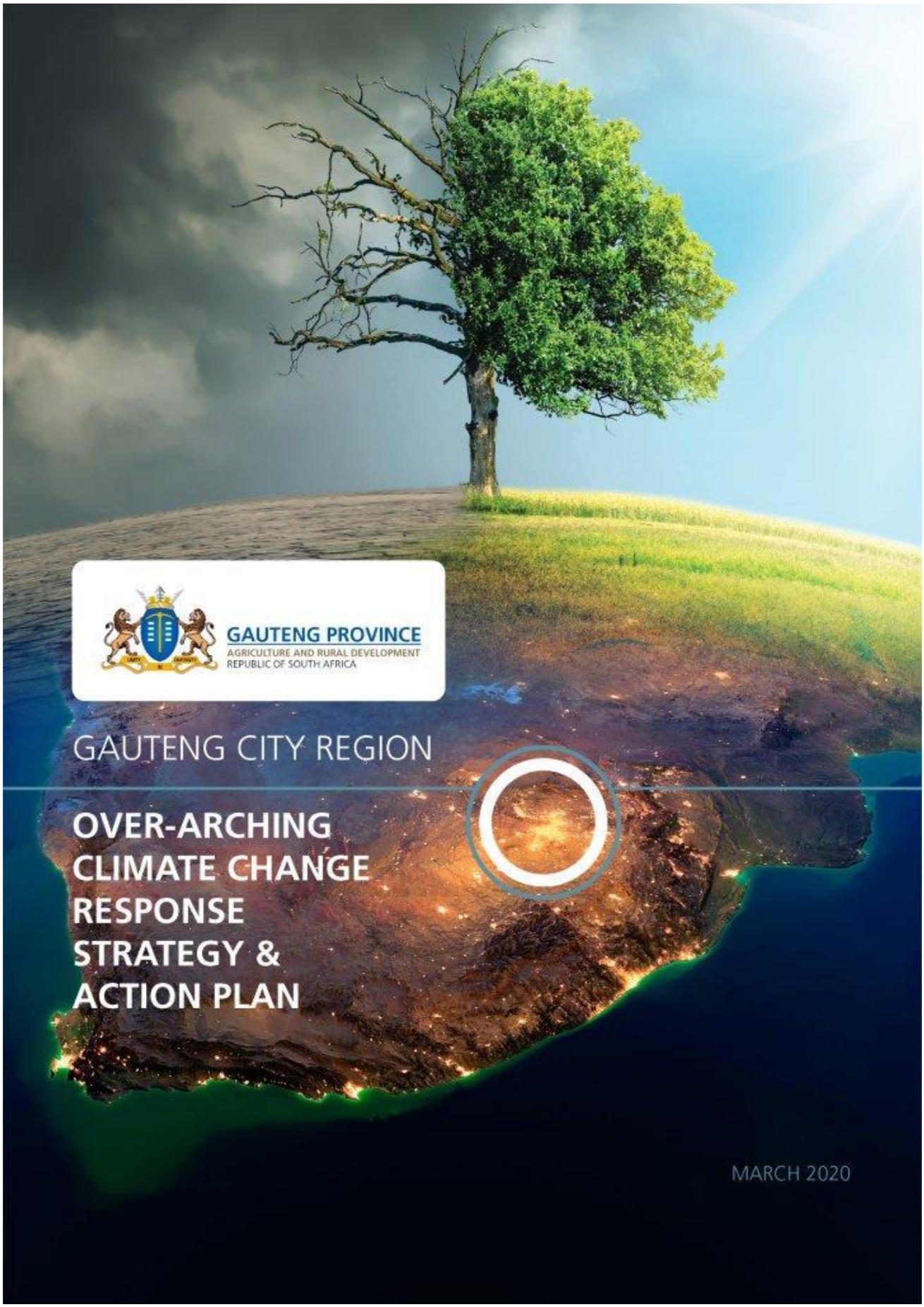
GAUTENG PROVINCE
AGRICULTURE AND RURAL DEVELOPMENT
REPUBLIC OF SOUTH AFRICA
GAUTENG CITY REGION
OVER-ARCHING CLIMATE CHANGE RESPONSE STRATEGY & ACTION PLAN
MARCH 2020

DOCUMENT DESCRIPTION

Document title and version: Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan (March 2020)

Project Name: Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan

Client: Gauteng Department of Agriculture and Rural Development

Royal HaskoningDHV reference number: MD2770

Authority reference: GT/GDARD/155/2016

Authors: Gerard van Weele, Karolina Euler-van Hulst, Janet Loubser, Michiel Nijboer & Rina Taviv

Contributions: Nicole Martens & Arnold Aldous (Talmar Sustainable Developments)

Acknowledgements:

The contributions and support from a range of stakeholders throughout the project are acknowledged. In particular, the **Gauteng Department of Agriculture & Rural Development** provided critical project support, whilst a **Project Steering Committee** assisted with key document reviews and decisions. Stakeholder contributions were also received on an *ad hoc* basis, and facilitated via the quarterly **Gauteng Climate Change Forum** and annual provincial **Climate Change Indaba**. These contributions, being too many to list individually, are deeply appreciated.

Also important to mention are two key studies used as input into this Strategy – a *Draft Climate Change Adaptation Action Plan* for the Gauteng Province compiled by the **Climate System Analysis Group at the University of Cape Town** and *A Climate Change Reference Atlas* generated by the **South African Weather Services** (for the purposes of this project specifically downscaled for Gauteng by **Dr. Hannes Rautenbach**).

FOREWORD

The Gauteng City Region (GCR) is South Africa's economic hub, and its greenhouse (GHG) emissions reflect the size of its economy and relatively high carbon footprint of its energy sources. At the same time, the physical manifestations of climate change are set to not only increase pressure on humans, animals and natural systems, but also on the social and economic systems that support human activity.

Therefore, adaptation to a changed climate becomes necessary. It is for this reason that the Department of Agriculture and Rural Development (GDARD) has developed the GCR Over-arching Climate Change Response Strategy and Action Plan ("The Strategy"). The Strategy was approved by the Gauteng Provincial Executive Council on 26 August 2020. The ongoing implementation of this Strategy is in furtherance of the National Development Plan (NDP) Vision 2030 and Growing Gauteng Together 2030 to manage climate change impacts as well as to meet international obligations of the 2015 Paris Climate Change Agreement. It is also in agreement with the Medium-Term Strategic Framework (MTSF) 2019-2024 and proposed Climate Change Bill in order to build capacity and integrate activities by implementing climate change programmes through all spheres of government in accordance with the principles of cooperative governance.

Through the implementation of this Strategy, Gauteng seeks to work towards addressing its 'fair share' of the national GHG mitigation target as a means to stimulate economic development and improve social well-being. The overall adaptation aim of the GCR Over-arching Climate Change Response Strategy and Action Plan is not simply to absorb or counter the impact of climate change. Instead, it aims to place the region on a path towards climate resilience, low carbon developments that capitalises on the opportunities presented by climate change and the need for adaptation. The overall outcome for the GCR should be a growing economy and improving human well-being.

The strength, weaknesses, opportunities and threats (SWOT) analysis undertaken as part of the development of this Strategy has revealed that Gauteng province and the wider GCR region need to capitalise on opportunities that allows a shift from unsustainable activities and technologies to innovative practices that are not only economically viable but also socially just and environmentally friendly. The urban and economic contexts of the GCR, opportunities lie in the transportation, energy, built environment, agro-processing and ecotourism sectors. These sectors offer possibilities for roll-out of climate-resilient interventions that are independent of external dependencies. Efficient urban design, linked to modernised mass transportation and safeguarded green infrastructure, is also a key ingredient towards making cities (and the people living in them) resilient and helps reduce disaster risks. These opportunities and possibilities have been used as a foundation for response programmes outlined in this Strategy.

Eleven response programmes have been identified for this Strategy. They include natural resources; agriculture and agro-processing; disaster risk reduction and management; water security; commercial and institutional buildings; human settlements; energy supply; industry and mining; transport; waste management; and health. For each intervention, responsible key stakeholders, targets and possible source of funding have been detailed. For each of the response programmes only one or two of the most important short-term interventions were prioritized. Furthermore, cross-cutting interventions such as research, green procurement, awareness and monitoring and evaluation were identified. In addition to full report that includes detailed information on how and why

the above programmes were selected and also on how interventions were prioritised, a much shorter “summary for policy makers” has also been prepared.

The Implementation Plan for the Gauteng City Region Over-Arching Climate Change Response Strategy and Action Plan, 2020 will be developed in consultation with key stakeholders listed in this Strategy. A governance framework including monitoring and reporting tool will also be developed to coordinate and track the implementation progress. Extensive consultations were undertaken during the development of this Strategy. I would like to take this opportunity to thank all the stakeholders who contributed towards making this process successful.

Ms Morakane Mosupyoe

MEC: Gauteng Department of Economic Development, Agriculture, Environment and Rural Development

EXECUTIVE SUMMARY

The Gauteng Provincial Government mandated the Gauteng Department of Agriculture and Rural Development (GDARD) to lead the process of developing Gauteng City Region Over-arching Climate Change Strategy and Action Plan.

Manifestations of climate change, such as increases in temperature around the globe, have been observed for many decades now. The effects of climate change are being felt in South Africa, together with rest of the continent and the world. Climate projections indicate that the overall outcome for Gauteng is likely to be a drier climate overall, with the higher temperatures and longer dry spells dominating the weather patterns. Intense rainfall events will aggravate the situation by increasing runoff rather than infiltration. These also increase the risk for flash floods and erosion, placing pressure on stormwater infrastructure and affecting agricultural practices. In a heavily urbanized province, such as Gauteng, the risks are more pronounced because of higher portion of paved/non-permeable surfaces. Notwithstanding the negative impacts that have been outlined above, the challenge for Gauteng is to respond to the impacts in a way that capitalises on particular opportunities for positive change.

The Gauteng City Region (GCR) is South Africa's economic hub, resulting in its contribution to the national carbon footprint being quite significant. However, this implies opportunities for leapfrogging into a low-carbon economy. These opportunities include access to climate change related funding as well as competitive advantages in adopting environmentally sustainable technologies which will benefit the region in a long term to replace a continued reliance on extractive industries that have high pollution legacy costs. Already, the GCR has been playing a very important and significant role in South Africa's intended transition to a lower-carbon economy, particularly driving and/or supporting implementation of programmes on energy efficiency, renewable energy (supply), sustainable transport, efficient spatial planning and waste management. **The Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan provides a consolidated short to medium plan to boost this role by defining ambitious targets and detailed interventions working towards a more carbon efficient local economy.**

The formal recognition of climate change as a shared global issue creates the necessary momentum for unilateral support for local efforts. The United Nations Framework Convention on Climate Change (UNFCCC) facilitates international agreements and supports a complex architecture of bodies that serve to advance the implementation of the Convention. In particular, the Paris Agreement, which is a comprehensive framework to guide international efforts to limit greenhouse gas (GHG) emissions and meet all the associated challenges posed by climate change, was reached in 2015. Further, several funds such as Global Environment Facility, Green Climate Fund and the Adaptation Fund have been established to enable global climate action. In South Africa, climate change response is guided by the National Development Plan (NDP) and the National Climate Change Response Policy (NCCRP), 2011. South Africa committed to the Paris Agreement in 2016, and subsequently the introduction of the Carbon Tax and the Climate Change Bill (recently gazetted for public comments) signified the country's intention in tackling climate change. In the GCR, a suite of programmes with climate change benefits (i.e. adaptation and mitigation) have been implemented. There are also interlinked plans and strategies at provincial level that make positive contributions to addressing climate change.

As per Provincial cabinet instructions, the Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan looks beyond provincial boundaries to the larger GCR, which was defined in the Gauteng Spatial Development Framework, (GPG, 2016). The GCR represents economic activity and human concentrations that connect across the provincial boundary to secondary nodes a short distance outside the province (e.g. Rustenburg, Klerksdorp, Sasolburg, Secunda and Emalahleni). These connected areas function as an economic whole, with people migrating between them, capital flowing from one to the other and strong regional business linkages. Any strategic interventions in Gauteng consequently need to be considered in respect of the *city region* rather than just the province. Therefore **one of the prioritised interventions is inviting provincial MECs and mayors representing the GCR, but located outside of the province, with relevant Gauteng Provincial MECs and Mayors to the Provincial Climate Change Committee to be established and be convened by the Gauteng Premier.** The establishment of Provincial Committees is suggested in the Climate Change Bill that is currently gazetted for public comment.

The Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan aims to address four broad over-arching outcomes. These outcomes can be seen as broad descriptions of what a well-adapted and resilient GCR must look like. Specifically, **the climate change response outcomes identified for the GCR relate to ecosystems, quality of life, disaster risk management and a green economy**. These outcomes intentionally integrate mitigation and adaptation outcomes to maximise the opportunities for co-benefit outcomes. The Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan identifies pivotal response programmes around which a range of important intervention actions can be structured, in consideration of the vulnerability assessment, SWOT analysis, desired adaptation outcome (DAO) sector breakdown and other considerations highlighted elsewhere in the document. Furthermore, detailed aspirational mitigation targets have also been proposed and used for selection of most cost effective mitigation options. Although there is no intention to enforce these targets as is, they provide a reference case from which further refinement of sector-based commitments can be negotiated or for the provincial downscaling of national targets. The selection of sector targets was based on quantification of the Gauteng carbon footprint (with a more comprehensive picture than previous GHG inventories), the emission projections and the mitigation potential analysis. The methodology used is the same one as used for the national mitigation potential analysis (DEA, 2014c) and targets calculation is fully aligned with the Nationally Determined Contribution (NDC) targets. The GHG emission mitigation costs were calculated for three scenarios – maximum reduction (nett cost to implement), zero cost (the cost of mitigation breaks even with savings achieved during the life cycle of the interventions) and negative marginal cost (savings). **It was estimated that the NDC target can be achieved by implementing mitigation interventions included in the zero cost scenario and these targets were adopted.** The full details for determination of targets and cost of mitigation interventions are provided in the Annexure A.

The Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan adopts a programmatic approach to direct specific action on climate change and also enable successful implementation of climate change key policy directions that have been identified for the GCR. Eleven response programmes that have been identified include:

1. Natural Resources
2. Agriculture & Agro-Processing
3. Disaster Risk Reduction and Management
4. Water Security
5. Commercial and Institutional Buildings
6. Human Settlements

7. Energy Supply
8. Industry & Mining
9. Transport
10. Waste Management
11. Health

For each of proposed intervention in the above response programmes, a responsible department is identified and the role(s) of government, targets and project types are detailed. For each of the response programmes one or two government interventions were prioritised as urgent and critical. Furthermore, cross-cutting interventions such as research, green procurement, awareness and monitoring and evaluation (M&E) were identified and prioritised.

It is suggested that the final decision on 'how' to achieve the recommended targets is the responsibility of the Provincial Department whose mandate specific targets and activities fall under. These government departments can be seen as 'lead agents' and though they can request the help of other department and organisations, ultimate responsibility will be with them. It should be noted that National Government actors were identified as lead agents for some interventions. Where national action is required, the approach will be to have the necessary provincial agents involved in related national processes and discussions rather than absolving provincial and local governments in the GCR from all responsibility. Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan provided more details for the actions to be led by private sector with the majority of interventions in the energy response programme.

The Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan also includes analysis of the existing monitoring and evaluation systems (international, national, sub-national, research and funding agencies) and outcomes of a research project on household vulnerability mapping by the Gauteng City Region Observatory were presented. Recommendations for development of provincial M&E system and potential for systems integration and data sharing were proposed. Finally the way forward was suggested for the Gauteng City Region Over-arching Climate Change Response Strategy and Action Plan implementation including immediate actions, communication, engagement with lead agents and monitoring.

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ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture, forestry and other land use'
AMD	Acid Mine Drainage
BEPP	Built Environment Performance Plan
BRT	Bus Rapid Transit
CbA	Community-based Adaptation
CER	Certified Emission Reductions
CNG	Compressed Natural Gas
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
CoGTA	Department of Cooperative Governance and Traditional Affairs
COP21	21st Conference of the Parties of the UNFCCC
DAFF	Department of Agriculture, Forestry and Fisheries (Now the Department of Agriculture)
DoA	Department of Agriculture
DEA	Department of Environmental Affairs (Now the Department of Environment, Forestry and Fisheries)
DEFF	Department of Environment, Forestry and Fisheries
DERO	Desired Emission Reduction Outcome
DFI	Development Finance Institutions
DMP	Disaster Management Plan
DoE	Department of Energy
DoH	Department of Health
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EbA	Ecosystem-based Adaptation
EIA	Environmental Impact Assessment
GBCSA	Green Building Council of South Africa
GCCRS	Gauteng Climate Change Response Strategy, 2011
GCM	Global Circulation Models
GCR	Gauteng City Region
GDARD	Gauteng Department of Agriculture & Rural Development
GDED	Gauteng Department of Economic Development
GDID	Gauteng Department of Infrastructure Development
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	greenhouse gas
GSDF	Gauteng Spatial Development Framework
IDP	Integrated Development Plan
ICT	Information and Communication Technology
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPPU	Industrial Processes and Product Use
ISP	Industrial Symbiosis Program
LED	Light Emitting Diode
LFG	landfill gas
LTAS	Long Term Adaptation Scenarios Flagship Research Programme
M&E	Monitoring and Evaluation
MACC	Marginal Abatement Cost Curve
MPA	Mitigation Potential Analysis
NAS	National Adaptation Strategy
NCCRWP	National Climate Change Response White Paper
NDC	Nationally Determined Contribution
NDMC	National Disaster Management Centre
NGO	Non-Governmental Organisation
PPD	Peak, plateau and decline
PPP	public-private partnership

PV	photo voltaic
RCP	Representative Concentration Pathways
SDBIP	Service Delivery and Budget Implementation Plan
SDG	Sustainable Development Goal
StatsSA	Statistics South Africa
SWOT	Strengths, Weaknesses, Opportunities and Constraints
TMR	Transformation, Modernisation and Re-industrialisation
TNC	Third National Communication
UNFCCC	United Nations Framework Convention on Climate Change
VSD	Variable Speed Drives
WEM	with existing measures
WOM	without mitigation
WRC	Water Research Commission

GLOSSARY

(From IPCC, 2014)

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Adaptive capacity: The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Anthropogenic: Resulting from or produced by human beings.

Biochar: Biomass stabilization can be an alternative or enhancement to bioenergy in a land-based mitigation strategy. Heating biomass with exclusion of air produces a stable carbon-rich co-product (char). When added to a soil system, char creates a system that has greater abatement potential than typical bioenergy. The relative benefit of bio- char systems is increased if changes in crop yield and soil emissions of methane (CH_4) and nitrous oxide (N_2O) are taken into account.

Biodiversity: The variability among living organisms from terrestrial, marine, and other ecosystems. Biodiversity includes variability at the genetic, species, and ecosystem levels.

Biofuel: A fuel, generally in liquid form, produced from organic matter or combustible oils produced by living or recently living plants.

Carbon dioxide equivalent: The amount of carbon dioxide (CO_2) emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO_2 -equivalent emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. For a mix of GHGs it is obtained by summing the CO_2 -equivalent emissions of each gas. CO_2 -equivalent emission is a common scale for comparing emissions of different GHGs but does not imply equivalence of the corresponding climate change responses.

Climate: Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change: Climate change refers to a change in the state of the climate that can be identified (e. g. by using statistical tests) by changes in the mean and / or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.

Ecosystem services: Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food, fiber, or fish, (3) regulating services such as climate regulation or carbon sequestration, and (4) cultural services such as tourism or spiritual and aesthetic appreciation.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Feed-in tariff: The price per unit of electricity (heat) that a utility or power (heat) supplier has to pay for distributed or renewable electricity (heat) fed into the power grid (heat supply system) by non-utility generators. A public authority regulates the tariff.

Global warming: Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.

Green Infrastructure: Refers to natural elements used as integrated parts of municipal services provision or for improvement of living spaces, for example functional open space networks that support stormwater management, microclimatic control, pest management, pollination services, water purification, energy use mitigation etc.

Marginal abatement cost: The cost of one unit of additional mitigation.

Mitigation (of climate change): A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). This report also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change , including, for example, the reduction of particulate matter (PM) emissions that can directly alter the radiation balance (e. g. black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides (NOx) , Volatile Organic Compounds (VOCs) and other pollutants that can alter the concentration of tropospheric ozone (O_3) which has an indirect effect on the climate .

Resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (Arctic Council, 2013).

Sensitivity: The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

1 Introduction

1.1 Global agreement on climate change

The last five years rank as the warmest years on record since formal record-keeping started in 1880, the arctic does not remain frozen in summer anymore, sea levels are slowly rising and precipitation patterns are changing. This evidence of global, anthropogenic climate change is indisputable, and it means that every one of the 7.5 billion people currently on earth, and the 10 billion estimated to be living in 2050, should be thinking about what they can do to reduce their contribution to climate change and adapt to the inevitable consequences of altered climate and weather patterns.

Figure 1 graphically illustrates how climate change is driven by human influence, how it impacts on the world, and how we need to respond. In short, we know that human activities such as land use change and fossil fuel burning intensify the greenhouse effect in the atmosphere, which in turn triggers a range of global climatic changes. These changes have implications for how habitable certain areas will be and which economic activities can be sustained.

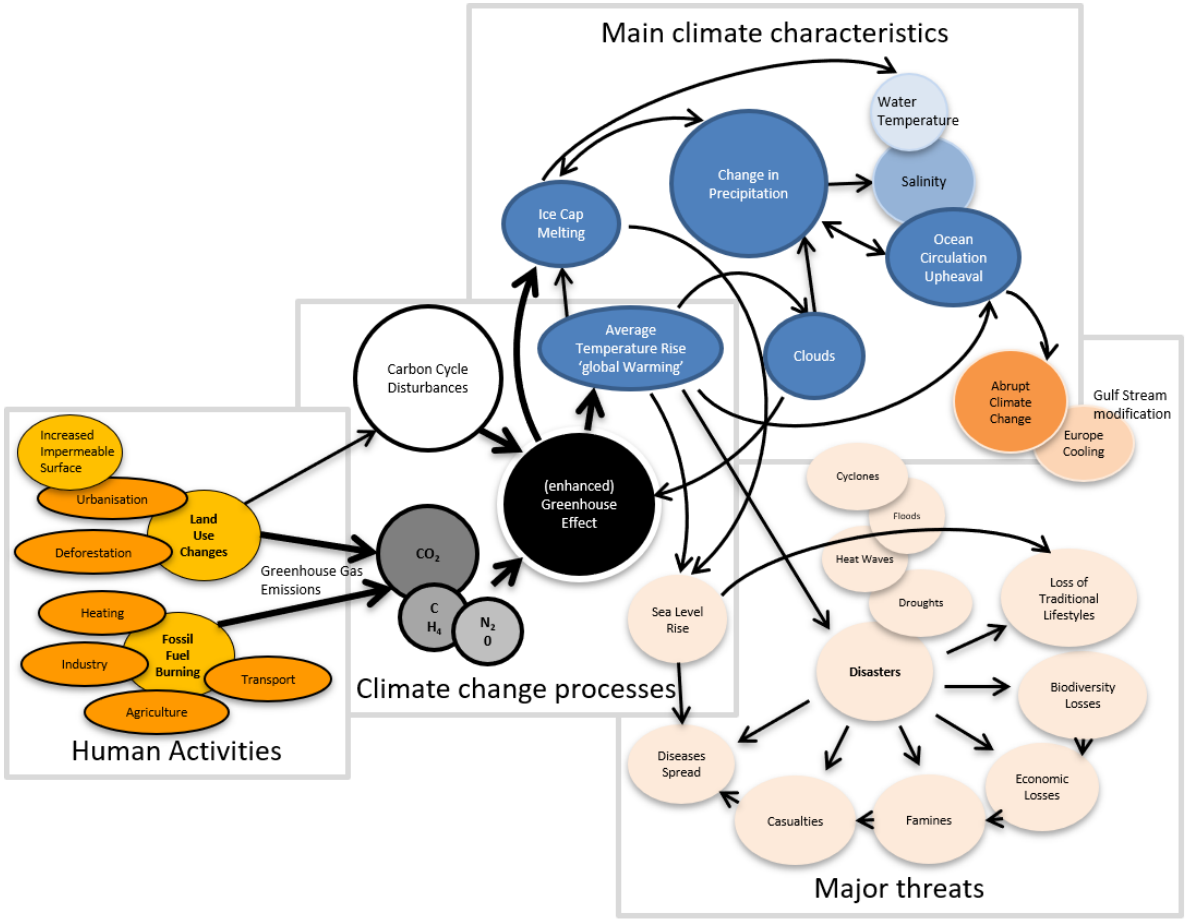


Figure 1: Climate Change Processes, Characteristics and Threats (courtesy of Philippe Rekacewicz, UNEP/GRID-Arendal - http://www.grida.no/resources/6889)

Some of the major changes, or potential threats, that ecological, social and economic systems will need to adapt to include:

- Changes in the distribution of disease vectors
- Extreme weather events
- Loss of traditional lifestyles
- Biodiversity losses
- Economic challenges
- Loss in food security

The World Bank recognises climate change is one of most critical and fundamental threats. In their summary on Climate Change they state: "*Over the next 15 years, the world will require about $90 trillion in new infrastructure – most of it in developing and middle-income countries. Making the right choices in favor of infrastructure that is climate resilient and locks in a low carbon development pathway is critical and urgent. Action now will avoid huge costs later*" (http://www.worldbank.org/en/topic/climatechange/overview).

But climate change need not be seen in purely a negative light. Granted, it implies risks, uncertainties and inevitable change, but it also offers an incredible opportunity for structural adjustments to how humanity is interacting with the planet and how we treat each other. Particularly in developing countries rapid technological changes and drastic reduction in the cost of renewable energy allows leapfrogging into more sustainable economic development as shown by China and some South American countries.

The coordination of international responses to the climate change threat is anchored by the United Nations Framework Convention on Climate Change (UNFCCC). This Convention facilitates international agreements and supports a complex architecture of bodies that serve to advance the implementation of the resolutions reached at the regular meetings of the parties to the Convention. In the form of the 'Paris Agreement', the outcome of the 21st Conference of the Parties (COP21) of UNFCCC at the end of 2015, the world took a small but significant step forward when agreement was reached on global cooperation in climate change mitigation through reduced greenhouse gas (GHG) emissions. It indicates a meaningful commitment towards equitable developmental goals and investment in environmentally responsible technologies.

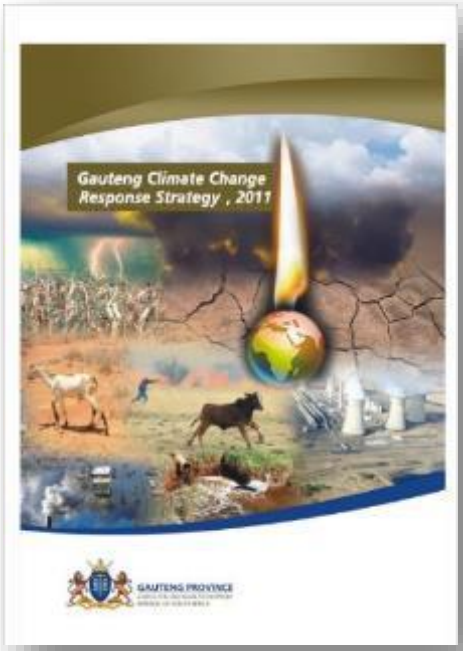
The formal recognition of climate change as a shared global issue also creates the necessary momentum for unilateral support for local efforts. This allows for concerted efforts in developing initiatives and for local voices to be heard, and more importantly for international funding to support climate change planning and interventions.

1.2 Recognition of climate change in Gauteng Province

Gauteng, as the economic powerhouse of South Africa, similarly needs to consider how climate change will affect its people and economy, and initiate response actions to reduce the scale of detrimental impacts. Work in this respect started in 2011 with the release of the first Gauteng Climate Change Response Strategy (GCCRS) but this strategy is in need of constant review and further refinement, given on-going change in national policy directives and related Provincial policies and planning.

The key messages reported by the 2011 GCCRS were that (GDARD, 2011):

- Climate change is one of the greatest threats to sustainable development
- Climate change is an inter-disciplinary and cross-cutting issue, which will require multi-disciplinary action from all stakeholders – national, provincial, local government, industry, civil society, the education and training sector, research organizations and communities
- Some of the proposed interventions already exist in policies, strategies and plans - they require consolidation, implementation and monitoring
- In the long-term, we need to redefine our competitive advantage and structurally transform the economy by shifting from an energy-intensive to a climate-friendly path as part of a pro-growth, pro-development and pro-jobs strategy.
- There is a need for radical and strong political commitments and administrative actions to implement both mitigation and adaptation interventions



When Gauteng developed its first comprehensive response to climate change in 2011, the national response was being finalised by the erstwhile national Department of of Environment, Forestry and Fisheries (DEFF) () as well, whilst datasets and knowledge creation were still relatively uncoordinated. Institutional change and contextual advances have since taken place, and hence it becomes necessary to relook the Provincial position on climate change; both in terms of the mitigation of its contribution to global warming and its ability to respond to the inescapable effects of climatic shifts. This review of the strategy is, however, not an isolated process. It builds on on-going work undertaking by the Climate Change unit within the Environmental Policy, Planning and Coordination Directorate of the Gauteng Department of Agriculture and Rural Development (GDARD) and parallel efforts at local, provincial and national level.

Important components of national government's approach to climate change response that have been finalised in recent years, or are likely to be finalised soon, include a revised Mitigation Potential Analysis (in preparation by the Department of Environment, Forestry and Fisheries (DEFF)), a revised Integrated Resources Plan (detailing South Africa's plans for its energy mix), a draft National Climate Change Adaptation Strategy (NAS) and a draft Climate Change Bill, 2018 (published for comment as Government Notice No.580 of 8 June 2018.

Key response actions are listed in Table 1, with a more comprehensive (and growing) list available from the Gauteng Climate Change Register to be incorporated as provincial module in the National Climate Change M&E system. The Gauteng Climate Change Register can be obtained from the Climate Change team of GDARD.

