed, as well as by its own successes and failures. This ultimately sets an impact agenda, which over time results in opening up of operating spaces such as those described in the case study. A successful boundary organization "will thus succeed in pleasing two sets of principals and remain stable to

external forces astride the internal instability at the actual boundary" (Guston, 2001, pg. 401). One of the critical elements highlighted is a need for sustained and systematic investment in the capability, resources and relationships for transdisciplinary knowledge-making. The "conversation [between academia and government] can happen because we are the right kind of space, but it does not automatically happen because the space exists" (Götz, personal communication 4 February 2019). The case presented highlights the need for trusted relationships and consensus building in the functioning and longevity of observatories.

Much interdisciplinary research is still conducted through temporary teams and collaborations (Klein, 2008). This is not always a satisfactory arrangement in addressing complex, long-term urban problems and there is growing emphasis on the need for institutions to build research relationships to undertake problem-based research that spans disciplines and sectors. The GCRO experience has demonstrated that it is from deep, established and evolving capability that the complexity and multifactorial nature of urban phenomena can be understood, drawing upon comprehensive data repositories and seasoned research skills that are specialised in this domain and the local context. This sustained investment is also essential for the establishment of considered and effective partnerships and networks that reach across institutional boundaries. This is crucial for navigating the inevitable (and often productive) tensions between partners and ensuring the uptake of the research into decision-making systems (Guston, 2001). This also affords the convening power, legitimacy and independence to stage initiatives such as the CityLab. It is thus essential that considered arrangements are made for the longevity of an observatory (including the institutional hosting, core funding etc.) so that it can build both the mature expertise and the appropriate spheres of influence needed to address complex long-term urban problems (Klein, 2008).

675 In addition to sustained investment, which has allowed GCRO to pursue long term
676 research projects, the recurring core grant funding from the provincial government and
677 the in-kind support from the university partners has allowed GCRO staff to focus
678 primarily on research rather than splitting their focus between conducting research and
679 pursuing research funding. This has freed up time for GCRO to undertake
680 transdisciplinary research, where significant time and effort is required to curate
681 effective spaces for knowledge co-production. It has also enabled the organisation to
682 dedicate time and resources to undertake major data collection on a regular basis and to
683 explore innovative visualisation and alternative outputs that enhance dissemination and
684 uptake of GCRO's data and research. The organisation's success and reputation have
685 been significantly furthered through these efforts.
686 GCRO's physical and epistemological location as part of the academy enables it in the
687 most practical sense to make independent research insights available for the governance
688 of the GCR and its connection to decision-making bodies assists both the relevance of
689 its research and its access to the knowledge metabolisms of the public sector. A hybrid,
690 interstitial enterprise of this nature requires a stable organisational platform, invested
691 with sufficient independence and autonomy to protect it from being unduly 'captured'
692 by the dynamics and agendas of any one domain, but that enables it to nourish its work
693 amply from both. It needs to have clear windows of insight into imperatives and
694 conditions that public policy must address, without being drawn into the political
695 urgencies of day-to-day government. Equally, it needs to make full use of the methods
696 and rigour of the academy without becoming committed to burgeoning responsibilities
697 that characterise contemporary academic labour. The GCRO is collectively and
698 divisibly mindful of the competing and complementary imperatives of both the
699 academic and decision-making realms. Through activities such as those described

