CLIMATE INFORMATION FOR BUILDING RESILIENT SOUTH AFRICAN CITIES

by Anna Taylor

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ABOUT THE CITIES SUPPORT PROGRAMME

The South African National Treasury's Cities Support Programme (CSP) works with national government departments to shift policy in a way that makes it easier for cities to work more efficiently; and at the same time working with the country's eight metropoles to ensure sustainable economic growth towards equal, inclusive cities.

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The African Centre for Cities, based at the University of Cape Town, is a leading knowledge centre conducting meaningful reseach on how to understand, recast and address pressing urban crises, particularly on the African continent.

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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. To do so requires robust, actionable climate information. In addition to having such information, capacities and mechanisms are needed to factor it into complex technical and political urban decision-making processes. This paper focusses on how climate information is brought to bear on key city development and urban management decisions in South African metropolitan municipalities and suggests how this can be further strengthened. Drawing on published literature and case studies from the City of Cape Town, eThekwini and Mangaung Metropolitan Municipalities, the paper highlights the diversity of types, sources and applications of climate information. It calls for a strong focus on sustainable knowledge partnerships to select and apply suitable metrics for measuring, enacting and learning about changes in cities and the climate.

ACRONYMS AND ABBREVIATIONS

BEPP	Built Environment Performance Plan
C40	Cities Climate Leadership Group
CCT	City of Cape Town
CDKN	Climate and Development Knowledge Network
CSAG	Climate System Analysis Group
CSIR	Council for Scientific and Industrial Research
CSP	Cities Support Programme
CWERR	City-wide Environmental Risk Register
DEA	Department of Environmental Affairs
DfID	UK Department for International Development
ERMD	Environmental Resources Management Department
GHG	Greenhouse gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IPCC	Intergovernmental Panel on Climate Change
IRM	Integrated risk management
MMM	Mangaung Metropolitan Municipality
MSDF	Municipal Spatial Development Framework
NOAA	National Oceanic and Atmospheric Administration
NRF	National Research Foundation
ODTP	Organizational Development and Transformation Plan
RCP	Representative Concentration Pathway
SAWS	South African Weather Service
SDF	Spatial Development Framework
SDGs	Sustainable Development Goals
SPLUMA	Spatial Planning and Land Use Management Act
UKZN	University of KwaZulu Natal
UNFCCC	United Nations Framework Convention on Climate Change
U.S.	United States of America
USAID	United States Agency for International Development
WEF	World Economic Forum
WRC	Water Research Commission

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1. INTRODUCTION

Cities around the world are increasingly recognized as hotspots of climate impacts and the source of a large proportion of global greenhouse gas (GHG) emissions (Bai et al., 2018; Castán Broto, 2017). Policy and scientific attention is being given to how cities can become more climate resilient through undertaking adaptation actions, and less carbon intensive by implementing climate change mitigation measures. For cities to identify, prioritize and invest in climate adaptation and mitigation measures that are suitable to their context, relevant information is needed about climate patterns impacting on the city and GHG emissions profiles over time, historically and into the future. In addition to such information being produced and available, capacities and mechanisms are needed to factor climate-related information into urban decision-making processes, together with multiple other sources of information and decision factors. Critical to its use in decision-making is the translation of climate and GHG emissions information into knowledge of the knock-on effects of climate impacts on the economic, social and physical functioning (or well-being) of the city and an understanding how significant (and costly) these cumulative effects might be under various scenarios. It is a solid understanding of the ramifications and the potential alternatives in the context of their city that enable decision-makers to engage meaningfully with the climate-related information that is presented to them. Strengthening the capacity of those shaping urban decisions and those conducting climate research to make and articulate the significance of the many connections and feedbacks between the functioning of the atmosphere and the functioning of the city is at the heart of building climate resilience. The recent drought and water crisis faced by the City of Cape Town, as well as the towns of Beaufort West and Oudtshoorn, brought this into sharp relief.

The question is how to build an evidence-base and understanding of such issues, including but not exclusively from a climate perspective, that enables suitable measures to be taken proactively.

This study focusses on how climate information is brought to bear on key city development and urban management decisions in South African metropolitan municipalities, suggesting how this can be further strengthened. While mitigation and adaptation action are both critical to tackling climate change, the scope of this study is limited to how information about climate conditions and climate risks and impacts can and are being used to adapt and transform cities in ways that make them more climate resilient. The climate resilience of cities is understood to mean the capacity of an urban system to minimize the impacts of hazardous climate events, trends or disturbances (like extremely heavy rainfall events, extended dry spells or rising temperature) through measures to maintain or transform the functioning, identity and structure of the city to uplift the most vulnerable now and in the future. The study does not deal with information on city scale GHG emissions and climate change mitigation measures because practical constraints (i.e. the project scope, timing, budget and expertise) required selecting a narrow focus and because the emissions and mitigation issues and indicators are already more extensively addressed in both the existing academic literature and the policy domain (at international, national and city scales) than those of climate impacts and adaptation. However, many opportunities for policy innovation and learning are potentially lost by treating climate change adaptation and mitigation as two separate (and thereby competing) agendas. It may therefore be beneficial to further this work by adding a set of cases that focus on the use of emissions and mitigation information in city decision-making, to draw wider insights on the science-policy interface required to build climate resilient cities in South Africa and beyond.

> The opportunity cost of not adapting to climate change will increasingly require the diversion of limited City resources to respond to the impacts of climate change, rather than being invested in service delivery and facilitating economic growth. South African Cities, therefore, need to be climate responsive to minimise vulnerability to climate shocks and also to strengthen their role in the national and regional economy. Building resilience and adapting to climate change is an inescapable priority for Cities. (National Treasury Cities Support Programme, 2018, Mainstreaming Climate Responsiveness: BEPP Guidance Note)

City governments generate, access and use varying levels of climate information as an input to policies, strategies, plans, proposals, operations and monitoring and review systems. Distilling city relevant climate information for urban decision-making and risk management is a key challenge that city governments face in effectively designing and implementing measures to build climate resilience. For climate information to be used in city decision-making it needs to clearly relate to the priorities set within political and administrative terms (at local, provincial and national scales), as well as align with international agreements like the Sustainable Development Goals (SDGs)[1] and the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC)[2].

1 The SDGs are a collection of 17 global goals, set by the United Nations General Assembly in 2015, to address global challenges, including poverty, inequality, climate change, environmental degradation, peace and justice. Targets for achieving the goals are set for 2030, including targets for building sustainable cities (goal 11) and acting on climate change (goal 13). Countries, and thereby cities, are required to report their progress towards meeting the targets.

2 In December 2015, nations that are party to the UNFCCC agreed to accelerate and intensify the actions and investments needed to tackle climate change. The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 (preferably below 1.5) degrees Celsius above pre-industrial levels. It also aims to increase the ability of countries to deal with the impacts of climate change, through mobilizing financial resources, transferring technologies and building capacity. Under the agreement, countries submit commitments, plans and progress reports on how they are tackling climate change, in which cities play a key part.

Drawing on relevant published literature and four case studies from three South African cities, this paper discusses how climate information is produced for and used by municipal governments. Based on a set of interviews with relevant actors that produce climate information for and use climate information in three South African metropolitan municipalities – the City of Cape Town, eThekwini and Mangaung – the paper explores the governance, financing and research implications of supporting decision-making with the evidence base needed to build urban climate resilience. The findings are based on 19 semi-structured interviews (10 municipal officials, 5 consultants and 4 researchers) conducted between July and November 2018, and a detailed review of the consulting, research and government reports produced in relation to the four case studies (the selection of cases is described in section 4). See Appendix 1 for the list of interviewees and the questions that guided interviews.

2. CHARACTERIZING CLIMATE INFORMATION FOR CITIES

2.1. WHAT IS CLIMATE INFORMATION?

Climate information is generated through the accumulation, analysis and interpretation of data relating to climate conditions and changes over periods of 20 years and longer (Jones et al., 2015; Singh, et al., 2018). Information describing atmospheric conditions at a specific location on the earth's surface for a short period of hours or days is considered weather information, rather than climate information (see table 1). Climate information includes the results of analysing historical observations and future projections of biophysical climate variables (e.g. temperature, rainfall, wind, etc.) as well as derivative variables (e.g. surface run-off, soil moisture, sea levels, etc.) (Singh, et al., 2018). Climate information is based on both observed data from monitoring stations and satellites, and simulated data from running computational models.

A broad definition of climate information could extend to variables and narratives of climate impacts, risks and vulnerabilities that are derived using biophysical climate variables as an input (Kirchhoff et al., 2015). This might include information on crop yields, flood extents and damage costs, and heat-induced morbidity and mortality. A broad definition might also include indigenous forms of climate information, based on localized, long-term observations and the inference of patterns, using different methods and approaches to those of scientists (Alexander et al, 2011; Codjoe et al, 2014, Singh et al., 2018). The definition could be even further expanded to include information about climate drivers, including greenhouse gases emissions, and information about climate change adaptation and mitigation measures, however this is generally not the case when reviewing how the term climate information is used in the international academic literature.

For the purposes of this report, to keep the scope manageable and in line with international research on this topic, a definition of climate information is used that includes both scientific and indigenous knowledge of long-term biophysical climate variables and climate impacts, risks and vulnerabilities that are derived from this, i.e. it does not go so far as to consider emissions information and information about climate change adaptation and mitigation measures.

2.2. WHAT IS CITY RELEVANT CLIMATE INFORMATION?

Climate information relevant to a city includes analyses of data relating to the area within a city's spatial boundaries. It also includes analyses of data from beyond the city / municipal boundaries in places that are linked to, or have an impact on, the functioning of the city (e.g. rainfall patterns in catchments outside of the city where the city draws its water from). With regards to temporal scale, climate information that is relevant to the decisions being made by city governments includes information at the seasonal scale, for example how much rain might be expected for the upcoming season relative to the long-term average of that area, and information at the decadal scale, for example what the annual average temperature might be for the period 2040 to 2060 relative to that measured between 1980 and 2000. It is important to note that information on projected climate conditions for the coming 2 to 10 years timescales is very difficult to produce with any reliability because of natural variations arising from the chaotic nature of ocean-atmosphere interactions, the output of the sun and volcanic eruptions (Wilby et al., 2009). This an active area of research, partly based on the recognition that this scale of climate information is what many city decision-makers are asking for, to align with terms of office, policy and strategic planning cycles and financing arrangements. Ziervogel et al. (2010) provide a useful overview of the different temporal scales of climate and weather information and the types of decisions each are used for in water management, see Table 1, page 4.