Table 1: Provincial climate change response initiatives

2014 First generation 'Phase 1' GHG Inventory (GDARD, 2014) based on 2007 base data. This study did not include comprehensive assessments of Industrial Processes and Product Use (IPPU) and the Waste sector.	***2016 Updated 'Phase 2' GHG Inventory*** (GDARD, 2016), which primarily investigated the process through which missing values for the IPPU and Waste sectors could be generated in future.	***2017 Draft Climate Change Adaptation Action Plan for the Gauteng Province*** (GDARD, 2017b). This project**,** coordinated by DEFF**,** establishes a prioritised framework for refinement of an adaptation plan for the province.	***2010 Gauteng Integrated Energy Strategy*** (GDLGH, 2010). This strategy commits the province to a 15% reduction in carbon emissions against a baseline of year 2000 emissions levels by 2015, and respectively 30% and 45% by 2025 and 2055.
Other strategic policies and guidelines related to climate change initiated or completed since the previous climate change response strategy report include: • Food Security Strategy, 2013 • Green Transport Policy, 2014 • Vision 2055, 2014 • Gauteng Energy Security Strategy, 2016 • Gauteng Energy Security Strategy Implementation Plan (under review) • Environmental Management Framework, 2016 • Disaster Risk Management Framework (under review) • Green Economy Strategic Programme (under review) • Water Security Perspective for the Gauteng City-Region, 2019			
All three spheres of **municipalities in Gauteng** – Local, District and Metropolitan – either commenced with development of their own climate change response strategies and GHG inventories, or received various forms of support in this respect.		Successful **Bus Rapid Transit (BRT)** roll-out in the Cities of Johannesburg and Tshwane, with Ekurhuleni following suit. The **Gautrain rapid rail** project has also been successfully implemented an alternative to increased private vehicle use and further extensions are planned that will extend the network further into the rest of Gauteng.	
Since climate change responses require inter-sector coordination, a dedicated Gauteng Climate Change forum meets quarterly. This initiative promotes sharing of information and knowledge on climate change, and responses to the challenges and climate change project synergies between organisations. In addition, the annual Climate Change Indaba also addresses climate change challenges and facilitates input into the implementation of the climate change strategy.			

Provincial representation is also ensured at national fora such as **Working Group 10: Inter-Governmental Committee on Climate Change** and the **National Committee on Climate Change lead by the DEFF.**

1.3 The consequences of a failure to respond to climate change

For the purposes of this strategy, climate projections for Gauteng are extracted from those contained in South Africa's Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC) (DEA, 2017b)[1], and verified against projections from the South African Weather Services' Climate Change Atlas (SAWS, 2017). To inform the TNC and its predecessors, the South African research community decided to develop a set of scenarios based as far as possible on updated emission scenarios representing high and mitigated pathways, namely the RCP 8.5 and 4.5 Wm^{-2} pathways[2]. These are roughly comparable to the Intergovernmental Panel on Climate Change (IPCC) AR4 A2 and B1 emissions scenarios.

As with most parts of the world, Gauteng can expect to become warmer over time as global atmospheric and sea surface temperatures rise, with regional variation among the different municipal areas. No significant changes are expected from a total precipitation perspective, although there is a high likelihood of both rainfall and droughts intensifying. Temperature projections of between +1.5 °C and +3 °C are indicated for RCP4.5, while temperature projections of between +2 °C and +5 °C are indicated for RCP8.5. Rainfall projections are variable, although a drying trend in annual rainfall totals is visible from the 2050s towards the 2080s (Rautenbach, 2018)(Figure 2). Seasonally, the higher temperatures increases will occur in winter and spring, whilst the wet summer and dry winter rainfall pattern will intensify.

The overall outcome is likely to be a drier climate overall, with the higher temperatures and longer dry spells dominating the weather patterns. Intense rainfall events will aggravate the situation by increasing runoff rather than infiltration. The intense rainfall events will also increase the risk for flash floods and erosion, placing pressure on stormwater infrastructure and affecting agricultural practices.

[1] Further detail on the GCM downscaling and climate change projections are provided in a preceding report available from GDARD (GDARD, 2017b), and for the full set of maps the reader is referred to the draft Chapter 3 of the TNC (DEA, 2017b).

[2] The designation 'RCP' refers to 'Representative Concentration Pathways' which define the target radiative forcing at the year 2100, at 4.5 Watts per square metre (W m^{-2}) for RCP4.5 and 8.5 W m^{-2} for RCP8.5. The RCP8.5 scenario can be seen as the 'worst case' scenario with little to no global mitigation of GHG emissions, and the RCP 4.5 scenario as a 'positive outlook' scenario with good global co-ordination of mitigation efforts. The latest global emission data shows that we are still following the 'worst case' scenario

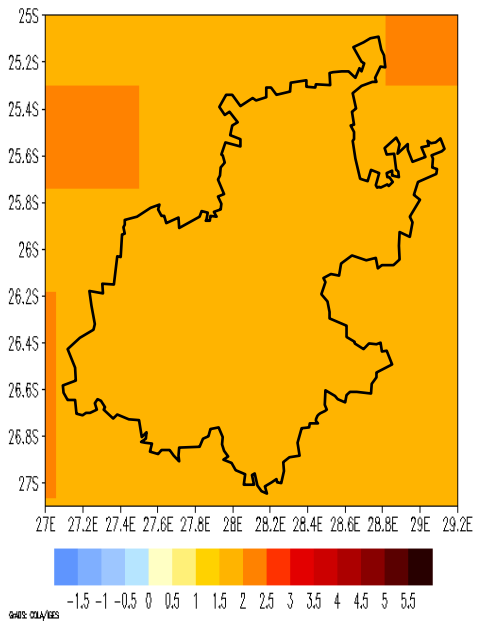
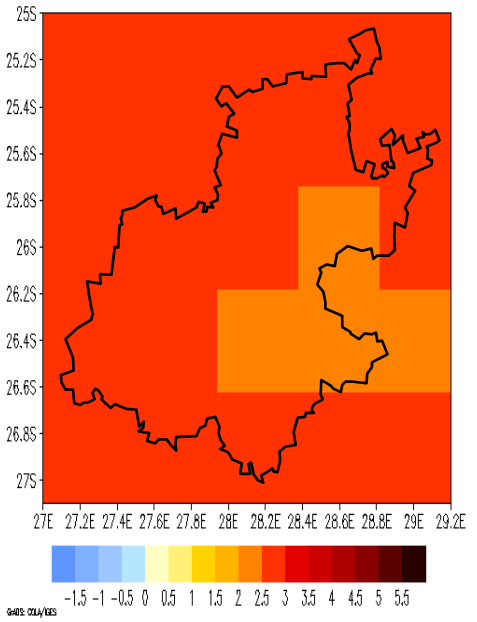
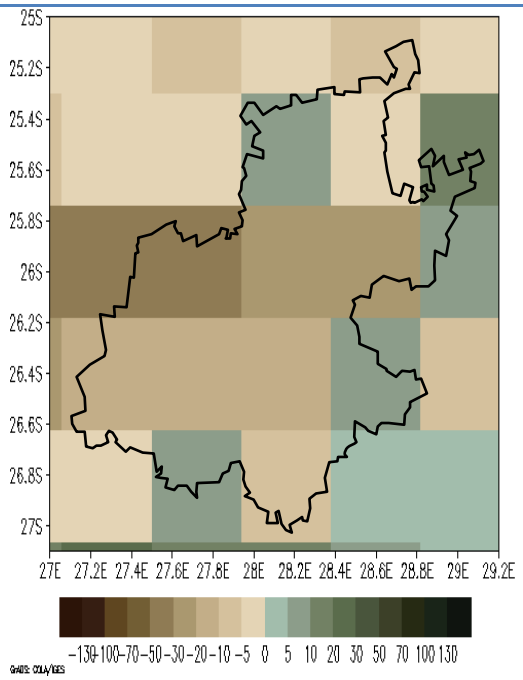
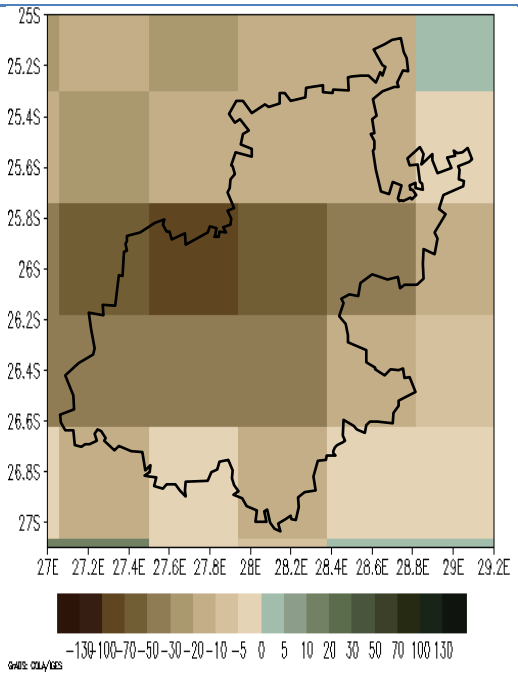
Projected temperature and rainfall changes under RCP 4.5 (relative to 1976 – 2005)	
2036-2065 (c:2050)	2066-2095 (c:2080)
ANNUAL temperature change (°C)	
	
ANNUAL rainfall change (mm/month)	
	

Figure 2: Annual mean near-surface (2m) temperature (°C) change (left two) and annual total rainfall (mm/month) change projected for the 2036-2065 (centred at 2050) and 2066-2095 (centred at 2080) periods under conditions of the RCP 4.5 (Rautenbach, 2018).

The projections, and their inherent uncertainties, suggest that two slightly different futures are possible – both warmer, but one slightly wetter than the other. These two are described as narratives below. Note that the narratives are provided as broadly plausible generalised futures rather than definitive and accurate predictions, and should be treated as such (GDARD, 2017b).

Narrative 1: A warmer drier future

In this narrative for Gauteng the province continues to experience cycles of wet and dry years, with dry years tending to be warmer than wet years. However, temperatures reach 2°C higher than the recent past sometime between 2040 and 2060, resulting in increased frequency and duration of hot spells in summer. Increased subtropical high pressure belts produce enhanced subsidence over the province, suppressing convective activity and moisture transport into the region. The result is a reduced frequency and magnitude of rainfall events, and generally reduced annual rainfall totals. However, convective events, when they occur are more intense resulting in localised flooding and related damage.

An increase in temperature and in the duration and intensity of hot spells impacts on human health, infrastructure, industrial activities, urban power demand for cooling, and the efficiency of air cooled power stations. Increasing temperatures increase evaporation, resulting in drier soils and increased water losses from dams, particularly shallow farm dams common in the province. Combined with generally reduced rainfall this means that even in relatively normal rainfall years, crops experience a greater water deficit, there is reduced water supply for irrigation and human consumption and livestock is placed under strain. Higher temperatures begin to impact some livestock as well. Dry years, combined with 2°C higher temperatures, produce higher impacts in the province than the 2015/2016 drought.*

Narrative 2: A warmer wetter future

In this narrative for Gauteng the province continues to experience cycles of wetter and drier years, with drier years tending to be warmer than wetter years. However, temperatures reach 2°C higher than the recent past sometime between 2040 and 2060, resulting in increased frequency and duration of hot spells in summer. An intensified heat low, driving enhanced moisture transport into the province, results in marginally increased annual rainfall totals. Convective rainfall events, when they do occur are more intense resulting in localised flooding and related damage.

An increase in temperatures and duration and intensity of hot spells impacts on human health, infrastructure, industrial activities, urban power demand for cooling, and the efficiency of air cooled power stations. Additionally, increasing temperatures increase evaporation, resulting in drier soils and increased loss from dams, particularly shallow farm dams. In wetter years, the increased rainfall offsets the evaporative losses to some degree depending on the area. Even in relatively normal rainfall years, by current normals, crops experience a greater water deficit, there is reduced water supply for irrigation and human consumption and livestock is placed under strain. Higher temperatures begin to impact some livestock as well. Dry years, though less frequent than currently experienced, combined with 2°C higher temperatures, produce greater impacts in agriculture and human settlements in the province than the 2015/2016 drought.

* *the latest information from DWS shows that evaporation from the large dam, such as Vaal dam on a very hot day can exceed amount of water transferred from Lesotho. So evaporation losses become a major economic factor in the water supply sector.*

Gauteng is particularly vulnerable at household level where poverty reduces people's adaptive capacity, but also at a macro-economic level due to the heavy dependence on carbon intensive energy. And in the background, the shift in climate envelope will result in a progressive change from a grassland dominated system to more savannah-type biome with more woody elements, thereby affecting species composition and the hydrological cycle.

Should Gauteng province and the broader region fail to adequately respond to climate change, the region's current socio-economic situation will deteriorate, thereby pulling the national economy down at the same time.

Socio-economic deterioration is likely to result if adequate adjustments are not made to improve resilience of infrastructure and living conditions, as this will compromise people's

health and productivity, and lead to social turmoil. The energy performance of the built environment should improve or the cost of doing business generally will increase. The pressure on economic performance will also mount if the energy footprint remains tightly bound to coal-fired electricity and coal/oil-based liquid fuels. The strategic financial sense of a switch to renewable energy is undisputed, and is also tied to the quality of international investment in local business.

The region centred around Gauteng province further represents a significant portion of the national carbon footprint. A revised carbon footprint for Gauteng (refer to Section 3.1 in this document) indicates that the province contributes 33% of the national emissions. A failure to specify and meet carbon emissions reductions targets within the Gauteng region will therefore compromise South Africa's position in international climate change response negotiations and ability to access climate change related funding.

1.4 Transformation, Modernisation and Re-industrialisation of Gauteng

The Gauteng Provincial Government (GPG) has adopted a Ten Pillar Programme of Transformation, Modernisation and Re-industrialisation (TMR) as the province's policy framework for transforming and modernising its economy. The TMR seeks to identify and develop economic sectors that have the potential to create decent employment and bring about greater economic inclusion. These sectors include manufacturing, pharmaceuticals, Information and Communication Technology (ICT), agro-processing and the automotive industry.

The ten pillars identified are:

- Pillar 1: Radical economic transformation
- Pillar 2: Decisive spatial transformation
- Pillar 3: Accelerated social transformation
- Pillar 4: Transformation of the state and governance
- Pillar 5: Modernisation of the public service
- Pillar 6: Modernisation of the economy
- Pillar 7: Modernisation of human settlements and urban development
- Pillar 8: Modernisation of public transport infrastructure
- Pillar 9: Re-industrialisation of Gauteng province
- Pillar 10: Taking the lead in Africa's new industrial revolution

Climate change impacts represent a real risk to the successful implementation of the TMR strategy, as increased burdens on the public services sector can easily counteract socio-economic welfare gains. Modernisation and re-industrialisation may also be stifled by the cost and availability of water and clean energy.

A strategic approach to climate change adaptation and mitigation, however, has the potential to not only avoid the threats emanating from climate change, but to use sustainability and resilience principles to support the TMR drive. For example, under Pillar 6: Modernisation of the Economy, the strategy aims to access opportunities within the Green Economy. This can be achieved by growing a market for products and services in the renewable energy and

construction sector that align with resource efficiency and building performance targets. The overall outcome would not only see greener, more efficient and functional buildings being constructed, but this would at the same time mitigate Gauteng's carbon footprint. Similar examples can be cited for the human welfare related pillars – investment in sustainable practices can reduce vulnerability whilst creating employment and improving household incomes.

Text Box: Economic value of the climate and air-quality benefits of wind and solar power in the United States

Wind and solar energy reduce combustion-based electricity generation and provide air-quality and greenhouse gas emission benefits. From 2007 to 2015, solar and wind power deployment in the United States increased rapidly while regulatory changes and fossil fuel price changes led to steep cuts in overall power-sector emissions. Using different health impact models and social cost calculations, this potentially led to cumulative wind and solar air-quality benefits to the value of US$112.8 billion, mostly from 3 000 to 12 700 avoided premature mortalities, and cumulative climate benefits of up to US$106.8 billion.

Source: Millstein, D., Wiser, R., Bolinger, M. & Barbose, G. (2017). The climate and air-quality benefits of wind and solar power in the United States. Nature Energy 6, Article number: 17134 (2017).

1.5 Important National Responses

1.5.1 International commitments

South Africa, as signatory to the UNFCCC's Paris Agreement of December 2015, committed itself to global goal of keeping global warming well below 2°C. This agreement entered into force on 5 October 2016, when the threshold for entry into force was achieved (i.e. 55 Parties representing 55% of global GHG emissions to have ratified, accepted and approved the agreement). The South African Government considers the agreement as binding, and has embarked on a process of ratifying the agreement ahead of the 2020 deadline. This potentially includes turning the draft Climate Change Bill into a 'Climate Act' which will create a legal framework for, amongst others, setting official national GHG emissions reduction targets.

It is indicated that the Intended Nationally Determined Contributions (INDCs) tabled by South Africa in preparation for COP21 have been accepted as Nationally Determined Contributions (NDCs) as part of the ratification period. These NDCs communicate what is considered as the national fair share of the global response to GHG emissions reductions, and reflect the target emissions range set out in the National Climate Change Response White Paper (NCCRWP), known as the Peak, Plateau and Decline (PPD) Greenhouse Gas Emission Trajectory as detailed elsewhere in this report.

In order to achieve these emissions reduction targets a range of sector policies have been developed and initiatives are underway to improve the emissions profile of the economy. Key strategic interventions include:

- National Climate Change Response White Paper, 2012
- Mitigation Potential Analysis, 2014

- Energy & Climate Change Strategy for the Public Building Sector 2015 – 2050
- Carbon Tax Act No 15 of 2019
- Ratification of the 2015 Paris Agreement on Climate Change, and country level emissions reductions commitments
- Third National Communication (2019)
- Integrated Resources Plan - The IRP2019
- Renewable Energy Independent Power Producers Procurement Bidding Programme (on-going)

1.5.2 Carbon tax

After being introduced as a Bill back in 2015, the Carbon Tax Act was finally promulgated as formal legislation and actual penalties for embodied carbon in products and services in May 2019.

The carbon tax Act imposes a tax of R120 per tonne of carbon dioxide (tCO_2) emitted, although an initial tax free threshold of 60%. effectively reduces the carbon tax to R48 tCO_2. Other measures which can further reduce the effective carbon tax payable (down to as little as R6 tCO_2) include a:

- Trade exposure allowance
- Performance allowance
- Carbon budget allowance
- Offset allowance

Due to difficulties in accounting for carbon emissions, the Waste and Agriculture, Forestry and Other Land Use (AFOLU) sectors are currently exempt from the carbon tax.. Though generalized, the carbon tax will have the following implications of relevance to this Strategic Action Plan:

- Electricity prices will remain the same in the first period. This is achieved by reducing the electricity generation levy and the renewable electricity generation premium (both included in the electricity price).
- Petrol and diesel prices are expected to increase. Assuming a 60 per cent tax free threshold the estimated carbon tax will amount to a maximum of 11 c/litre for petrol and 13 c/litre for diesel. This carbon tax will be raised as an addition to existing fuel taxes.
- Industry will pay carbon tax on fossil fuel combustion emissions (excluding diesel and petrol to avoid double counting), process emissions and fugitive emissions.

The tax is expected to have a positive impact on the sustainability of renewable energy, and energy efficiency interventions and industries, by making the sector more attractive for capital investment. A further implication is that the mandatory emissions reporting to DEFF becomes increasingly important in terms of enforcing compliance with the tax scheme and ensuring that future adjustments of the tax are appropriate and fair.

In respect of emissions trading schemes, it should be noted that despite there being provision for carbon trading schemes within the scope of overall emissions reduction ambitions, no

formal scheme is in existence in South Africa. A limited number of Clean Development Mechanism projects have been certified for use within international schemes.

1.6 Broadening the scope to the Gauteng City Region

Gauteng is the business hub of South Africa. Gauteng's share of national Gross Domestic Product (GDP) increased to 34% in 2017 (StatsSA, 2017) which represents of 10% of the total GDP of the entire African continent (GPG, 2016). However, under close examination, the economic activity and human concentrations connect across the provincial boundary to secondary nodes a short distance outside the province. Especially mining and industrial centres in adjacent provinces, such as Rustenburg, Klerksdorp, Sasolburg, Secunda and Emalahleni extend away from the dense urban core of the three Metropolitan Municipalities of Tshwane, Ekurhuleni and Johannesburg (Figure 3). The Gauteng Spatial Development Framework (GSDF) indicates that this broadly corresponds to a 175km radius drawn from the centre of Gauteng (GPG, 2016).

These connected areas function as an economic whole, with people migrating between them, capital flowing from one to the other and strong regional business linkages. The functioning of the Gauteng economy is strongly tied to the operation of the broader regional economy. The concentration of people also brings the conurbation into the list of 20 largest such city spaces in the world.

It is therefore clear that interventions in the provincial area are bound to have a spill-over effect on the satellite cities and towns, and *vice versa*. It is furthermore clear that most of the people and activities that have an influence on climatic forcing are located in the urban nodes as most of the rural activities are not energy intensive. Any strategic interventions in Gauteng consequently need to be considered in respect of the *city region* rather than just the province, and hence this strategy is aimed at the Gauteng City Region or 'GCR'.

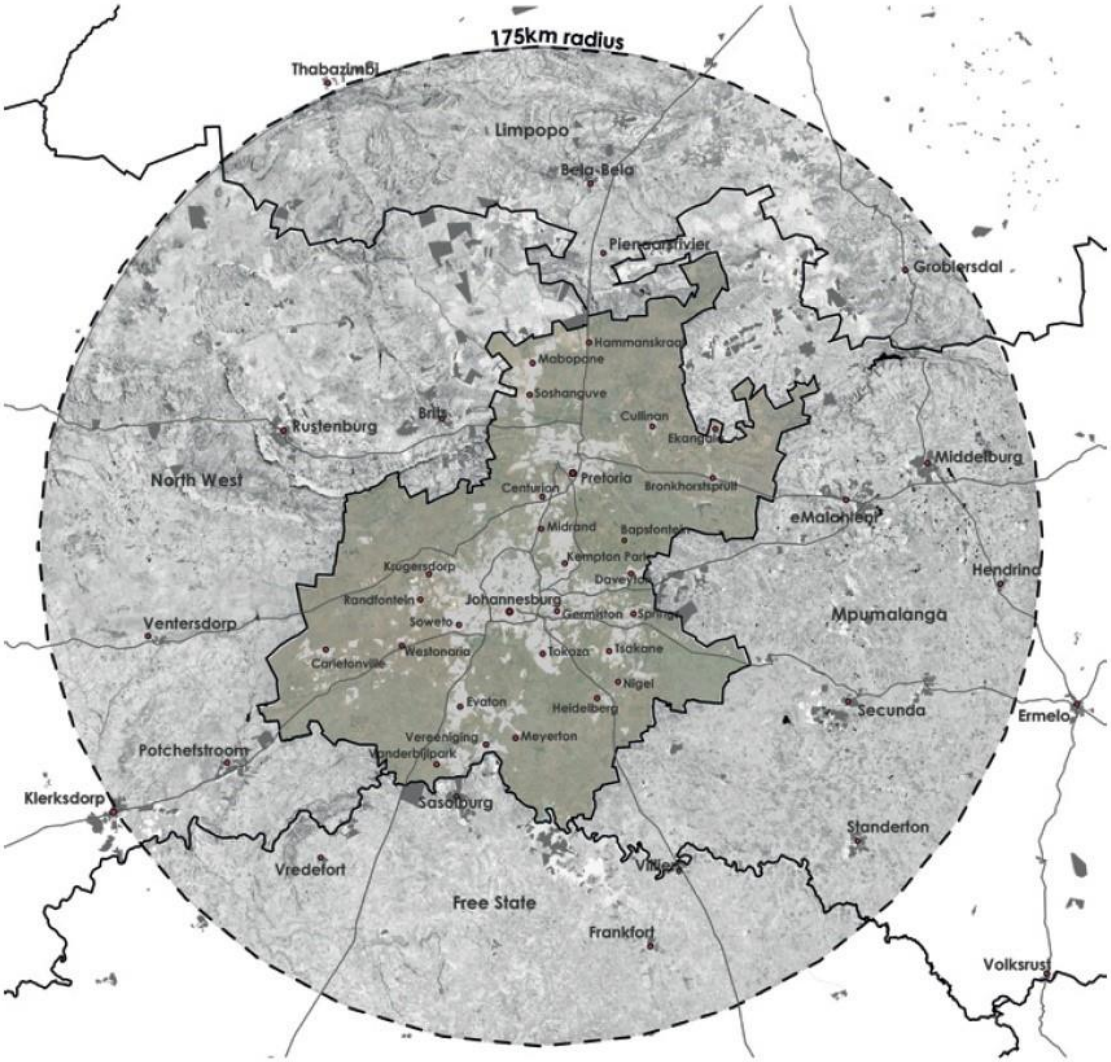


Figure 3: Gauteng City Region (GPG, 2016)

Importantly, this Climate Change strategy does not purport to define strategy, responsibilities or targets for provincial and municipal entities outside of the boundaries of Gauteng province. Instead, it follows the lead of the GSDF and aims to "…*consider development within the provincial boundaries [with] due consideration to the reciprocal linkages and influences between Gauteng and the areas beyond the provincial boundaries*…" (GPG, 2016).

In this manner, the strategy also hopes to support institutions outside the boundaries of the province where they are planning and developing responses to climate change by offering a level of integrated assessment and planning that can hopefully lead to more coordinated and therefore more effective response actions.

References to the 'GCR' should therefore be read from a Gauteng perspective, but with regional influences and outcomes in mind. However, most of the data collected and used in this document is within the boundary of the province, and so the monitoring and evaluation function of this strategic plan remains within this boundary.

2 Strategic Approach

2.1 Over-arching Objectives

The late Minister of Environmental Affairs, Edna Molewa, stated that "*South Africa's short, medium and long-term vision is to contribute towards an environmentally sustainable, climate change resilient, low carbon economy and just society*" at the third BRICS meeting of Ministers of Environment in Tianjin, People's Republic of China, 2017[3]. This is effectively the short-hand version of the various aims and commitments expressed in national climate change response strategies and plans.

With its central role in the economic, social and organisational character of South Africa, the GCR needs to ensure that its response to climate change is aligned with the national aspirations. However, it is recognised that a successful embodiment of the national vision in the GCR context must be based on a firm economic foundation. It also has to attend to the social challenges that arise from suboptimal spatial functioning, rapid population growth, unemployment and inequality. In accordance with Sustainable Development Goal (SDG) 13, to "*Take urgent action to combat climate change and its impacts*", the following goals are set for the global community in terms of climate response actions:

1. Strengthen **resilience and adaptive capacity** to climate-related hazards and natural disasters in all countries
2. Integrate climate change measures into **national policies, strategies and planning**
3. Improve **education, awareness-raising and human and institutional capacity** on climate change mitigation, adaptation, impact reduction and early warning
4. Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of **mobilizing jointly $100 billion annually** by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
5. Promote mechanisms for raising capacity for **effective climate change-related planning and management** in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities

For these reasons, the GCR Over-arching Climate Change Strategy will aim to address four broad over-arching goals or outcomes. These can be seen as broad descriptions of what a well-adapted and resilient GCR must look like. Specifically, the climate change response outcomes identified for the GCR are shown in Figure 4, and respectively relate to **ecosystems**, **quality of life**, **disaster risk** and the **economy**:

[3] https://www.environment.gov.za/mediarelease/molewaonsouthafricascommitmenttosdgs

Figure 4: Four overarching goals of climate change response in Gauteng

These outcomes intentionally integrate mitigation and adaptation outcomes to maximise the opportunities for co-benefit outcomes where there is overlap between the two fields. Apart from the last outcome which speaks directly to the need for climate change mitigation, the other points, though focussed on adaptation, also communicate the need for mitigation. For example:

- Climate change mitigation will reduce the detrimental impact that climate change will have on ecosystems and their functioning
- Many mitigation measures, such as renovation and construction of low energy buildings and renewable energy at a household level (solar water heaters, solar lighting), also improve the quality of life of the least advantaged members of society
- Mitigation of climate change will aid in disaster risk reduction (DRR)

It can be pointed out that mitigation of the GCR's economy's carbon footprint is a necessary adaptation response to declining global appetites for carbon-heavy products and services.

Through the pursuance of these four objectives, the GCR Over-arching Climate Change Strategy shows commitment to the national vision, and commits the region to a trajectory that can mobilise economic and social development through environmentally and socially responsible development. This Strategy has been aligned with the Growing Gauteng Together 2030 Action Plan which charts a path for sustainable development for future generations.

2.2 SWOT Analysis

The process of moving from broadly defined response objectives to implementable actions necessarily needs to also gain an understanding of the operational environment and

institutional conditions that determine the functioning and performance of Gauteng and the GCR. In this regard, a 'Strengths, Weaknesses, Opportunities and Threats' (SWOT) analysis of these situational factors is presented below. This analysis is conducted to identify both internal and external factors that may limit or enhance the internalisation and operational implementation of appropriate climate change responses.

The analysis is preliminary and needs to be refined over time, in order to capture increasing detail as the GCR matures on its climate change adaptation and mitigation path. For current purposes, primarily to inform the overall strategic focus of the GCR Over-arching Climate Change Response Strategy, a focus on the main aspects is sufficient. The objective is to find out where opportunities lie, and where the greatest risks or obstacles are located. In this way co-benefits can be realised against a context that dictates that there is no single way of creating value from sustainable interventions.

Table 2: Climate change response SWOT analysis

Strengths	**Weaknesses**
Large labour force Strong economic base Transformed into a tertiary sector economy Massive infrastructure network Agricultural base International connections Gautrain & BRT systems Dominant in platinum sector Established Disaster Risk Management (DRM) network Dominated by three Metro municipalities which are national frontrunners in climate change responses	Political instability Provincial and municipal boundaries Pervasive poverty and inequality, and entrenched patterns of discrimination Corruption Aging infrastructure Suboptimal municipal services in some areas Surface and groundwater pollution Informal settlements Constrained public health sector Urban sprawl (with consequent heat island effect) and dormitory townships Neglected rural spaces and satellite towns Public resistance to change Fragmented DRM sector
Opportunities	
The need for expansion of existing transport infrastructure, especially mass transit infrastructure Freeing up of water and electricity infrastructure capacity as industry increases efficiency and reduces their consumption High solar energy potential Technological 'leapfrogging' - as a developing economy, the GCR can jump over several stages to move rapidly from standard to advanced technologies Diversification of the energy mix energy – different sources and suppliers of energy, esp. solar, to reduce dependence on a single resource or provider to protect the GCR from energy disruptions, strengthen its energy security and reduce its carbon footprint Innovation for infrastructure development – use of green infrastructure that is climate resilient, e.g. Sustainable Urban Drainage Systems Improved building performance in terms of energy, water and waste efficiency for both old and new buildings	

Responsible densification to reduce the need for travel and improve social cohesion Ecosystem-based adaptation (specifically, green infrastructure, co-benefits of ecosystem resilience) Young population can contribute to increased advocacy and implementation of sustainability principles Strong Non-Governmental Organisations (NGOs), including potential for climate leadership by women Unused high potential agricultural land can be utilized to address food security and job creation Eco-tourism and wildlife economy potential
Threats
External energy and water supply Automation and an unskilled labour force Global resistance towards fossil fuels National level mitigation action falling short of national GHG emissions reduction targets being in conflict with national level mitigation action Rising and extreme temperatures Variable and extreme rainfall Loss of revenue streams linked to water and energy sales Taxation of fossil fuels (e.g. fuel levy, electricity tariffs) Declining availability and rising costs of water Decline in platinum demand National oversupply of electricity shortages combined with high Eskom electricity costs and restrictive legal framework

The SWOT analysis above suggests that the GCR's core strengths lie in its extensive infrastructure network and the human resources attracted to the urban metropolis. These two factors must be used as a foundation for mitigation and adaptation interventions. However, both represent liabilities if not managed well. Infrastructure networks require maintenance and continuous capital investment, and contain many points of potential failure, whilst the large population of the region necessitate extensive coverage by municipal services and the constant expansion of the jobs market.