700 briefly above, it strives to meet the need for high-quality academic outputs (the primary
701 currency of scholarly credibility in the university sector) as well as the appropriate
702 products and publications intended for a wider (especially public sector) readership. In
703 this process, the respective operating boundaries are repeatedly negotiated, contested,
704 and maintained as stakeholders work to resolve a fundamental tension that emerges
705 when science is brought into the policy arena: maintaining scientific credibility while
706 assuring political saliency (Jasanoff, 1987). Ultimately, its outputs are a balance
707 between the two. It is this distinctive tension and dilemma that the GCRO and other
708 boundary organisations must resolve on an ongoing basis; striking a balance between
709 potentially competing purposes, values and practical considerations. A positive lens in
710 the boundary space, posits that where research is confronted by scrutiny from
711 sometimes opposing perspectives, this can increase the difficulty of finalising research
712 outputs, but the credibility of the final output may be of higher quality than without the
713 double accountability (Parnell, 2007).
714 One of the benefits of working as an interstitial organisation is the relative
715 independence that this can provide. This has relevance in the emerging need for
716 observatories to be also 'intermediary organisations', or bodies that broker relationships
717 between other agencies and sectors, that might not otherwise be in dialogue. Certainly,
718 the GCRO has found itself facilitating conversations and debate that extend across
719 government, academia and civil society with the intention of mobilising their individual
720 strengths in pro-active and constructive ways. GCRO has also been active in extending
721 research across a large and heterogeneous geographic space. These processes, like the
722 Green Infrastructure CityLab, often require significant time and effort beyond the pure
723 research endeavour. The potential successes from such engagements can justify this
724 additional effort. However, the risk that some effort might not pay off in the short term

725 needs to be taken into consideration when planning the structure and institutional
726 positioning of observatories, as well as the indicators and measures by which the
727 organisations and their staff are evaluated. Typically, knowledge co-production within
728 boundary organisations results in more varied and nuanced roles for both academic and
729 governmental actors (Guston, 2001 and sub-refs: Braun 1993; Guston 1996; Caswill
730 1998; van der Meulen 1998). The utility of boundary organisations, broadly, is that they
731 sit between two different social worlds, such as science and non-science, and they can
732 be used by individuals within each for specific purposes without losing their own
733 identity (Guston, 2001 pg. 400). While these insights reflect enticingly on the
734 experiences of those interacting with the boundary organisation, the implications for
735 those working within the organisation are notably different and worthy of further
736 reflection. The demands of working life in an observatory can be challenging,
737 presenting a wide range of engagements and accountabilities, different from those of
738 government agencies and academic departments. Researchers in these settings must not
739 be daunted by ambiguity, or the many barriers and frustrations that characterise policy-
740 oriented research, but should rather find fluid and unpredictable contexts to be triggers
741 for innovation. Certainly, in the case of the GCRO, it has been these motivations, skills
742 and capabilities that have helped to shape the paths of enquiry and the research
743 methods, as well as the modes of publication and how these are mediated across
744 audiences. Because of tensions between what is valued in different academic disciplines
745 and the skewed system of research incentives, ways of tracking success are not
746 straightforward and have historically imitated a narrow path to professional excellence
747 and impact (Rijnsoever and Hessels, 2011). In a positive move, with respect to
748 individuals working within an increasingly complex and technical world, some
749 postgraduate programmes in universities encourage and train these boundary-crossing

skills. Observatories and similar bodies are natural destinations for individuals with strong disciplinary skills, but also with an appetite for wider intellectual territory beyond their own disciplines, for problem-oriented enquiry, and for boundary-spanning approaches to research.

Taking urban observatories seriously

Global bodies emphasise the necessity for enhanced research capability to support sustainable urban development objectives, particularly in the global South where urban growth and its consequences are concentrated. In light of calls for urban scholarship that extends beyond traditional Western approaches to enhance knowledge in the global South (Pieterse 2011), it is pertinent that this paper's selected case study is located in one of Africa's major city-regions and is increasingly cited as a global exemplar of boundary organisations.

Ongoing work in this space with academics and practitioners across a range of global settings points to its timeliness and significance, as in the international agenda-setting efforts highlighted in the introduction to this paper. This extended holistic single case study has been produced to illustrate the experience of GCRO as an exemplar boundary organisation in the urban knowledge space. The case connects with many of the documented challenges and benefits surrounding boundary organisations and can assist in informing similar new bodies tasked with data collection and analysis for urban governance, or governance more broadly. The GCRO demonstrates the real potential for the longevity of transdisciplinary research that extends beyond the project level. Observatories are valuable examples of boundary organisations within urban knowledge systems that contribute to weaving larger landscapes of knowledge-to-action for urban governance. Observatories also reveal the potential for collaboration to enable spaces of