City decision-makers usually need climate information that is locally specific that goes beyond biophysical climate conditions and related risks to include information on strategies for addressing climate impacts (Howarth and Painter, 2016). City decision-makers need climate information to understand the impacts of climate change on urban development and public service delivery and to adapt to emerging and projected future changes in climate conditions (Jones, et al., 2015; Singh et al., 2018). However, climate information still tends to focus on biophysical variables at coarser regional to global spatial scales and at long-term (50 to 100 year) time scales (Dilling and Lemos, 2010; Singh, et al., 2018). Much of the available climate information is not directly associated with the kinds and scale of risk or strategic planning information required at the city

TYPE OF DECISION	CLIMATE		WEATHER	
	LONG-TERM (10-50 YEARS)	MEDIUM-TERM (3-9 YEARS)	MEDIUM-TERM (7-30 DAYS)	SHORT-TERM (0-7 DAYS)
TYPE OF INFORMATION	Decadal changes; climate change scenarios	Seasonal forecasts	Weekly and monthly weather forecasts	Daily forecasts; observations
STRATEGIC	Supplying demand; reservoir sizing; reservoir safety; land management			
TACTICAL		Operating rules; water orders; water allocation; demand management		
OPERATIONAL			Irrigation scheduling; field operations; flood warning; stormwater drainage clearing	Flood emergency response

Table 1: Types of climate and weather information and the types of water management decisions each are used for, adapted from Ziervogel et al., 2010, p.540

scale (a notable exception would be localized sea level rise projections factored into spatial planning and land use management in some coastal cities). Therefore, despite a growing call to integrate future-oriented climate information into decision-making (especially long-lived infrastructure and land use decisions), limited cases exist in sub-Saharan Africa to date (Jones, et al., 2015). But, as this study finds, as do Singh et al (2018) and Lötter et al (2018), such cases are starting to emerge.

3. USING CLIMATE INFORMATION IN CITIES

Much of the international and South African academic literature on scientific climate information either speaks very generically about potential users and uses of climate information or focuses predominantly on the agricultural sector (Changnon, 2004; Haigh et al., 2015; Singh et al., 2018) and the water sector (Ziervogel et al., 2010; Vogel et al., 2016). Very little is said about the specific needs for and uses of climate information at the city scale, beyond a general call for climate information to be used by city decision-makers to understand urban climate impacts and adapt to emerging and projected future changes in climate conditions (Jones et al., 2015).

The few studies that do focus on cities and climate information, notably Mills et al. (2010), Grimmond et al. (2010), Ng (2012), Solecki et al. (2015) and Cortekar et al. (2016), point to applications in:

- Infrastructure planning (especially drainage, water, transport and energy infrastructure);
- Spatial planning and land use management;
- Building design (including building codes and standards);
- Water resource management;
- Transport planning;
- Open space and ecosystem management;
- Disaster risk management;
- Health services.

Within each of these domains, climate information may be used to:

- identify and assess climate risks, impacts and vulnerabilities;
- appraise options for reducing levels of climate risk and vulnerability;
- design the technical specifications of infrastructure and land management practices;
- stress-test existing systems (e.g. infrastructures, emergency response measures, tariff models, ecosystems, etc.) and planned interventions to assess resilience, identify thresholds and test alternatives;
- monitor changes and evaluate performance.

ADAPTATION	EXAMPLES OF ACTIVITIES USING CLIMATE INFORMATION
New infrastructure	Cost-benefit analysis, infrastructure performance and design
Resource management	Assessment of natural resource availability, status and allocation
Retrofit	Scoping assessments to identify risks and reduce exposure to extreme events
Behavioural	Measures that optimize scheduling or performance of existing infrastructure
Institutional	Regulation, monitoring and reporting
Sectoral	Economic planning, sector restructuring, guidance and standards
Communication	Communicating risks to stakeholders, high-level advocacy and planning
Financial	Services to transfer risk, incentives and insurance

Table 2: Examples of the uses of climate information to guide adaptation actions across various sectors that build climate resilience (Wilby et al., 2009, p.1196)

Wilby et al. (2009) provide a useful overview of the kinds of adaptation activities within various sectors that require using climate information, see Table 2.
International studies agree in most cases there remains a mismatch between the climate information produced by the science community and the climate information needed by decision-makers. This mismatch is both in terms of the content of the information and, the timing and format of its delivery. Useful climate information helps to clarify areas for concern and intervention, expand alternatives, appraise options and improve outcomes of management decisions (Pielke, 2007).

For climate information to be actionable, Vogel et al. (2016) building on Cash et al. (2002) suggests, it needs to be:

- Salient (i.e. striking or clearly of importance) and context sensitive;
- Based on accepted standards of practice;
- Seen as legitimate, coming from a source that is deemed worthy of trust;
- Produced through iterative engagements with the intended information users.

To meet the requirements for actionable climate information, careful thought and engagement must go into developing indicators and monitoring systems that are feasible to establish and maintain over time. All the while, capacity needs to be strengthened to analyse the emerging data and communicate the resulting information into suitable technical and political forums at appropriate times to support decision making. For climate information to be considered salient or of primary importance to city decision-makers (both technical and political decision-makers) it needs to provide clarity on what the potential impacts are to the city system, within reasonable and accepted bounds of uncertainty and confidence that are innate to any information about the future. Using examples of past climate impacts experienced in the city, or similar cities, such as losses of life and the cost of damages to homes, businesses, hospitals, schools and ro ads from flooding, can help increase the salience of information about projected future climate conditions. If climate information is seen as too distant and vague then it is not assimilated and acted on within a decision context (Stoknes, 2015).

A useful set of questions to guide the development of urban climate indicators, proposed by Solecki et al. (2015, p.92), include:
a) What are the critical climate variables, indices and extreme events to monitor in order to know whether the climate of the metropolitan region is changing?
b) What is the baseline reference for the data (i.e. start date and end date)?
c) For a given indicator, should it be calculated annually, seasonally, monthly or weekly?
d) What is the appropriate averaging period (e.g. 1-day or 4-day precipitation)?
e) What is the appropriate spatial averaging (e.g. precinct, ward, city, metropolitan region)?
f) How should thresholds be chosen: statistically (e.g. 95th percentile) or relative to a critical value based on infrastructure or physiological vulnerability?
g) What evidence is needed to determine if/when certain thresholds are being reached?
h) What systems and areas are most at risk of climate impacts?
i) What are targeted policy questions for which indicators should be designed?
j) What information is needed to improve resiliency to extreme events of rapid changes in the climate?

RELEVANCE	POTENTIAL INDICATORS
ANALYSING THE CLIMATE	Number of heat advisories per year Number of extreme precipitation events (95th percentile) per year Number of days per year with sustained winds or gusts exceeding certain thresholds Trend in length of dry spell duration Trend in peak storm surge for 100-year storms
ASSESSING CLIMATE IMPACTS	Number of days per year with air quality index exceeding a certain threshold Number of weather-related transport disruptions reported per year Costs of additional water treatment owing to extreme events Spatial extent of flooded areas / number of flood-affected households and businesses Duration of electricity blackouts per year associated with weather-related events
ASSESSING CLIMATE VULNERABILITIES	Disparity in heat-related morbidity and mortality across sub-city areas with respect to a variety of equity conditions (e.g. income, housing stock) Social Isolation Index in flood zones Percentage of water lost from the distribution network (i.e. unaccounted-for or non-revenue water) Percentage population with a disability or chronic health condition Disparity in households without home insurance across neighbourhoods with respect to a vari ety of equity conditions
ASSESSING CLIMATE RESILIENCE	Population growth/decline living in 100-year floodplain Number of jobs created through climate resilience programmes Number of government subsidized housing units fitted with heat stress and/or flood protection measures Area of restored wetlands and dunes (i.e. buffer zones to regulate flooding) Area of green open space per ward

Table 3: Examples of potential climate related indicators for cities, adapted from Solecki et al. (2015)

Examples of the kind of climate, impact, vulnerability and resilience indicators that cities might need to guide decisions are listed in Table 3. It is only an indicative sample of potential climate-related indicators for use in city decision-making. The able primarily shows the four categories of indicators needed to go beyond the biophysical assessment of climate patterns to establish the linkages between climate variables and urban outcomes, as well as to evaluate the effectiveness of various policy and planning interventions.

In selecting a suitable set of climate-related indicators for a particular city / municipality, or a set of municipalities, careful consideration must be given to what is technically and financially feasible to consistently collect and analyse on a long-term basis, and what other monitoring frameworks need to be aligned with (for example those stemming from the SDGs, the National Development Plan, the National Climate Change Response Policy and the Provincial Climate Change Strategy). Doing so requires input from a whole range of stakeholders that make up the climate information ecosystem, see Figure 1.