Weaknesses within the GCR related to governance and administration include its current political instability, the presence of many municipal and provincial borders, and the need for different layers of government to provide an integrated service (for example in health care, DRM and transportation). This is closely linked to public dissatisfaction with service delivery that has a marked influence on decision-making, especially compromising the long-term view required for investment in sustainable development and climate change adaptation. In very much the same way, the pervasive poverty and inequality spurs investment in short-term solutions to joblessness and poverty rather than long-term sustainable economic development. Entrenched patterns of discrimination against women, the aged, and people living with disabilities or systematic racism remain obstacles to generalised progress as they concentrate resources in the hands of elites rather than spread them generally within society.

The perception of natural resources tends towards viewing natural features as more of a risk than a resource, given the neglect of surface and groundwater systems and compromised ecosystem functioning in the Gauteng context. Some opportunity must be salvaged through

the integration of green infrastructure (e.g. natural stormwater management, vegetated surfaces) into the urban fabric and improvement in pollution management. Although the province is the most urbanised one in South Africa it has significant urban greenery in some areas that mitigates heat island effect (see Figure below).

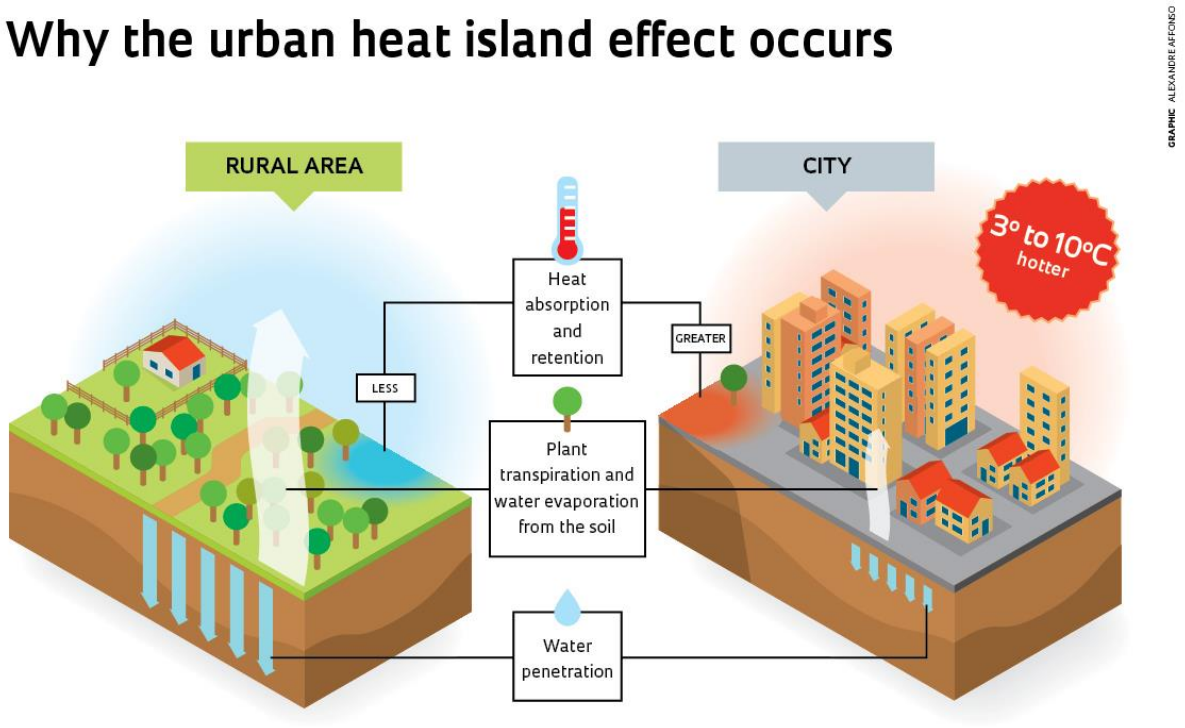


Figure 5: The heat island effect (Graphic by Alexandre Affonso)

The manifestation of climate change in changing temperature and precipitation patterns are also set to increase pressure on people, ecosystems, animals, economic activities and the built environment.

To counter the threats and weaknesses, Gauteng province and the wider GCR region need to capitalise on opportunities that allows a migration from unsustainable activities and technologies to innovative practices that are not only economically viable but also socially just and environmentally benign. Given the urban and economic context of the GCR, opportunities lie in the transportation, energy, built environment, agro-processing and ecotourism sectors. These sectors offer possibilities for roll-out of climate-resilient interventions at scale, and independently of external dependencies. Efficient urban design, linked to modernised mass transportation and safeguarded green infrastructure, is also a key ingredient to making cities (and the people living in them) resilient and reducing disaster risks.

2.3 Gaps Identified

2.3.1 Mitigation

Containment of global warming and thereby limiting the effects of climate change is to be achieved through mitigation actions – i.e. interventions that reduce the overall build-up of greenhouse gases in the atmosphere. This requires effort at a global scale, and commitments

at national and local level. Naturally, Gauteng and the GCR becomes central to the mitigation of the South African carbon footprint, given that it is home to some of the most energy intensive industries and the largest urban conglomeration in South Africa. The GCR is consequently obligated to look at reducing its carbon footprint as led by aspirational reduction targets.

Gauteng province has previously committed to lowering its carbon emissions, with emissions reduction targets set in the Gauteng Integrated Energy Strategy (GDLGH, 2010). Although a range of public and private sector interventions aimed at reducing emissions have commenced, more needs to be done if the targets are to be achieved. It is also necessary to review these targets on the basis of a complete greenhouse gas inventory in order to apportion the national commitments fairly to the province. At the same time, the actual potential for emissions mitigation must be determined as a means to identify interventions, industries and economic sectors that offer the best 'return on emissions reduction investment'.

The development of emission reduction targets must recognise the GCR context and must support the overall objective of radical 'Transformation, Modernisation and Reindustrialisation'. Following these objectives, the mitigation target must not be designed to negatively impact on (limit) economic activity and productivity in the region, but to stimulate transformation and re-industrialisation through modernisation.

Emission mitigation targets for Gauteng, in the context of existing national emission mitigation commitments, therefore have a two-fold aim:

- To take responsibility for Gauteng's 'fair share' of the national GHG mitigation target, set a benchmark for development or alignment of municipal targets and pro-actively start achieving this target.
- To potentially be more ambitious than the national GHG mitigation target as a means to stimulate economic development and improve social well-being.

2.3.2 Adaptation

The physical manifestations of climate change are set to not only increase pressure on humans, animals and natural systems, but also on the social and economic systems that support human activity. Adaptation to a changed climate therefore becomes unavoidable.

The overall adaptation aim of the of the GCR climate change response strategy is not simply to absorb or counter the impact of climate change. Instead, the objective is to place the region on a path towards climate resilient, low carbon development that capitalises on the opportunities presented by climate change and the need for adaptation. The overall outcome for the GCR should be a growing economy and improving human well-being indices. This is envisaged as adaptation outcomes in four dimensions, namely a resilient economy, improved human well-being, a functional ecosystem and reduced disaster risk.

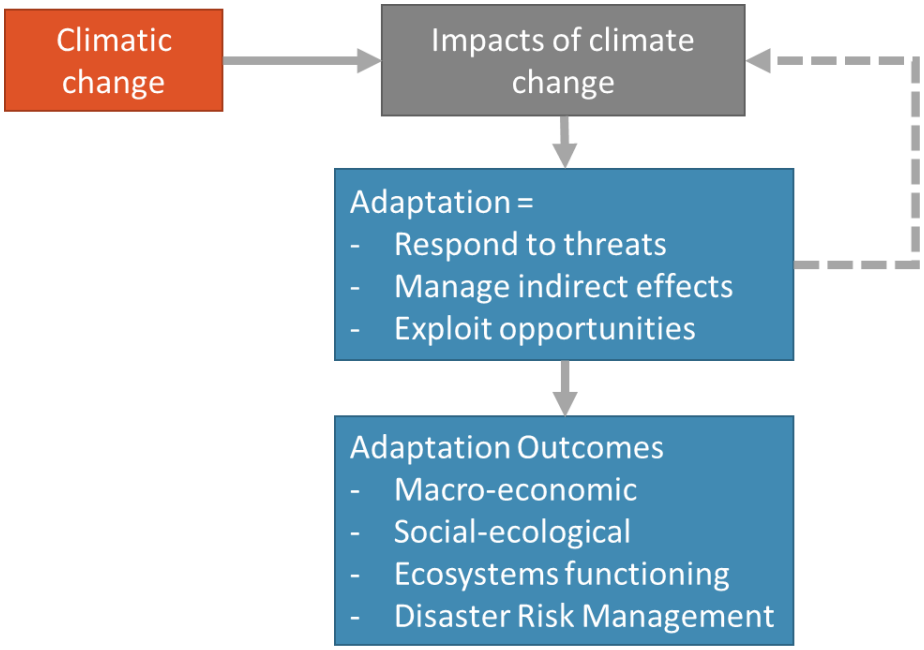


Figure 6: The case for climate change adaptation

By implication, climate sensitive policies and practices need to be transformed into climate resilient states, or replaced by equivalents that can withstand the climatic change and the changing requirements of a low-carbon world. The new policies and practices need to address the impacts of climate change in a manner that also realises growth from the opportunities presented by the need for adaptation.

The primary threats to the intended adaptation outcomes can be listed as the direct and indirect impacts that climatic change (precipitation patterns, temperature indices, extreme weather) will have, irrespective of mitigative or aggravating effects of vulnerability and adaptive capacities. These are shown in Table 3.

Table 3: Adaptation outcomes and primary impacts addressed

Outcome	Climate Change impacts
Improved Quality of Life (socio-economic well-being, fundamental human needs)	Health risks (disease, heat stress,) Physical risk (flooding) Food security Water availability Employment shifts due to structural economic adjustments Pressure on agriculture Disproportionate impact on women
Protected Ecosystems Services	Shifting climate envelopes Increased pressure on threatened species
Effective Disaster Risk Management (DRM)	Damage to infrastructure Interrupted production and operations Displaced people

Outcome	Climate Change impacts
	Incapacitated / injured people Livestock mortality and damage to crops
A Low Carbon, Resilient Economy	High carbon footprint of energy production Water availability Structural shifts due to changing international conditions (indirect effects) Climatic pressure on agricultural production

The climate change impacts identified in this way can be used as structuring elements for adaptation strategies, by allowing for a consideration of where people, the economy and the environment are exposed to the threats, and a consideration of the adaptive capacities that relate directly to those potential impacts.

2.4 Key Decisions & Consequences

In order to identify actions or interventions that can address both adaptation and mitigation, and find synergy and alignment between the two response components, adaptation outcomes and mitigation responses can be integrated into major strategic directions that determine trajectories. These key decisions act like business models that determine which actions are possible, and which are not in alignment with the overall objectives.

1. **Decarbonisation of energy, transport, industry, mining and the general built environment**

The decarbonisation of sectors with the highest carbon footprints is important from a mitigation perspective. The mining sector alone consumes about 15% of Eskom's annual electricity output, with gold (47%) and platinum (33%) mining (i.e. the two main underground mining industries in the country) being the largest contributors to this demand. At the downstream level, industrial sectors account for a further 25% of the utility's generation (Montmasson-Clair, 2016). The aim is, however, to achieve GHG emissions reductions without compromising on positive adaptation outcomes or the cost efficiency of mitigation. The integrated strategic direction should therefore select mitigation targets and interventions that are the most cost-efficient, and focus on interventions that result in co-benefits.

2. **Institutional changes to facilitate an energy, transport and development planning transition**

Because of the challenges being faced and opportunities being created within the energy, industry, transport and development planning sectors, specifically due to the rapid rise of renewable energy and information technologies, institutional changes will be required to accommodate the inevitable changes - on the one hand, current procedures and operational parameters will need to be adjusted to accommodate new and changed technologies and methods, but institutions will also need to reconsider their involvement in the sectors to protect sources of revenue and disengage from detrimental external factors.

3. **Resilient built environment**

A resilient built environment is a so-called 'no-regrets' decision. This suggests that by creating a built environment that is better able to withstand and recover from shocks, an improved living space is created irrespective of whether climate change leads to serious impacts. Such a resilient built environment will capitalise on ecosystem goods and services, optimise resource use and withstand impacts from climatic changes. A resilient built environment will necessarily also invest in energy saving measures, decentralised renewable energy solutions (solar, micro-hydro, biogas), improved sanitary conditions and the protection of clean water resources.

4. **Resilience supported through protection of key natural systems, functions and resources**

Many opportunities exist in urban environments to supplement or replace built (hard) infrastructure with natural (soft) solutions or 'green infrastructure' - for example functional open space networks that support stormwater management, microclimatic control, pest management, pollination services, water purification etc. Also, in rural areas, such functional ecosystems will support agricultural activities, water resources management and sustainable livelihoods. Investment in natural resources management furthermore supports the conservation of water resources.

5. **Climate change awareness and awareness materials**

If wide-spread support and action is to be mobilised with the aim of achieving the adaptation and mitigation outcomes, then a general awareness should be created of both the threats posed by climate change and the opportunities that can be capitalised on. The message must reach vulnerable social groups that need to increase their state of resilience, government employees who need to lead a systematic transition, the new generation of climate-conscious world citizens that are currently in school, as well as economic sectors that are key to a reduced carbon footprint. The existing initiatives within various spheres of government, notably the on-going mobilisation campaign around climate education and awareness should be extended. These should be incorporated into programmes run by Environmental Empowerment services in GDARD.

6. **Climate smart agriculture**

Climate smart agriculture suggests an approach that carefully manages agricultural ecosystems for improved productivity, profitability and food security, while maintaining the integrity of the natural resource base. It steers agricultural activities towards sustainable practices, climate resilient product selection and opportunities to benefit from ecosystem services. Therefore it can be extended into agro-ecology and Ecosystem-Based Adaptation (EbA) initiatives where appropriate.

7. **Climate change and ecosystem services responsive DRM capacity building**

In order to mitigate the impact of climate change, the DRM and social development sectors need to respond to the changing risk profile of economic sectors and communities. This implies that the projected extreme climate events need to be planned for, and that inevitable

changes to economic activities, such as contraction in energy or water dependent industries, have to be anticipated in terms of social impacts. An opportunity to be exploited lies in the need for standardisation of DRM protocols throughout the province – this process can include an internalisation of ecosystem services.

8. Water conservation and demand management

Water is a scarce resource in South Africa, and the GCR is heavily dependent on imported water. The overall sustainability of water supplies in the face of ever-growing demands is therefore a concern that needs to be tempered through resource planning and water use management. The water losses are of particular concern. Rand Water (the biggest Water Board in the country) provided on average 4 684 Ml/d in 2015/6 while the levels of non-revenue losses fluctuated between 40% and 77% (GDARD, 2017a). With Johannesburg charging R7.14/kl for any consumption above 6 kl, this loss represents about R13.4 million a day. Irrigation losses can also be in order of 50%.

9. Innovative solutions to services provision

Although great strides have been made in providing formal basic services to communities throughout the GCR, backlogs and unserviced areas remain. The reality is that current models of services provision will not be able to satisfactorily provide formal services to these areas. Innovative and 'alternative' solutions will therefore need to supplement the provision of services – such as off-grid systems and renewable energy-based solutions. A shift to entrepreneurial urban governance (see more detailed explanations in later chapters) is one of the possible solutions. Given the finite resources available to the Health Sector, innovation will also be required in the field of community health in order to accommodate the anticipated increase in climate related health impacts.

3 Mitigation Targets[4]

3.1 The carbon footprint of Gauteng

A GHG inventory or carbon footprint is a starting point from which to determine appropriate mitigation actions, as it shows what activities and sectors generate (the highest) emissions and therefore where mitigation activities should be focussed. For the purposes of the 2018 Gauteng City Region Over-arching Climate Change Strategy, the incomplete GHG inventory of 2014 (GDARD, 2014) was updated using national data. Key details of the inventory and analysis are provided below, but a standalone document is available – see ANNEXURE A: Gauteng Greenhouse Gas Inventory (as separate document). Since it includes non-territorial emissions it could be called carbon footprint, which is also described as total of scope 1 or direct emissions and scope 2 indirect emissions resulting from purchase or electricity, heat or steam). In case of Gauteng the scope 2 emissions are mainly Eskom emissions (Lotz & Brent, 2017) emitted while generating electricity consumed in Gauteng.

3.1.1 Approach to calculating Gauteng's carbon footprint

As a first step to compiling a comprehensive GHG inventory, existing GHG data for the province of Gauteng were reviewed. The review shows that the latest inventories covering the full physical area of the province were based on 2007 data (Enerkey (2012) and GDARD (2014)), and exclude emissions from Industrial Processes and Product Use (IPPU). A more recent study, compiled for 2011, does not include the full area of the province or all sources of emissions (SEA, 2015).

Table 4: Review of GHG Inventories conducted for (part of) Gauteng province

Study	Inventory Year	Aspects included	Total emissions as tonnes carbon dioxide equivalent (tCO_2eq)[5]
State of Energy in South African Cities (2015), Sustainable Energy Africa **(SEA, 2015)**	2011	Ekurhuleni, Tshwane, Johannesburg Energy use only No emissions from IPPU, Waste and AFOLU sectors	54 142
Energy related GHG Inventory and energy balance Gauteng: 2007-2009 (2012), Enerkey **(Enerkey, 2012)**	2007 (extrapolated for 2009)	Energy use only No emissions from IPPU, Waste and AFOLU sectors	121 628

[4] Further details, including Marginal Abatement Cost Curves, can be obtained from ANNEXURE A: Gauteng Greenhouse Gas Inventory (as separate document)

[5] For a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale

Study	Inventory Year	Aspects included	Total emissions as tonnes carbon dioxide equivalent (tCO_2eq)[5]
The development of the Gauteng GHG emissions inventory: Phase 1 (2014), Gauteng Province **(GDARD, 2014)**	2007	IPPU sector is excluded	90 565
Note: all studies include the emissions from non-territorial electricity production			

As a follow-up study to the 2012 GHG Inventory (GDARD, 2016) showed that the inventory's failure to cover industrial process emissions could be very significant, a **high level GHG Inventory** was developed for the 2018 GCR Climate Change Response Strategy based on publicly available data. A top down approach was taken, combining the 2010 National Greenhouse Gas Inventory data with economic activity data for the Gauteng province. Results were then cross-checked with the previously mentioned studies to pick up on anomalies.

The South African 2000-2010 National Greenhouse Gas Inventory was submitted to the UNFCCC in 2014 (DEA, 2014a). This National Greenhouse Gas Inventory is structured according to the IPCC 2006 Guidelines and, in accordance with these guidelines, describes the Quality Assurance and Quality Control activities taken to ensure that the report is of the best possible quality and therefore is a reputable source.

Data on regional distribution of economic activity for 2011 as obtained from Statistics South Africa (StatsSA) is used for the inventory. This data describes different economic sectors, and the share (%) of the national economic activity each of the provinces contribute (Figure 7). The provincial contribution was taken as the proxy for the share of the national GHG Inventory attributable to the Gauteng province and it includes non-territorial/scope 2 emissions that are indirectly accounted for by the GDP share. The approach of using the economic activity contribution of the province as the share of the National GHG Inventory is judged appropriate for a high-level assessment as it provides more complete estimate of carbon footprint than the incomplete GHG inventories collated to date.

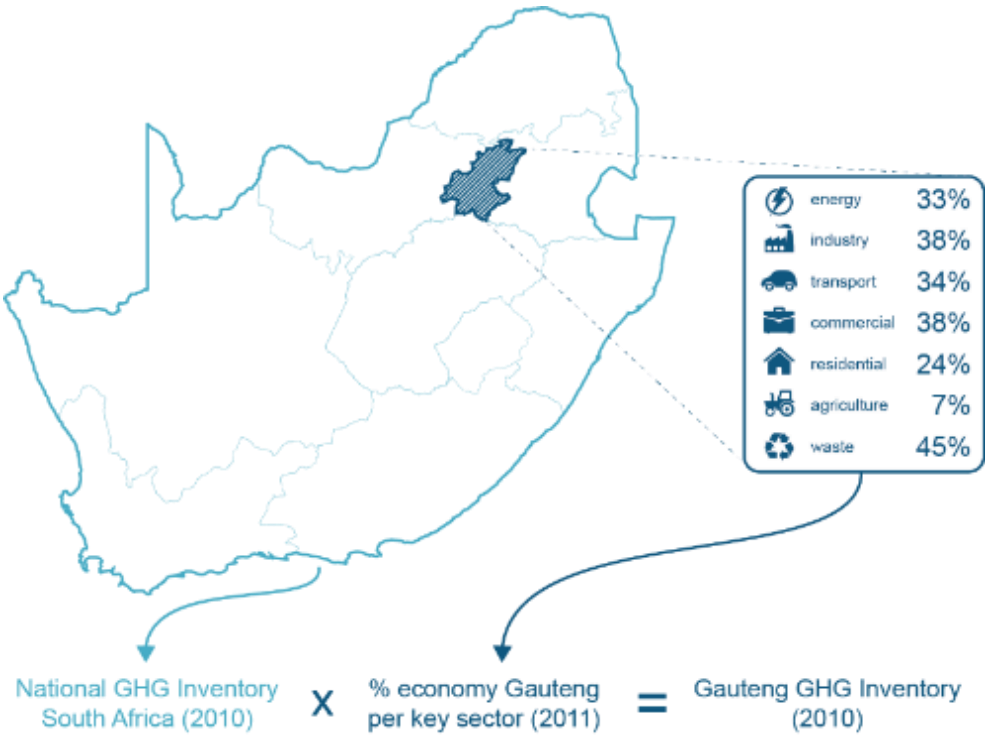


Figure 7: Visualisation of calculation method for Gauteng carbon footprint

To improve the accuracy of calculations two exceptions were made to the use of economic activity data to determine the GHG emissions. For the Waste sector the doctoral thesis of Shaazia Bhailall (Bhailall, 2016), which estimates that Gauteng province contributes to 45% of all general waste within South Africa, was used. Waste water also falls within the category of waste. In total, the waste related emissions result in 9 164 tCO_2eq for the waste sector.

The second exception was for the AFOLU sector. Here, use was made of the comprehensive DEA Report '*Towards the development of a GHG emissions baseline for the agriculture, forestry and other land use (AFOLU) sector in South Africa*' (DEA, 2016), which reported the value of 1 920 tCO_2eq. This was used instead of 1 543 tCO_2eq that is derived from calculations based on national economic activity.

3.1.2 GHG Inventory/Carbon footprint of Gauteng Province

The GHG inventory results for the four main sectors identified in the IPCC 2006 Guidelines, namely Energy, IPPU, AFOLU and Waste, are presented in the table below. The results were compared with results of previous studies and no significant outliers were found (see Annexure A for details).

The IPCC category code is presented in brackets next to the sector name.

Table 5: Overview of the estimated GHG inventory for Gauteng using the National Greenhouse Gas Inventory 2010 combined with economic activity representation of Gauteng

Sector (IPCC categories)	National Emissions 2010 ($ktCO_2eq$)*	% economic activity	Gauteng GHG Inventory 2010 ($ktCO_2eq$)
Energy	297 691	33%	97 393
• **(1A1 Energy industries)**	267 693	-	88 339
• **(1A4c Agriculture)**	3 308	-	247
• **(1A5 Non-specified)**	1 139	-	376
• **(1B Fugitive Emissions from Fuels)**	25 551	-	8 432
Industry	85 468	38%	32 181
• **(1A2 Manufacturing Industries and Construction)**	41 117	-	14 218
• **(2 Industrial Processes and Product Use)**	44 351	-	17 962
Transport (1A3)	47 607	34%	16 186
Commercial (1A4a)	17 137	38%	6 439
Residential (1A4b)	24 817	24%	5 904
AFOLU (3)	25 714	7%	1 920
Waste (4)	19 806	45%	9 164
TOTAL	**518 239**	**33%**	**169 187**

** Though there has been an update available in the form of a 2012 GHG inventory as made available in South Africa's Third National Communication to the UNFCCC, it was decided to use the 2010 GHG inventory data as it provided a higher level of detail. Furthermore, the 2012 GHG Inventory merely recalculated the 2010 data, resulting in a small (1.6%) increase of the national GHG emissions.*

3.2 GHG emission trends and projections

It is important to understand emission trends when developing a mitigation plan. Emission trends support the development of emission projections in combination with expected changes in influencing factors, such as regulations, technology and socio-economic factors. At present, however, information is only available on national level, given that this study represents the first complete GHG inventory for Gauteng.

Trends in South African greenhouse gas emissions, and projections of future emissions, are found in the following documents:

- National Climate Change Response White Paper (2011), Department of Environmental Affairs (DEA, 2011)
- National Greenhouse Gas Inventory 2000-2010, Department of Environmental Affairs (DEA, 2014a)
- South Africa's Greenhouse Gas (GHG) Mitigation Potential Analysis (2014), Department of Environmental Affairs (DEA, 2014c), currently being revised

National Greenhouse Gas Inventory 2000-2010

A national increase of 22% in greenhouse gas emissions was found between 2000 and 2010. There was a 24.3% and 12.4% increase in CO_2 and CH_4 (in CO_{2eq}) respectively between 2000 and 2010, and a decline (7.0%) in N_2O emissions over this period. Though a previous inventory of 1990 has been conducted, it is difficult to compare these results with the 2010 results as the methodology changed significantly and data availability improved over this time.

South Africa's Greenhouse Gas Mitigation Potential Analysis, 2014

The Mitigation Potential Analysis (MPA) has, following the UNFCCC reporting guidelines (UNFCCC, 2000), produced two types of projections:

- A **'without mitigation' (WOM)** projection: This is a projection of emissions from 2000 to 2050 which assumes that no climate change mitigation actions have taken place since 2000. This projection finds that if no mitigation measures would have been implemented from 2000, the emissions in 2010 would have been 28% higher. Projected emissions following this reference scenario rise steadily, largely due to economic growth, to 699 307 $ktCO_{2eq}$ in 2020 and 903 700 $ktCO_{2eq}$ in 2030.
- A **'with existing measures' (WEM)** projection: This projection incorporates the impacts of climate change mitigation actions including climate change policies and measures implemented to date. In this scenario, the 2000-2010 emission trajectories follow the emissions as calculated by the National Greenhouse Gas Inventory. It projects that in 2020, the national greenhouse gas emissions will be 663 270 $ktCO_{2eq}$ and 857 745 $ktCO_{2eq}$ in 2030.

It must be noted that the future opportunities identified as part of the Mitigation Potential Analysis are not policy measures, but additional measures.

National Climate Change Response White Paper, 2011

The NCCRWP 'details the "*peak, plateau and decline (PPD) trajectory*" used as the initial benchmark against which the efficacy of mitigation actions will be measured'. The PPD is a GHG emissions trajectory range that considers mitigation measures and thus approximates the actual form or shape which South Africa's mitigation ambition is to follow. The first refinement of the National Trajectory emissions trajectory is underway, with an update every five years.

The NCCRWP spells out key reference points of this scenario, namely:

> **Peak**: South Africa's GHG emissions peak in the period 2020 to 2025 in a range with a lower limit of 398 Mt CO_2eq and upper limits of 583 Mt CO_2eq and 614 Mt CO_2eq for 2020 and 2025 respectively.
>
> **Plateau**: South Africa's GHG emissions will plateau for up to ten years after the peak within the range with a lower limit of 398 Mt CO_2eq and upper limit of 614 Mt CO_2eq.

Decline: From 2036 onwards, emissions will decline in absolute terms to a range with lower limit of 212 Mt CO_2eq and upper limit of 428 Mt CO_2eq by 2050.

Figure 8 presents GHG emission projections for the Gauteng province, which are derived using the MPA WEM reference emissions projections. For each of the sectors included in Figure 8, the relative national growth was calculated and multiplied with the GHG Inventory 2010 for Gauteng. As can be seen emissions increase to about 290 Mt CO_2eq by 2030.

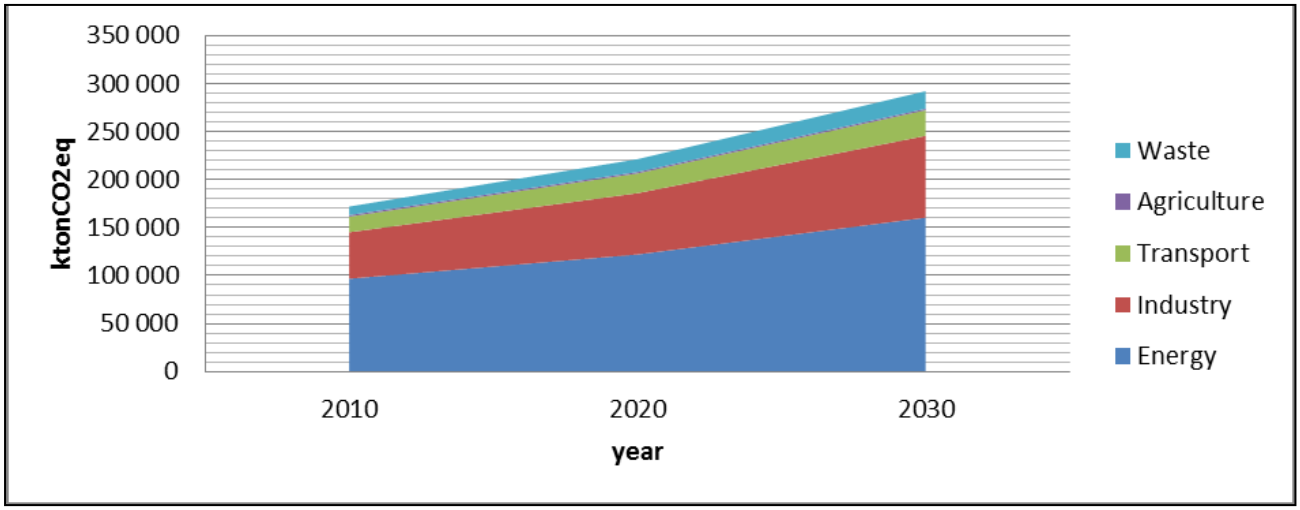


Figure 8: Gauteng GHG emissions projections (including emission mitigation)

3.3 GHG emissions reduction targets

3.3.1 Existing targets

The MPA study was commissioned by the Department of Environmental Affairs in 2012, to support with the implementation of the NCCRWP. The MPA contains different scenarios for emission projections, of which the 'With Existing Measures' is the most likely scenario which forms the baseline for calculating the mitigation potential and costs throughout the study. The WEM scenario contains interventions and policy and regulations implemented by 2010. The WEM scenario projects emissions to be at 663 Mt CO_2eq in 2020 and 858 Mt CO_2eq in 2030. This means that additional measures, such as presented in the MPA are necessary to achieve the NDC target of South Africa. When the additional mitigation measures as identified by the MPA are implemented, the target of emissions between 398 and 614 Mt CO_2eq by 2025 can be achieved.