774 creativity and innovation to support transdisciplinary research for urban decision-
775 making (Siedlok and Hibbert, 2014).
776 The complexity of contemporary urban challenges, and demands for reporting against
777 global agendas, increasingly requires multi-level approaches to research, where local
778 knowledge is critical for benchmarking and understanding success against global
779 agendas. This complexity and scalability have implications for the nature and scope of
780 organisations and communities that generate and mobilise knowledge into concerted
781 policy programmes including global policy agendas. Beyond the observations
782 developed in this paper, there would be considerable value in a programme of
783 comparative research across existing observatories (structures, partnerships, methods,
784 outputs etc.). This research could provide both further insights into practices and a
785 means for initiating conversation and reflection across agencies operating within this
786 space, deepening the qualitative and quantitative appreciation of their operations,
787 impact and effectiveness in contributing to urban governance.

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Declaration of interest statement

Dr Robin Moore and Christina Culwick are both currently employed by the Gauteng City-Region Observatory, the paper's primary case study institution. Since August 2018 Dr Carla-Leanne Washbourne has been an honorary Research Associate at the Gauteng City-Region Observatory, but is not employed by the institution. No other potential conflict of interests reported by the authors

797 **References**

798 Acuto, M., & Parnell, S. 2016. Leave no city behind. *Science*, 20 May 2016: Vol. 352,
799 Issue 6288, pp. 873

800 Acuto, M., Steenmans, K., Iwaszuk, E., & Ortega-Garza, L. 2018. Informing urban
801 governance? Boundary-spanning organisations and the ecosystem of urban data. *Area*.
802 Online first: https://doi.org/10.1111/area.12430

803 Acuto, M., Parnell, S., & Seto, K. C. 2018. Building a global urban science. *Nature*
804 *Sustainability*, 1(1), 2.

805 Albertini, M. 2017. Grand Challenges in Urban Science. *Frontiers in Built*
806 *Environment*, **3**, 6.

807 Anderson, P.M.L., Brown-Luthango, M., Cartwright, A., Farouk, I. and Smit, W. 2013.
808 Brokering communities of knowledge and practice: Reflections on the African Centre
809 for Cities' CityLab programme. *Cities*, *32*, pp.1-10.

810 Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E. and Patton, E. 2011. Co-
811 management and the co-production of knowledge: Learning to adapt in Canada's Arctic.
812 *Global Environmental Change* **21**(3): 995-1004

813 Bai, X., Dawson, R. J., Ürge-Vorsatz, D., Delgado, G. C., Barau, A. S., Dhakal, S. &
814 Roberts, D. 2018. Six research priorities for cities and climate change. *Nature*,
815 *555*(7694), 23-25.

816 Ballard, R. 2017. Prefix as policy: Megaprojects as South Africa's big idea for human
817 settlements. *Transformation: Critical Perspectives on Southern Africa* **95**(1): i-xviii

Ballard, R., Culwick, C., Everatt, D., Götz, G., Katumba, S., Trangoš, G., Wray, C. 2015. The location of planned mega housing projects in context. GCRO Map of the Month, (Accessible here http://www.gcro.ac.za/outputs/map-of-the-month/detail/the-location-of-planned-mega-housing-projects-in-context/).

Barnett, C. and Panell, S. 2016. "Ideas, implementation and indicators: Epistemologies of the post-2015 urban agenda." *Environment & Urbanization,* 28 (1), 87-98.

Batty, M. 2013. Big data, smart cities and city planning. *Dialogues in Human Geography*, 3(3), 274-279.

Batty, M. 2012. Building a science of cities. *Cities*, *29*, S9-S16.

Berkes, F. 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of environmental management* **90**(5): 1692-1702.

Braun, D., 1993. Who Governs Intermediary Agencies? Principal-Agent Relations in Research Policy-Making. *Journal of Public Policy* **13**, 135.