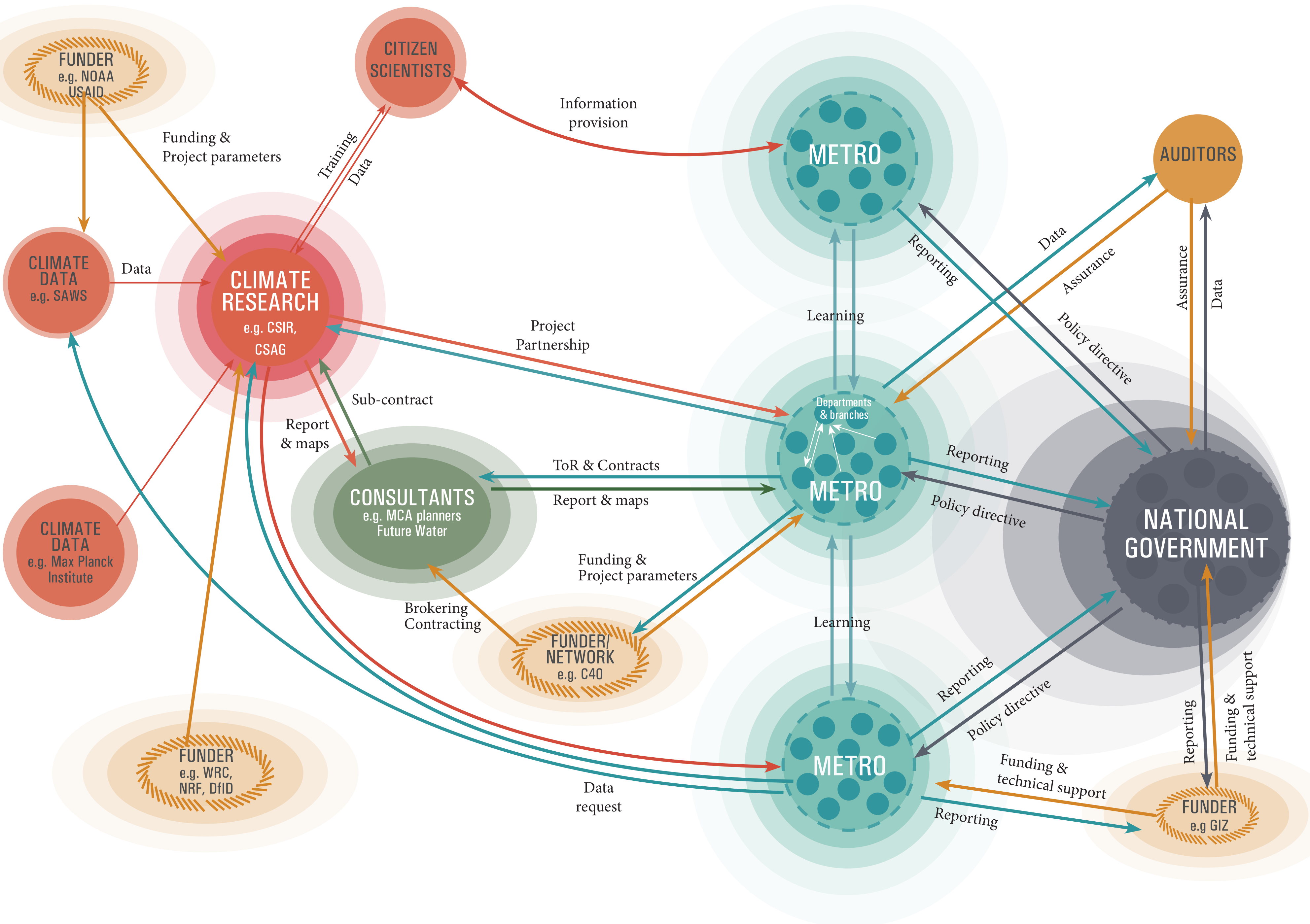

Figure 1: Climate information ecosystem

4. CASES OF CLIMATE INFORMATION USE IN SOUTH AFRICAN METROPOLITAN MUNICIPALITIES

To gain a deeper understanding of how climate information is currently being used in South African cities, or metropolitan municipalities (referred to below as metros), four case studies were developed. Based on selective sampling, the City of Cape Town's Spatial Development Framework review was selected as a case of government commissioning climate information to inform a policy process. The City of Cape Town's risk register was selected to explore how and what climate information was sourced to guide integrated risk management within a municipality. eThekwini's latest climate risk assessment was selected as a leading example of co-producing context sensitive and actionable climate information. Mangaung's Climate Change Strategy was selected as a case of consultant driven climate information provision. The cases are designed to be explorative rather than representative. They do not account for all uses of climate information in South African cities. For example, climate information has also been used in urban water management (Ziervogel et al., 2010), coastal management (Mather and Stretch, 2012; Colenbrander et al., 2015; Daron, 2015) and stormwater management (Taylor, in press).

4.1. CITY OF CAPE TOWN

The City of Cape Town (CCT) has a history of working to integrate climate change into their policies, planning and operations that stretches back to 2000/1 but picked up in earnest in 2005/6 (Taylor and Davies, in press). There have been numerous attempts along the way to bring climate information into various CCT decision-making processes. The work of the Climate Change Think Tank, a partnership between CCT and the University of Cape Town to generate new knowledge on local dimensions of climate change that have a strong bearing on city government operations, marks a significant component of this (Cartwright et al., 2012). Other key efforts to integrate climate information include: commissioning a Global Sea Level Rise Risk Assessment for the City of Cape Town to inform coastal management policies and practices; identifying key climate risks and vulnerabilities to guide the development of a Climate Adaptation Plan of Action (or set of plans); integrating climate and sea level rise projections into hydrological and catchment models as a basis for stormwater master-planning (see box 1); commissioning a multi-hazard disaster risk assessment to underpin disaster risk management plans; the commissioning of updated climate projections (in the form of climate risk narratives) for Cape Town to support the preparation, adoption and implementation of a Climate Change Policy for the city; and most recently the inclusion of climate scenarios in water resource modelling work being done to guide the design and implementation of a new Water Strategy, drawing lessons from the recent drought. Building on previous research into CCT's climate change efforts, this study focuses on processes of integrated risk management and strategic spatial planning as two functions where climate change considerations are evident, but little is known about what and how climate information is brought into these processes.

BOX 1: ASSESSING THE IMPLICATIONS OF CLIMATE CHANGE ON FLOODING IN THE SALT RIVER CATCHMENT TO GUIDE STORMWATER MANAGEMENT INTERVENTIONS

Flooding in Cape Town is impacted by both inland and coastal storm effects, from intense rainfall, increased stream flows and surges in sea level. There is concern that local flood risks are changing under anthropogenic climate change, in combination with the development, expansion and densification of the city. Between 2009 and 2011, the City of Cape Town worked with consulting coastal engineers, hydrologists and climate scientists to develop a more detailed knowledge of how various scenarios of increasing sea-level, storm surge, rainfall intensity and freshwater run-off translate into altered flood levels in the Salt River catchment. Detailed analysis, which included runoff modelling for the Salt River catchment together with coastal storm surge and wave height modelling, was undertaken to determine flood levels in the lower catchment for 1:20, 1:50 and 1:100 year return periods. The results show that localized scenarios of climate change, calculated for 2035 and 2060 using downscaled data from ten global climate models, together with projected sea level rise, alter the flood risk profile of the catchment significantly. As a result, CCT is accounting for such changes in the planning of bulk drainage infrastructure and the delineation of floodlines, with implications for the assessment of land rezoning applications, the requirements placed on property developments, and the implementation of additional flood mitigation measures. The component of this work that investigated climate impacts at the freshwater-marine interface of the Salt River catchment (Harris et al., 2012) was undertaken as part of the Climate Change Think Tank, a collaboration between the City of Cape Town and the University of Cape Town bringing researchers and practitioners together to explore various local dimensions of climate change in Cape Town (Cartwright et al., 2012).

4.1.1. CCT INTEGRATED RISK MANAGEMENT

The first case study investigates how climate information is brought into the CCT's risk management process; not disaster risk management focused on extreme events and emergencies, but the city government's strategic management of cross-cutting risks that impact the functioning and effectiveness of the organization to deliver on its mandate. CCT has an Integrated Risk Management (IRM) system that entails the establishment and regular updating of risk registers. CCT has a corporate risk register owned by the City Manager, for managing risks facing the organization as a whole. Recognizing the cross-cutting nature of environmental risks and the multi-sectoral nature of the measures needed to reduce environmental risks and build the environmental sustainability of a city, the King III audit identified the need for an environmental risk register for the CCT organization as whole (i.e. not only owned by the environment department). The audit finding led to the development of a City-wide Environmental Risk Register (CWERR) that, since December 2017, forms part of the corporate risk register owned by the City Manager, on which climate change features as a priority risk for the City to manage. CCT also has over 100 specialist operational risk registers, owned by each Executive Director and Director across the organization, many of which also contain reference to climate change as a risk and/or a contributing factor to other risks (such as intermittent water supply).

The risk registers document the process of identifying and assessing key risks to the operations of the organization (specifically linked to delivering on targets set in Service Delivery and Budget Implementation Plans) and tracking actions to reduce and manage these risks (targeting root causes and contributing factors).The risk registers are used to monitor progress and formalizing updates on a quarterly basis. Each risk is rated on a 10x10 matrix of impacts and likelihood. The Risk Management Committee (RiskCo), made up of all Executive Directors and a representative of the Audit Committee, is tasked with collectively applying their minds to whether risks are adequately being perceived, rated and addressed. In addition to the quarterly updates overseen by the RiskCo, the corporate risk register is internally and externally audited every year.

Climate risk appears on the corporate risk register (in the CWERR) as a cross-cutting risk to be managed at the strategic level of the city government. It is articulated as the "Inability to effectively mitigate and cope with the impact of climate change" and is further elaborated in terms of consequences, such as water insecurity, increased natural disasters from extreme weather events, loss and damage to coastal infrastructure and properties, loss of ecosystem services, and changes in disease vectors. From when the CWERR was incorporated in the CCT's corporate risk register in December 2017 to date (latest version signed 18 September 2018), the impact and likelihood of the climate change risk to the City of Cape Town are both rated 8 out of 10, indicating that the impact is assessed to be critically high (but not catastrophic) and the likelihood is deemed to be high such that the risk is certain to occur within the next 1 to 2 years.

With the aim of ensuring that risks are managed to an acceptable level, the IRM Branch supports the City's directorates and departments in monitoring and reviewing all action plans documented in the risk registers (twice per financial year) and to verify any actions linked to significant risks that have been marked as complete by line departments. The key challenge for the City, like any large organisation instituting such an approach, is how to ensure that the IRM system is run with foresight, agility and strategic intent, rather than as a narrow exercise of compliance.

4.1.2. CCT SPATIAL PLANNING REVIEW

In 2016 CCT undertook to review and revise their 2012 Spatial Development Framework (SDF) in light of new regulations introduced by the Spatial Planning and Land Use Management Act (SPLUMA) and Western Cape Land Use Planning Act (LUPA), and the establishment of the Integrated Urban Development Framework and CCT's Municipal Planning By-Law. SPLUMA, for example, by including the principle of 'spatial resilience' added emphasis to the requirement that municipal SDFs include a strategic assessment of environmental pressure and opportunities within the municipal area, identify the spatial location of key environmental sensitives, and limit the develop of land considered to be at high risk and/or important for reducing environmental risks (for example through protecting the functioning of riverine, wetland and coastal ecosystems to provide flood attenuation services)[3]. Through the review process the focus of the CCT SDF[4] shifted from land use planning to the principles of spatial integration and transformation to guide public investment (with the Built Environment Performance Plan articulating the investment strategy).

As part of the review process CCT commissioned consultants to review the previous SDF through a climate change adaptation lens and make recommendations on how to further incorporate climate change adaptation considerations and measures into the revised SDF and into the planning processes guided by the SDF (CCT, 2016). This work was jointly commissioned and managed by the Spatial Planning and Environment departments, building on the Environment

3 See Taylor et al (2016) for a review of legislative and policy tools, including SLUMA, available to South African metropolitan municipalities to address climate risks, vulnerabilities and impacts.