Table 6: National GHG emissions projections for 2030

National GHG emissions ($ktCO_2eq$) under the reference case With Existing Measures projection (DEA, 2014b)					
Sector	**2010**	**2020**	% Increase	**2030**	% Increase
Energy	298 109	375 994	26%	494 066	31%
Industry	113 116	149 182	32%	199 296	34%
Transport	47 715	60 242	26%	78 106	30%
AFOLU	54 311	53 268	-2%	52 506	-1%
Waste	16 421	24 584	50%	33 771	37%

National GHG emissions ($ktCO_2eq$) under the reference case With Existing Measures projection (DEA, 2014b)					
Total	**529 672**	**663 270**	**25%**	**857 745**	**29%**

To achieve the desired emission reductions (for example through implementation of the measures defined in the MPA), DEFF is developing an integrated mitigation system which contains regulatory tools such as carbon budgets and sectoral emission targets. This mitigation system/process is presented in Figure 9.

In accordance with this overall system, Sectoral Emission Targets (SETs) have been specified for the period 2016 to 2020. The second and subsequent phases SETs were intended to be defined and allocated by 2018, pronouncing the 3 cycles for the period (2021-2025; 2026-2030 and 2031-2035), and reviewed every 5 years. The responsibility to ensure emissions remain within the limits of the first 5-year period is allocated to national government departments (SET departments). The allocation of carbon budgets at company level is set to commence in 2021 (DEA, 2017).

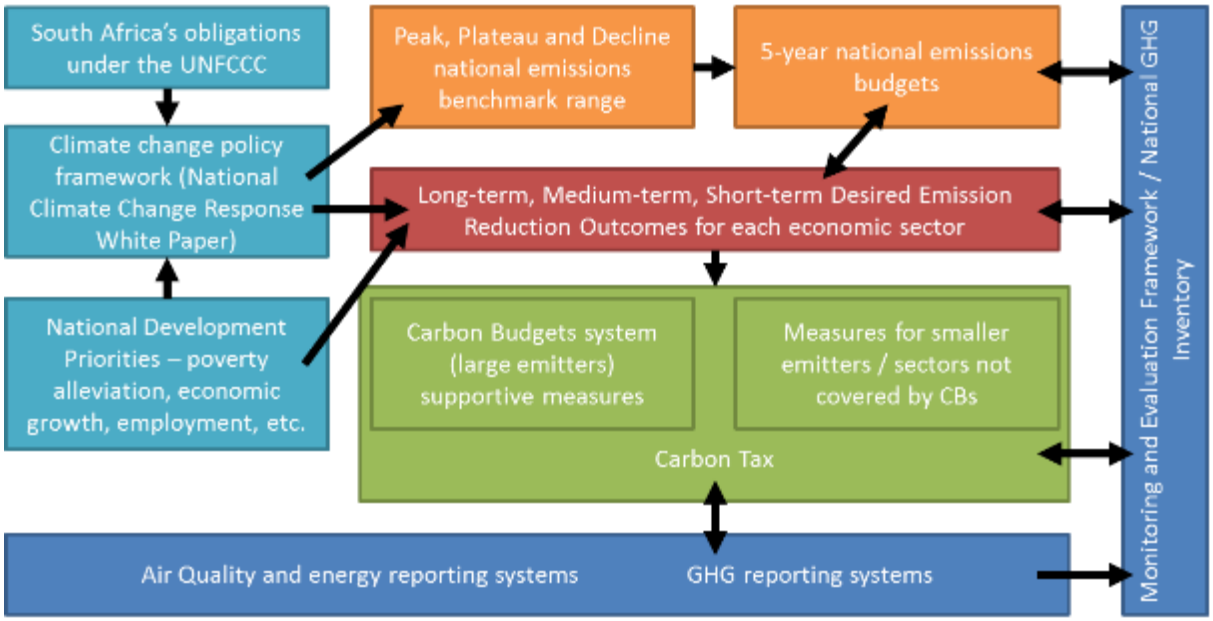


Figure 9: South Africa's Mitigation Process (Source: Energy Resource Centre, University of Cape Town)

The following table presents national targets related to energy use:

Table 7: Current national targets related to energy use

Action	Target	Year	Source
National target for energy efficiency improvement	12%	2015	Energy Efficiency Strategy, DME, 2005 (DME, 2008)
Transport Final Energy Demand Reduction	9%	2015	Energy Efficiency Strategy, DME, 2005 (DME, 2008)
Residential Sector Final Energy Demand Reduction	10%	2015	Energy Efficiency Strategy, DME, 2005 (DME, 2008)
Industry and Mining Final Energy Demand Reduction	15%	2015	Energy Efficiency Strategy, DME, 2005 (DME, 2008)

Action	Target	Year	Source
Commercial and Public Building Sector Final Energy Demand Reduction	15%	2015	Energy Efficiency Strategy, DME, 2005 (DME, 2008)
Power generation - an interim target of reduction in 'parasitic' electrical usage	15%	2015	Energy Efficiency Strategy, DME, 2005 (DME, 2008)
Renewable energy target: 10 000GWh (0.8Mtoe)	4%	2013	White Paper on Renewable Energy Policy, 2003
Electrification targets (universal access)	100%	2025	Integrated National. Electrification Program, DoE, 2013

3.3.2 New GHG emissions reduction targets for Gauteng

Gauteng has previously committed to its own energy and carbon emissions reduction targets. These are found in the Gauteng Integrated Energy Strategy (GDLGH, 2010) and adopted by the GCCRS, 2011 (GDARD, 2011).

Table 8: Interim targets for energy use and carbon emissions reduction (GDARD, 2011)

Action	2015	2025	2055
Overall energy efficiency against business as usual scenario	22%	30%	40%
Transport energy efficiency	15%		
Residential energy efficiency	20%		
Industry energy efficiency	25%		
Commercial energy efficiency	25%		
Government energy efficiency	25%		
Renewable energy consumption (electricity only)	15%	30%	50%
Carbon dioxide emissions reduction (against 2000 levels)	15%	30%	45%
Electrification targets	100%		
Solar water heaters installations	15%	50%	100%
Energy poverty reduction/low-income reduction in heating and cooling costs	10%	20%	

One of the purposes of this strategy is to update Gauteng's mitigation targets. More ambitious goals should be developed and be based on modern cost-effective technologies to support the shift of Gauteng into the low carbon economy.

This study aims to inform provincial Government on technical possibilities of mitigation within the province, the financial implications of the mitigation potential and relate the financial and technical possibilities to the national target. As reference, Table 9 shows the projected emissions volumes for Gauteng for 2020 and 2030, based on the With Existing Measures reference case described by the national Mitigation Potential Assessment (DEA, 2014c).

Table 9: Gauteng emissions projections 2030

Gauteng Province GHG Emission Projections with Existing Measures (DEA, 2014c)			
Key sector	**2010**	**2020**	**2030**
Energy	97 393	122 839	161 413

Industry	32 181	42 441	56 698
Transport	16 186	20 436	26 496
Agriculture	1 920	1 883	1 856
Waste	9 164	13 719	18 846
Total ($ktCO_2eq$)	**169 187**	**201 318**	**265 310**

Presented in Figure 10 is the emission target for the Gauteng province, assuming that the province's average contribution to national economic activity is a representable proxy for its share of emissions. South Africa's NDC states an emission target between 398 and 614 Mt CO_2eq by 2025 and 2030. This would translate to an emission target for Gauteng between 139 and 215 Mt CO_2eq by 2025 and 2030.

As can be seen in the figure, the current emission target based on the NDC would be lower than the projected emissions which already include the impact of existing policies and measures. For that reason, additional measures, such as presented in the Mitigation Potential Analysis, should be implemented.

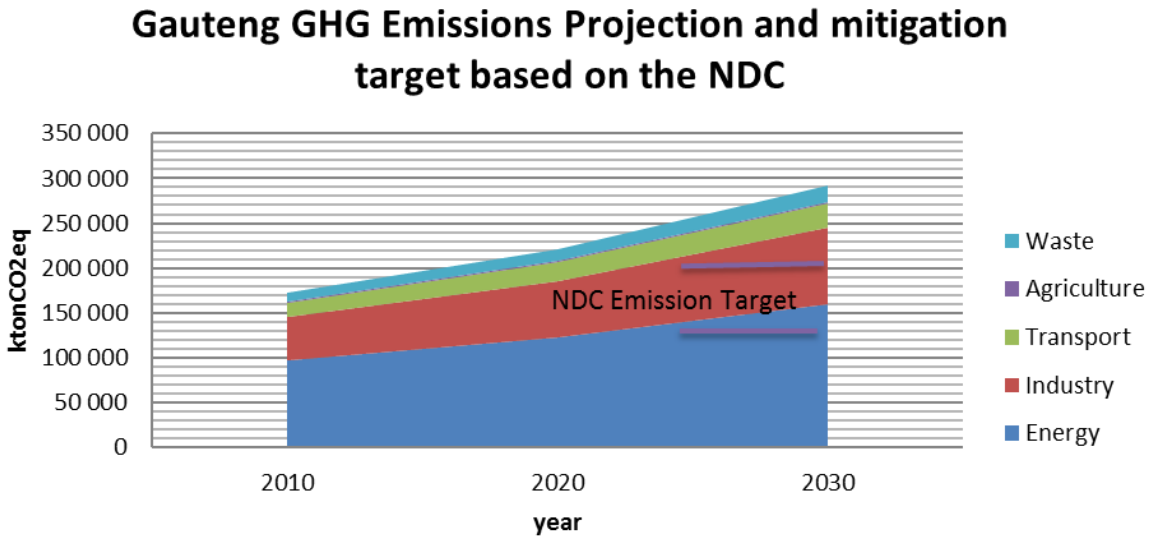


Figure 10: Gauteng GHG Emissions Projection compared to Gauteng's share of the national emission mitigation target

GHG emission reduction targets have been developed for the seven key GHG Inventory sectors. For each sector three scenarios for GHG emission reduction have been calculated, based upon the appendices of the MPA study:

1. **Maximum** abatement scenario: selects all measures from the MPA study
2. **Zero cost** scenario (breakeven): selects measures from the MPA study for which the sum is zero marginal costs (i.e. no extra cost to the economy). This analysis was done for all sectors combined to achieve the most cost-efficient implementation of activities. Afterwards this combined target was translated to sectoral targets.
3. **Negative cost** scenario: only selected measures with negative marginal costs (i.e. implementation of the measure saves money)

For each scenario the total abatement of all selected measures has been calculated, for the years **2020** (Table 10) and **2030** (Table 11). Next, the total abatement is compared with the total sectoral emissions in 2010 to define reduction targets. The last row shows the total expected emissions after abatement. The projected emissions for 2020 (200 Mt CO_2eq) and 2030 (264 Mt CO_2eq) have been used to calculate the emissions after abatement.

Table 10: Total GHG emission abatement and corresponding reduction targets for 2020, as compared to 2010

Scenario 2020:		Maximum		Zero cost		Negative cost	
Key sector	Emissions 2010	Abatement ($ktCO_2eq$)	Reduction target	Abatement ($ktCO_2eq$)	Reduction target	Abatement ($ktCO_2eq$)	Reduction target
Energy	97 393	10 909	11%	9 671	10%	1 170	1%
Industry	32 181	8 655	27%	7 514	23%	4 623	14%
Transport	16 186	4 059	25%	2 681	17%	23	0%
Commercial	6 439	2 510	39%	2 510	39%	2 510	39%
Residential	5 904	5 133	87%	5 133	87%	4 631	78%
AFOLU	1 920	372	19%	372	19%	169	9%
Waste	9 164	4 489	49%	4 489	49%	2 264	32%
TOTAL	**169 187**	**36 127**	**21%**	**32 370**	**19%**	**15 391**	**9%**
Total emissions in 2020 (projected emissions – abatement)		**165 191 $ktCO_2eq$**		**168 949 $ktCO_2eq$**		**185 927 $ktCO_2eq$**	

As can be seen in Table 10, all mitigation scenarios for 2020 would keep the province's emissions within the NDC translated targets for the province of 139 and 215 Mt CO_2eq by 2025 and 2030 respectively. It is recommended that the zero cost mitigation target is adopted as a minimum to make the transition to more stringent targets for 2030 possible.

Due to the approach of achieving the highest possible cost efficiency, the resulting emission mitigation targets vary among the sectors. For 2020, a target of 10% is recommended for the energy sector, while an 87% target is recommended for the residential sector. Though this can come across as 'unfair' and 'unbalanced', the costs for society are minimalized through this approach. There is no legislation or intention to enforce these targets by provincial government and they were determined to prioritise most cost- effective intervention.

Table 11: Total GHG emission abatement and corresponding reduction targets for 2030, as compared to 2010

Scenario 2030:		Maximum		Zero cost		Negative cost	
Key sector	Emissions 2010	Abatement ($ktCO_2e$)	Reduction target	Abatement ($ktCO_2e$)	Reduction target	Abatement ($ktCO_2e$)	Reduction target
Energy	97 393	55 098	57%	37 669	39%	2 619	3%
Industry	32 181	23 716	74%	19 075	59%	13 914	43%
Transport	16 186	13 517	84%	8 644	53%	134	1%

Scenario 2030:		Maximum		Zero cost		Negative cost	
Key sector	Emissions 2010	Abatement ($ktCO_2e$)	Reduction target	Abatement ($ktCO_2e$)	Reduction target	Abatement ($ktCO_2e$)	Reduction target
Commercial	6 439	3 735	58%	3 735	58%	3 735	58%
Residential	5 904	5 322	90%	5 322	90%	4 336	73%
AFOLU	1 920	714	37%	714	37%	367	19%
Waste	9 164	9 954	109%	9 954	109%	5 403	59%
TOTAL	**169 187**	**112 058**	**66%**	**85 114**	**50%**	**30 508**	**18%**
Total emissions in 2030 (projected emissions – abatement)		**153 252 $ktCO_2eq$**		**180 196 $ktCO_2eq$**		**234 802 $ktCO_2eq$**	

As can be seen in Table 11, both the 'maximum' and 'zero costs' mitigation scenarios for 2030 would keep the province's emissions within the NDC translated target for the province of 139 and 215 Mt CO_2eq. The 'negative costs' mitigation scenario would not have sufficient impact to achieve the NDCs translated target for the province.

Table 10 and Table 11 both show the sectoral targets which are required to be adopted to achieve the overall provincial emission reduction target. For each of the 7 key sectors, more information on the potential of target setting and mitigation activities is provided ANNEXURE A: Gauteng Greenhouse Gas Inventory (as separate document). For each sector a Marginal Abatement Cost Curve (MACC) is presented as these curves provide detailed information about the mitigation potential and costs within the sector.

Text Box: Bioenergy Atlas for South Africa – including opportunities for beneficiation of waste

Bioenergy in South Africa has limited potential on account of relatively low primary productivity, largely constrained by rainfall and exacerbated by significant inter-annual variability. However, when keeping these constraints as well as food security as a first priority in mind, there is still room for energy derived from biomass. Techno-economic assessment of options for biomass conversion to energy, and considerations such as job creation, impact on rural economies, GHG mitigation and likely subsidies required to make energy products cost-competitive, were evaluated and resulted in a set of feasible options for biomass utilisation which may be able to contribute approximately 3 500 MW of electricity equivalent to the national energy mix over the planning horizon of 20 years:

- Utilisation of all available urban domestic (household) organic waste - up to 1 400 MWe
- Household or communal digesters in rural, unserviced areas - up to 250 MWe
- Combination of all available lignocellulose biomass (invasive alien plants, plantation residues, sugar mill bagasse and agricultural residue) - up to 1 300 MWe
- An energy crop industry on subsistence farmland - 587 MW, 235 MWe as electricity equivalent, 570m l/a of biodiesel

Source: Hugo, W (Ed), 2016. BioEnergy Atlas for South Africa – Synopsis Report, Department of Science and Technology, Pretoria, South Africa.
http://dx.doi.org/10.15493/SAEON.BEA.DOCS.10000001

4 Desired Adaptation Outcomes

South Africa's adoption of the Paris Agreement commits the country amongst other things to an on-going review of adaptation effectiveness and progress made towards the global adaptation goal of a climate resilient world. In this respect, DEFF is in the process of devising a list of Desired Adaptation Outcomes (DAOs) for the country that describe a desired state that will contribute to a climate resilient South Africa in the short to medium-term (i.e. over the next five to 20 years). The outcomes are designed to specifically facilitate and focus on monitoring and evaluation, provide a means of assessing the capacity of 'at risk' sectors and their stakeholders to adapt to climate change and whether the measures being taken are appropriate, efficient and effective. They also provide a framework for national, provincial and local stakeholders to express their sectoral adaptation goals in plans, policies and actions. (DEA, 2019).

Currently, the draft National Adaptation Strategy define nine DAOs that are considered generic or universally applicable (Table 12) (DEA, 2019). A process is currently underway to localise these DAOs, with the aim of deriving a list of provincially relevant DAOs, but also to ensure that provincial reporting aligns with the national list and related reporting. The provisional DAOs relate directly to the envisaged key outcomes of this GCR Climate Change Response Strategy.

Table 12: Desired Adaptation Outcomes (DEA, 2019)

Desired Adaptation Outcomes
Inputs to enable effective adaptation
G1. Robust/integrated plans, policies and actions for effective delivery of climate change adaptation, together with monitoring, evaluation and review over the short, medium and longer-term.
G2. Appropriate resources (including current and past financial investments), capacity and processes (human, legal and regulatory) and support mechanisms (institutional and governance structures) to facilitate climate change adaptation.
G3. Accurate climate information (e.g. historical trend data, seasonal predictions, future projections, and early warning of extreme weather and other climate-related events) provided by existing and new monitoring and forecasting facilities/networks (including their maintenance and enhancement) to inform adaptation planning and disaster risk reduction.
G4. Capacity development, education and awareness programmes (formal and informal) for climate change adaptation (for example informed by adaptation research and with tools to utilise data/ outputs).
G5. New and adapted technologies, knowledge, research and other cost-effective measures (for example nature-based solutions) used in climate change adaptation.

Desired Adaptation Outcomes
G6. Climate change risks, impacts and vulnerabilities identified and addressed.
Impacts of adaptation interventions and associated measures
G7. Systems, infrastructure, communities and sectors less vulnerable to climate change impacts (for example, through effectiveness of adaptation interventions/response measures).
G8. Non-climate pressures and threats to human and natural systems reduced (particularly where these compound climate change impacts).
G9. Secure food, water and energy supplies for all citizens (within the context of sustainable development).

More details on the data and information needed to monitor progress towards achieving DAOs and the DAOs for priority sectors appears in Annexure E.

5 Cross-cutting issues

In many ways mitigation and adaption are very different approaches to climate change, and the mitigation and adaptation responses are often implemented separately. It can be useful though to find linkages between the two types of response measures in order to reduce duplication and multiply benefits.

Five specific cross-cutting issues are identified in this strategy:

- Research & Innovation
- Public Awareness
- Capacity Building, Education & Training
- Governance
- Finance (*also refer to Annexure C*)

These issues are unpacked in Table 13 in terms of associated activities. The issues can be treated as stand-alone sectors that merit their own specific strategy and programme of action, but for this GCR Over-arching Climate Change Strategy, the key activities identified are used as informants, along with the mitigation and adaptation targets, for detailed intervention programmes. For example, although an overall research agenda is necessary, research questions of specific relevance to different core sectors or urgent actions were specified for immediate attention. Monitoring and evaluation is also cross-cutting, but addressed separately in Section 7.4.

Table 13: Cross-cutting issues for climate change responses in the GCR

	Description	Sub-activities
1) Research	Research on new mitigation and adaptation options	Province-specific studies on alternative mitigation and adaptation options, including both high tech options (e.g. fuel cell) and ecologically based approaches. Research should be based on economic advantages and job creation opportunities.
	Evaluation of risks, benefits, governance frameworks, ethical and equity issues, value judgements, economic assessments and uncertainty	Vulnerability mapping using increased resolution and improved accuracy of climate change projections and localised contextualisation of impacts to ensure relevance and practicality, such as including information on vegetated areas for mapping heat stress impacts and provincial floodline data for mapping risk of flooding Evidence on success or failure of response measures – for example agricultural and biomass beneficiation projects Inclusion of traditional and indigenous knowledge and systems in design of responses

	Description	Sub-activities
2) Public Awareness	Generating public support for climate change-responsive actions, and holding government to account	Messaging via different public channels, including social media Targeting of vulnerable groups and specifically youth and women who can make a difference Sector-specific guidance Promotion of key concepts – resilience, vulnerability, adaptation, renewable energy etc. Communication of government actions and incorporation of stakeholder feedback Wider data dissemination and information sharing with all affected stakeholder groups
3) Capacity Building, Education & Training	Skills development for improved climate change responses, and as alternative livelihoods	Alignment of existing skills development and education programmes with climate change response needs assessment Capacity building in government with focus on decision makers to ensure designated roles and responsibilities are fulfilled Community-led/based skills development Development of alternative livelihoods Skills development in emerging green sectors such as renewable energy Improved communication of science
4) Governance	Political and administrative systems to facilitate and guide trajectories and actions aligned with stated targets and outcomes	Intersectoral and interdepartmental monitoring, coordination and alignment of statutory legislation, frameworks, policies and strategies An enabling environment for collaboration, and direct partnerships with the private sector (business, investors, developers, academia and communities) and NGOs Incentives / disincentives and enabling administrative systems, given that an enabling regulatory environment is a key success factor Building institutional capacities for establishing a multi-stakeholder, transparent process in which cross-sectoral adaptation needs and actions are identified, vetted and assessed
5) Finance	Facilitate access to global climate funding by tailoring development projects to the funding requirements	Identification of appropriate climate funding sources Partnering between sector departments or spheres of government to identify opportunities for (re)design of development projects Documenting successes and failures related to climate funding applications Align with international carbon offset schemes

6 Action Plan

To direct specific action on climate change in Gauteng and the GCR, a programmatic approach is adopted. This process identifies pivotal response programmes around which a range of important intervention actions can be structured, in consideration of the vulnerability assessment, SWOT analysis, DAO sector breakdown and other considerations highlighted elsewhere in this strategy.

The selection of sectors is informed by the need to align mitigation targets with the IPCC GHG reporting structure, the sectors identified in the 2017 Updated Climate Change Adaptation Plan for Gauteng (GDARD, 2017b), key adaptation sectors, as well as the NAS (DEA, 2019). Accordingly, eleven response programmes are identified:

1. Natural Resources
2. Agriculture & Agro-Processing
3. Disaster Risk Reduction and Management
4. Water Security
5. Commercial and Institutional Buildings
6. Human Settlements
7. Energy Supply
8. Industry & Mining
9. Transport
10. Waste Management
11. Health

For each of the response programme a responsible department is identified and the role(s) of government, target and project types detailed. Importantly, the final decision on ‘how’ to achieve the recommended targets is the responsibility of the Provincial Department whose mandate specific targets and activities fall under. For example, the energy sector is the responsibility of the Energy Office in the Gauteng Department of Co-operative Governance and Traditional Affairs (COGTA). These government departments can be seen as ‘lead agents’ and though they can request the help of other department and organisations, ultimate responsibility will be with them. It should be noted that local government, national government and other actors have also been identified as lead agents for some projects, but this does not absolve the role of provincial government regarding the specific response programme.

Each project intervention is also assessed in terms of whether it addresses one or more of the four core strategy objectives, namely:

- a functional ecosystem (Eco),
- improved quality of life (QoL),
- reduced disaster risk (DRR) and
- a resilient low-carbon economy, and its contribution to mitigation targets (GHG).

Targets are set in a manner that allows for progress reporting on a regular basis, and a full review after a 5-year implementation period.

For each response programme priority projects for provincial government (all departments, not only GDARD) have been selected based on the following factors;

- Impact (mitigation or adaptation potential)
- Costs (cost effectiveness)
- Social, economic and environmental impact
- Strategic importance; specifically those projects that are currently not the focuses of other spheres (national, local) of government, the private sectors or NGOs.

These prioritised projects are marked in bold. They are summarised in chapter 7.

6.1 Response programme 1: Natural Resources

South Africa includes nine major biomes of which two, Savanna and Grasslands, extend through Gauteng Province. The Savanna Biome is the largest biome in Africa, and occurs mainly within the northern portion of Gauteng and on rocky ridges through the southern part. The Grassland Biome covers the rest of the province. A very limited portion of the Forest Biome, present along the Magaliesberg Mountains, falls within Gauteng. Grasslands is one of the most at-risk of South Africa's biomes with more than 40% already irreversibly modified and the remainder considered 'Threatened'. Only about 3% of the extent of grassland is formally protected (GDARD, 2017a).

A number of ecosystems that fall into the most threatened ecosystem threat status category occur in Gauteng – seven classified as Vulnerable, seven as endangered and ten as critically endangered (GDARD, 2017a). It is therefore important that a sufficient portion of these threatened ecosystems be formally conserved, but very little of the remaining extent of these ecosystems is currently protected in formal protected areas in Gauteng.

The main climate change related impacts in the biodiversity sector are related to shifting biophysical envelopes that will alter ecological processes and pose a threat to water resources. Significant species loss is not expected, given the similarity between the species present in the grasslands and savannah biomes, but local level distribution shifts and/or extinctions will be present where low adaptive capacity and absence of migratory options prevent species from adjusting to changes in microclimatic conditions and altered habitats. Especially those species already considered to be under threat are likely to disappear. A report by the CSIR (Davis, 2011) warns that: "*Due to the changing climate a disconnect may occur between the timing of behaviour and the available resources on which the behaviour depends. The individual impacts of these changes will likely scale up to have several ecosystem responses, including the range and distribution shifts of species and communities, the composition of and interactions within communities, and the structure and dynamics of ecosystems.*"

By implication, at a finer scale, animals and plants will require migratory pathways to allow them to 'escape' intolerable heat or drought conditions either temporarily, seasonally or permanently. This would require the presence of suitable habitat on a local scale – e.g. in the immediate vicinity but with different microclimatic conditions – and at a landscape level where migration pathways can link nodes of habitat together to create extensive migratory routes. These pathways should ideally consist of a climate-resilient network of protected areas.

The threat posed by invasive alien plants should also not be underestimated. Since most invasive plants in South Africa are subtropical, it follows that hotter conditions with higher atmospheric CO_2 levels may favour the spread of opportunistic invasives. In the Grassland Biome, invasion by tropical grasses (e.g. Fountain grass (*Pennisetum setaceum)*), invasive cacti (e.g. Queen of the night (*Cereus jamacaru*)) and invasive Prosopis spp. (Mesquite), and wattles is indicated as a threat (Price, n.d.). Bush encroachment in both grasslands and savanna by indigenous species is also intensifying (e.g. slangbos). The spreading of bush encroaching species demonstrates degradation of natural veld conditions (various forms of erosion).

Drafting of alien/bush encroachment control strategy currently underway (to interface with C-Plan).

Natural systems offer valuable opportunities for sustainable and resilient adaptation, in particular in respect of the provision of ecosystem services to urban dwellers and agricultural activities. As indicated in the Strategic Framework and Overarching Implementation Plan for Ecosystem-Based Adaptation (EbA) in South Africa (DEA and SANBI, 2016), *"…linkages between biodiversity and ecosystem services mean that actions taken to improve natural resilience to climate change are also likely to improve social resilience to climate change.*" Restoration of degraded wetlands and sustainable management of grasslands are identified as examples of EbA measures that can benefit society and the environment in a range of ways, and in a cost-effective manner. Implementation of EbA should follow the prescriptions laid down in the Guidelines for Ecosystem-Based Adaptation (Eba) in South Africa (DEA & SANBI, 2017).

The Gauteng Conservation Plan (C-Plan) is a spatial biodiversity plan which highlights Critical Biodiversity areas (CBAs) and Ecological Support Areas (ESAs) in the Gauteng Province. These areas of remaining biodiversity are those that are identified as required to ensure biodiversity and ecological processes are maintained into the future, but with the least spatial conflict with other land uses. C-Plan informs other forms and tiers of planning, including bioregional plans, SDFs, etc.

By increasing the health of biomes and ecosystems, not only the adaptation capacity increases, but additional carbon can be sequestered in both above ground biomass as in the soil. Following the Mitigation Potential Analysis, it is expected that:

- Mesic grassland restoration (by improving conservation and re-establishing the mesic grassland if it is expected that natural restoration is not possible) could improve carbon sequestration with as much as 13 $ktCO_2$/yr in the Gauteng province. To achieve this target, basically 18 000 hectares need to be restored, which is approximately 1% of the total area of the Gauteng province.
- Rural and urban tree and thicket planting could improve carbon sequestration with as much as 135 $ktCO_2$/yr. To achieve this, approximately 4 million thickets or trees should be planted. Though this sounds like a lot, this is only one tree/thicket for every three persons living in Gauteng. The planting of trees and thickets also improves adaptation capacity (e.g. more uptake of water during heavy rainfall events) and livelihoods, and potentially production of food or feed. It is also important to realize that though the yearly carbon sequestration per tree is relatively little, it takes place over a period of at least 15 to 20 years, thereby creating a long-term carbon benefit.

Although trees have many social, economic and adaptation benefits the planting of trees should be restricted to developed areas, as Gauteng has already lost a significant portion of its grassland biome to development. The greening of urban areas may have more adaptation benefits than mitigation, particularly in terms of minimising the heat island effect and storm water management (see Section 6.4) and should be based on water wise plants where possible.

The wildlife economy has been supported by the GDARD as economically viable and ecologically sustainable alternative to conventional agriculture, whilst also improving climate resilience.