Brewer, G. D. 1999. The challenges of interdisciplinarity. *Policy Sciences* **32**(4): 327-337.

Campbell, L. M. 2005. Overcoming obstacles to interdisciplinary research. *Conservation biology* **19**(2): 574-577.

Caprotti, F., Cowley, R., Datta, A., Broto, V.C., Gao, E., Georgeson, L., Herrick, C., Odendaal, N., Joss, S., 2017. The New Urban Agenda: key opportunities and challenges for policy and practice. *Urban Research & Practice* **10**, 367–378.

839 Cash, D., Clark, W.C., 2001. From science to policy: Assessing the assessment process.
840 John F. Kennedy School of Government Faculty Research Working Papers Series
841 RWP01-045.
842 Caswill, C., 1998. *Social science policy: Challenges, interactions, principals and*
843 *agents. Science and Public Policy*.
844 Culwick, C., Bobbins, K., Cartwright, A., Oelofse, G., Mander, M. and Dunsmore, S.
845 2016. GCRO research report No. 04 *A framework for a green infrastructure planning*
846 *approach in the Gauteng City-Region*, Johannesburg: Gauteng City-Region
847 Observatory.

848 Culwick, C., Götz, G., Butcher, S., Harber, J., Maree, G., Mushongera, D. 2017. Doing
849 more with less (data): complexities of resource flow analysis in the Gauteng City-
850 Region. *Environmental Research Letters* 12: 125006.

851 Evans, R. and Marvin, S. 2006. Researching the sustainable city: three modes of
852 interdisciplinarity. *Environment and Planning A* **38**(6): 1009-1028.

853 Everatt, D., 2017. Quality of Life in the Gauteng City-Region, South Africa. *Social*
854 *Indicators Research* **130**: 71–86.

855 Farah, J. 2011. *A draft for a typology of urban observatories*. In international
856 Conference: Sustainable economics within the new culture of development, Liège 2011.

857 Guston, D. H. 2001. Boundary organizations in environmental policy and science: an
858 introduction, Sage Publications Sage CA: Thousand Oaks, CA.

859 Guston, D.H., 1999. Stabilizing the Boundary between US Politics and Science:: The
860 Rôle of the Office of Technology Transfer as a Boundary Organization. *Social Studies*
861 *of Science* **29**, 87–111.

862 Guston, D.H., 1996. Principal-agent theory and the structure of science policy. *Science*
863 *and Public Policy*.
864 Holden, M. 2006. Urban indicators and the integrative ideals of cities. *Cities* **23**(3): 170-
865 183.

866 Jasanoff, S.S., 1987. Contested Boundaries in Policy-Relevant Science. *Social Studies*
867 *of Science* **17**, 195–230.
868 Klein, J. T. 2008. Evaluation of interdisciplinary and transdisciplinary research: a
869 literature review. *American journal of preventive medicine* **35**(2): S116-S123.

870 Komninos, N. 2013. *Intelligent cities: innovation, knowledge systems and digital*
871 *spaces*. Routledge.

872 May, T., Perry, B., 2017. Reflexivity: The Essential Guide. SAGE Publications Ltd, 1
873 Oliver's Yard, 55 City Road London EC1Y 1SP.
874 https://doi.org/10.4135/9781473983052
875 McPhearson, T., Parnell, S., Simon, D., Gaffney, O., Elmqvist, T., Bai, X., Roberts, D.
876 and Revi, A. 2016a. Scientists must have a say in the future of cities. *Nature*, 538(7624),
877 pp.165-166.
878 McPhearson, T., Pickett, S. T., Grimm, N. B., Niemelä, J., Alberti, M., Elmqvist, T. &
879 Qureshi, S. 2016b. Advancing urban ecology toward a science of cities. *BioScience*, *66*(3),
880 198-212.
881 Mills, A., Durepos, G., Wiebe, E., 2010. Encyclopedia of Case Study Research. SAGE
882 Publications, Inc., 2455 Teller Road, Thousand Oaks California 91320 United States.
883 https://doi.org/10.4135/9781412957397

884 Moore, R. 2016. The Gauteng City-Region Observatory – a case study. Occasional paper
885 for Programme to Support Pro-poor Policy Development, Department of Planning,
886 Monitoring and Evaluation (DPME).
887 Mushongera, D., Culwick, C. 2017. Boundary organisations and the New Urban Agenda:
888 the importance of policy research for evidence-based planning. *International Development*
889 *Planning Review* **39**: 368–371.
890 Panda, A. and R. K. Gupta. 2014. Making academic research more relevant: A few
891 suggestions. *IIMB Management Review* **26**(3): 156-169.