4 SDF became the Municipal Spatial Development Framework (MSDF)

department's track record of addressing climate change while tailoring the work to the needs of the spatial planners tasked with updating the SDF. The review process got interrupted and redirected due to elections and the CCT's roll out of their Organizational Development and Transformation Plan (ODTP). This interruption curtailed the impact of the climate component, as did limitations on the scope and depth of the work created by the small budget and very short timeframe for the climate review. The small scope and budget of the project meant that the consultants were not able to interrogate primary climate information. Rather the consultants used their professional experience and judgement, notably based on climate change work done for the provincial government, to articulate the kinds of local climate impacts that CCT line functions needed to account for. Despite the limitations, the study marked an important step in thinking about the different scales at which climate information can be brought to bear in the planning process, and what critical connections exist between climate risks and the spatial configuration of various municipal functions and services. But more is needed to develop spatialized climate information (covering climate related risks and vulnerabilities) at a scale and in a format that spatial planners can use in revising and developing district and master plans (both precinct and infrastructure master plans), especially for the areas that are being spatially targeted for public investment (i.e. as articulated in the MSDF and Built Environment Performance Plan). The scarcity, inaccessibility and inconsistency of relevant spatially referenced data sets presents many challenges to developing such information, as detailed by Storie (2017) with a focus on climate adaptation and disaster risk management data in South Africa.

4.2. ETHEKWINI CLIMATE PROJECTIONS AND RISK ASSESSMENT

The eThekwini municipality, like the City of Cape Town, has a long track record in addressing climate change (Roberts, 2008 and 2010; Taylor et al., 2014). As early as 2000/1 the city government formally committed to a climate change agenda, with an initial focus on reducing the emissions of greenhouse gases through energy efficiency initiatives (Roberts, 2008). Over the years the climate adaptation agenda has grown. The adaptation agenda picked up in 2005/6 after the initiation of the Municipal Climate Protection Programme in 2004, which included a partnership between eThekwini municipality and the Council for Scientific and Industrial Research (CSIR) to review global and regional climate change science and data sets and translate these into an understanding of local impacts for Durban (Roberts, 2008). This gave rise to the development of a Headline Climate Change Adaptation Strategy and sectoral Municipal Adaptation Plans to mainstream climate measures across municipal operations, as well as an Urban Integrated Assessment Framework and Cost Benefit Analysis to simulate, evaluate and compare strategic development plans and policies in the context of climate change, and a programme of Community-based Ecosystem Adaptation (Roberts and O'Donoghue, 2013; Roberts et al., 2016). These have led to Durban becoming recognized as an international leader in this field. It laid the groundwork for undertaking the recent climate assessment for updating eThekwini's climate action plan, which is the focus of this case study.

Through an initiative by the C40 international network[5] , Durban was selected as one of the cities to receive funding to update their climate action plan (both adaptation and mitigation) to align with the 1.5°C ambition of the Paris Agreement. This entailed developing updated climate and socio-economic projections for the Durban city region / eThekwini Municipality as a basis for assessing key climate risks and vulnerabilities to address and prioritizing actions. Building on the experience of supporting municipalities in the Netherlands to conduct climate stress tests, and a recognition that climate adaptation cannot only be top-down but has to be mainstreamed into many municipal decisions, activities and services, considerable emphasis was placed on visualizing climate information in a way that connects it with the priorities of the city government and other city stakeholders. Consultants and municipal officials worked together to co-produce a series of maps that link climate science with city priorities and concerns. Not only are maps easier for a variety of decision makers to engage with, than a dense technical report, but they can more easily be integrated with other types of information and updated as new information becomes available (if the necessary resources, capacities, capabilities and incentives are in place to do so). The difficulty with maps, however, is adequately representing a range of plausible future scenarios and avoiding an inflated impression of accuracy at high resolutions that is not warranted by the underlying data.

4.3. MANGAUNG CLIMATE CHANGE STRATEGY

Mangaung Metropolitan Municipality (MMM) is in the early stages of integrating climate considerations into its policies, plans and operations (SACN, 2014). Responding to a national directive stemming from National Climate Change Response Policy (DEA, 2011), MMM procured consulting services to develop a Climate Change Adaptation and Mitigation Strategy. The strategy development process included engagements with senior managers and political leadership, as well as representatives from civil society, industry and business. Despite these engagements in the formative stages, it is proving difficult to get the

5 C40 is a global network of 96 cities, representing 700+ million citizens and one quarter of the global economy, committed to addressing climate change. C40 supports cities, represented by their mayors, to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change, to deliver on the most ambitious goals of the Paris Agreement at the local level. See: https://www.c40.org/

necessary traction to implement the Strategy. There is much work still to be done translating the Strategy into the operational plans and budgets of the relevant line functions with the mandate and expertise to implement the listed actions. The climate information included in the strategy is of a long-term and broad nature that does not readily map on to the concerns and priorities within the municipality. There remains the need for MMM to take ownership of and institutionalize the Climate Change Strategy by taking the large scale and long-range projections and the elaborate lists of possible interventions and actions provided by the consultants and turning those into a set of priorities that are spatially targeted and aligned to the division of organizational mandates and functions, as well as talking to the near-term political commitments of the elected leadership. To do so MMM have identified the need to grow their local knowledge base and capacity through developing a partnership with the universities based in the city. Through such a partnership, climate information can be translated into a scale and format that matches municipal planning, budgeting, project development and implementation, thereby guiding and evaluating action to ensure that it is robust and credible. This aligns strongly with the experiences and successes, as well as challenges, to-date of CCT and eThekwini.

5. CASE COMPARISON

The table below compares the four cases on the basis of how climate information has been sourced, produced and used. The table is followed by a description of what each case, and comparing between them, reveals about the process of building an evidence-base to shape decision that have a bearing on the climate resilience of a city.

	CAPE TOWN IRM RISK REGISTERS	CAPE TOWN SDF REVIEW	ETHEKWINI CLIMATE PROJECTIONS & RISK ASSESSMENT	MANGAUNG CC STRATEGY
PURPOSE OF CLIMATE INFORMATION	To manage risks affecting the CCT's ability to fulfil their mandate and deliver on their goals	To revise the CCT's strategic framework for managing the city's spatial growth and public service delivery	To update the municipal climate action plan to be in line with the 1.5°C ambition of the Paris Agreement	To develop a strategy for how the municipality will tackle climate change
FORMAT OF CLIMATE INFO	Risk related reports	Narrative description in consulting report, focus on impacts	Interactive online map with supporting technical report	Highly technical description with supporting maps in consulting report / strategy
DATE PRODUCED	Varied	June 2016	July 2018	December 2015
SPATIAL SCALE OF CLIMATE INFO	Various, focus on city region	Metro scale focus on climate impacts	Metro scale	Sub-national region (i.e. central South Africa)
TIMEFRAME OF CLIMATE INFO	Seasonal forecast and long-range projections	2050 and end of the century	1996-2015 baseline period; projections for 2041-2060 period	1971-2000 baseline period; projections for 2021-2050 period
EMISSIONS SCENARIOS	Unclear as multiple indirect sources and sources not referenced in the register	"the current emissions trajectory" (likely to be RCP 8.5)	Report covers RCP 2.6 (1.5°C ambition), RCP 4.5 and 8.5; online map only presents RCP 2.6 and 8.5	RCP 4.5 and 8.5
PRODUCERS OF THE CLIMATE INFO	Various, information gleaned from various reports e.g. WEF Global Risk Report, PwC & CDKN Climate Risk Report	Royal Haskoning DNV, the Cape Town office of a global engineering consultancy, sub-contracted to MCA Urban and Environmental Planners	FutureWater and Climate Adaptation Services, both consultancies in the Netherlands	CSIR Natural Resource and Environment Unit via NM Envirotech Solutions consultancy in Pretoria

MODELS USED	Not traceable as information sources not referenced in the register (indicative example of CCT sea level rise risk assessment based on GIS inundation model driven by scenarios partly derived from IPCC AR4 findings[6])	Not directly based on modelling, climate impact information produced through a SWOT assessment based on professional experience and judgement (i.e. indirectly drawing on previous modelling work)	3 global climate models; statistical downscaling using delta change / perturbation method	5 global climate models; dynamical downscaled using a regional climate model
VARIABLES INCLUDED	Climate variables not traceable, focus on qualitative description of climate impacts (e.g. loss and damage to coastal infrastructure and properties; changes in disease vectors)	Qualitatively refer to: average temperature (air and water temp); temperature extremes (max and min); heat waves; sea levels; storm surge frequency; rainfall patterns; wind direction and speed	Total annual precipitation; annual max daily precipitation; total seasonal precipitation; #[7] dry periods[8]; longest dry period per year; annual mean air temp; mean, max, min temp per season; # hot nights; #heatwaves[9] ; relative humidity; evaporation rate; wind speeds; sea level	Total annual precipitation; # extreme rainfall Type 1 event[10] days (proxy for lightening); annual average temperature; # very hot days[11] ; # heatwaves[12] ; # high fire-danger days[13] ; dry spell[14]
SEQUENCE OF PROVISION	N/A: no targeted provision or commissioning of climate information specific to IRM	Inception meeting, draft meeting, 1 final report	1 technical report (presented at 2nd workshop); 3 workshops; online interactive Climate Story Map	3 workshops; 1 final report
CLIMATE RISK AND IMPACT INFO	Sought and gleaned from scanning and reviewing various existing sources	Focus on describing climate impacts per line function and adaptation options per department / branch	Spatial info on droughts, pluvial flooding, coastal flooding, heat risks; online map app designed for people to add information about stress locations and impacts	Broad inferences of possible impacts mentioned; sectoral vulnerabilities broadly described based mainly on literature review
FUNDED BY	N/A	CCT ERMD	C40	MMM

6 See Brundrit (2008) for details

7 # indicates number of

8 A dry period is defined in the eThekwini study as a period of at least 5 consecutive days with less than 1mm of rainfall (Lutz, 2018).

9 A heatwave is defined in the eThekwini study as a period of at least 6 consecutive days with daily maximum temperature at least 5⁰C higher than the long-term average of the daily maximum temperature for that period of the year (Lutz, 2018).