PROGRAMME AMBITION	RESPONSIBILITY
Outcome 1-1: Carbon emissions sequestration of 149 kt CO_2e achieved through increased natural biomass and ecosystem restoration. **Outcome 1-2:** Stronger protection and expansion of urban and rural green spaces which provide critical ecosystem services through Ecosystem-based Adaptation (EbA) and Community-based Adaptation (CbA) practices, specifically to arrest the on-going loss of green spaces and untransformed rural areas **Outcome 1-3:** General public awareness of the importance of urban and rural ecosystems and their goods and services for livelihoods, service delivery, human well-being and disaster risk management	Lead: GDARD Support: Department of Agriculture (DoA), DWS, Municipalities, SANBI, DEFF, COGTA **GCR FOCUS** • Cross-border skills and learning exchange • Cross-border ecological and spatial planning **FINANCE AND FUNDING** Climate funds often target the natural resources sector, but the private sector can also get involved, such as in the form of 'blended finance'.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME (years from now)	TARGETS	ROLE PLAYERS	FINANCE
1. Ground truthing of urban conservation areas (still to be defined) for inclusion into refinement of municipal bioregional plans	**Eco QoL DRR**	N/A	<5	Surveys of all green/natural/conservation areas in urban areas by 2020.	Municipalities	
2. Review and implementation of biodiversity management plans and incorporation of results into development planning to achieve an increase in biomass, specifically through mesic grassland restoration and increased tree cover	**Eco QoL DRR GHG**	149	<5	Update C-Plan 3 by adding green urban areas and areas of high restoration potential in terms of environmental infrastructure, climate change response and biodiversity by 2021 Increase restoration of degraded areas and tree planting	GDARD, SANBI, DEFF	Global Environment Facility (GEF) (via DEFF)
3. Monitoring and compliance enforcement of biodiversity	**Eco QoL DRR**	N/A	On-going	On-going M&E, improved biodiversity GIS information for EIA stakeholders		

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME (years from now)	TARGETS	ROLE PLAYERS	FINANCE
management plan implementation, also within the ambit of the EIA regulatory scheme				and reporting on efforts and compliance status at least annually		
4. Support projects aimed at collaborative flood management, use of green infrastructure, erosion risk management and open space planning	**Eco QoL DRR**	N/A	<5	At least one Provincially supported project per year	Municipalities, DEFF, DRT	MIG Urban Settlements Development Grant
5. Increased efforts in invasive alien vegetation management and beneficiation of by-products where appropriate	**Eco QoL DRR**	N/A	<5	On-going projects must ensure annual nett increase in the area kept clear of alien invasive plants and include long term benefits for trained people (products such as charcoal or biochar, Land User Incentives of DEFF)	DEFF, GDARD	Working for Water, Working for Wetlands and Working for Land and Land User Incentives (DEFF)

6.2 Response programme 2: Agriculture and Agro-processing

The agricultural sector needs to adjust to changing climatic conditions and indirect effects of climate change in order to sustain both a commercial farming sector and subsistence (smallholder) household level food production. A full assessment of agriculture and agricultural activities in the GCR informs this adjustment. The full details of this assessment can be found in ANNEXURE B: Adaptation Strategy for Agriculture (as separate document).

Maize production makes up the majority of field crop production in the province, much of it relying on rainfall as its source of water. Other significant field crops include grains such as wheat and sorghum, oilseeds (soya and sunflower), groundnuts and cotton. Small amounts of orchard crops including peaches and pecans are also grown within the province. Access to major markets has also resulted in Gauteng being home to the country's largest floriculture industry and fresh produce market (the Johannesburg Fresh Produce Market). The Gauteng Agricultural Census of 2007 (StatsSA, 2007) indicate that carrots are the major fresh produce crop in the province, with over 1 200 ha being planted, followed by green beans, cabbages and potatoes.

Access to both national and international markets, as well as feed crops has resulted in a well-developed livestock production industry in Gauteng. The lack of extensive grazing land in the province means that livestock are generally concentrated in feedlots and batteries, making them heavily reliant on the production of fodder crops such as maize. As a result, the livestock industry is sensitive to adjustments in the cropping industry. Livestock production within the province is consequently dominated by cattle farming with some of the largest feedlots (Karan Beef and Beefcor) in the country. Other livestock farming includes pig, sheep and poultry farming (with the latter including both broilers and layers).

Agricultural households are vulnerable by default, due to the biophysical dependence of agricultural activities – the dependence on the rainy season, temperature, climate variability, extreme weather events and CO_2 concentrations in the atmosphere (DAFF, 2015). Vulnerability is, however, shaped by a range of factors – i.e. whether one is dealing with dryland (i.e. rainfed) or irrigation farming, supplementary or permanent irrigation, crop or livestock farming, summer or winter crops, commercial or subsistence farming, phenologically sensitive or less sensitive crops, highly productive areas vs. areas already climatically marginal, and the potential for irrigation. It is also relative to social and economic factors (DAFF, 2015).

Text Box: Agricultural production and social collapse

A study by Zhang et al. (2011) found a correlation between social collapse and climatic change in pre-industrial Europe. Specifically, any natural or social factor that causes large resource (supply) depletion, such as climate and environmental change, overpopulation, overconsumption, or non-equitable distribution of resources, may lead to a general crisis, according to a set of causal linkages. The scale of the crisis depends on the temporal and spatial extent of resource depletion. This is believed to also apply to implications for industrial and post-industrial societies.

There is evidence that food production and security are at risk from future projected water supply constraints, declines in water quality, and competition from other sectors (Table 14). The erstwhile Department of Agriculture, Forestry and Fisheries (DAFF) (2015) also suggested that small-scale and urban homestead dryland farmers are most vulnerable, while large-scale irrigated production is less vulnerable to climate change as long as sufficient water supply for irrigation is assured.

Text Box: Agricultural price increases and social unrest

As described by Lagi, Bertrand, & Bar-Yam (2011), '*social unrest may reflect a variety of factors such as poverty, unemployment, and social injustice'*. Though there are many contributing factors, the above study found that the timing of historic violent unrest in North Africa and the Middle East coincided with large peaks in global food prices. Apart from the correlation between peaks in global food prices and violent social unrest, it was found that the unrests were more violent the higher the increase in food prices. It has been widely recognized that climate change can have an impact on agricultural yields due to the changed weather conditions. Lower yields will lead to increased food prices which can be the tipping point leading to social unrest.

Gauteng has taken a stance to prioritise agriculture through the Agriculture Hubs programme specified under the Gauteng Agricultural Potential Atlas (GAPA III). There are seven such hubs in the province, where large amounts of high potential agricultural land are located and the area, rather than individual commercial units, can be managed as a holistic agricultural unit inclusive of services and associated activities up- and downstream of actual production units. This is roughly similar to the Agri-parks concept promoted by the DoA and the Department of Rural Development and Land Reform. Both these components are to culminate in the gradual development of Sedibeng and West Rand Districts as an 'Agrotropolis' (GDARD, 2016).

Table 14: Impacts of projected climate change on crop and livestock production (DAFF, 2015)

Agricultural sector	Specific impact in the GCR
Cultivated crops	
Decreased crop productivity as critical temperature thresholds are exceeded (e.g. 32°C for wheat) Increased crop productivity due to CO_2 fertilisation Absence or presence of frost creates uncertainty in crop selection and planting schedules Absence of frost creates a problematic weed and pest control factor Reduction in water availability during planting and flowering leads to reduced yield due to plant stress Increased wet spells lead to waterlogging of fields or soil erosion, and increased runoff rather than groundwater recharge	Maize productivity loss due to temperature stress is offset by CO_2 fertilisation Potential improvement in sorghum yield Irrigation demand increases by ~10% in the intermediate future
Livestock	
Desertification increasing the area of marginal rangelands, and leading to further deterioration of currently marginal lands	Bush encroachment and invasive species leading to rangeland degradation

Agricultural sector	Specific impact in the GCR
Bush encroachment, denudation, spread of unpalatable plants and other factors leading to degradation of rangelands Increased prevalence of animal diseases as climate variability affect the distributions, competences and abundances of vectors and ectoparasites Reduction in livestock productivity by increasingly exceeding the temperature thresholds above the thermal comfort zone of livestock, which could lead to behavioural and metabolic changes (including altering growth rate, reproduction and ultimately mortality) Increases in temperature during the winter months could reduce the cold stress experienced by livestock, and warmer weather could reduce the energy requirements of feeding and the housing of animals in heated facilities Increased frequency of disturbances, such as wild fires Changes in biodiversity and vegetation structure leading to changes in herbage yield of rangelands, and potentially secondary land degradation Flow reductions in watercourses or failure of wells reducing the scope for small-scale subsistence farming	Increased productivity in certain pasture grasses Increased carbon sequestration Heat stress leading to lower productivity in broilers, piggeries even when offset by higher ventilation costs Heat tolerance levels for feedlot cattle exceeded towards the end of the century No marked effect on dairy cattle Concentration of pests and pathogens
Socio-economic/ livelihood impacts	
Overall changes in food production and security Changes in incomes derived from crop and livestock production due to rising input costs (e.g. cost of transport)	
Shifts in land use (including consequences of land reform) Exposure to shifting disease distributions Sensitivity to price fluctuations as costs of production rise due to carbon-intensive energy use and water scarcity	

Within the agricultural sector there are several interventions which both support adaptation as well as carbon sequestration. Examples of such projects are livestock waste utilization for biogas production, establishing biomass on degraded (mining) land, biochar addition to agricultural land and reduced tillage. It must be noted though that the Biofuels Regulatory Framework is yet to be approved by the Department of Energy.

The interventions 'livestock waste utilization',' establishing biomass on degraded land' and 'biochar addition' are quantified in mitigation potential as per the MPA:

- To achieve a yearly sequestration rate of 169 $ktCO_2$, approximately 2 500 hectares of degraded, low value land should be planted with thickets or trees which don't need watering or intensive care to survive. This intervention will keep on sequestering over a period of 15 to 20 years and provide additional benefits for the environment and adaptation capacity.
- Per tonne of biochar added to the soil, about 2 tonnes of CO_2 are sequestered (Filibert & Gaunt, 2013) in addition to many other benefits such as improved soil fertility. It is however very important that the biochar is sustainably produced and not made

from protected forest or processed in open fire pyrolysis. To achieve a biochar related sequestration potential of 43 ktCO_2/yr, around 20 kt of biochar must be obtained from agricultural land.

- By using livestock waste in biogas digesters, an average of 1 050 kgCO_2/yr per cow can be mitigated (Marañón, Salter, Castrillón, Heaven, & Fernández-Nava, 2011). This is highly variable and influenced for example by the type of cow (meat or dairy), living conditions and the baseline waste treatment conditions. However assuming an average of 1 tCO_2/yr per cow, this would mean that 11 000 cows are needed to achieve the target of 11 ktCO_2/yr mitigation. The is currently around 250 000 cattle in Gauteng.

Another intervention that should be investigated for potential adaptation and mitigation value is land-based aquaculture. A study on the Feasibility of Implementation of Aquaculture in Gauteng indicated that although there is potential for growth in the sector, its cost-competitiveness, the absence of large-scale processing facilities and the receptiveness of the local market present significant barriers to commercial success of fish farming (GDARD, 2015). In 2018 there were 50 tilapia breeders and farmers that have permits from the GDARD. However, if successful models for small to medium scale projects can be devised, then aquaculture could contribute significantly to household level food security and job creation.

It was suggested that the following projects are prioritised:

- Commercial and sustainable small to medium scale aquaculture business in townships, focussing on recirculating systems.
- Improvement of the efficiencies of existing small scale aquaponics systems and adaptation of those for household and community food gardens.

The path towards a resilient GCR partly involves the implementation of conservation agriculture practices, which will ensure the sustainability and environmental responsibility of agriculture. Small-scale and emerging farmers are the initial target of the climate change strategy, as they are the most in need of support (in the form of information, and capacitation) in order to cope with the impacts of climate change, and since the transference of agricultural knowledge is required for the continuance of the agricultural sector in general given that small-scale and emerging farmers are likely to become the large-scale farmers of the future. Conservation agriculture would increase the yields of smallholder farmers while also improving soil fertility and reducing soil erosion; all of which would make these farmers more resilient to the effects of climate change. Due to low land availability and heavy urbanisation of the province, similar support need to be provided for urban agriculture (e.g. allotment, roof and vertical gardens). The support and empowerment of urban farmers would enhance the sustainability of the sector. Innovative agricultural sectors such as land-based aquaculture, aquaponics, alternative sources of animal-based protein (e.g. maggot farms) or forays into using natural genomic wealth for pharmaceuticals can be investigated for contribution to the overall outcome, and as means of adaptation by household and community food gardens. At the same time, the localised processing of agricultural products needs to be supported as a growing industrial sub-sector. The GDARD Agriculture Chief Directorate is the primary lead in this respect, giving support to farmers through its extension officer programme. Extension officers should be trained on improved carbon sequestration practices as well as climate change adaptation.

PROGRAMME AMBITION	RESPONSIBILITY
Outcome 2-1: Carbon footprint reduction of 223 ktCO_2e achieved through land stewardship and waste beneficiation **Outcome 2-2:** Strengthening of early warning systems for farmers, with co-benefits for disaster risk management and biodiversity and ecosystem services **Outcome 2-3:** Social and economic support systems to buffer vulnerable people against rising food prices, and agricultural activities against the rising cost of agricultural inputs (e.g. rising water and energy prices) **Outcome 2-4:** The preservation of high potential agricultural land for food production, along with the surrounding natural areas that provide critical support services such as pollination and soil conservation **Outcome 2-5:** Climate proofing of agro-processing through investment in appropriate product selection and facilities that can withstand weather extremes	Lead: GDARD Support: ARC, DoA, DWS, Municipalities, SANBI, DEFF, PDMC
	GCR FOCUS • Cross-border skills and learning exchange • Cross-border social and economic support to reduce the number of people exiting the agricultural sector • Cross-border ecological and spatial planning
	FINANCE AND FUNDING Agricultural adaptation to a changing climate includes many strategies that should result in higher profitability in the long run. These might, however, need additional funding and/ or financing. Debt funding is used extensively in the agricultural sector. Funders use it to manage investment risk, but, depending on the structuring, it could be cumbersome for actors in the agricultural value chain. Some government funding agencies are mandated to issue concessional debt to achieve government objectives like sectoral transformation, employment creation and ensuring food security. The term of most of these debt instrument range from medium to long-term. Equity funding is also available.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME (years from now)	TARGETS	ROLE PLAYERS	FINANCE
1. Groundtruth the productive potential of urban & rural agricultural areas	**QoL**	Unknown	<5	Surveys of all agricultural areas by 2020.	DEFF, DoA, GDARD, ARC	Green Fund UFF Agri Fund
2. Formal or institutional protection for identified agricultural areas, including protection of water resources and supportive biodiversity areas	**Eco QoL DRR**	N/A	<10	Resolution of spatial conflicts, identification of agricultural priority areas and formal planning protection of those areas by 2027.	DEFF, DoA, GDARD, ARC	

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME (years from now)	TARGETS	ROLE PLAYERS	FINANCE
3. Farmer support – community level farmer training programme (conservation agriculture and ecosystem protection) and capacitation of extension officers for institutional support to improved land care	**Eco QoL DRR GHG**	213	<5	Climate change and conservation agriculture -related training of all extension offices by 2022 for implementing projects such as: - Improved soil management for increased soil CO_2 storage, erosion control - Appropriate density (or carrying capacity) of feedlots and farms - Establishing plantations for example on degraded mining land Demonstration projects for sustainable agricultural practices (improved soil management, erosion control, conservation agriculture, crop selection etc.)	GDARD, DEFF, DoA, ARC, Social Development	NEF (Rural and Community Development Fund) Phatisa (Technical Assistance Facility)
4. Plan for bolstering or refining of agricultural household social security systems through diversification within and outside the sector	**QoL DRR**	N/A	<5	Sector plan for climate change response in the agriculture sector in Gauteng by 2020	DEFF, DoA, GDARD, ARC, Social Development	Industrial development Corporation (IDC) AgriBEE Fund – DoA
5. Support structural adjustments to agricultural systems – from product selection to processing facilities e.g. shift to heat tolerant	**Eco QoL DRR**	N/A	<5	Support at least 2 projects for improved climate resilience of the agricultural sector in GCR	GDARD, DEFF, DoA, ARC,	Exeo Capital (Agri-Vie Fund II) National banks

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME (years from now)	TARGETS	ROLE PLAYERS	FINANCE
crops and livestock breeds, including indigenous variants and species (e.g. antelopes replacing sheep and cattle) and aquaculture					Economic Development	IDC Masisizane Fund – Old Mutual Phatisa (Technical Assistance Facility)
6. Food security programme to increase food production at household level	**QoL**	N/A	<5	As per GDARD Annual Performance Plan	GDARD	
7. Support projects aimed at agricultural waste beneficiation, especially for the production of biogas	**Eco GHG**	11	<5	Two additional projects by 2022 – focussing on determinants of success such as viable size and barriers to implementation.	SANEDI, GDARD, DoA, ARC, Municipalities	Environmental and Energy Partnership (EEP)

6.3 Response programme 3: Disaster Risk Reduction and Management

Target 13.1 of the SDG 13 aims to "*Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries*". Therefore, national and local DRR strategies that comply with the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework)[6] are called for. Proactive DRR plans, as part of overall Disaster Risk Management (DRM) strategies will address climate change impact and enhance the resilience of nations.

The National Disaster Management Centre (NDMC) maintains a national risk profile, based on indices of disaster hazards, vulnerabilities and response capacities. Although not strictly climate change related, this profiling informs DRM planning and should be updated as projections of various hazards and information on vulnerabilities improve. Current outputs suggest that the GCR compared to other provinces, has low exposure to hazards, and that the response capacity is high. However, the sensitivity of the area is high due to size and density of population and economic activities (NDMC, 2017).

The Gauteng Provincial Disaster Management Level 1 Plan (GDCOGTA, 2017), lists several natural phenomena amongst the highest priority risks – flooding or severe storms, weather-related incidents (winds & lightning), landslides and fires. Veldfires are considered to have high probability and moderate severity, whereas flooding has high probability and catastrophic severity. Focus must consequently be placed on flooding for strategic planning purposes.

However, since Gauteng has very expensive infrastructure and because of increased risks of mega-fires, the risks of fires and response plans should be reviewed. Climate change is indicated as a future risk driver. Given that droughts, heat waves, fires and flash floods are likely become more severe and frequent, the following can be considered as factors that increase the GCR's disaster-related vulnerability:

- Low-lying structures
- Extended supply lines
- Insufficient flood or drought management / handling capacity
- Insufficient resourcing of DRM and DRR systems
- Dysfunctional or non-performing health systems

Many factors influence people's vulnerability with respect to disaster risks. These include access to requisite information, response capacity, social support or financial ability, as well as effective governance systems. These factors are socio-economic factors which determine vulnerability of households and described in more details in Section 6.6.1.

Natural biophysical factors contribute to vulnerability by increasing or decreasing the exposure of people to climatic impacts. This is especially relevant for people living in marginal areas, such as areas

[6] http://www.unisdr.org/we/coordinate/sendai-framework

prone to drought, fire or floods, where small changes to the climate can materially influence the viability of livelihoods or the extent of impact. For example, in water stressed areas, intensification of drought can prevent people for planting crops for long enough that their physical and material needs exceed their income and they are forced to change their sources of income or migrate to different areas.

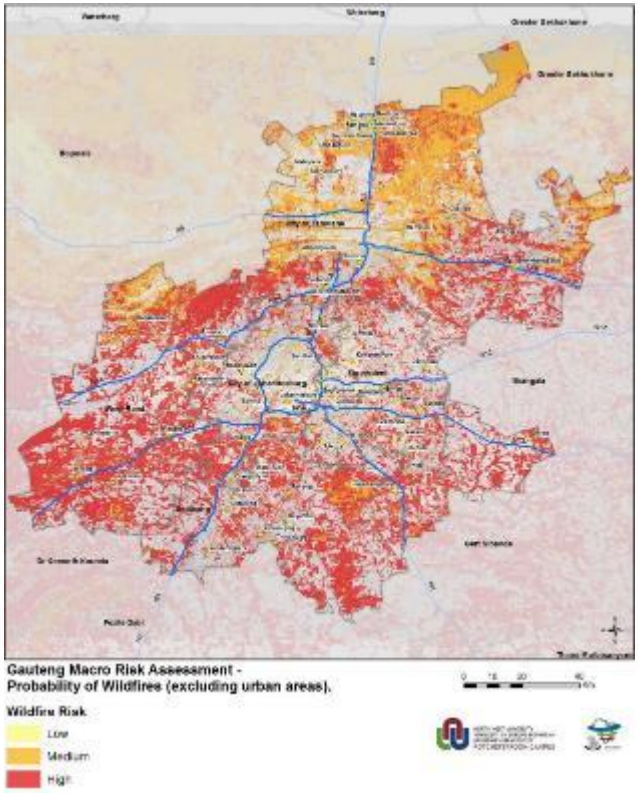
Other physical location factors that determine the vulnerability that people face include unstable slopes, dolomitic areas and shallow undermined areas, as well as flood-prone areas and areas where uncontrolled wildfires are possible. These physical conditions will change along with altered temperature and runoff regimes, especially when groundwater levels and acidity changes or surface runoff reduces.

Areas where geological instability is present are concentrated along the east-west mining belt running along the Witwatersrand reef complex. This band of historic and current mining activities is sensitive to acid mine drainage and changes to the water table that can contribute to unhealthy living conditions. People's exposure to the toxicity and radioactivity found in mine tailings will also be affected as increased temperatures lead to further desiccation of soils and increased convection produces wind that can mobilise the dust. There are also areas of dolomitic rock in the areas between Carletonville and Centurion, and in these areas variation of the water table will increase or decrease foundational stability.

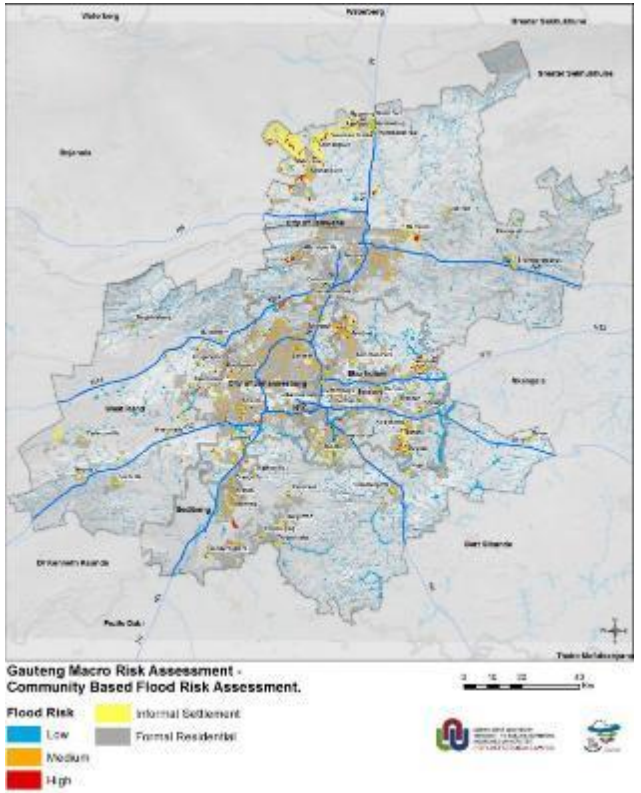
Risks for key infrastructure, such as bridges and roads, dams, airports and other strategic structures need to be considered, especially in terms of flooding. Failure of infrastructure is a major concern in urban areas, as people are typically highly reliant on functioning transport systems and the supply of municipal services such as potable water, electricity and waste removal. Severe disruptions in these systems can lead to significant economic losses as productivity becomes impaired, but the impacts on the poor will be multiplied as their adaptive capacities become further impaired.

In terms of the spatial distribution of major natural hazards, it is indicated that (GDCOGTA, 2017):

- **Veld fire** risks in all rural areas, but especially West Rand and Sedibeng Districts, as well as the southern part of Ekurhuleni and eastern part of Tshwane
- **Flooding** is also a widespread risk, but the most extensive risk areas are densely settled informal township areas



Veld Fire Risk



Flood Risk

Figure 11: Veld Fire and Flooding risk (GDCOGTA, 2017)

Adaptation responses are inherently about reducing and managing risk in a range of sectors or fields. However, specific responses are required in the disaster risk management sector in order to supplement adaptation measures taken within the broader economy and social sphere. It is unlikely that all sectors of society will be sufficiently resilient in the face of progressive changes to the general climate, and inevitably extreme events will require direct intervention. The indirect effect of disaster response can also be considered as a factor contributing to vulnerability, as the cost of disaster preparedness and response would divert funding away from other important economic and governance activities.

Disaster preparation and recovery, to a great extent, relies on warning, relief and rehabilitation support from government, and rapid communication and coordination between different spheres of government. In accordance with the Disaster Management Act, 2002 (Act No. 57 of 2002) the overall mandate or disaster risk management in South Africa resides with the NDMC, whose objective is to coordinate and promote integrated disaster management at all levels of government. Similar structures are set up at provincial and municipal level. Rising concerns about the political, administrative and financial support for the subnational entities has, however, led to the promulgation of the Disaster Management Amendment Act, 2015 (Act No. 16 of 2015) which provides for improved coordination and support to disaster management centres. Disaster risk management systems are required to offer timeous warning of impending risky situations and to provide resources with which disaster recovery can be kick-started. This also includes services and facilities that provide a social safety net such as health care facilities.

There also needs to be reflection on past disasters, in order to learn from disaster experiences and improve on future preparations and responses. Understanding what contributed to creating a disaster and how disaster responses matched real needs, and calculating the costs of disasters, will assist in motivating for on-going improvement in disaster management. Making these post-disaster analyses publicly available will assist in creating awareness of risks, hazards, vulnerabilities and successful response strategies.

<table>
<tr><td>PROGRAMME AMBITION

Outcome 3-1: Emphasis to shift towards disaster risk reduction (including ecosystem-based approaches like alien clearing and wetland protection/ rehabilitation with job creation co-benefits) with appropriate capacity</td><td>RESPONSIBILITY

Lead: PDMC

Support: NDMC, Municipalities, GDARD, Social Development, Health

GCR FOCUS

• Regional forecasts and integrated disaster response</td></tr>
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building (skills and resources) in disaster risk management units and systematic general disaster risk awareness raising **Outcome 3-2:** Strengthening of early warning systems **Outcome 3-3:** Gauteng Sector Departments who are primarily affected by major incidents or disasters have established disaster management units within their functional area to support the nodal point and ensure that the roles and responsibilities of the Sector are executed (as per Gauteng Disaster Management Framework).	**FINANCE AND FUNDING** Disaster management is primarily funded directly by the three spheres of government, with discretionary national and provincial disbursements being released in response to disastrous events. The overlap between DRM and climate change planning means, however, that projects can potentially access available funding streams in in either sphere.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME (years from now)	TARGETS	ROLE PLAYERS	FINANCE
1. Provincial and municipal DRM and DRR strategies must be current, and reflect climate change considerations and participatory community-based approaches	DRR	N/A	<5	Current and climate change responsive DRM and DRR plans in place in each municipality and for the province by 2022	PDMC, Municipalities, GDARD	
2**. Review and enhance early warning systems for:** - **Agriculture** - **Flooding and fire** - **Heat waves**	QoL DRR	N/A	<5	Provincial EWS is functional, covers multitude of forecast timelines and includes suggested Early Actions and their triggers by 2022	PDMC, NDMC, South African Weather Services, Municipalities	
3. Develop Disaster Management Plans (DMP) for each relevant provincial functional area and implement them	DRR	N/A	<5	GDARD updates Agriculture DMP and develops Biodiversity DMP with focus on Climate Change impacts and also supports other departments in including Climate Change in their DMPs.	GDARD, PDMC, provincial departments	

6.4 Response programme 4: Water Security

Water is an important input into most economic sectors and its availability is therefore paramount to the growth and sustainability of economic activity and productivity. Not only is it a key basic input into most production processes, but it is also key to commercial scale conventional power generation.

Agriculture, in particular, is sensitive to water shortages, given that it is responsible for around 65% of the surface water in South Africa (DAFF, 2015). It is shown that in Gauteng most agricultural households currently rely on municipal water schemes (Figure 12). These are generally small producers that do not produce on a commercial scale. Boreholes, springs, dams and rivers/streams tend to be commonly used water access points for commercial scale producers in the province. Any future pressures on water availability, whether in affordability or physical availability, will therefore have direct bearing on the agricultural production capacity in Gauteng and the ability of small-scale producers to remain agriculturally active.

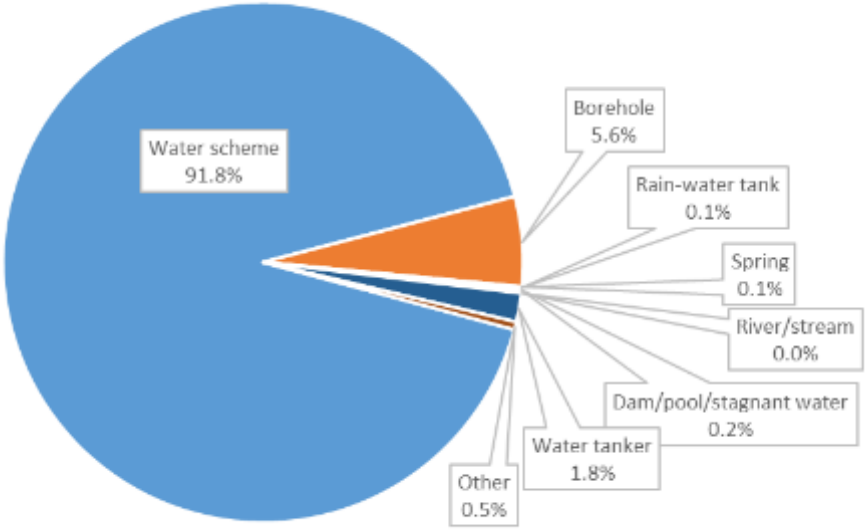

Figure 12: Type of water access for agricultural households in Gauteng (StatsSA, 2016a)

Despite concerns over the future variability of rainfall over the Highveld, overall water security in terms of water availability for consumption and use is likely to remain largely unaffected due to the high level of development and integration of the South African water supply infrastructure and supply system (DEA, 2015a). This interconnectedness means that Gauteng can access the higher annual catchment runoff projected for the Eastern escarpment area via the Lesotho Highlands Water Project.

Nevertheless, the sustainability of water resources and water use in the GCR is a concern given the anticipated urban growth and the potential for changes to groundwater recharge as ecosystem changes gain traction. Adaptation responses should therefore address both supply and demand, with an overall objective of reducing the amount of water that needs to be sourced from outside the province and region. As part of this, the inherent weaknesses of extensive supply and distribution networks have to be addressed, in order to protect against system leakages (see details in Section 2.4) and interruptions of water supplies.

The water quality is as important as water supply and quality of waste water effluent should be improved. Pricing of effluent management must ensure the price reflects costs to municipalities.