892 Parnell, S.. 2007. The academic—policy interface in post-apartheid urban research:
893 Personal reflections. *South African Geographical Journal* **89**(2): 111-120.

894 Parnell, S., & Robinson, J. 2018. The Global Urban: Difference and Complexity in
895 Urban Studies and the Science of Cities. In Hall, S., & Burdett, R. (Eds.). (2017). *The*
896 *Sage handbook of the 21st century city*. SAGE.

897 Perry, B., May, T., 2010. Urban knowledge exchange: devilish dichotomies and active
898 intermediation. *International Journal of Knowledge-Based Development* **1**, 6.
899 Petts, J., Owens, S., Bulkeley, H. 2008. Crossing boundaries: interdisciplinarity in the
900 context of urban environments. *Geoforum* **39**(2): 593-601.

901 Pieterse, E., 2011. Grasping the unknowable: coming to grips with African urbanisms.
902 *Social Dynamics* **37**, 5–23.

903 Robin, E., Acuto, M., 2018. Global urban policy and the geopolitics of urban data.
904 *Political Geography* **66**, 76–87.
905 Robinson, J. (2006). *Ordinary cities: Between Modernity and Development*. London:
906 Routledge.

907 Roy, A. (2011). Conclusion. Postcolonial Urbanism: Speed, Hysteria, Mass Dreams, in
908 Roy, A. and Ong. A., (Eds) *Worlding Cities. Asian Experiments and the Art of Being*
909 *Global.* Oxford: Wiley-Blackwell.

910 Satterthwaite, D. 2017. Successful, safe and sustainable cities: towards a New Urban
911 Agenda. *Commonwealth Journal of Local Governance*, (19), 3-18.

912 Seto, K. C., Golden, J. S., Alberti, M., & Turner, B. L. 2017. Sustainability in an
913 urbanizing planet. *Proceedings of the National Academy of Sciences*, *114*(34), 8935-
914 8938.

915 Schäffler, A. with Christopher, N., Bobbins, K., Otto, E., Nhlozi, M.W., de Wit, M., van
916 Zyl, H., Crookes, D., Gotz, G., Trangoš, G., Wray, C., Phasha, P. 2013. *State of Green*
917 *Infrastructure in the Gauteng City-Region*, Johannesburg: Gauteng City-Region
918 Observatory

919 Schön, D.A., 1983. The reflective practitioner: how professionals think in action. Basic
920 Books, New York.
921 Siedlok, F. & Hibbert, P. 2014. The Organization of Interdisciplinary Research: Modes,
922 Drivers and Barriers. *International Journal of Management Reviews*, **16**, 194–210.

923 Simon, D., Arfvidsson, H., Anand, G., Bazaz, A., Fenna, G., Foster, K., Jain, G.,
924 Hansson, S., Evans, L.M., Moodley, N. and Nyambuga, C. 2016. Developing and
925 testing the Urban Sustainable Development Goal's targets and indicators–a five-city
926 study. *Environment and Urbanization*, **28**(1), 49-63.

927 Sutcliffe, S. and Court, J. 2005. Evidence-based policymaking: What is it? How does it
928 work? What relevance for developing countries? (No. Folleto 1427.).

929 Thorpe, R., Holt, R., 2008. The SAGE Dictionary of Qualitative Management Research.
930 SAGE Publications Ltd, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United
931 Kingdom. https://doi.org/10.4135/9780857020109
932 Townsend, A. 2015. Cities of data: Examining the new urban science. *Public Culture*,
933 27(2 76), 201-212.