10 An extreme rainfall Type 1 event is defined in the Mangaung study as more than 20mm rainfall within 24h over a 50x50km area (Mbileni et al., 2015).

11 A very hot day is defined in the Mangaung study as a day when the maximum temperature exceeds 35⁰C (Mbileni et al., 2015).

12 A heatwave is defined in the Mangaung study as a period of at least 3 consecutive days with daily maximum temperature at least 5⁰C higher than the average temperature of the warmest month of the year (Mbileni et al., 2015).

13 A high fire-danger day is defined in the Mangaung study as having a McArthur fire-danger index score exceeding 24 (Mbileni et al., 2015).

14 Dry spells are defined the same in the Mangaung and eThekwini studies (see footnote 8).

As intended through the selection of the cases, the four cases show a variety of ways in which cities seek, receive and use climate information. It highlights that there is no singular need for, or way in which metro governments access, climate information. Consequently, there is no one-size-fits-all approach to producing and providing climate information to cities; a finding that supports those of Cortekar et al. (2016) and Vogel et al. (2016). Instead there are a diversity of urban decision-making processes in which climate information, of some sort, features. There does, however, appear to be a common and consistent need for climate data and information to be translated into locally relevant, context specific expressions of risks and impacts that clearly relate to the roles and responsibilities of those making policy and planning decisions. There also appears to be a progression over time as to how capacitated city governments are to procure and integrate the climate-related information suited to their decision-making needs. This cannot be generalized to the city government as a whole.

The Cape Town cases (including box 1) show how different units and decision-making processes within the City are at different stages of prioritizing and building the capacity to access, procure and integrate climate information that is suited to their needs. Comparing across the cities, the case of Mangaung reads much like the early experiences of the environment departments of both the eThekwini and CCT municipalities. Both had early experiences of commissioning climate studies that were difficult to integrate into their operations and decision processes. Over many years they iteratively learnt from and built on these early experiences to develop new and deeper partnerships and commission more targeted, contextually relevant and actionable climate information. This is progression entails an ongoing process of slowly developing a clearer understanding and articulation of their needs and ability to engage with and guide the work of climate information producers. Similarly, providers of climate-related information also have differing capabilities to interpret and address the information needs of city governments. As such, capacity strengthening is needed across the information ecosystem (see figure 1 in section 3), sharing experiences, insights and lessons between various climate information users and producers within and between cities.

The case studies show that when efforts to integrate climate considerations into municipal decision-making begin with a dedicated focus on the climate then the information tends to be of a technical and primarily biophysical nature, making it difficult to assimilate into existing decision-making processes. When the focus is on the planning and management processes themselves (such as spatial planning and integrated risk management) then the information sought focusses much more on impacts and actions, directly addressing questions about the significance of the climate conditions and patterns on the functioning of the city. When focusing on impacts and adaptation actions the biophysical climate information often falls out of direct view, making it difficult to trace the origins and interrogate the underlying assumptions and methodologies. While the emphasis on climate impacts and actions may be what is needed by practitioners and decision makers, the lack of visibly or traceability of the underlying biophysical climate information is problematic. It is problematic because it masks the contingent nature of the information and makes it difficult to revisit the choices based on new information, which is emerging all the time in the climate sciences. Therefore, while the approach of focussing information generation on climate impacts and actions in the specific context of the city is necessary, the sources of climate information underpinning these assessments and professional judgements should be documented to enable further interrogation and revision.

It is also evident from the cases that there is no standardized set of climate variables, definitions, methods and tools used. This makes building an integrated and coherent climate knowledge base for a metro difficult. It also makes comparative work between metros difficult. However, full standardization across cities is probably not desirable because of the different physical contexts and different planning and management needs that metros have. For example, humidity information might be important for health-related decisions in eThekwini but hold little relevance for Mangaung municipality. Sea level is another obvious example.

The CCT spatial planning and Mangaung strategy cases highlight the difficulties associated with procuring climate expertise from consultants on a short-term basis and translating the resulting work into the processes and decisions of the metro government. Both cases highlight the issue of timing. They show how budget cycles, funding opportunities and/or national directives often determine the timing of consultancy projects, which do not always align well with the timeframes and iterations of city-scale policy and planning processes, thereby undermining the full impact of the work.

The cases, in different ways, show how considerable resources, capacity and leadership are needed to firstly conceptualize and develop Terms of Reference that adequately convey the needs of the government to potential service providers and knowledge partners. Secondly, considerable resources, capacity and leadership are then needed to transform an externally produced document – one that includes lots of technical details and options, not all well aligned to the scale, mandate and operations of the metro government – into a workable strategy that can be widely adopted and implemented. Building the necessary resources, capacity and leadership requires sustained investment by municipalities and their knowledge and funding partners, including proactive measures to increase staff retention and development and build an organisational culture that prioritises the allocation of time to undertake such tasks (that extend well beyond the transactional practices of traditional consultancy projects). The experiences of CCT and eThekwini show that the knowledge and skills required to do this type of work takes years, if not decades, to foster and remains in scarce supply, at both the individual and organisational scales. Staff turn-over and organisational redesign often curtail or redirect work on producing and integrating climate information, or undermine the impact thereof.

The eThekwini case has the makings of a good example of how to "bridge the gap between climate science and city level action, going the last mile by translating climate impact information to policy relevant and usable science and embedding that information with the relevant stakeholders" (eThekwini Climate Story Map, accessed 27/10/2018). The process is still unfolding. The case presents, in one sense, only the beginning of what needs to be a long-term process of further developing and integrating relevant information from various sources and institutionalizing the use thereof. The success cannot be evaluated yet. But what is already evident is that many years of prior work within the municipality – building capacity, relationships and knowledge – was needed to get to the point where an engagement, partnership and co-production process of this kind was possible. So in another sense the case presents not a beginning but rather a milestone within a multi-decadal process that can be traced back to the start of the Municipal Climate Protection Programme in 2004 and earlier to 2000/1 when the climate change agenda started taking shape in the municipality. This long-term process of developing, refining and updating actionable climate information and integrating it into various local government decisions and operations has involved many partnerships along the way. These partnerships are still being negotiated and renegotiated, and lessons are constantly being learnt about what is needed, what is possible, what works well and what does not. By contrast, the Mangaung case highlights the importance, yet the challenges, of getting started and building the experience, capacity and partnerships to do this kind of climate resilience building work.

The CCT integrated risk management case reveals that there is still some way to go in connecting the production of climate information to all of the relevant and necessary processes of decision-making in which such information is needed and can be acted on. Because of the cross-cutting, forward looking, transversal nature of the integrated risk management process in CCT, it is a critical vehicle for regularly assessing and reassessing the local risks and opportunities presented by climate variability and change, and for evaluating the effectiveness of various interventions (controls and actions), in a systematic, iterative and strategic way. The focus on combined assurance – through internal and external auditing – provides a mechanism for bringing the latest climate science to bear on the risk perceptions, ratings and responses of government representatives tasked with managing and overseeing the management of the municipality. But it does not yet bring climate information into the process in a structured and traceable way. There are however some signs of this starting to change, largely prompted by the recent drought. CCT has recently appointed consultants to stress test the Western Cape Water Supply System under various climate scenarios. This work is underway and will likely be an example of how analysis of this kind can feed into and support the risk rating and action prioritization process facilitated through the IRM branch. The drought and resulting water crisis in Cape Town showed up the current short-comings of the IRM system within the functioning of the metro government as a whole. Despite the risk ranking of water scarcity steadily increasing during the onset of the drought, it did not trigger the kind of proactive, integrated, coordinated and evidence-based response required to avoid a crisis situation (as documented in the accompanying report by Ziervogel in this ACC-CSP series). While the IRM system holds much promise, more is needed to break down organizational silos of information, knowledge and practice, such that metros can act with foresight and systemic capacity to build climate resilience.

Finally and importantly, the eThekwini climate risk assessment and climate action plan update highlighted the need to frame climate adaptation not only as a means of risk reduction or risk avoidance, but also as a value creation or value enhancing proposition. The recognition of the need to reframe climate adaptation and ideas of how to do so stemmed from the many years of experience and numerous preceding iterations of promoting climate action in the municipality, led by the Environmental Planning and Climate Protection Department, together with the expertise brought by the consultants from the Netherlands, who have worked with many Dutch municipalities on these issues. By reframing the aim to that of using the climate agenda to improve the city, the traditional approach of generating climate information to feed into risk, impact and vulnerability assessments as a basis for identifying adaptation options is challenged. Rather than starting with information about the climate, the starting point becomes aspirations of what needs to change for the better in the existing city and then layering climate information on to see what climate adaptation and mitigation measures can be used as part of the strategy for achieving such improvements

6. CHALLENGES OF AND OPPORTUNITIES FOR INTEGRATING CLIMATE INFORMATION INTO CITY DECISION MAKING

The literature reviewed and the cases studied together highlight that metropolitan governments cannot act on biophysical climate information alone. It needs to be processed further into information about variables that have a direct bearing on the running of the city, such as water availability, health threats, critical buffer zones for flooding and coastal erosion, etc. Working out what those variables are and how to calculate them at a suitable scale in light of a range of future climate scenarios is something that can only be co-produced between climate specialist and urban practitioners. A number of lessons regarding the challenges of and opportunities for co-producing climate information to be used in South African metros emerge from the research, relating to themes of scale, variables, process, format, users, capacity and resourcing.