PROGRAMME AMBITION	**RESPONSIBILITY**
Outcome 4-1: In collaboration with Department of Water and Sanitation (DWS) and non-governmental stakeholders, strengthen integrated water resources management **Outcome 4-2:** Increase public awareness of water use efficiency and demand management, and the utilisation of multiple water sources (especially rainwater harvesting and use of grey water) **Outcome 4-3:** Reduced water losses, improved water conservation and re-use **Outcome 4-4:** Improved groundwater recharge and DRR through use of green infrastructure (i.e. protection of watercourses, wetlands and aquatic habitat) **Outcome 4-5:** Improved surface and groundwater quality	Lead: Economic Development Support: GDARD, DWS, DEFF, DoA, municipalities **GCR FOCUS** • Collaborative water resources planning • Cross-border sharing of skills and knowledge • AMD management, treatment and re-use coordination (more details in section 6.8) **FINANCE AND FUNDING** Government supported funding is paramount where regional supplies and infrastructure is involved, but smaller scale projects can access a range of climate funds.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
1. Water supply infrastructure network maintenance and rehabilitation and reduction of leaks	**Eco** **QoL**	N/A	<5	By 2022, less than 25% of water lost from the supply system	DWS, Municipalities	MIG Municipal Disaster Grant and Regional

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
						Bulk Infra-structure Grant
2. Research, pilot and implement Sustainable Urban Drainage Systems (SUDS) and Ecologically based Adaptation (EbA) approaches to stormwater management	**Eco QoL DRR**	N/A	<5	Develop provincial manual for SUDS implementation by 2020. All municipalities to include green infrastructure elements in their stormwater management plans by 2022	GDARD Municipalities, DWS, DHS,	Water Research Commission (WRC) MIG Urban Settlements Development Grant
3. Safeguard and rehabilitate wetlands and watercourses, especially in urban and agricultural areas, through municipal planning and building approvals and the EIA regulatory scheme with the aim to improve ground- and surface water management	**Eco QoL DRR**	N/A	<5	Provincial research on constructed wetlands by 2020. Appropriate zoning or formal protection for all urban wetland areas and watercourses by 2022	DWS, Municipalities, DoA, DEFF	GEF (via DEFF)
4. Pilot project aimed at improving the coverage of effluent collection and treatment systems, with specific reference to informal settlements	**Eco QoL**	N/A	<5	Three pilot projects that demonstrate innovation in effluent management in informal settlements by 2022	WRC	WRC
5. Water supply infrastructure network maintenance and rehabilitation and reduction of leaks	**Eco, QoL**	N/A	<5	Programme in place for improvement of water supply systems and leaks reductions, including reduction of losses from water storage by 2023	DWS, Municipalities, GDARD	

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
6 Wastewater treatment system maintenance and rehabilitation to ensure standards are met	**Eco QoL**	N/A	<5	Green Drop certification with low risk profiles for all service authorities by 2022	Municipalities, DWS	MIG Urban Settlements Development Grant
7. Litter management in storm water systems and watercourses	**Eco QoL**	N/A	<5	Stormwater and watercourse litter management included as performance standard in municipal development and budgetary plans, with associated monitoring and reporting based in GDARD standards on an annual basis by 2022	Municipalities and EPWP, monitoring by GDARD: Waste management and Environmental Empowerment	
8. Long-term demand and supply forecasting	**Eco QoL DRR**	N/A	<5	An updated water balance calculation and associated long-term water supply plan by 2022	DWS, Catchment Agencies	WRC
9. Re-use of secondary water sources (recovery of runoff, AMD water, grey water and industrial recycling)	**Eco QoL DRR**	N/A	<5	By 2022, have a regulatory requirement in place in at least one Metro that makes rainwater capture and greywater re-use mandatory in all new buildings By 2022, have draft financial incentives and regulations for the recycling of grey and black water.	DWS, Municipalities	MIG Urban Settlements Development Grant

6.5 Response programme 5: Commercial and Institutional Buildings

Investment in sustainability within the commercial and institutional buildings response programme will have universal benefits. Not only can it create better work environments, but it will reduce operational expenditure and improve resource use efficiencies and hence benefit the economy as a whole. Improvements in the functioning of government buildings will furthermore facilitate better service delivery. Whilst it can be pointed out that the Finance & Business, and Community Services collectively represent more than half the GDP of the Province (GPG, 2016), it is calculated that the operation of non-residential buildings in South Africa account for 10% of the total national emissions (CSIR, 2011). By implication, this is a response programme that will have impacts on both mitigation and adaptation targets.

The embodiment of sustainability in commercial and industrial buildings in so-called 'green buildings'. These are buildings that are designed with environmental responsibility, resource efficiency and occupant well-being in mind. Regulatory schemes that address energy and water efficiency provide some direction and minimum compliance benchmarks. For example, environmental responsibility, including energy efficiency, are regulated by the application of the National Building Regulations applicable to energy efficiency, i.e. SANS 10400 Part X Environmental sustainability and more specifically SANS 10400 Part XA Energy usage in buildings. However, building developers and users could increase the energy efficiency performance criteria of their buildings or facilities to a higher standard through planning and design based on holistic life cycle assessment and costing.

Many green building certification schemes exist across the globe, and in South Africa the Green Building Council of South Africa (GBCSA)[7] has developed Green Star SA rating tools, to provide the property industry with an objective measurement for green buildings and to recognize and reward environmental leadership in the property industry. Each Green Star SA rating tool reflects a different market sector (e.g. office, retail, multi-unit residential, etc.). Since 2009, the GBCSA has certified approximately 350 buildings as being 'Green Star' rated, implying compliance with amongst other things energy efficient design specifications.

Since 2013, the GPG has committed itself to promoting the use of sustainable buildings. The Gauteng Department of Infrastructure Development (GDID), which oversees maintenance of facilities, plant, equipment and other assets used in the course of service delivery by the Province, has committed itself to the implementation of the Gauteng Green Building Policy (GDID, 2013). In terms of this policy, Gauteng is committed to ensuring that all GPG buildings, new and existing, are designed or retrofitted to be energy, water and waste efficient. This includes the specification that all new buildings of CIDB tender grade 7 and above, and all leased buildings of 1 000m^2 or more, be certified with at least a 4 Star Green Star SA rating. The 5 years Strategic Plan of the GDID set the objective "*To ensure that 50% of existing and new buildings have been built or*

[7] www.gbcsa.org.za

upgraded using green technology by 2018/19 resulting in reduction of carbon footprint" (GDID, 2014).

The policy mirrors efforts at national level to refine the Department of Public Works's Green Building Policy.

Bringing about change in the commercial and institutional building sector, especially with respect to public facilities, is primarily a matter of re-aligning existing procurement processes with more sustainable standards. Once policy direction is committed to, revised procurement specifications can instantly require the sourcing of green star rated buildings, energy efficient fittings or even renewable energy generation.

The GPG can stimulate the transition to more sustainable buildings in the following ways:

- By retrofitting existing buildings and demanding all new buildings that are government owned or used (leased) have a 4 Star Green Star SA rating (the GDID is already committed to this);
- Developing policy (setting a more ambitious minimum compliance benchmark) for commercial buildings within the province,
- By including energy efficiency as one of the award criteria when procuring different (than buildings) products or services. Energy efficiency of a product or service as an award criterion in procurement could stimulate companies to improve the energy efficiency of their (industrial) buildings.
- Engaging with municipalities to set and impose more ambitious energy and water efficiency by-laws.
- Provide more information and know-how to companies and open one of its successfully retrofitted buildings to the public to learn from.

The Mitigation Potential Analysis identified the following interventions as most cost effective for the commercial and institutional buildings response programme:

- Heat Pumps;
- Improved thermal building design;
- Improved HVAC systems (heat recovery, Variable Speed Drives (VSD) and centralized systems);

A **heat pump** can save 67% of the energy used by a conventional electrical resistance water heater (Zhang M. , 2013). As water heating makes up between 30 and 50% of total residential energy demand, this will reduce total energy consumption on average with 50% (Zhang M. , 2013).

Improved thermal building design has an energy saving potential of 23 kWh/m^2/yr (based on spatial heating demand for passive building of 5 kWh/m^2/yr compared to 28 kWh/m^2/yr for reference service building in southern Europe) and energy saving benchmark in the MPA (Appendix D), (DEA, 2014c).

An **HVAC system** with heat recovery saves approximately 30% energy compared to an HVAC system without heat recovery (MPA Appendix D) (DEA, 2014c).

Possible implication for reaching the indicated target: The mitigation impact of each intervention is difficult to determine in

isolation. However, reference was found that in commercial buildings, specific energy consumption of modern office and retail buildings are typically 200 – 500 kWh / m^2 / yr including all end-uses, whereas advanced buildings have frequently achieved less than 100 kWh / m^2 / yr in climates ranging from cold to hot and humid (IPCC, 2014). For example: assuming a new commercial building to be on average 10 000 m^2, and achieve a yearly energy saving of 250 kWh/m^2/yr, it would result in a yearly emission saving of 2.5 tCO_2/yr. By implication, 1 000 buildings are required to achieve the target of 2 510 $ktCO_2$/yr. Any lower efficiency gain would necessarily require even more new buildings.

PROGRAMME AMBITION	**RESPONSIBILITY**
Outcome 5-1: Emissions reductions of 2 510 kt CO_2e through energy efficient building design **Outcome 5-2:** Water demand management **Outcome 5-3:** Reduced energy requirement for the built environment	Lead: Economic Development Support: Infrastructure Development, Human Settlements, GDARD, Department of Energy, DWS, municipalities
	GCR FOCUS • Cross-border sharing of skills and knowledge
	FINANCE AND FUNDING Interventions in the built environment typically involves improved energy performance and a switch to renewable energy, and hence tends towards financing, often from the private sector. There is also an increase in international equity investment in this sector. Responses aimed at improving the well-being of the poor, however, would more easily access direct funding.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
Improved energy and water efficiency in new building design, including; • Heat pumps for water heating • Passive building/improved thermal design • HVAC including heat recovery • HVAC central air conditioners	**Eco** **QoL** **GHG**	2024	<5	Imposing water and energy efficiency specifications in municipal by-laws by 2022 Demonstration programme to retrofit suitable government	Municipalities, GDARD, private sector	Eco-loans, green bonds and other green finance mechanisms from private banks Private equity

• HVAC variable speed drives				buildings with heat pumps in place by 2022		
Energy efficient lighting of streets and public areas	**Eco QoL**	Unknown	<5	All new installations and any retrofits to be energy efficient by 2022, and powered by renewable energy where possible	Municipalities, GDARD, Roads & Transport	Private Energy Service Company
Implement Gauteng Green Building Policy and revise the target of "50% of existing and new buildings built or upgraded using green technology" to 100% for existing buildings and 100% for new buildings.	**Eco QoL GHG**	486	<5	All GPG new buildings are designed to be energy, water and waste efficient and large ones (multi-storey) are certified by GBCSA. All of old buildings are retrofitted to be energy, water and waste efficient	Gauteng Department of Infrastructure Development	Private Energy Service Company Private equity

6.6 Response programme 6: Human Settlements

Several aspects of human settlements need specific attention when developing an action plan; services and infrastructure, as well as climate change mitigation and adaptation measures which also address poverty (inequality) aspects.

6.6.1 Mapping vulnerability of households

An assessment of vulnerability typically includes measurement of both exposure to risk factors and sensitivity to the factors, together comprising the potential impact of such risks, as well as an assessment of the capacity to manage and respond to those risks (Figure 13). Definitions of these terms can be found in the Glossary.

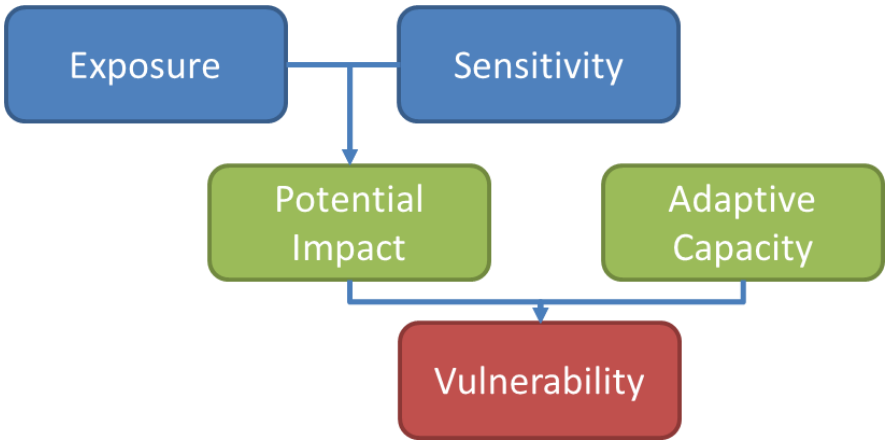

Figure 13: The principal determinants of vulnerability

Some specific aspects of vulnerability are further described and presented spatially, particularly in Section 6.3 in terms of vulnerability to disaster risk.

It is important to note that the mere occurrence of a hazard, such as a drought or flood, does not automatically lead to a disaster. It is only when the hazard affects a system or community that is vulnerable to that hazard. Vulnerability is affected by a range of social, economic and environmental factors that interact with natural risks.

Although the urban poor and particularly those living in informal settlements are likely to be the worst affected by disasters, vulnerability to disasters is affected by more than just low income. Factors such as access to basic services, transport, communication, social capital and education are also important in influencing vulnerability. There is a growing emphasis on the role of minor every-day risks that accumulate over time to increase vulnerability to hazards such as floods and drought.

The map in Figure 14 was developed collaboratively between GCRO and GDARD to map household vulnerability to disasters in Gauteng, using data from the GCRO's fourth Quality of Life (QoL) survey conducted in 2015/16. The QoL IV (2015/16) survey was used to construct a Vulnerability Index that takes into account 35 variables representing everyday factors that shape individual and household vulnerability including poverty, health, dependency, access to housing and services, communication, mobility, and coping capacity (Table 15).

Table 15: QoL IV (2015/16) variables used to construct the Vulnerability Index

Dimensions	Indicators
Poverty & other risks	1. Monthly household income less than R1600/month 2. Unemployed 3. Has not obtained Grade 9 equivalent 4. An adult in the household often or always goes hungry because not enough food is available 5. Agree that environmental factors have harmed respondent or their family
Health	6. Respondent has a disability 7. Health has been poor or very poor in past four weeks 8. Health status always affects work 9. Health status always affects usual social activities
Age	10. There are children in the household 11. Respondent is 60years or older
Housing	12. Live in informal dwelling 13. Live in one room & share with one or more households
Services	14. No access to a flush toilet 15. Water not piped into dwelling 16. Water is hardly ever or never clean 17. Does not have secure access to electricity 18. Refuse not removed from house 19. Dissatisfied with stormwater infrastructure or the area has none
Communication & access	20. Does not have access to the internet 21. Household does not have a working cell phone 22. Household does not have a working radio 23. Household does not have a working television 24. Household does not have a working car 25. Household does not have a working bicycle 26. Not in easy walking distance to transport
Coping capacity	27. Dissatisfied with emergency services where respondent lives 28. Respondent does not trust people in their community 29. Dissatisfied with time spent with family 30. Dissatisfied with friends 31. Dissatisfied with or not in a relationship 32. Respondent feels no one cares about people like them 33. Could not borrow any money in a health emergency 34. Respondent finds it difficult or impossible to save money 35. Not covered by any medical insurance

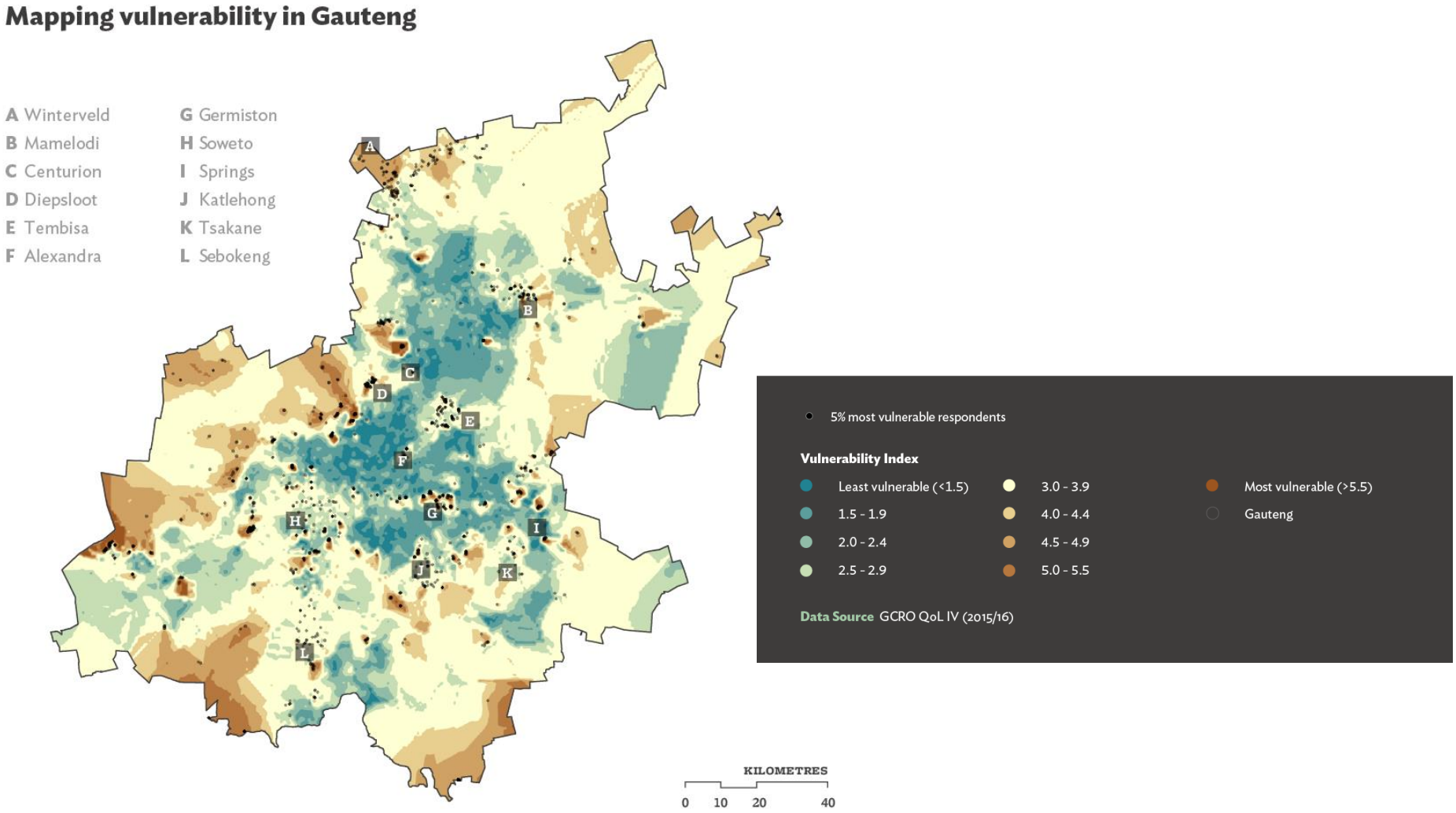

Figure 14: Mapping vulnerability to disaster in Gauteng (Maree, et al., 2018)

The map shows relatively high concentrations of vulnerability in areas such as Soweto, Diepsloot, Mamelodi, Sebokeng, Tembisa, Tsakane, Germiston and Winterveld. By contrast, areas such as Centurion and Sandton are home to the least vulnerable respondents (Maree, et al., 2018).

Further comment on the map is provided by the authors:

It needs to be noted that in some more densely populated areas of Gauteng there is a mix of many highly vulnerable people living side-by-side with less vulnerable neighbours. For example, areas such as Tembisa and Diepsloot have large numbers of vulnerable people, but also many people who are less vulnerable. Because of this mix, the average Vulnerability Index scores for these areas do not reflect their high concentrations of very vulnerable people, and these areas do not always appear as a darker brown colour on the map. Other areas may have more consistently vulnerable people and a higher average score, and therefore appear as vulnerability hotspots on the map, even though they may not have such large clusters of vulnerable people in total as somewhere like Tembisa. Examples include Lindelani Village, Rietfontein, Stinkwater and the Winterveld. It is also worth noting that some areas might have relatively low average Vulnerability Index scores, but be highly exposed to disaster risk because they are prone to hazards like floods. Diepsloot is a good example. Exposure to risk is not factored into this mapping. These distinctions are important when government decides where to focus its efforts in responding to vulnerability challenges.

While mapping vulnerability at an aggregated level is useful for government planning, disasters are experienced at the individual scale. Hence, assessing averages and scores has the potential to dissociate vulnerability from the person who is vulnerable. Put differently, it can dehumanise the issue. The following comparison (Figure 15) provides a glimpse into the actual lives of two respondents from the QoL IV, one among the least vulnerable in the province (with a score of 0/10), the other among the most vulnerable (with a score of 7.4/10).

While mapping vulnerability at an aggregated level is useful for government planning, disasters are experienced at the individual scale, thus assessing averages and scores has the potential to dissociate vulnerability from the person who is vulnerable. The comparison in Figure 15 thus provides a glimpse into the lives of two respondents from the Quality of Life IV survey, to re-humanise those living at risk in Gauteng.

The hypothetical respondent on the left is among the least vulnerable in the province (with a score of 0/10) and the one on the right is among the most vulnerable (with a score of 7.4/10).

The vulnerability mapping described above, provides a baseline for **household** vulnerability and does not cover other aspects of vulnerability. It will be improved as new data becomes available for this type of spatial analysis and its integration into national mapping under SARVA project will be explored.

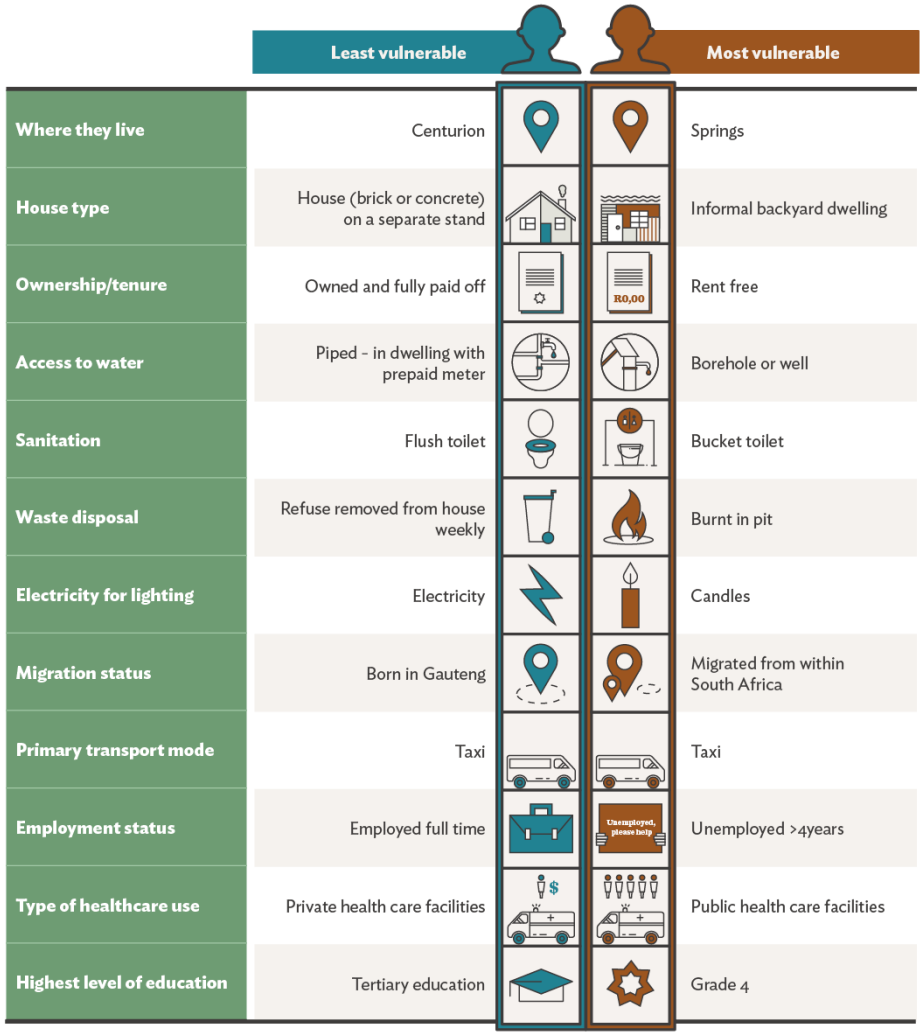

Figure 15: Comparison between least and most vulnerable individuals (Maree, et al., 2018)

6.6.2 Services and infrastructure

Human settlements in the GCR, especially in the major urban areas, are supported by extensive infrastructure networks. However, these networks, and the quality of settlements are threatened by roll-out and maintenance backlogs, as well as rising climate change related risks. This necessitates a focus on opportunities that can be created through climate change responses. Instead of simply countering climate change impacts, responses can transform human settlements into sustainable and resilient living environments. Adaptation outcomes should therefore be bold and progressive.

Basic services, specifically the supply of water and electricity and the removal of waste and effluent, are determinants of a person's human dignity, as well as of public and environmental health. The absence or inadequacy of these services can increase social vulnerability by increasing people's dependence on natural resources such as biomass as fuel source, or streams for water, or by exposing people to environmental risks such as water-borne diseases. The level of access to electricity throughout the GCR is shown in Figure 16.

Of concern are the large rural areas of Dr. JS Moroka and Thembisile Hani municipalities, as well as various other places scattered throughout the GCR where less than 33% of households have access to electricity. Generally, the rural areas of the GCR show low levels of access (i.e. below 66%) (StatsSA, 2017).

Some areas lacking access to electricity also show a lack of access to clean water (water supplied by service providers or drawn from boreholes), in particular areas in Thembisile Hani municipality, but also a number of other locations throughout the GCR (Figure 17).

The ability (or inability) to pay for services is also an important factor to consider. An example is the concept of ‘energy poverty’. According to the Department of Energy, a household is considered energy poor if more than 10% of the household income is spent on energy purchases (DoE, 2013). Census data show that 28% of households in Gauteng would thus qualify as energy poor (StatsSA, 2013).

Unhealthy living conditions created by the unavailability or unaffordability of services can be exacerbated by increased temperatures and decreased water availability. The prevalence of water-borne diseases, for example, is likely to increase as climatic conditions increasingly favour the spread of disease vectors typical to poor sanitation and uncontrolled waste disposal. Reduced household access to clean water will also increase dependence on less healthy alternatives, which could be aggravated if people can’t afford energy with which to sanitise water.

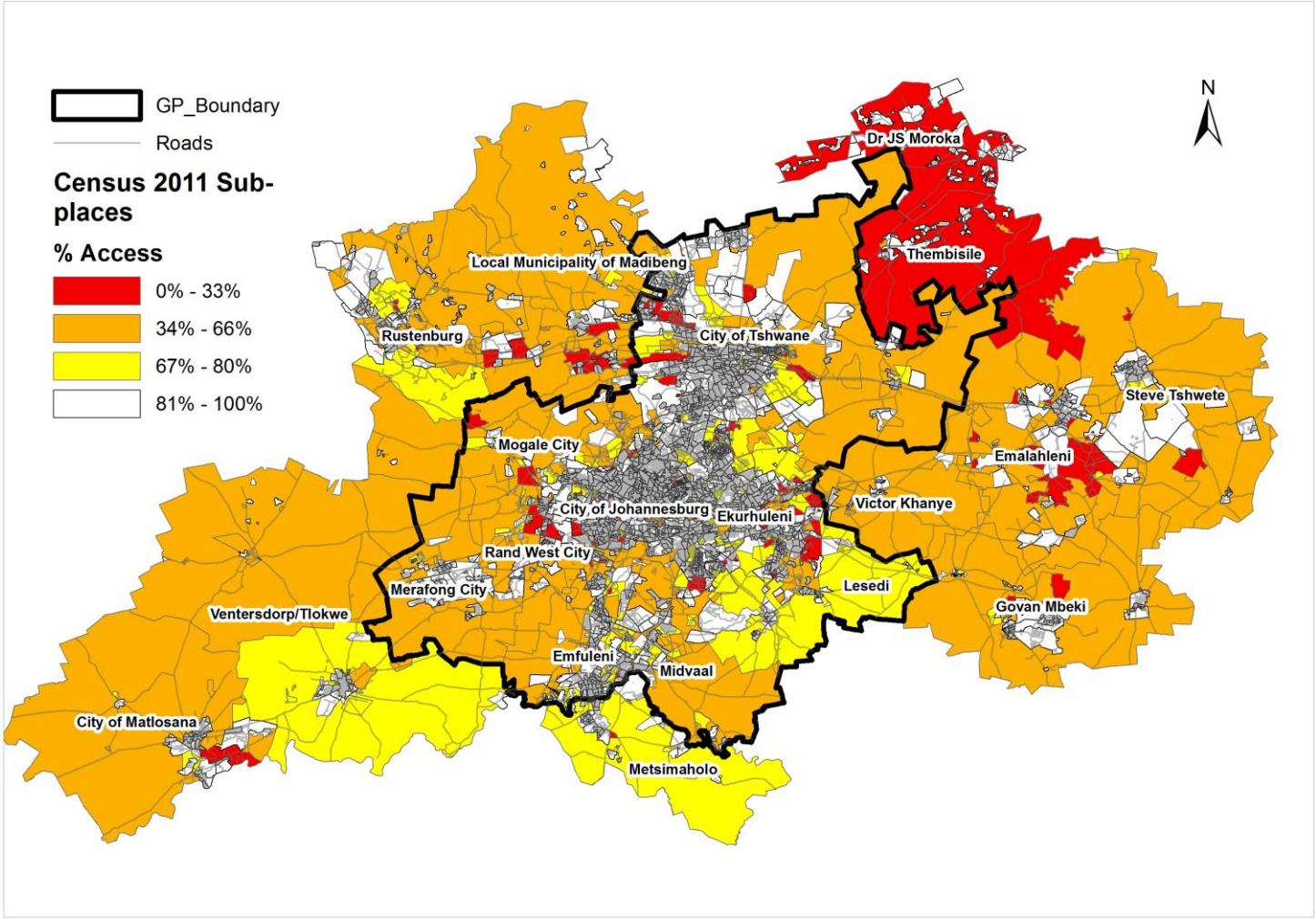

Figure 16: Household access to electricity as % of total in each 2011 census sub-place (StatsSA, 2017)

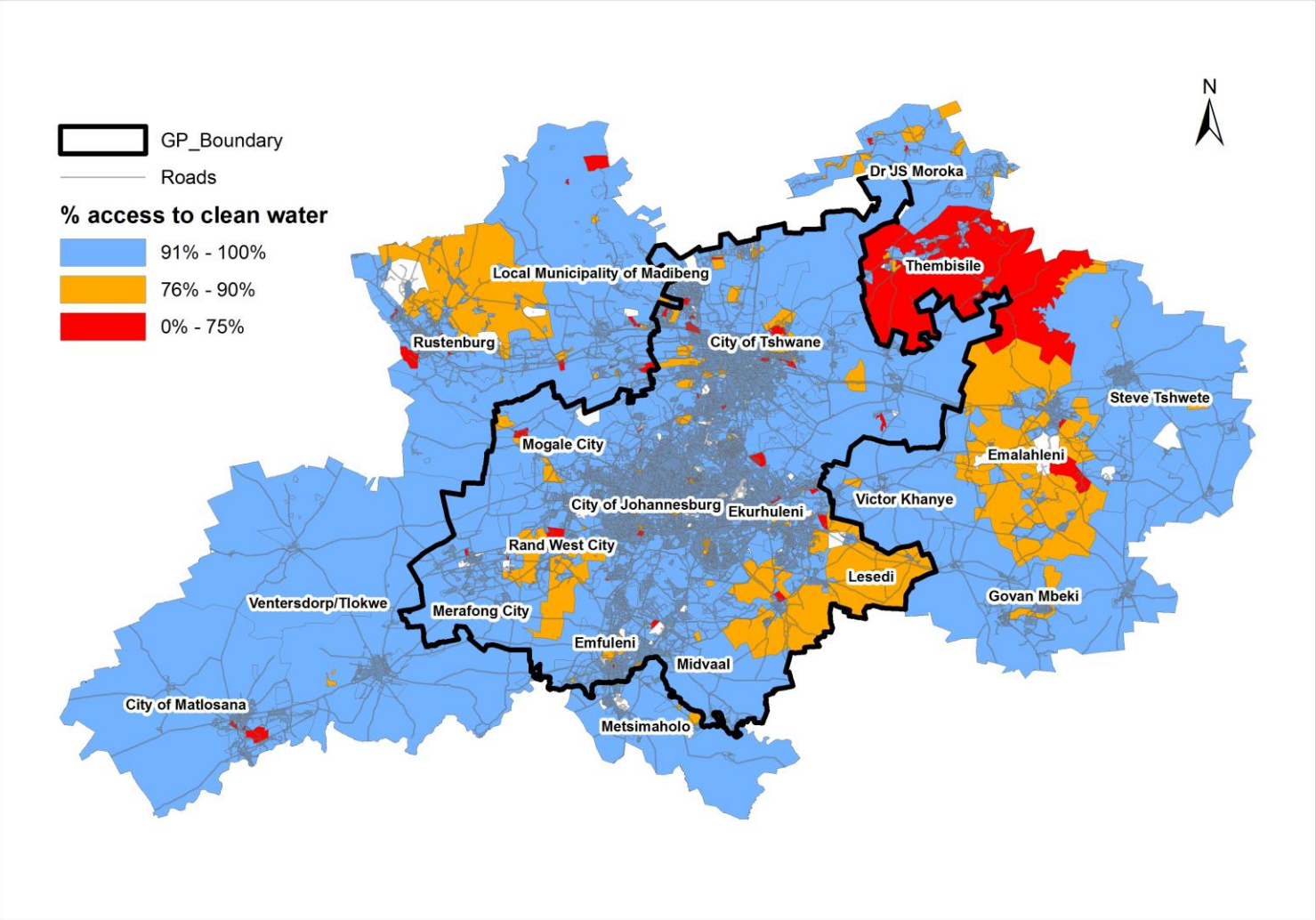

Figure 17: Access to clean water at household level as % of households per sub-place (StatsSA, 2017)

6.6.3 Poverty

Poverty is one of the most important contributors to social vulnerability. Poverty implies a household income which is inadequate to meet basic needs such as food, transport and services. It therefore also implies a dependence on free resources offered by their immediate natural environment such as firewood, wild fruits and herbs, medicines and craft materials which contribute to their livelihoods, as well as the ability to adequately feed, clothe and house themselves, or improve their socio-economic conditions and status. An increased dependence on natural resources means an increased vulnerability, but also a growing risk of unsustainable natural resource use that, over time, will compromise the overall yield that can be expected.