934 United Nations Statistical Commission. 2017. Global Action Plan for Sustainable
935 Development Data.

936 United Nations. 2015. The Sustainable Development Goals.

937 UN-Habitat. 2016. The New Urban Agenda, Quito.

938 UN-Habitat, Global Urban Observatory (GUO). Accessed 2018. Lists of global urban
939 observatories. https://unhabitat.org/urban-knowledge/guo/

940 UN-Habitat, Global Urban Observatory (GUO). 2015. A Guide to Setting up an Urban
941 Observatory.

942 UNFCCC (The United Nations Framework Convention on Climate Change). 2015.
943 Adoption of the Paris Agreement. Report No. FCCC/CP/2015/L.9/Rev.1.

944 UNISDR (United Nations International Strategy for Disaster Reduction). 2015. Sendai
945 framework for disaster risk reduction 2015–2030. Geneva

946 Van der Meulen, B., 1998. Science policies as principal–agent games. *Research Policy*
947 **27**, 397–414.
948 Van Kammen, J., de Savigny D. and Sewankambo N. 2006. Using knowledge brokering
949 to promote evidence-based policy-making: the need for support structures. *Bulletin of*
950 *the World Health Organization* **84**(8): 608-612.

951 Van Rijnsoever, F.J., Hessels, L.K., 2011. Factors associated with disciplinary and
952 interdisciplinary research collaboration. *Research Policy* **40**, 463–472.
953 Vogel, C., Scott, D., Culwick, C.E., Sutherland, C. 2016. Environmental problem-
954 solving in South Africa: harnessing creative imaginaries to address 'wicked' challenges
955 and opportunities. *South African Geographical Journal* **98**, 515–530.

956 Webb, R., Bai, X., Smith, M.S., Costanza, R., Griggs, D., Moglia, M., et al. 2017.
957 Sustainable Urban Systems: Co-Design and Framing for Transformation. *Ambio*, pp. 1–
958 21.

959 Williams, L. A. 1972. The Urban Observatory Approach: A Decade of
960 Conceptualization and Experimentation. *Urban Affairs quarterly*, *8*(1), 5-20.

961 **Tables**

962 **Table 1: Methods used, outputs generated and engagement undertaken as part of**

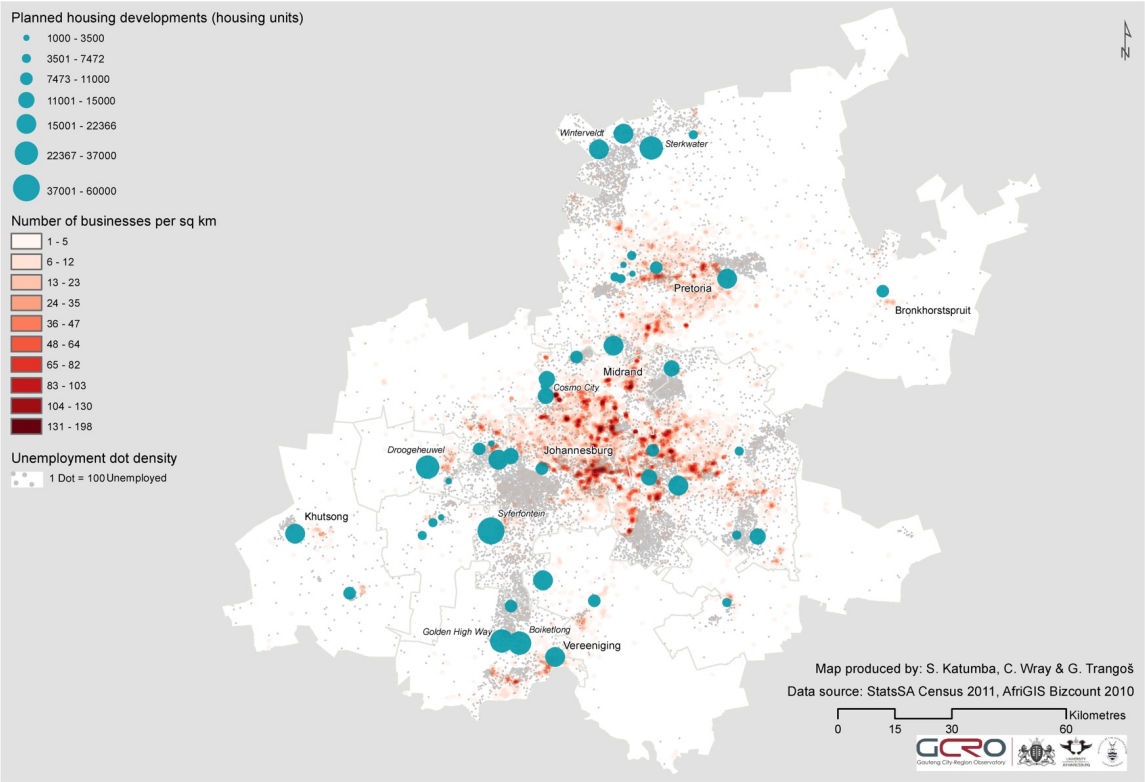
963 **the 'Green Assets and Infrastructure (GAI)' project**