6.1. SCALE AND VARIABLES

- Scale is a key issue for integrating climate information. The spatial scale is of primary concern, but the temporal scale alsocreates difficulties. The CCT SDF review is a clear example of this. An attempt was made to (very quickly) develop a high-level climate risk map for Cape Town. But the spatial planners found it difficult to integrate the resulting climate risk map with other spatial layers because of a mismatch in the resolution of the information. The resolution could not be achieved for many of the variables because of the lack and patchiness of suitable data. The extensive work that has gone into developing detailed assessments of the localised impacts of various scenarios of climate change along both Cape Town and eThekwini's coasts stand as examples of what is possible and what it entails to develop information at the necessary resolution required for detailed spatial planning.
- The selection of climate indicators must enable municipalities to build the evidence base of how climate conditions and patterns relate to the priority urban development agendas of spatial integration, affordable housing, job creation and the universal delivery of basic services (i.e. the provision of water, energy, sanitation and waste management). And thereby how investments in climate adaptation contribute to achieving development goals.
- Meaningfully integrating biophysical climate information with social and economic information that contributes to climate vulnerability remains a challenge. This is a methodological challenge, as well as a data challenge. It relates to mismatches of scale and of expertise.
- Just like urban development, climate adaptation (and mitigation) strategies and actions play out over decadal timescales and so the procurement and application of climate information cannot be dealt with on a short-term, piecemeal basis. A more strategic and iterative approach needs to be taken to ensure the availability and integrity of longitudinal data that forms the necessary basis for information to guide and evaluate decisions that impact the climate resilience of the city or the metropolitan municipality.
- Ultimately, managing climate risks requires multi-level collaborative government and governance (i.e. not only all spheres of government but private and civil society actors too). As such, the use and integration of climate information into decisions that affect cities does not only occur at the city scale. A clear example of this is in water management. One of the important decision processes that climate information (including forward looking climate change information) feeds into is the regional water reconciliation strategy processes that involve national government, provincial government, municipalities and water utilities and agencies. For example, between 2008 and 2012 the Department of Water Affairs, Bloemwater, MMM and all other relevant stakeholders developed a Bloemwater Reconciliation Strategy that factors in the impacts of climate change on water availability and management (SACN, 2014). Similarly, the drought and water crisis in Cape Town has prompted a review of the Western Cape Supply System Reconciliation Strategy in light of a range of possible climate scenarios. A number of methodological innovations are being explored to develop a robust assessment that can aid in the CCT's decision-making.

6.2. PROCESS

- Because climate risks and adaptation measures cut across the functions of metro governments, the wider set of city governance actors and across a range of spatial and temporal scales, climate information is needed at both the strategic, transversal management level and at the specialist operational level. The information needs, in terms of both content and format, are different for making strategic, transversal and operational decisions. The production of climate-related information needs to reflect these different needs.
- Climate information needs to relate clearly and directly to the policy, planning and management processes that are deemed to potentially be climate sensitive. To achieve this requires considerable and iterative engagement between those with the domain expertise of the policy, planning or management process in question and those with climate expertise (see section 7 for more on this).
- The infrastructure and service delivery backlogs and resource constraints faced in most municipalities translate into an almost permanent state of crisis management that undermines long-term, forward looking, cross-cutting agendas such as climate adaptation. Climate information therefore has to be framed in a way that emphasises the contribution it makes to delivering a better city for all, rather than a narrow risk avoidance framing.

- The idea of and methods for 'stress testing' are surfacing extensively in both the international literature on decision making under uncertainty and in interviews with various experts dealing with the integration of climate information into decision making. Stress testing involves simulating how a system (e.g. a water supply system, road network, wetland ecosystem or fire response service) will be impacted by and behave under extreme conditions. Stress testing is used to gauge the thresholds at which systems malfunction and break down and the resulting outcomes. For example, in CCT interviews there was mention of the lack of, and the need for, stress testing the water tariffs and City revenue model with drought conditions. The appeal of this approach is that detailed climate projections with high levels of confidence and accuracy are not needed. Instead, the range of available climate projections can be used to inform the selection of a range of hypothetical, plausible changes in climate conditions against which systems and measures can be assessed to identify chronic impacts and critical failures.

6.3. FORMAT AND USERS

- Maps consisting of various relevant data layers are a very powerful format for presenting spatialized climate information and making it easier for planners to integrate such information into decisions. The benefit of maps is that they translate the information into familiar places and force a certain amount of simplicity in what can be readily displayed in a legible format. However, the problem with maps is that they can give an inflated sense of accuracy, making it difficult to represent uncertainties in which multiple potential scenarios coexist and need to be accounted for in a decision. Innovative methods of representation need to be used to overcome this.
- The use of climate narratives and storylines are one method being developed and experimented with as a means to represent multiple potential scenarios that need to be accounted for in a decision (Sheppard et al., 2018). The eThekwini Climate Story Map is an example of how a series of maps and narratives are being interwoven on a digital platform to present a complex set of information and scenarios of climate risks, impacts and actions for people to explore.
- The focus cannot only be on the supply of scientific information to the technical staff. There is a need to strengthen and deepen engagement between the politicians and the technical staff, well before difficult decisions have to be made. The climate information needs to be used to tell a compelling story so that politicians can understand the technical requirements, the technical people can understand the political pressures, and both can understand what climate variability and climate change mean with regards to impacts on residents, businesses, and municipal responsibilities. The Mangaung Climate Change Strategy is a clear example of the need for this kind of engagement, otherwise the strategy does not get the political support required to implement it.

6.4. CAPACITY AND RESOURCING

- While progress has been made (to varying degrees) in many metros over recent years, many are still struggling with a scarcity of capacity to address cross-cutting, systemic and long-term risks such as climate change. This capacity deficit is at an individual level and at the organizational level. There are too few people with the knowledge, expertise and skills to understand and act on these issues. As the cases have shown, much has been done and things are starting to change. But on the whole, there are still insufficient or inadequate organizational processes and structures in place to facilitate the joined-up thinking, planning, decision-making and implementation that is needed to address climate risks in a strategic and operational manner. As a result, climate information is still brought into the work of the metros in a largely ad hoc and fragmented way that is not conducive to building the evidence base and expertise required for sustained decision-making that builds climate resilience. What has started needs to be further strengthened, expanded and given the necessary weight to shift to a more holistic and proactive system of governing and managing cities in a time of rapidly changing environmental, social, economic and political conditions. A clear example of this is the extent to which the CCT's IRM system detected and reported the rising risk of a water crisis as the drought progressed, but did not trigger a sufficiently coordinated level of response across departments, spheres of government, the private sector and the public to avoid the uncertainty, panic, blaming and crisis measures that ensued.
- Integrating climate information into urban decision-making requires considerable time and resources to procure specialist services to undertake climate assessments and to produce climate information that is both scientifically robust and sufficiently targeted to be actionable in the procedures and structures of a city government. Also, as the work of integrating climate consideration progresses new and different climate information is needed. The procuring and integrating of climate information cannot be a once off activity. It needs to be resourced in such a way that enables follow up research to be done, climate information to be refined, extended and deepened, and policies, plans, programmes and projects to be revised in light of this new information.

- Grant funding can help in designing and setting up processes to procure, refine and integrate climate information and assess progress towards reducing climate risks and building climate resilience. The international grant funding available, for example through the Green Climate Fund, is difficult to access and so many metros need assistance in accessing such funds. Ultimately though, internal financing mechanisms and institutional partnerships need to be built to sustain such processes over the long-term and keep them tailored to addressing the changing nature of local needs. For funds to be channelled in this way, the intent and commitment to pursue climate resilient (and low carbon) urban development has to be a clear policy priority for the municipality, as exercised by both the Council and the administration.
- Despite considerable progress over the last decade, notably in the eThekwini and CCT metropolitan municipalities, none of the metros have a consolidated system in place to monitor and analyse direct and indirect climate impacts and the efficacy of adaptation measures. This undermines the potential for reporting, for flexible yet robust decision making, and for evidence-based evaluation and learning. It is not realistic to expect municipal governments to undertake this independently. Rather municipalities need to be encouraged and supported to establish a network of partnerships, including research institutes, NGOs and corporates, that can conceptualize, design, set up and maintain such a system. Further investigation and engagement with the full range of stakeholders is required to establish the extent to which such a system could be coordinated and funded nationally. This should form part of the phased development and implementation of the National Climate Change Response Monitoring and Evaluation System, led by the national Department of Environmental Affairs.
- The growing field of citizen science or community science – the collection and analysis of data and sharing of findings by members of the general public in collaboration with professional scientists – presents an exciting area for development that could contribute to a metropolitan climate monitoring system, generating considerable data while growing the awareness and knowledge about climate and climate change issues that is necessary to drive the political will and thereby the technical capacity to further such agendas.
- Progressively growing a better understanding – of the climate risks, vulnerabilities and impacts facing municipalities and of the opportunities for climate resilient development – that is shared between citizens / residents / voters, their elected representatives, government officials, scientists and those in the business and industry, is at the heart of building climate resilient cities and municipalities. It is this need for a shared understanding, and a recognition of the distributed nature of the relevant information and expertise needed to build such an understanding, that underpins the notion of an information ecosystem (as depicted in figure 1).

7. STRATEGIES TO INTEGRATE CLIMATE INFORMATION INTO CITY DECISION MAKING

The findings from the case studies align with those emerging in the international literature (notably Kirchhoff et al., 2013; Asrar et al., 2013; Cortekar et al., 2016; Vogel et al., 2016; Hewitt et al., 2017), suggesting that the elements listed in the table below are key to addressing the challenges of creating credible, salient, context sensitive climate information.

In light of these needs, there are increasing calls to co-produce climate information in ways that break down the prevailing mismatch between suppliers and users of climate information. Literature on climate services go beyond the content of the climate information to discuss the procedural aspects of co-producing it and applying it to decisions (Moss et al., 2013; Vaughn and Dessai, 2014; Vogel et al., 2016; Steynor et al., 2016). The U.S. Department of the Interior's Advisory Committee on Climate Change and Natural Resource Science (Beier et al., 2015) suggest five guiding principles for co-producing actionable climate information:

1. Actionable science is most reliably co-produced by scientists and decision makers or resource managers working in concert.
2. Start with a decision that needs to be made.
3. Give priority to processes and outcomes over stand-alone products.
4. Build connections across disciplines and organizations, and among scientists, decision makers, and other stakeholders.
5. Evaluate co-production products, processes, and the actionability of the science produced by projects.

It is increasingly acknowledged that the co-production processes needed to generate usable climate information are time consuming and resource intensive (Briley et al., 2015; Vogel et al., 2016). There is no way to avoid this; instead it must be designed for and adequately resourced. With training and practice the skills, understanding, relationships and spaces are built that make co-producing actionable climate information easier and more cost effective. Considerable and sustained investment is required to achieve this, especially in light of the high turn-over and mobility of professional and management staff in municipalities.