As climate change takes hold, some environmental stressors will increase pressures on the poor. This includes exposure to excessive heat, exposure to diseases and decreased quality of water access. Poverty implies that people will not be able to afford improved thermal insulation in dwellings, or access to clean energy and water. They also remain bound to public health systems that might become overloaded due to increased heat stress and water contamination related disease incidence. The resources spent in the community to deal with people affected by such impacts may therefore divert money away from capital investments necessary for economic development, entrenching the so-called poverty trap even more.

Figure 18 indicates where the highest concentrations of low (<R19 600 per household per year) and no income households are found in respect of ‘sub-place’ enumeration areas for the 2011 census. The lowest incidence is found within urban areas, whereas the higher incidence is typically in peri-urban township areas.

Poorer groups typically have less capacity to cope (e.g. lack of assets and insurance), less adaptive capacity, less state provision to help them cope, and less legal protection or protection from insurance. Low-income groups also have far less scope to move to less dangerous sites; indeed, the more dangerous sites are often the only sites where lower-income groups can find housing they can afford or can build their own homes. No-income households are typically clustered around the urban areas where informal or poor settlements abound, or where job seekers are attracted by the prospect of employment.

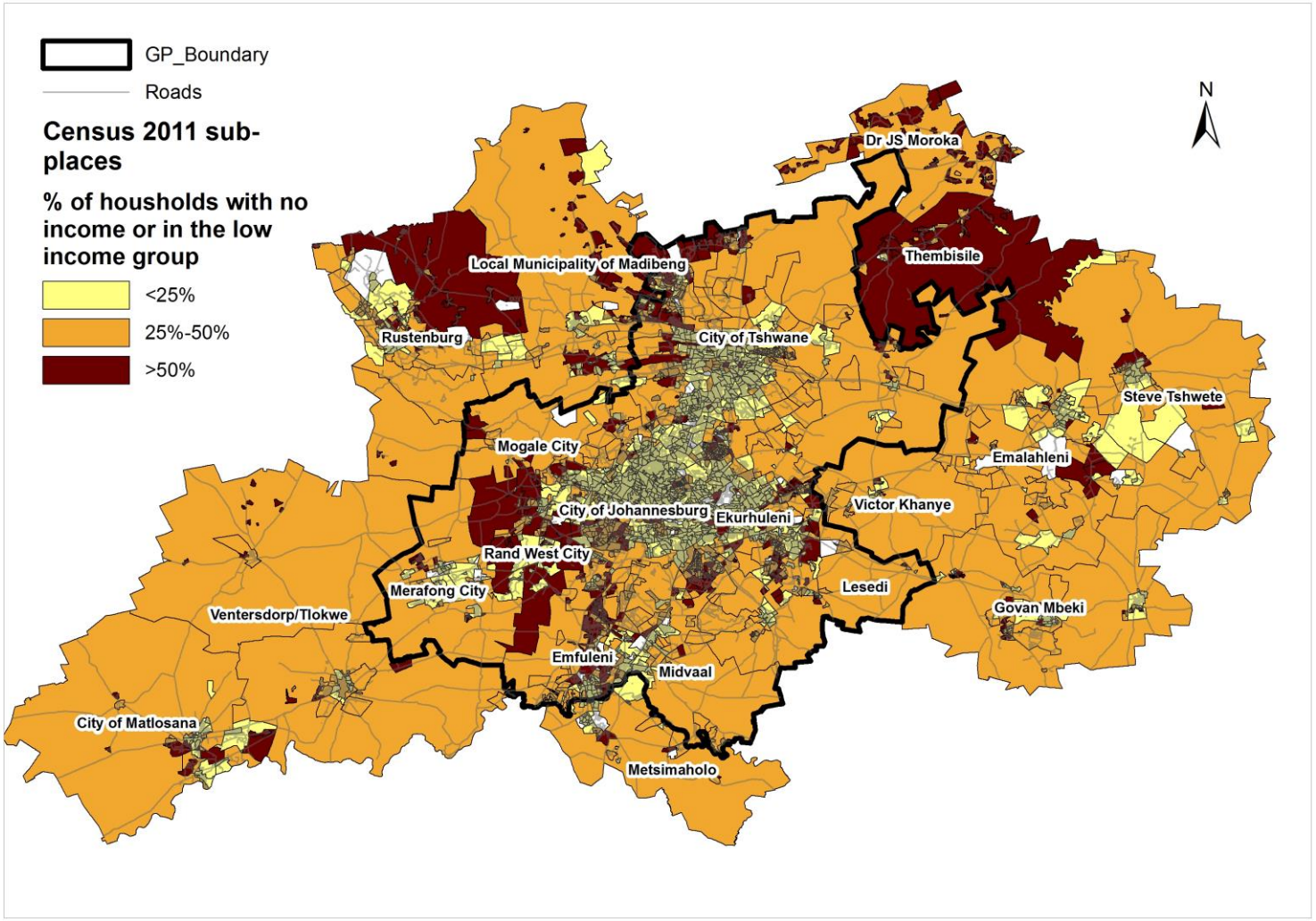

Figure 18: Concentration of low income households in the GCR (StatsSA, 2017)

6.6.4 Municipalities and Energy Efficiency

Local municipalities have been identified as the lead agent for the implementation of the actions identified for the human settlements response programme. Local municipalities best understand their residents' unique circumstances and are set up to respond to these needs.

However, when it comes to improving energy use efficiency within the residential sector, municipalities licensed to sell electricity face a disincentive because revenue from electricity sales makes up on average about 26.8% of their revenue (GIZ, 2017), which is a third more than what they receive in grants and subsidies (StatsSA, 2016b). This income is often used to cross-subsidise provision to indigent households or other services, and the dependency means that there is little incentive for municipalities to have households and businesses switch from grid-tied electricity to off-grid, renewable energy such as solar water heaters and photo voltaic (PV) panels that could reduce people's vulnerability to electricity price hikes and grid interruptions, or simply to consume less electricity.

This disincentive for municipalities to stimulate energy efficiency is not unique and has been addressed in the USA through a mechanism called 'revenue decoupling' (see text box), and has been the subject of investigations into transformation of South African municipal finances models (see resources on http://www.cityenergy.org.za and CSIR (2015)).

National and/or provincial government can overcome this disincentive for municipalities to stimulate energy efficiency in two ways:

- By setting minimum energy efficiency requirements (laws or by-laws) for the residential sector;
- By informing municipalities on the mechanisms to decouple revenue from sales volumes.

Various initiatives are underway to standardise regulations (e.g. grid connected feed-in) and these need to be implemented in a manner that encourages legal participation rather than illegal 'competition.

Text Box: Electricity Network Access and Sales Decoupling

Decoupling mechanisms are fairly widespread in the US with more than half of the states having some form of decoupling for electric utilities. Decoupling is initiated by a policy severing the direct link between sales volume and revenue. There are different mechanisms for decoupling, but the most common form used is based on revenue stabilization. In this case, the level of revenue to be collected for a certain period is set. Rates are adjusted based on energy efficiency improvements and customer growth to ensure the set revenue is achieved. There are other mechanisms all with different con's and pro's and suitable for different situations.

Adapted from '*The Brattle Group, decoupling in the US and its impact on cost of capital and profit (2014)*'

The following interventions have been identified as high potential (cost effective and with significant potential) for the residential response programme:

- Efficient lighting (existing and new houses)
- Efficient appliances (existing and new houses)
- Geyser blankets (existing and new houses)

- Improved insulation (existing and new houses)
- Improved thermal design (new houses)
- Energy efficient and safe cook stoves – Wonderbags (non-electric portable slow cookers), Liquefied Petroleum Gas (LPG) stoves, solar cookers and renewable fuels
- Solar water heaters

Energy efficient lighting can reduce energy consumption with approximately 370 kWh based on replacing 6 conventional lights with Compact Fluorescent Lights (CFL) (Eskom, 2011). To achieve the goal of 2 750 $ktCO_2$/yr, 6 million households would need to replace conventional lights with CFLs or LEDs and in new buildings only CFLs and LEDs should be installed. This is less than the 47 million CFLs installed by Eskom as part of Demand Side Management in the period 2006-2011 (Eskom, 2011).

Solar Water Heaters reduce on average residential energy demand with 200 kWh per month. Based on a yearly energy reduction of 2.4 MWh, 230 000 solar water heaters would need to be installed to achieve the goal of 556 $ktCO_2$ saving per year by 2022. Between 2008 and 2011, about 125 000 solar water heaters were installed as part of the national Eskom rebate programme for solar water heaters. However, there needs to be a clear maintenance plan of the installed solar water heaters, particularly those that are installed on low cost housing developments.

PROGRAMME AMBITION	**RESPONSIBILITY**
Outcome 6-1: Emissions reduction of 5 133 kt CO_2e through improved household energy efficiency, cleaner fuels and alternative energy use **Outcome 6-2:** Emphasis on disaster risk reduction and disaster response in informal settlements and poor urban and rural communities, especially during extreme weather events **Outcome 6-3:** An increase in basic service delivery in informal settlements and poor urban and rural communities, particularly relating to water-related services **Outcome 6-4:** Integration of climate change considerations into housing and land use planning for increased resilience **Outcome 6-5:** Awareness raising on the importance of climate adaptation and involvement of affected communities in the planning and implementation of adaptation measures **Outcome 6-6:** Integration between the health sector, disaster response services and the human settlements sector	Lead: Municipalities Support: GDARD, Economic Development, Human Settlements, Health, Eskom, Social Services **GCR FOCUS** • Cross-border sharing of skills and knowledge **FINANCE AND FUNDING** Government supported funding is the primary funding platform, but international adaptation funding may also be accessed for defined projects.

Outcome 6-7: Increased community health worker / NGO capacity	

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
1. Investigations into (new and innovative) alternative services provision (e.g. off-grid solutions, community co-operatives), based on knowledge groups in academia and other developing countries	**Eco QoL DRR**	N/A	<5	Strategic plan for alternative services provision models by 2022	Municipalities, GDARD, Human Settlements	GIZ Danida
2. Capacitation of the public and community support organisations in respect of services provision (e.g. off-grid solutions, community co-operatives) through demonstration projects	**Eco QoL DRR**	N/A	<5	One demonstration project per year	Municipalities, GDARD, Human Settlements	GIZ Danida
3. Revising the regulatory framework to speed up progress on the implementation of proven energy efficient technologies and designs.	**Eco QoL GHG**	4 339	<5	Revise specifications for housing as related to energy efficiency and implement by 2022, including the following • Efficient lighting (existing and new houses) • Efficient appliances (existing and new houses) • Geyser blankets (existing and new houses) • Improved insulation (existing and new houses	Human Settlements, Municipalities, GDARD, SANEDI	Urban Settlements Development Grant

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
				• Improved thermal design (new houses)		
3. Energy efficient and safe cook stoves: • Wonderbags • LPG stoves • Solar cookers • Renewable fuels such as wood pellets or bioethanol	**Eco QoL GHG**	237	<5	Further roll-out and monitoring of pilot projects stemming from the "*A Feasibility Study and an Implementation Plan of Alternative Energy Technology Options for Unelectrified Informal Settlements, 2015*" – one demonstration project and evaluation report per year.	Municipalities, GDARD	GIZ Oxfam Adaptation Fund (SANBI)
5. Ensure that solar water heaters are placed on new houses, that broken geysers are replaced with solar water heaters and that there is an incentive to place these on existing low-cost houses.	**Eco QoL GHG**	556	<5	Enforcement of relevant by-laws	Eskom, Municipalities, GDARD, SANEDI	
6. No encroachment onto floodplains, protection and expansion of high value open spaces (use EIA, SDF and EMF, C-plan and bioregional plans)	**Eco QoL DRR**	N/A	<5	Co-ordinated annual compliance monitoring and enforcement programme to ensure compliance with open space and biodiversity planning (including river buffers)	GDARD, Municipalities, Human Settlements	
7. Innovation in how landless and indigent people are given shelter. Provision of shelter can be done using eco-friendly house building materials	**Eco QoL DRR**	N/A	<5	Reduction in number of people living in informal settlements by 2022	Municipalities, Human Settlements, Social Services	

6.7 Response programme 7: Energy Supply

Although Gauteng has significant energy requirements, very little generation takes place within the borders of the province. Bulk electricity generation capacity in Gauteng is limited to three coal fired power stations, all of which are currently operating below installed capacity due to age and/or the high costs of feedstock, as well as smaller projects based on landfill gas extraction and gas turbine generators. Energy is consequently supplied to Gauteng through the national electricity grid operated by Eskom and various municipalities; as well as road, rail and pipeline-based transportation of liquid and gas fuels. These are considered 'dirty' forms of energy due to their reliance on fossil fuels and associated large carbon footprint. Gauteng province is therefore generally beholden to developments in the energy sector at national level, and sensitive to what changes in energy supply and costs will do to municipal and household finances.

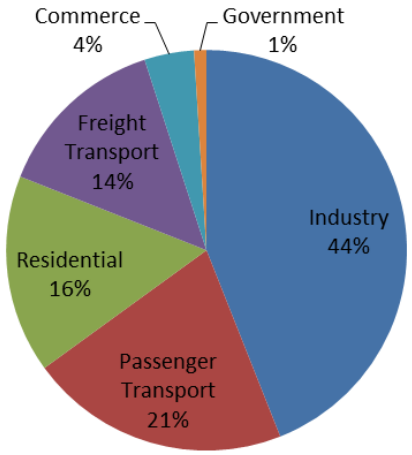

Figure 19: Final Energy Demand by sector – 2007 (GDLGH, 2010)

Recent data on energy consumption are not available, but in 2007, 44% of energy was used in the industrial sector, with 35% going to transport (Figure 19. 35% of the energy came in the form of coal, and a further 35% was sourced as petrol or diesel (Figure 20).

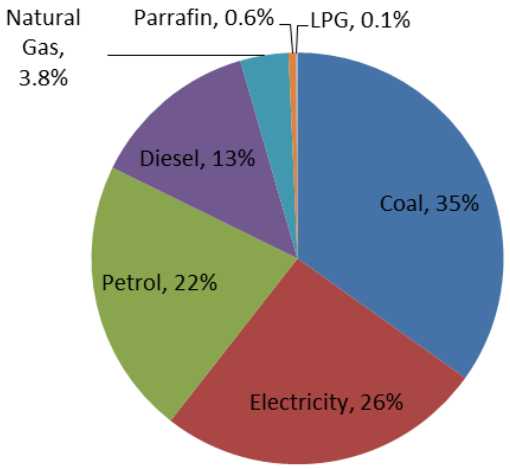

Figure 20: Final Energy Demand by energy carrier – 2010 (GDLGH, 2010)

The reliance on externally sourced carbon-intensive forms of energy brings about vulnerabilities and uncertainties in the energy sector in Gauteng:

- An increased demand for energy expected to increase at a rate of between 1.31% and 2.17% over time due to economic growth, increases in population and the need to ameliorate rising temperatures (DoE, 2016)
- Output efficiencies of coal-fired power plants will decline due to decreasing thermal conversion efficiency (ECF, WEC, CJBS & CISL, 2014).
- Water availability will constrain coal supplies and power plant operations, as well as hydropower generation (ECF, WEC, CJBS & CISL, 2014)
- Extreme weather will damage energy generation and transmission infrastructure, especially through flooding and wind damage
- Progressive penetration of renewable energy will disrupt existing energy supply and pricing systems, with renewable energy becoming increasingly viable at all scales
- Penalties for carbon-intensive energy will drive a rise in energy prices
- South Africa has committed to reducing its carbon footprint over time, which necessitates conversion of some of the national energy supply to lower carbon energy types

Expected changes in the energy sector in the GCR

For Gauteng and the GCR, the main concerns lie in the anticipated shake-up of the energy pricing system, and localised energy infrastructure risks. Most changes to the energy sector are likely to increase the cost of sourcing fossil fuel-based energy, thereby decreasing the economic efficiency of the region and increasing household-level vulnerability. Damage to infrastructure will also reduce the reliability of energy supplies, whilst the increasing risk from flooding will make more areas unsuitable for formal electricity infrastructure.

The energy sector is virtually guaranteed to see a complete upheaval in coming years – energy use efficiencies are reducing demand, whilst the costs of renewable energy and energy efficient installations are rapidly undermining the market dominance of fossil fuels. This is as true for the liquid fuels sector as for the bulk electricity provision sector. Carbon tax is expected to initially increase the costs of fossil fuel use by (non-energy) industry which might lead to an increase in

demand for electricity. After the initial period of 5 years it is expected that fossil fuel based electricity will also become liable for carbon taxation.

The role of provincial government in energy security and the GCR energy transition

Provincial Government has a role to play in developing the energy sector within the province as per direction set out in the Gauteng Energy Security Strategy (GESS) (GDED, 2016). The GESS, compiled by the Gauteng Department of Economic Development (GDED) envisions *"A resilient and energy secure province that invests in diversified low-carbon energy sources and innovative technologies, that delivers reliable and affordable energy services to all citizens, and contributes to an economically transformed and modernised and re-industrialised Gauteng City Region".* To realise this vision, the GESS is grounded on the following 6 pillars:

- Pillar 1: Enhance security of supply
- Pillar 2: Promotion of energy security
- Pillar 3: Modernisation of the energy infrastructure
- Pillar 4: Contribution to economic development through re-industrialisation and creation of jobs
- Pillar 5: Ensure universal access for the poor
- Pillar 6: Reduction of impacts on the environment

The strategy has defined the following key interventions to be pursued by the Gauteng province to achieve, through its main pillars, its vision:

- Solar photovoltaic energy with a capacity of 500 MW in the next 5 years
- Refurbish and expand existing coal power stations with a capacity impact of 1 200 MW
- Reduce electricity demand in the household, commercial and industry sectors by 1 000 MW
- Develop a fuel cell industry in the transport sector
- Diesel to natural gas fuel switching in the transport sector
- BRT

The above-mentioned target for (roof top) solar photovoltaic energy (500 MW) would result in a yearly emission saving of about 1 750 $ktCO_2$. This is less than the current existing targets in the strategic action plan for solar energy, which is about 3 600 $ktCO_2$. This indicates that additional mitigation projects are needed in the energy sector in addition to the solar PV and transition to gas as described in the Gauteng Energy Security Strategy.

The GESS describes six enabling functions of provincial government to achieve the goals set; Provision of guidance by government, Knowledge development and capacity building, Information and knowledge dissemination, Market stimulation, Resource mobilisation and Advocacy. The GESS furthermore describes that as part of 'guidance by government', the provincial government can enforce by-laws that for example promote renewable energy and energy efficiency. However, it is expected that provincial government's most important (initial) role is through resource mobilisation (as described in GESS) and advocacy with national government and local municipalities.

The role of national government in the GCR energy transition

With respect to interaction with national departments, the Gauteng provincial government should advocate the need for increased renewable energy in the energy mix. In both interaction with national government and state-owned entities such as Eskom, the need to renew and increase the number of contracts with Independent Power Producers should be pressed. It is important also to remove the current barrier for Independent Power Producers to obtain a generation license from NERSA.

The role of municipalities in the GCR energy transition

Provincial government can support municipalities, who are responsible for electricity distribution and sales within the municipality, to address the existing revenue loss disincentive for energy efficiency gains. This disincentive could be addressed by decoupling of the electricity revenue and sales. Provincial government can further cooperate with municipalities with respect to renewable energy uptake. Examples of possible cooperation and support could be joined research, demonstration projects but also purchasing of municipalities' renewable energy.

There are different roles which municipalities can take on with respect to generation and sales of renewable energy. These different roles are described in the text box 'municipalities and renewable energy'.

Text Box: Municipalities and Renewable Energy

Municipalities can play an important role when it comes to renewable energy production. The discussion paper 'New Roles for South African Municipalities in Renewable Energy – A Review of Business Models' (South African – German Energy Partnership, March 2017) distinguishes 3 main types of business models:

- For municipalities to operate their own generation capacity.
- For municipalities to be a procurer of electricity. Procurement could take place from embedded generators and large independent power producers. The IPPs would need a generation license but would no longer be dependable on Eskom to buy their electricity.
- For municipalities to take on a facilitating role, such as aggregating and trading electricity, providing storage facilities and providing electricity services.

The different business models have different advantages, disadvantages and risk profiles.

For more information: '*New Roles for South African Municipalities in Renewable Energy – A Review of Business Models*' (South African – German Energy Partnership, March 2017)'

Renewable Energy Interventions

Following the assessment presented in the National Mitigation Potential Analysis (2014) and taking into account the needs and possibilities within the Gauteng province, the following types of renewable energy projects should be pursued in the energy sector:

- Solar energy, including CSP

- Wind projects;
- Biomass combustion

Solar Energy – To achieve the target of about 3 600 $ktCO_2$ emission mitigation from solar energy, the planned 500 MW of roof top solar PV should be extended with approximately 500 MW of either solar CSP or PV. In the case of CSP this would amount to 5 plants, as average CSP plant size in South Africa are between 50 and 100 MW.

Wind Energy – Though there are no wind farms within Gauteng, the potential for wind generated energy is significant; the University of Stuttgart found the potential to be 27.5 TWh/year (Marathe, 2014). In this assessment, land suitability (including land availability, slope of the land and appropriate buffers to land use types) and wind potential were overlaid to assess the potential. The amount of CO_2 saving per year included as a target in this action plan is about 15% of the potential as calculated by the University of Stuttgart. To achieve the mitigation target, 7 windfarms of 160 MW need to be built when assuming an average load factor of 40%. There are 3 windfarms in South Africa with a capacity of 140 MW. The largest windfarms in the world are in China and are 7 000 MW.

The national wind atlas project further corroborates that the better wind resources are located in the south-western parts of the province, but it indicates that the relative potential in Gauteng is of medium to low national values (SANEDI, 2017).

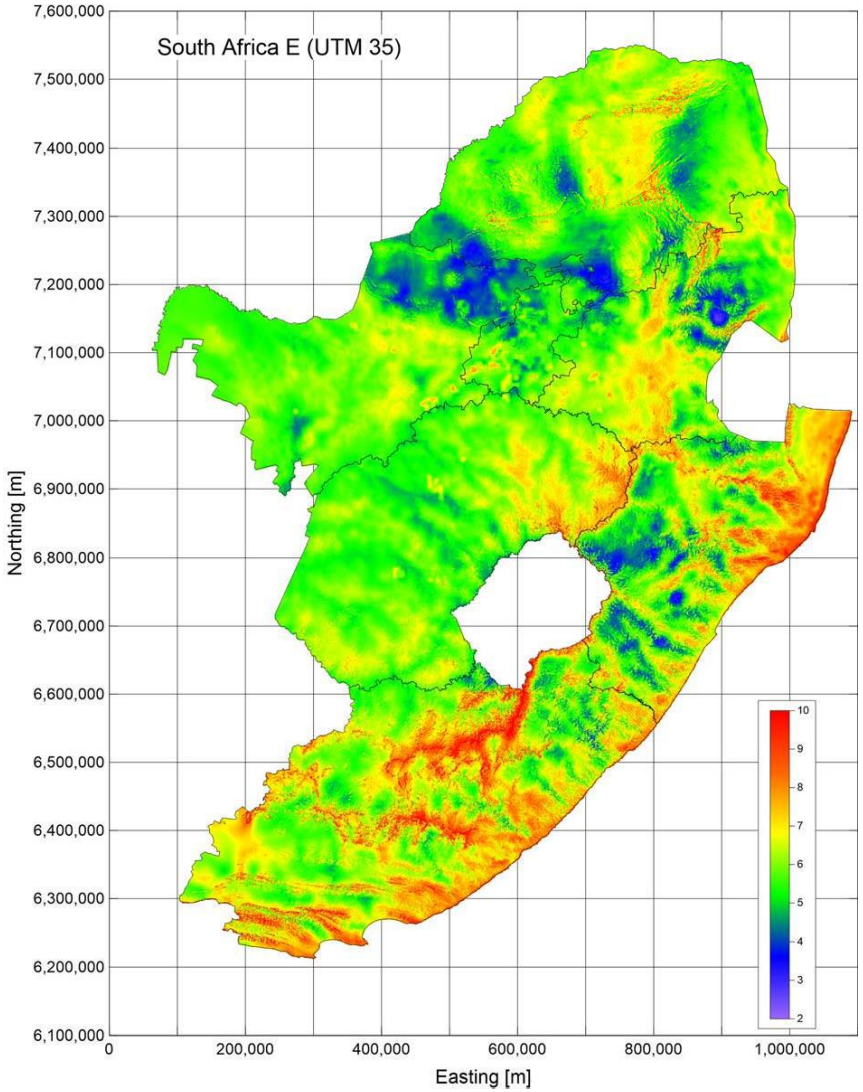

Figure 21: South Africa (East) mean wind speed at 100 m a.g.l. (SANEDI, 2017)

Energy Industry Interventions

The energy industry, however, comprises of more than electricity generation; it also includes coal mining, petroleum refining and other energy industries. The following project types have been identified as important with regard to emission saving potential and cost efficiency:

- Smart energy controls
- Energy efficiency
- Waste to energy projects

National government can provide incentives for the coal mining and petroleum refining industries to reduce energy consumption and emissions through:

- Energy efficiency standards/requirements
- Carbon tax which increases the urgency to reduce carbon emissions

PROGRAMME AMBITION	RESPONSIBILITY
Outcome 7-1: Emissions reduction of 9 671 kt CO_2e through cleaner and alternative energy generation **Outcome 7-2:** In collaboration with the Department of Energy and Eskom strengthen community resilience through more diversified and decentralised energy systems (including the utilisation and expansion of renewables as well as smart and mini grids, with associated job creation), and energy efficiency measures for housing **Outcome 7-3:** Climate-proof energy operations and infrastructure so they are able to withstand weather extremes **Outcome 7-4:** Revised electricity supply and revenue collection system	Lead: Economic Development Support: GDARD, Department of Energy, Roads and Transport, Human Settlements, Eskom, municipalities **GCR FOCUS** • Investment in renewable energy generation **FINANCE AND FUNDING** Decarbonising energy conversion, or more specifically, the production and distribution of electricity and heat, is often approached using a three-tier hierarchy of reducing energy demand, replacing fossil fuel-based conversion by renewable energy and using the most efficient / cleanest fossil fuels / technologies. Typically, climate funding, rather than financing, would be used promote the uptake of these technologies.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
Supporting systematic implementation of wind energy generation projects, including piloting of demonstration projects.	**Eco** **GHG**	4 133	<5	Localised feasibility plan for wind power installations in Gauteng by 2022	Eskom, Department of Energy, municipalities, IPPs	IPP DBSA GEF Danida REFSO (DoE)
Identify financial models and funding mechanisms and support systematic implementation of wind and solar energy generation projects under 1 MW and small-scale embedded generation	**Eco QoL** **DRR** **GHG**	3 593	<5	5 IPPs by 2022	Municipalities, IPPs	
Waste to energy conversion projects such as landfill gas and waste heat utilisation	**Eco QoL** **GHG**	954	<5	One commercial scale PPP WtoE project by 2022	Department of Energy, municipalities, IPPs	National Development Finance

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
						Institutions (DFI) (e.g. IDC) Banks
Biofuels such as biodiesel and bioethanol brought into the energy mix as per national strategies or as stand-alone projects	**Eco** **GHG**	301	<5	Annual report on biofuel penetration in energy mix	Department of Energy, IPPs, DoA, GDARD	DST
Smart energy controls: • Energy monitoring and management • Improved process control These are energy saving/energy efficiency measures which have been found to have potential especially within the non-power (coal mining and petroleum refining) sector.	**Eco** **GHG**	202	<5	A sector support programme to advise project developers on design and technology set up by 2022	Department of Energy, municipalities, SANEDI, NCPC, National Treasury	DTI Green Fund (fully subscribed at present) NCPC Banks Private funds IPPs & energy service companies DBSA National DFIs Development banks
Energy efficiency – • Lighting • Motor control systems • Utility systems • Boilers • Use of process heat These are energy saving/energy efficiency measures which have been found to have potential especially	**Eco** **GHG**	488	<5	A sector support programme to advise project developers on design and technology set up by 2022	Eskom, Department of Energy, municipalities, IPPs, National Treasury	DTI Green Fund (fully subscribed at present) NCPC Banks Private funds IPPs & energy service companies DBSA National DFIs

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
within the non-power (coal mining and petroleum refining) sector.						
Hydropower (incl. micro-hydro in pipe networks)	**GHG**	0	<5	Two further demonstration projects based on experience in Tshwane Metro by 2022	Eskom, Department of Energy, DWS, DEFF, municipalities	Private equity
Identify climate-related pressures on power generation efficiencies and risks to infrastructure during procurement processes	**DRR**	N/A	<5	Energy infrastructure risk assessment by 2020	Eskom, Department of Energy, municipalities	
Revised electricity supply and revenue collection systems	**Eco GHG**	N/A	<5	Strategic plans for revised electricity supply and revenue collection for each municipality by 2022, with net metering or feed-in tariff schemes adopted in all Metros	Municipalities, DoE, GDARD	

6.8 Response programme 8: Industry and Mining

6.8.1 Industry

Industries located in the province include iron and steel processes, brickworks, foundries, chemical manufacturers and small boiler operations, to name a few. Most are in the City of Ekurhuleni Metropolitan Municipality, followed by Sedibeng District Municipality, the City of Johannesburg and City of Tshwane. Depending upon their processes, inputs and outputs, industrial activities release various pollutants into the atmosphere, including GHG. Manufacturing represents 13.8% of the provincial GDP (GPG, 2016). In terms of the IPCC GHG reporting categories, IPPU accounts for approximately 10% of the GHG emissions in the province, with energy use in industry, manufacturing and construction contributing 29% of the GHG emissions related to energy usage (GDARD, 2017a).