Methods	**Outputs**	**Engagement**
Interviews	Research reports	Green Infrastructure
Facilitated co-production	Maps	CityLab
Case studies	Vignettes	Ad hoc policy support
GIS analysis	Academic publications	Presentations for
GIS mapping	Photo essays	government & academia
Literature review	Blog posts	Steering committees
	Animated video	

964

965

966 **Figures**

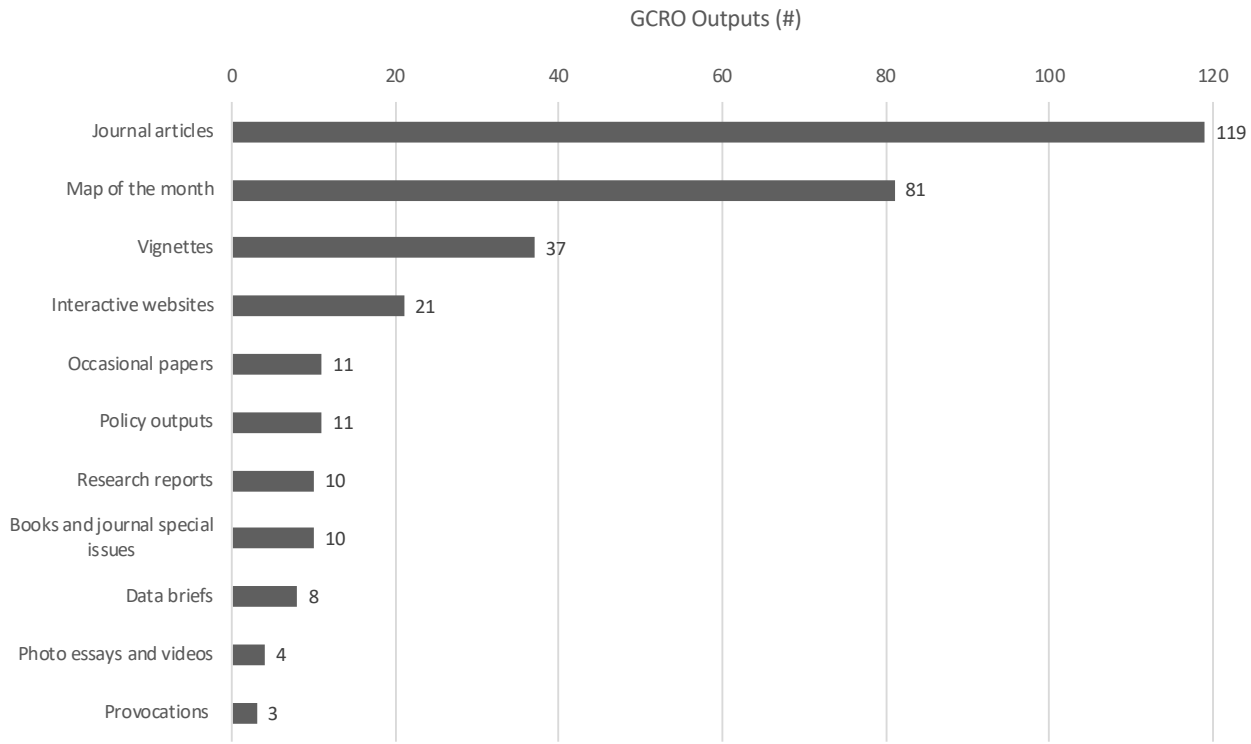


967

968 Figure 1: May 2015 Map of the Month: The location of planned mega housing projects

969 in context (Ballard et al., 2015)

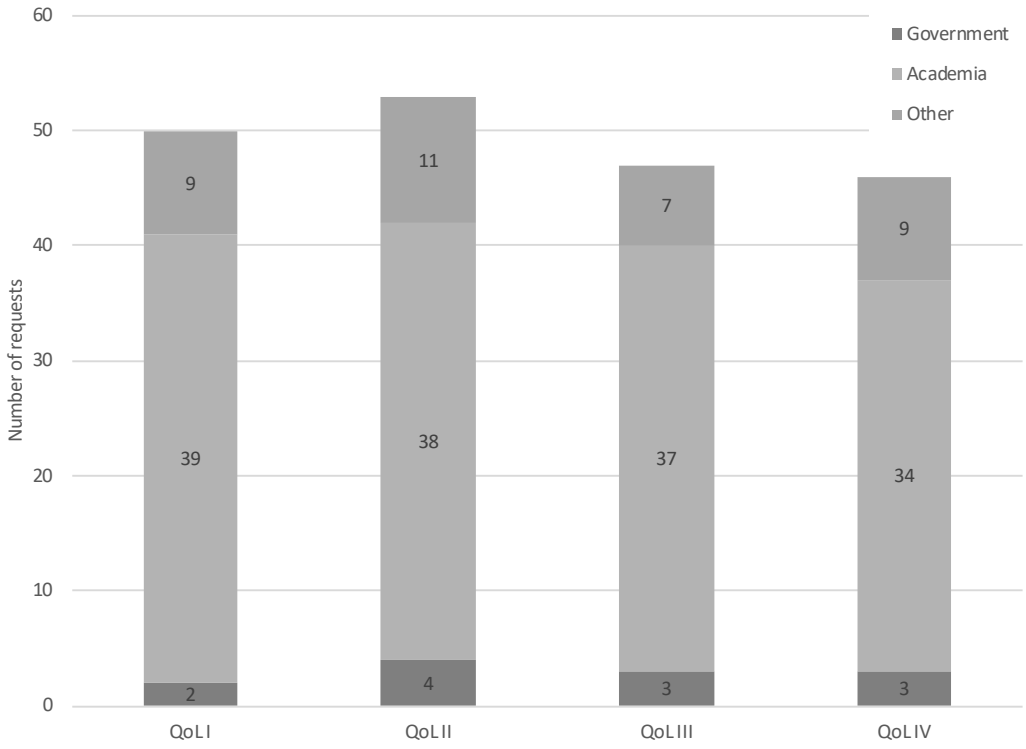
970



971

972 Figure 2: GCRO's publication outputs and number of each published (Jan 2009 – June

973 2018)



974

975 Figure 3: Number of requests for Quality of Life survey data directed from GCRO, and

976 the sector from which the requests derived (as of June 2018)

977

Figure captions as list

- Figure 4: May 2015 Map of the Month: The location of planned mega housing projects in context (Ballard et al., 2015)
- Figure 5: GCRO's publication outputs and number of each published (Jan 2009 – June 2018)
- Figure 6: Number of requests for Quality of Life survey data directed from GCRO, and the sector from which the requests derived (as of June 2018)