The experiences of eThekwini and the City of Cape Town, stretching back to the early 2000s, both show this to be an ongoing process that requires champions, partnerships and an experimental learning approach to keep moving forward.
The study by Vogel et al. (2016) of four projects designed to co-produce actionable climate science with water utilities in the US, found three principles and associated practices that are central to building closer linkages between knowledge, decision-making and action on climate resilience:

KEY TO CREATING ACTIONABLE CLIMATE INFORMATION DOCUMENTED IN THE INTERNATIONAL LITERATURE	SUPPORTING EVIDENCE FROM THE SOUTH AFRICAN CASE STUDIES
Improve communication between climate information producers and those needing/wanting to use climate information, especially breaking historical patterns of a one-directional flow of communication from scientists to 'users'/decision makers. This relates to selecting appropriate biophysical and socio-economic variables/indicators to generate information about impacts and response measures at a scale that can be acted on.	Mangaung highlights the need for more engagement between MMM – both the officials and politicians – and CSIR to make sense of the implications of the biophysical climate information, especially future climate scenarios, for it to manage the development and growth of its urban areas. The eThekwini case shows how an intermediary, such as C40, can assist in facilitating improved communication. Both cases show the difficulty of doing so if not located in the same city.
Build mutual trust between those generating and using climate-related data and information (across organizations, sectors and scales) to establish the legitimacy of the process and thereby the ability to integrate the resulting products and outcomes into all relevant decision-making processes.	The CCT SDF case shows how the relationship between environment and spatial planning departments was critical to designing, financing and procuring the climate review of the SDF, but how the organizational redesign interrupted and undermined that.
Overcome an initial lack of knowledge from all sides about what information is needed and best suited to addressing the unique problems and decisions in a particular context. Engaging repeatedly to enable iterative development and refinement of the information. And having the resources and staff capacity to do so.	The workshops in eThekwini case were vital for reaching a shared understanding between the consultants and municipal officials about what was needed, what was possible and what the priorities were. International funding support made that possible. Timeframes and the diverse user needs meant that full alignment was still not achieved.
Persist through unsuccessful or partially successful attempts as matching information supply with decision needs (what is supplied is not targeted enough or because decision needs change). Reconciling the spatial and temporal scales of climate information and other decision factors.	Clear across all the cases. The CCT SDF case shows how difficult it is to translate climate information into the scale at which land-use management decisions are made, but how progress is being made as evidenced by the sea level rise work.
Grapple with technical and lay interpretations and implications of uncertainties and likelihoods. Translating climate risk and impact information into action on an iterative, progressive and coordinated basis.	The CCT IRM case highlights the need to integrate perceived climate risk ratings with available scientific evidence, possibly through the combined assurance process. Stress testing methods to assess systems and interventions against a range of plausible scenarios hold particular promise in this regard.
Navigate different approaches to problem formulation, problem solving and decision making, different organizational mandates and career incentives between technicians, scientists, managers and political actors.	All the cases evidenced that climate scientists, consultants, funders, officials in different departments and politicians view problems and priorities differently, requiring considerable engagement and intermediation to build an evidence base that supports decision making. The eThekwini case showed the benefit of framing the climate agenda as enhancing urban development and creating public value, over and above risk avoidance.

1. The first strategy is that the specific contextual realities of those using the information have to be heavily factored into the generation of the information. In other words it is essential that partners are brought together with an overarching goal that provides sufficient direction to develop a collaboration but with enough flexibility to fine-tune the co-production process to fit the unique set of local conditions, capacities and decisions faced in the place and time where/when the information is needed. This may include customizing the research questions, customizing definitions of and methods for calculating extreme events, and customizing the selection of tools, datasets and capacity building activities.
2. The second strategy is an intentional and organized process of extending and strengthening knowledge networks through brokering early, frequent and iterative engagements between scientists, technical staff and managers across multiple organizations. These engagements are to be designed in such a way as to ensure strong two-directional communication and mutual capacity development.
3. The third strategy that is key to the success of co-producing climate information is taking an entrepreneurial approach to the process. By this they mean being innovative, learning by trial and error, and being agile to adjust to emerging barriers and opportunities – some version of fail fast, fail safe, fail forward. It is not just research scientists who need to be taking this approach, but also those in government agencies and utilities who are working with scientists to produce climate information that meets their needs. They often have necessary expertise and practical knowledge to work with scientists to direct the innovation of techniques, methods and datasets that meet their contextual requirements. Most traditional consulting contracts, however, do not readily enable the entrepreneurial approach.

These strategies resonate with the lessons emerging from the four cases studies and provide guidance on how to move forward in these and other South African metros, not only for the local governments themselves but for others in the climate information ecosystem too. A similar set of strategies are suggested by the Climate System Analysis Group at the University of Cape Town, through an approach referred to as climate information distillation (Jack, forthcoming). Together with several city partners across South Africa (including the CCT and eThekwini municipalities) and the southern African region, these strategies for co-producing climate information that is actionable at the city scale are being trialled through the Future Resilience of African Cities and Lands project[15].

8. RECOMMENDATIONS

The following recommendations emerge from the research undertaken in this study:

Conduct a full audit of all climate data and information held by metropolitan governments, whether generated internally or commissioned from external service providers, and what that data and information has been or is being used for. The audit should be the basis of a needs assessment, to establish where there are critical data and information gaps, and where there are significant competency and/or capacity gaps that limit the extent to which data and information can be used. These gaps may be within the technical teams of the city administration and/or in the ability and willingness of political representatives to adequately factor such evidence into their decision making. There may also be critical competency gaps in the research and consultancy organizations from which municipalities source their climate information and decision support. A national entity or network organization could play a key intermediation role, enabling the flow of climate information and expertise from areas of high capacity to those where more support is needed. This aligns strongly with, and supports, the phased development and implementation of the National Climate Change Response Monitoring and Evaluation System Framework[16], led by the national Department of Environmental Affairs. Undertaking such an audit and needs assessment will provide the basis for strengthening the collaborations needed to collect, share and integrate the biophysical and socio-economic data and information linking climate with the local development agenda.

Establish an Urban Climate Resilience Indicators, Monitoring and Evaluation Working Group made up of representatives from all the organizations and sub-organizational units that collect and use climate data and information at the city scale in each metro. The Working Group should have the mandate to review the status quo of climate data collection and availability and guide the integration of existing data set and curation of existing climate information at the municipal scale. The Working Group should also strategize around the means for filling key gaps in the evidence base, and collaboratively design a system of monitoring and evaluation that enables all relevant urban actors to get an updated picture of progress towards building the metros climate resilience. This will necessarily include identifying key thresholds and decision triggers (linked to stress testing approaches), as well tracking the efficacy of various climate adaptation and mitigation interventions from a systemic perspective. The work of the group therefore needs to extend beyond biophysical climate indicators to that of climate impacts, vulnerability, adaptation and resilience, across issues of primary concern for the city (e.g. water availability, water

15 http://www.fractal.org.za/
16 https://www.environment.gov.za/sites/default/files/reports/nationalclimatechangeresponse_MESF.pdf

quality, flooding and coastal inundation, electricity distribution, biodiversity and ecosystem functioning, health, agricultural productivity and food security). Aligning with other national and international monitoring and reporting processes (e.g. the National Development Plan, Integrated Urban Development Framework, Sustainable Development Goals) will also need to be considered, to enhance synergies and make trade-offs to ensure that the system can realistically be sustained. It could be through such Working Groups that the aforementioned audit and needs assessment is overseen. Or it may be that the audit could inform the constituency of the Working Group. It is important that the Working Group include representatives from civil society groups (linking to the potential for citizen science), as well as other spheres of government, the research community, and private sector. To avoid it becoming an onerous task and getting locked into a particular organisational culture, the hosting and convening of the group could be done on an annual rotation amongst members. Pragmatically the Working Group may need to start small to get going, with a few representatives from key sectors and organizations (e.g. the local government and local university), especially in municipalities such as Mangaung that are just getting started on their journey of mainstreaming climate concerns into their work. But the Working Group should be designed and run on the principles of openness and inclusivity, so that others can be aware of the work being done, offer contributions, and can join the group as and when there is mutual value to be added.

Articulate policy priorities, structure funding and maintain partnerships to ensure consistent and continuous monitoring of key climate-related variables over decadal timescales. Remote sensing technologies can be used to provide continuous coverage over large areas, but such data must be integrated with ground-based observations (especially socio-economic data) to increase their applicability to urban scale decision making. Expertise in data management and integration must be prioritised and invested in. Strengthening analytical and communication expertise is equally critical to fostering a climate information ecosystem that supports decision-making and guides action towards building the climate resilience of municipalities. Indicators and monitoring frameworks for climate impacts and actions in cities is a growing area of international funding, as shown by the eThekwini case study linking to the C40 network. However, considerable capacity and expertise is required to access and administer such grant funding, especially at the scale sought by the global funders, such as the Adaptation Fund and Green Climate Fund. National entities, like DEA and CSP, could provide the necessary networking and support to cities to develop collaborative proposals that build off and scale up existing experiments within leading metros. Ultimately, national and metro financing mechanisms and institutional partnerships need to be built to sustain such processes over the long-term, tailored to addressing the changing nature of local needs.

Ensure that the research community plays a key role in co-designing the indicators framework and contributing to (including co-resourcing) the implementation of the monitoring network and the data processing, integration and analysis work. The research community has an important role to play in developing and providing the training needed to strengthen climate competencies within metropolitan governments. But the research community also needs to strengthen its own capacity to be able to understand and meet the applied research and information needs of municipalities. This learning on all sides is at the heart of being able to co-produce information and knowledge that is actionable at the city scale. To overcome the fragmented nature of the research landscape relating to climate information for cities, it is recommended that DEA, the Department of Science and Technology, the National Research Foundation, the Applied Centre for Climate & Earth System Science (ACCESS) and CSP, convene South African research entities working in relevant fields to chart a national strategy for co-producing and making accessible the needed climate information, together with representatives from city governments and others. This should build on the work of and lessons learned from the Let's Respond Toolkit, the South African Risk and Vulnerability Atlas, the Future Resilience for African Cities and Lands project, and the Green Book project.

Undertake follow-up research to investigate and document a set of cases that focus on the use of emissions and mitigation information in city decision-making. As noted in the introduction, this study has focused on how information about climate conditions and climate risks and impacts can and are being used to adapt and transform cities to make them more climate resilient. In so doing it did not deal with information on city scale GHG emissions and climate change mitigation measures. There are potentially important lessons regarding the production and use of information in decision-making that can be learnt across the climate adaptation and mitigation domains. Together with the cases presented above, such follow up research could yield further insights into developing the science-policy interface required to build climate resilient cities in South Africa and beyond.

9. CONCLUSIONS

Metropolitan governments need climate information that can be used to target (spatially and/or socio-economically) and sequence interventions, i.e. information that factors into deciding how to manage land use, what to invest in now with limited available resources, where to make those investments, and what to put on hold. They also need climate information that provides the justification to invest in building flexibility and preparedness based on a recognition that the past is no longer a good enough proxy for the future and the metro will face unprecedented conditions and events that will require a departure from current business-as-usual to address. To do so in a timely and cost-effective manner will require having plans and processes in place to experiment with alternatives (to establish costs, timeframes, efficacy, procurement and maintenance requirements, etc.). Based on such experimentation, municipalities will need procedures in place to fast track and/or switch between options when needed, based on long-term monitoring and the detection of thresholds that trigger new actions and unlock the resources to do so. Such future oriented investments are of course difficult to make when there are so many pressing needs and basic service and infrastructure deficits. But to transform the system requires not only playing catch up. To transform the urban system into one that is more climate resilient requires being strategic and forward-looking about how to do so. The scale and variables of most relevance vary according to the sector or management function. There is no one-size-fits-all climate information package that will work for every city, every sector and every municipal department. Instead the focus must be on building the networks and capacities to direct the production of actionable climate information on an ongoing basis, to meet different and changing needs.

Each metro government is at a different stage in terms of accessing and co-producing locally relevant climate information and using it in their decision-making. When comparing the City of Cape Town, eThekwini and Mangaung metropolitan municipalities, it is clear that the sourcing, commissioning and integration of climate information into government decision making takes considerable time, effort and engagement. This entails progressing from high-level acknowledgement of climate-related problems and the need to act on them, to very in-depth and widespread adjustment of practices to fully account for climate considerations, from strategic, city-wide policies through to specialist operations and targeted investments. What cities need is not simply more climate science, but knowledge partnerships that provide decision support such that cities are better equipped to detect changes, pre-emptively experiment with alternatives (to work out time frames, costs, procurement requirements, etc.), monitor effectiveness of various programmes and investments, and deal with climate extremes as they emerge.

Consulting projects, providing tailored climate information, are important to meet specific needs, but short lived and leaving little opportunity to fully engage with the information provided and build the capacity required to fully make sense of, and work with, what is given. There is limited capacity within municipalities to take on and build on the climate information that consultants provide. From the interviews conducted with city officials ,and reviewing the academic literature on climate information and climate services, it is apparent that there remains a gulf between what is needed in city governments to progress the local climate agenda and what is provided by the climate science community. This points to the need for intermediaries to assist in translating the data, information, knowledge and decision support requirements of governments into a research agenda and contextualizing research findings based on the operations and decision-making processes of municipal governments. For example, the role of C40 staff in undertaking such intermediation between the Dutch climate service providers and the eThekwini municipal staff was noted from both sides as being critical. International experiences are starting to suggest that multiple intermediaries, each with different mandates, expertise and networks, may be required to meet different aspects of the information needs of decision-makers at the city scale (Kirchhoff et al., 2015, refer to these as boundary chains).

Metropolitan governments cannot act on biophysical climate information alone. Decision-makers, both technical and political, need contextual and clearly applicable information about climate risks, impacts and adaptation or resilience-building actions that have a direct bearing on the functioning of the city. Establishing the climate-relevant variables and how to integrate the resulting information into various decision-making processes at suitable time-steps is something that can only be co-produced between climate specialists, urban practitioners and other disciplinary experts through sustainable partnerships that enable progressive capacity development and learning for all involved. For the resulting information and knowledge to be given weight in the political processes of democratic decision-making, the perceptions and priorities of city residents, businesses and elected officials also need to be reflected in such co-production processes. This study puts forward a number of strategies and recommendations for how to go about co-producing climate information rooted in city decision-making. Central to these are: framing climate information and action as a means of delivering on social and economic development goals; fostering a network of partners to build and operate a city-wide climate monitoring, evaluation and learning system to sustain over decades; using intermediaries to translate between scientific, technical and political aspects of the climate agenda; securing resources to build the capacity for evidence-informed decision-making on climate resilient and low-carbon development; stress testing decision options against multiple future scenarios; and integrating maps and narratives of risks, impacts and opportunities to communicate the outcomes of climate stress tests and resilience assessments to high level decision makers.

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APPENDIX 1
LIST OF INTERVIEWEES

NAME	POSITION	NATURE OF DISCUSSION	DATE
Chris Jack	Senior Researcher, Climate System Analysis Group, University of Cape Town	Climate information provision to CCT	24 July 2018
Piotr Wolski	Associate Professor, Climate System Analysis Group, University of Cape Town	Climate information provision to CCT	24 July 2018
James Cullis	Technical Director, Aurecon	Exploring a CCT water resource planning case	2 August 2018
Tirusha Thambiran	Senior researcher, Council of Scientific and Industrial Research (CSIR)	Exploring eThekwini case	6 September 2018
Ludwig Geldenhuys	Chief: Risk, Ethics and Governance, City of Cape Town	CCT integrated risk management case	17 September 2018
Maureen Noonan	Principal Professional Officer, Integrated Risk Management, City of Cape Town	CCT integrated risk management case	17 September 2018
Rebecca Cameron	Professional Officer: Climate Change, Energy and Resilience at ICLEI, formerly with MCA Urban Planners	CCT spatial planning case	25 September 2018
Craig Kesson	Executive Director Corporate Services, Chief Data Officer, and Chief Resilience Officer, City of Cape Town	CCT drought risk management	27 September 2018
Lulu van Rooyen	eThekwini embedded researcher / UKZN post-doctoral researcher	eThekwini climate risk assessment case	1 October 2018

Amy Davison	Head: Climate Change, Environmental Management Department, City of Cape Town	CCT spatial planning and integrated risk management cases	1 October 2018
Keith Wiseman	Manager: Environmental Compliance, City of Cape Town	CCT integrated risk management case	2 October 2018
Peter Ahmad	Manager: City Growth Management, City of Cape Town	CCT spatial planning case	2 October 2018
Felix van Veldhoven	Climate adaptation and geo-information specialist, Climate Adaptation Services	eThekwini climate risk assessment case	2 October 2018
Arthur Lutz	Climate scientists, FutureWater	eThekwini climate risk assessment case	2 October 2018
Vivian Minnaar	General Manager, Environmental Management, Planning Directorate, Mangaung Metropolitan Municipality	MMM climate change strategy case	11 October 2018
George Masuabi	General Manager, Strategic Support, Planning Directorate, Mangaung Metropolitan Municipality	MMM climate change strategy case	16 October 2018
Sean O'Donoghue	Head of Climate Change Adaptation Branch, eThekwini Municipality	eThekwini climate risk assessment case	16 October 2018
Nongcebo Hlongwa	Climate Protection Scientist, eThekwini Municipality	eThekwini climate risk assessment case	16 October 2018
Gerard van Weele	Associate, Royal HaskoningDHV	CCT spatial planning case	9 November 2018

INTERVIEW QUESTIONS FOR MUNICIPAL STAFF

1. What is the core mandate of your work in the city government?
2. Do you use climate data and/or information in your work; or are you aware of it being used by others that you work with?
3. Why / for what purpose is it being used?
4. What kind of climate data / information is used (format, scale, variables, temporality) and where does it come from (i.e. who provides it)?
5. In what ways is climate data / information used? How does it feed into decisions? [e.g. at the policy and/or strategy levels, in spatial planning, in financial planning & budgeting, in the feasibility and design phases of projects, in M&E mechanisms, etc.]
6. What makes it possible to access and/or use climate data / information? What key mechanisms, agreements, partnerships or intermediaries are involved?
7. What makes it difficult to access and/or use climate data / information? (i.e. are there problems with what is available, what format it's in, having expertise to analyse and interpret it, weighing it us against other criteria / priorities, etc.)
8. Do you have particular climate data / info needs that are not being met? Why are these needs not being met? (i.e. it is a cost issue, an availability issue, an expertise issue)
9. Are you being pushed to use climate data / info that is not useful or relevant or your needs? By whom and why?
10. Does the integration of climate considerations meet any resistance? From who; why?
11. What support might be needed to access and use climate data / info more extensively or effectively in the City's decision making processes?

12. Is the City collecting and reporting on any climate related indicators?
13. How are these being collected and where are they being reported?
14. Are there any climate related reporting demands that you are struggling to meet; why?
15. How can the flows of city relevant climate data and information be improved?
16. Where is CSP support most needed in this regard?

NOTE: for the purposes of this study, climate information is understood to include both information based on: historical data (i.e. observations from monitoring stations and satellites); future projections (i.e. model results), data from within a city's spatial boundaries; data from beyond the city's boundaries linked to impacts within the city (e.g. rainfall in catchments outside of the city where the city draws its water from). Climate information presents patterns in atmospheric variables, like air temperatures, rainfall, pressure, wind speed and direction, as well as related land and ocean variables, such as surface run-off, soil moisture, river discharge, sea levels and sea surface temperatures. While weather information describes atmospheric conditions at a particular location and point in time (daily, up to 2 weeks), climate information presents statistical patterns of these conditions over the long term (seasonal to decadal). Climate change information, regarding altered patterns of climate conditions due to human-induced emission of greenhouse gases (GHGs) and increasing concentrations of GHGs in the atmosphere, is a subset of climate information. This study deals with climate information broadly, but with a particular interest in climate change information. Climate information can be quantitative (e.g. statistics) or qualitative (e.g. narrative descriptions).

INTERVIEW QUESTIONS FOR CLIMATE INFORMATION PRODUCERS

1. What climate information is produced by you and your organization [that could have relevance to city governments]?
2. How is the climate information you produce distributed and disseminated?
3. Who are the intended users of the information?
4. Is any of the climate information you produce specifically tailored to / targeted at city stakeholders and city governments in particular?
5. Do you know of particular uses of the climate information by city government actors and/or their service providers? If yes, what are these uses and where are they happening?
6. If the climate information you produce is not being much used in cities, do you have a sense of why not? What are the challenges associated with it?
7. Are there key intermediaries for getting climate information used in cites? What roles do they play?
8. What else makes it possible [or not] for city actors to access and/or use climate data / information? What key mechanisms, agreements, training or partnerships are involved?
9. Do you receive particular climate data / info requests that you are not able to deliver? (i.e. is it a cost issue, a data availability issue, an expertise issue, etc.)
10. Does the provision of climate data / information meet any resistance? From who; why?
11. How can the flows of city relevant climate data and information be improved?
12. Where is CSP support most needed in this regard?
13. Are there models of or approaches to climate information production and provision operational in other countries that you think we could learn from in South Africa? Or, alternatively, reasons why these can't work here?

AFRICAN CENTRE FOR CITIES
urbanism from an african perspective

ABOUT THIS REPORT

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