Manufacturing in the GCR will be subject to pressure coming from a reduced availability of water and rising cost of energy. The sector will need to address these 'shortages' and also manage human resources in terms of increased automation and facility standards.

Response actions should focus on cleaner energy and more efficient energy use, as this will a) reduce the carbon footprint and b) through lower energy costs facilitate improvements in facility standards to better adjust to climatic change. These should form an integral part of the ten-pillar programme of Radical Transformation, Modernisation and Re-industrialisation as adopted by the Province as a macro-economic strategic direction.

6.8.2 Mining

Although mining has been overtaken by the services sector in terms of economic value in the GCR, it remains important and will likely persist for the immediate future even if some historic operations are terminated. The market penetration by electric vehicles will influence demand for platinum though, and social or labour unrest in the sector is constraining production and growth.

Mining is concentrated along an east-west mining belt running along the Witwatersrand reef complex. This band of historic and current mining activities is sensitive to pollution and changes to the water table that can contribute to unhealthy living conditions. The relation between mining activities and water resources is under severe scrutiny, given the impact that mining has on ground and surface water quality, and the use of water for mining and processing activities.

A particular water-related issue for mining is Acid Mine Drainage (AMD) – the decant of acidic subsurface water that collects in mine tunnels into surface water resources. AMD is still a significant problem in the province, although the risk has subsided somewhat in recent years with efforts to manage the situation. Currently AMD is being treated by an oxidation process that removes heavy metals and this treated AMD from the Witwatersrand is released into the rivers. However, it still poses a threat to the Vaal Catchment where accumulation of salts may take place. Release of water from the Vaal Dam is the only way to alleviate extensive salt loading within the system. However, because the Vaal Catchment is already over-

utilised, a reduction in the availability of surface water due to climate change would compromise the dilution of the salt in the system.

Complicating the issue further are mine residue areas which are areas of localised mine wastes that not only impact on water quality but also on air pollution. Mine residue areas can further exacerbate AMD issues, especially where contact between surface water and groundwater supply allow for cross-contamination through the leaching of toe-dams into groundwater.

6.8.3 Interventions

Cost efficient interventions for both mining and industry are mostly energy efficiency, clean production and fuel switch related. Off all the interventions which are recommended to be implemented (based on cost efficiency and mitigation potential) to achieve the target for the industry sector by 2020, about 60% are cost negative and cost neutral. This is the so called 'low hanging fruit', which would require an investment, but afterwards provide a financial benefit to the company. The most important barriers to implementing these kinds of projects are financing availability for large investments and a lack of technical knowledge and experience.

The industry and mining sector will be impacted by the pending carbon tax. In the initial 5 year phase, the electricity price is not expected to increase as the electricity generation levy and renewable electricity generation fee is reduced to compensate for the carbon tax. The carbon tax will however be charged on fossil fuel combustion emissions, fugitive emissions and process emissions. The carbon tax will therefore improve the pay-back rate and profitability of projects such as fuel switches (coal to biomass and coal to gas), energy efficient boiler systems, N_2O abatement and combined heat and power generation.

National government (the National Treasury for the carbon tax and Department of Environmental Affairs for the carbon budgets) already engages with the industry sector to reduce emissions. Though the emission reduction potential for this sector is significant, the fact that it is a subject of national focus could be a reason for provincial and local government to put their focus elsewhere. With regard to provincial/municipal actions that could fill a gap with respect to national actions the following activities have been identified:

- **Financial programme** which provides industry with information on where to apply for funding or possibilities to engage in a Public Private Partnership and Demonstration projects with the aim of **sharing technical knowledge and expertise and practical experience. An industry sector support programme** to advise on design, technology and access to finance for clean industrial processes and energy efficiency interventions – along the lines of the NCPC and Private Sector Energy Efficiency Programme (PSEE) specific comments from Innovation Hub. The emission mitigation potential in the industry sector is significant and in general very cost efficient. As national government is in the process of implementing carbon tax and carbon budgets, which will increase the pressure on industry, provincial government could fill the gap of providing support to implement energy efficiency projects. Macro-economic planning should inform industry transformation where significant need is identified. **The functions, activities and funding of Gauteng Innovation hub must be reviewed to improve its support to emerging**

entrepreneurs and commercialisation of new technologies addressing climate change.

- Engage with industry on the opportunities which **renewable energy generation** might create such as protection against future electricity taxation in the second phase of the carbon tax and general price increases. Municipalities could take on a facilitating role, such as buying excess electricity and allowing access to the local grid.

- **Improved mine land rehabilitation practices** have the potential to sequester additional CO_2 compared to conventional mine land rehabilitation practices. Mine land rehabilitation could also be undertaken on historically degraded mining land. One of the criteria for registering emission reducing projects under standards such as Clean Development Mechanism and Verified Carbon Standards is proving that the project is different from standard (the baseline determining) practices and wouldn't have been undertaken without the benefit from carbon credits. Improved mine land rehabilitation practices and rehabilitation of historically degraded mining land could, if also successfully recognized by a carbon credit scheme allowed as offset under the carbon tax, used as offsets for the carbon tax.

PROGRAMME AMBITION	**RESPONSIBILITY**
Outcome 8-1: Emissions reduction of 7 514 kt CO_2e through cleaner production processes, energy efficiency and use of cleaner fuels **Outcome 8-2:** An understanding of the role of the mining sector in weakening the climate resilience of ecological systems (biodiversity and water) **Outcome 8-3:** Social development and support schemes that will reduce the impact of contraction in industry and mining **Outcome 8-4:** Energy efficiency gains in mining operations and associated processing activities **Outcome 8-5:** Energy and water efficient facilities throughout the value chain	Lead: Economic Development Support: Department of Mineral Resources, Social Development, GDARD, Department of Energy, municipalities **GCR FOCUS** • Cross-border skills and learning exchange • Cross-border social and economic support to reduce the number of people exiting the mining sector • Cross-border ecological and spatial planning **FINANCE AND FUNDING** Largely characterised by private companies as project sponsors, whereas government (agencies) can use finance to influence design and implementation of programmes to promote the use of certain technologies to increase energy efficiency, switch to alternative fuels, reduce GHG emissions or reach other policy goals (e.g. less emissions of local pollutants, less transport, less noise, etc.)

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
A sector support programme for Cleaner production processes for industry, including: - **Process integration** - **Best available production techniques** - **Bio-carbon reductants as coal replacement**	**Eco GHG**	3 548	<5	Audit of mitigation potential by 2020, and demonstration PPP project showcasing best practice cleaner production processes or technologies by 2022 If the announced carbon tax is implemented, industry will have a financial incentive to implement project which reduce fossil fuel combustion, fugitive and process emissions.	Innovation Hub of GDED, NCPC, SANEDI, Economic Development, Department of Energy, municipalities, IPPs	DTI Green Fund (fully subscribed at present) NCPC Private funds IPPs & energy service companies DBSA National DFIs
2. Energy efficiency and cleaner fuels, including: - Smart energy controls - Energy efficiency transformers and motors - Energy efficient lighting - Waste heat optimisation - Motor controls & VSD - Cleaner fuels (coal to biomass or gas) - Energy efficient utility systems - Biodiesel	**Eco GHG**	3 976	<5	If the announced carbon tax is implemented, industry will have a financial incentive to implement project which reduce fossil fuel combustion, fugitive and process emissions. A sector support programme to advise project developers on design, and technology and access to finance set up by 2020		

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET (kt CO_2e)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
- Waste heat and gas recovery						
3. Improved mine land rehabilitation practices and rehabilitation of historically degraded mining land	**Eco QoL GHG**	Unknown	<5	By 2021 finalize a study into the sequestration potential and costs of - Historically degraded mining land rehabilitation and; - Applying best practice rehabilitation instead of standard rehabilitation of mining impacted land;	DMR, Land Rehabilitation Society of Southern Africa (LaRSSA)	
4. Ensure that long-term and contingency planning considers climate change projections	**Eco QoL DRR**	N/A	<5	Sector plan for climate change response in the industry and mining sector in Gauteng by 2022, as localised interpretation of national equivalent	Economic Development, GDARD	
4. Address threat from AMD to surface water resources	**Eco QoL DRR**	N/A	<5	Project aimed at the productive use of treated AMD rather than wasteful and environmentally hazardous release into watercourses to be functional by 2022	DWS, Water Services Authorities, GDARD, TCTA	
5. Refine industrial water demand management plans	**Eco DRR**	N/A	<5	Industrial water demand management plan and one pilot project by 2022	DWS, Municipalities, Water Services Authorities	

6.9 Response programme 9: Transport

Gauteng hosts a well-developed transport network, consisting of road, rail, air and pipeline routes. These routes facilitate internal circulation as well as connections with the wider GCR and beyond.

The transport sector was responsible for about 21% of the total final energy demand in Gauteng in 2010 (GDLGH, 2010). Within the three Metro areas, it rises to 61% for 2011 (SEA, 2015). Emissions from road transportation, i.e. petrol and diesel fuelled vehicles, are also responsible for a significant share of air pollution and 10% of the provincial GHG emissions (GDARD, 2017a).

In theory, the interconnectedness of the transport network improves the overall resilience of the sector. However, historic and current factors related to network development and maintenance, and the optimisation of transport modes, have served to compromise the smooth functioning of the transport system. Combined with spatial development planning that created sprawling residential areas at the outskirts of the urban areas, this has resulted in congested, private car-dominated roads as people are forced into a daily commute. Furthermore, between 1975 and 2013 people have been turning away from substandard bus and rail systems in favour of cars and minibus taxis, thereby exacerbating the congestion (GDARD, SALGA, WITS University & University of Johannesburg, 2014). It is also the low-income earners who are most reliant on the private minibus taxi service – 85% vs. 15% for high income earners (Figure 22). The reverse is true for private car usage (GDARD, SALGA, WITS University & University of Johannesburg, 2014).

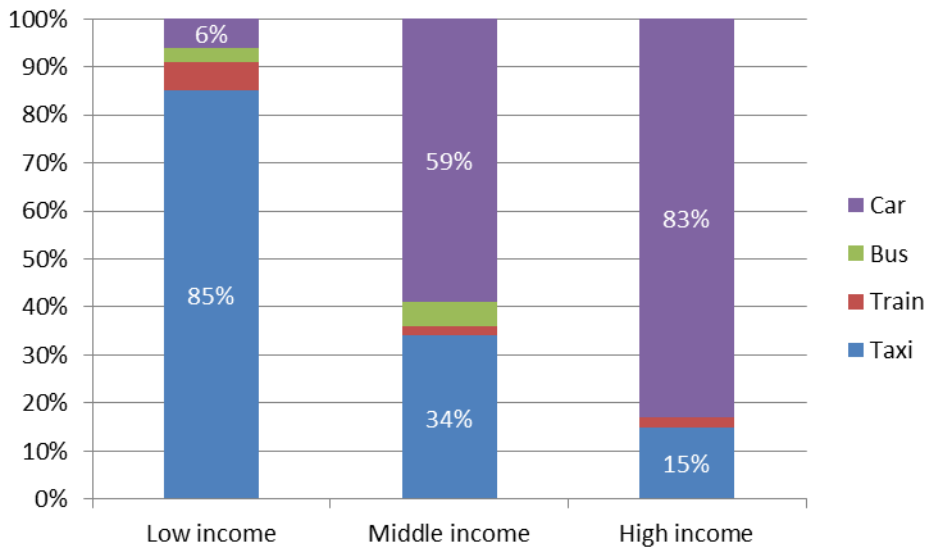

Figure 22: Transport mode preferences of different income groups according to the 2009 Quality of Life Survey (GDARD, SALGA, WITS University & University of Johannesburg, 2014)

A transformation of the transport sector holds major promise in terms of reducing the provincial carbon footprint and in improving the resilience of households as well as the provincial or regional economies. Opportunities such as the build-out of modern mass transit systems, closer integration between transport and development planning and a transition to a more energy efficient transport system stem directly from the challenges facing the current transport system, and are, in fact, necessitated by the rising costs in

the fossil fuel energy sector and the need to mitigate carbon footprints.

The Gauteng Integrated Transport Master Plan 2025 (ITMP25) aims to promote more sustainable transport operations and systems in Gauteng (GPDRT, 2013). Sustainable transportation can be defined as a system with low negative environmental costs yet high positive social value, which supports resource efficient economic development. More specific, the master plan mentions "…*promoting a shift away for private car use; support for public transport, the removal of subsidies for fossil fuel and penalising high fuel consumption…"*.

In terms of improving mass transport, the Bus Rapid Transition Programme is well underway, with successful roll-out in the Cities of Johannesburg and Tshwane. Roll-out in Ekurhuleni is also underway, with construction having commenced in Tembisa and Kempton Park. The Gautrain Project has been successfully implemented in all three Metropolitan Municipalities and further extensions are planned. A reliable public transport system can facilitate movement of people in a manner that connects them to employment opportunities, social services and public amenities, thereby reducing their vulnerability. However, the transport must be affordable to low-income households for it to translate into positive effects. It is difficult to predict the emission savings due to public transport as the use doesn't translate to a 100% reduction of other transport options; it also provides access to transport for people who previously didn't have this access. For the purpose of calculating the potential emission savings of the Ekurhuleni BRT system, a 10 km average transportation distance, 76 424 passengers per day[8] of whom 25% previously made use of private cars and an emission saving compared to private car (1 person per car) use of 7.5 kg CO_2/km (ITMP25) was assumed. Using these assumptions, the Ekurhuleni BRT system will result in a saving of 430 ktCO_2 per year, which is already more than the recommended emission reduction based on cost effectiveness. However, to achieve the actual use of the BRT system is not a matter of ´providing the necessary capacity' (the amount of busses), it entails amongst others good 'feeder' systems, convincing people to change from car use to bus use, reasonable and competitive prices and good security.

There is a need for integrated tickets for all forms of public transport as per the Gauteng Transport MEC's objective of 'One Province – One Ticket'. Public transport projects have not only a large emission mitigation potential, but also make an important contribution to social and economic development. Furthermore, future public transport projects need to complement existing transport modes by providing 'first and last miles' (transport options from residence to public transport stations and last miles to places of work). This could be achieved by improved opportunities for Non-motorised transport (NMT), such as walkways and bicycle lanes, supported by shared bicycle systems; carpooling; promotion and support of cheaper and safer 'uber' type taxis. It is very difficult to stimulate people to share a car and the uptake of carpooling is very slow to start with, but once it has reached a certain amount of users and familiarity, it will increase in uptake. Provincial government should take its part in stimulating this in ways it can. However, national government should

[8] https://www.dbsa.org/EN/About-Us/Projects-2017/Pages/Ekurhuleni.aspx

provide direction in terms of appropriate design standards for safe NMT, particularly bicycle lanes.

Integration of transport planning and spatial development planning, with the aim of creating mutually reinforcing drivers for public transport adoption and urban densification along transport routes, is critical to a spatial and energy transformation. The proper integration of rail and road freight transport would also bring significant mitigation benefits and reduce pressure and maintenance costs of main highways.

The most important intervention is development of mixed residential/commercial areas. Examples of integrated spatial and transport planning, such as the City of Johannesburg's 'Corridors of freedom' should be closely studied, and the successes replicated in more locations.

Further opportunities lie in conversion of the transport system to alternative energies and through adoption of improved (more fuel efficient) and modern technologies. More fuel efficient technologies are expected to become available and used in new vehicles. Following the MPA, it is expected that these new, more efficient vehicles will reduce fuel use and therefore emissions. The potential impact of this intervention is expected to be 2 300 kt CO_2/yr. It is expected that this intervention will be implemented as a result of supply/availability of the new, more efficient vehicles and a demand for new vehicles. The carbon tax is expected to put an add-on tax on petrol and diesel which could result in people more consciously choosing fuel efficient vehicles or new types of vehicles such as electric vehicles.

Electric vehicles offer the opportunity to renew vehicle fleets with technology that use energy more efficiently and potentially run on renewable energy without any compromise in performance. Similar modernisation of rail transport can have similar benefits. If the energy used is sourced from locally produced renewable energy (e.g. solar power), then it will lower the provincial carbon footprint and decrease the provincial reliance on externally sourced energy (a factor that is linked to higher relative vulnerability). Active mobility (e.g. non-motorised transport, electric bicycles or kick bikes) can also be encouraged as a way to avoid carbon emissions altogether.

Text Box: China has the largest electric vehicle charging network in the world

China has built the largest electric vehicle charging network in the world to date, with the highest number of facilities, the broadest coverage, and the most advanced technology. Statistics show that State Grid Corporation of China (SGCC) has built 5 526 charging and battery swap stations and more than 40 000 charging piles since 2006, with a fast-charging motorway network that covers 121 cities in 16 provinces. A total of 167 000 charging piles have now been connected to the telematics platform of the SGCC. The average distance between two stations is less than 50 kilometres.

Source: People's Daily online – http://en.people.cn/n3/2017/0906/c90000-9265487.html

Following the above description of actions undertaken it can be concluded that there is a lot of activity in the transport sector within Gauteng. Most importantly, BRT is rolled out, the carbon tax is expected to make diesel and petrol more expensive and vehicles will become more fuel efficient over time.

The emission reduction target for this sector has been designed based on cost effectiveness of interventions over all sectors combined. In general, emission reduction interventions within the transport sector are relatively expensive and therefore the (initial) target is not that ambitious, especially compared to the activities being undertaken in the sector. However, emission mitigation interventions within the transport sector have a high social value, which should inform the implementation of projects instead of cost effectiveness only.

Therefore, it is recommended that the relevant parties within this sector continue with new types of projects which will function as demonstration projects, just as the first BRT project showed what could be done and was further rolled out. Examples of projects which can be developed as demonstration projects with the goal of further roll out include:

- Active mobility project (a bike lane route in a city centre)
- An electric vehicle fleet for provincial government, supporting municipalities with achieving a fuel switch in their corporate fleet and providing electric charging stations
- Support the establishment of CNG depots/fuelling stations

A further critical aspect to pursue is the optimisation of integrated transport planning – allowing different modes of transport to contribute in the most efficient way, and for transport to support a process of sustainably densifying the urban areas of the GCR. Integrated Transport Planning is a requirement for all planning authorities as per the National Land Transport Act, 2009 (Act 5 of 2009), and allows these planning authorities to align transport planning with spatial development plans, economic development priorities, user requirements etc. Importantly though, these plans should evolve to use full cost accounting to inform the network planning and service specifications – specifically focussing on the atmospheric emissions and GHG footprint of different modes of transport.

PROGRAMME AMBITION	**RESPONSIBILITY**
Outcome 9-1: Emissions reduction of 2 681 kt CO_2e through improved fuel efficiency and investment in public transport systems **Outcome 9-2:** Integrated transport systems at national, provincial and local level that capitalise on the opportunities offered by modernisation and innovations such as mass public transport, renewable or clean energy sources, active mobility alternatives and electric vehicles **Outcome 9-3:** Sustainable transport systems supporting densified and socially just spatial development **Outcome 9-4:** Climate resilient transport infrastructure	Lead: Roads and Transport Support: GDARD, municipalities, Department of Energy, Office of the Premier, Economic Development, Human Settlements **GCR FOCUS** • Continued development of high speed rail links between GCR nodes and wider (including the GCR-eThekwini link) • Coordinated freight transport planning **FINANCE AND FUNDING**

	There is a multitude of sources for funding and financing to support sustainable transport programs, ranging from international funding to local public-private partnerships. The nature of the intervention will determine the financial need.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
Investment in public transport systems, especially mass transit (commuter rail, Gautrain and Bus Rapid Transit) along major corridors in urban areas and their integration	**Eco QoL GHG**	280	<5	Completion and operationalising of BRT systems and modernisation of rail systems as planned. Focus on achieving the planned amount of travellers.	Gauteng Department of Roads & Transport, PRASA, Transnet, Gautrain, Roads & Transport, Municipalities	IDC DBSA UNIDO Private equity
Improved fuel efficiency	**Eco GHG**	2 320	<5	Inclusion of increasingly fuel-efficient vehicles such as electric and hybrid, or LPG/CNG-fuelled vehicles, in all government fleets	Private sector, PRASA	
Innovative demonstration projects, such as: - Electric vehicle fleet (provincial government and/or municipalities) - Non-motorised transport, e.g. a bike lane in a city centre - CNG depots/ electric car charging stations	**QoL Eco GHG**	Unknown	<5	Develop at least 1 innovative demonstration project by 2022.	Gauteng Department of Roads & Transport, Municipalities, Innovation Hub & CSIR	
Improved inter-city and inter-provincial railway services	**Eco QoL GHG**	Unknown	<5	Continuation of rail modernisation programme	PRASA, Roads & Transport, Municipalities	

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
Traffic reduction measures	**Eco QoL GHG**	Unknown	<5	Travel Demand Management programmes in all Metros by 2022, including NMT, carpooling and car sharing	GDARD, Municipalities	
Compressed Natural Gas (CNG) as alternative fuel	**Eco GHG**	79	<5	Scale-up of pilot projects to commercial level – at least one major PPP scheme by 2022	Gauteng Department of Roads & Transport, Municipalities	
Smart controls for transportation and logistics	**Eco QoL GHG**	N/A	<5	Incorporation of smart controls in transport infrastructure design plans for all Metros by 2022	PRASA, Roads & Transport, Municipalities	
Revised infrastructure standards that accommodate climate change risks over the lifetime of the structures	**QoL DRR**	N/A	<5	Climate change to be referenced in the design standards for all transport infrastructure services authorities by 2022	PRASA, Roads & Transport, Municipalities	DBSA MIG Urban Settlements Development Grant Public Transport Infrastructure and Systems Grant
Life cycle cost assessments that recognise climate risk	**Eco QoL DRR GHG**	N/A	<5	All major new infrastructure projects to be subject to life cycle cost-benefit analysis that includes social and environmental costs	Gauteng Department of Roads & Transport, Municipalities	

6.10 Response programme 10: Waste Management

Solid and liquid waste is generated through human activities, mostly in the form of unwanted or hazardous materials and liquid effluent. The production of waste materials necessarily imply GHG emissions, as does the process of disposal or the natural decomposition thereof. The accumulation of waste in the environment also contributes to a compromised living space where situations force people to co-exist with waste, thereby affecting their general state of health and vulnerability.

In total, waste related emissions result in 9 164 tCO_2eq. This is about 5% of the total provincial emissions. Much of it is generated through the decomposition of biodegradable waste in landfills that produces landfill gas comprising 60% methane (CH_4) and varying concentrations of carbon dioxide, water vapour, nitrogen, hydrogen sulphide and other contaminants. When released, these gases contribute to global warming. CH_4, in particular, is of concern, as its Global Warming Potential is 28 times stronger than CO_2. The recovery of landfill gas can therefore contribute significantly to emissions reductions, and since CH_4 is a viable source of energy, the process of gas recovery can be made cost-efficient.

Many examples exist of viable gas recovery projects, including on all the major landfills in Gauteng. Typically, private entities would invest in the gas generation and recovery infrastructure, sometimes within the scope of Public-Private-Partnership agreements. The gas may be used as is, or converted to electricity for distribution via the established municipal or national grid. In Bronkhorstspruit, for example, a 4.6 MW facility is converting organic waste to electricity for use in the BMW manufacturing facility in Rosslyn, and several landfill sites in Ekurhuleni and Johannesburg are being tapped for landfill gas recovery.

Further emission reduction is possible by diverting waste from final disposal through the recovery and re-use of materials. When waste materials are re-used, it implies a nett reduction in the amount of raw materials required and consequently a positive environmental effect. This could extend to a reduction in overall energy use and less impact on natural biomass, both of which reduces the overall GHG footprint. Waste recovery can also be linked to socio-economic upliftment schemes as it often involves labour or activities that do not require specialised skills or qualifications, which would reduce the vulnerability of marginalised people.

The Gauteng Department of Agriculture and Rural Development is responsible for provincial integrated waste management. This responsibility entails amongst others (DEA, 2012):

- Reviewing first-generation IWMPs received from municipalities and where necessary, assisting with the drafting of these;
- Developing provincial guidelines and standards;
- Developing and enforcing provincial regulations for general waste collection, and supporting local government in the implementation of waste collection services;
- Implementing and enforcing waste minimization and recycling initiatives, and in particular, promoting the development of voluntary partnerships with industry;

Following this mandate, the GDARD could support continued landfill gas capture and use at existing (legacy) landfills. A priority action would be the commissioning of a study to identify landfills where gas capture and use is financially feasible based on the gas potential and general condition of the landfill. Private companies will require this information to take investment decisions. Secondly, provincial government can also develop regulations which makes it required that where it is proven to be financial feasible, landfill gas is captured/utilized. This will give municipalities an incentive to partner with private companies (for technology and financing) and give access to the municipal electricity grid to feed the produced electricity into. Note that this is a short-term intervention with limited long-term potential, as progressively the disposal of waste to landfill will be reduced to an insignificant amount.

As a longer-term strategy, GDARD can partner with municipalities to improve the collection and disposal/use of different waste streams and promote alternative treatment options. For example, by developing by-laws which require citizens to separate organic waste, paper and possible other waste streams such as glass and plastics. This should ideally be managed on a municipal or sub-municipal level, as this will improve the efficiency of collection and establishment of processing sites. In its engagement with municipalities, GDARD could promote improved waste separation uptake in the IWMPs. Health Care Risk Waste can also be considered as a specific sector where a range of alternative treatment options could contribute to reduced GHG emissions.

Waste-to-energy plants should be considered as an alternative to new landfill capacity. This is a controversial issue and should be approached with the necessary sensitivity, as the question arises whether waste can't be used in better ways than for energy production. However, based on the general issues related to landfill management (the number of unlicensed landfills in South Africa and the difficulty of containing waste and effluent), it is possible that at this point in time waste combustion is a better option than landfilling. Such plants should, however, only combust waste which can't be recycled (from a financial or technical perspective). Provincial Government could drive this development through the development of provincial regulations which forbid the establishment of new landfill sites unless other alternatives have been exhausted. Provincial Government could also partner with municipalities in this activity by requesting uptake of waste-to-energy plants in the IWMPs and support with the development of projects. Furthermore, SALGA and municipalities should to analyse successes and challenges of Waste-to-Energy proposals and projects on Waste Water Treatment Technologies and come with recommendations on selecting appropriate scales and technologies.

As mentioned in the different waste management projects described above, an important role is envisaged for the private sector. Apart from developing waste-to-energy projects the private sector has a significant role to play in complying with mandatory industry waste management plans. This entails amongst others the diversion of waste to landfill and supporting recycling.

The Gauteng Industrial Symbiosis Programme, a programme coordinated by National Cleaner Production Centre with GDARD support, has made significant contribution in diverting industrial waste from landfills for use in other industrial processes..

PROGRAMME AMBITION	RESPONSIBILITY
Outcome 10-1: Emissions reduction of 4 489 kt CO_2e through energy recovery from landfill and waste reduction	Lead: Municipalities, GDARD Support: DEFF, Economic Development, Department of Energy, NERSA
	GCR FOCUS • Cross-border sharing of skills and knowledge
	FINANCE AND FUNDING Financial institutions and private sector financing are likely to associate with waste-to-energy projects, whereas incentive schemes (funding) would support sustainable waste policy action.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
Landfill gas (LFG) flaring, or capture and use	**Eco GHG**	3 114	<5	Operationalised LFG recovery at all landfills where this has been found to be financial feasible by 2022	GDARD, Municipalities, IPPs, NERSA	IPPs
Projects for waste avoidance, recycling, reduction and reuse and strengthening of the regulatory framework. Examples of these projects: - **Composting (including home composting)** - **Paper recycling** **Urban litter management**	**Eco QoL GHG**	985	<5	Waste reduction programmes and by-laws for waste separation in place in all municipalities by 2022	GDARD, Municipalities, Districts, private sector	Private equity, Donor funding

Municipal Solid Waste to energy conversion plants. It is important that only waste that can't be recycled is combusted for energy generation. Waste products such as metals, plastics, paper, glass and organic waste should be extracted from the final waste fraction to optimize the environmental benefit of these projects.	**Eco** **GHG**	391	<5	Two commercial scale energy production facilities other than landfill gas recovery systems by 2022	GDARD, Municipalities, IPPs, NERSA	National DFIs (e.g. IDC) Banks
Industrial Symbiosis Program (ISP) - Reduction in industrial waste deposited in landfill sites and reduce costs on waste management. Total tonnes of waste diverted from Land fill sites (solid effluent & Pollutants) through ISP	**Eco** **GHG**		<5	Conduct 10 ISP waste assessments for participating companies by 2021.	NCPC (Co-funded by GDARD)	Private sector

6.11 Response programme 11: Health

Human health is determined to a great extent by the quality of our surrounding environment. Under compromised living conditions people are more likely to be exposed to disease vectors or climatic stress, and less likely to be in an economic position to manage the effects on their health. Increased temperatures in the GCR are likely to change the ranges of certain diseases, in particular waterborne diseases such as cholera and diarrhoea, and lead to increased heat stress. When such exposures are combined with low adaptive capacity, then increased mortality and morbidity could result. Groups with low adaptive capacity includes (DoH, 2019a):

- Infants and children under 5
- The elderly
- Women- and child -headed households
- Those with pre-existing health conditions – priority health conditions, including mental health conditions
- The poorest in urban and remote rural areas
- Those performing work in sun-exposed conditions including those living and working in the hottest parts of the country
- displaced people and those living in informal settlements
- Inmates in prisons
- Outdoors sports people
- Learners in container class rooms;
- Patients and personnel at container clinics
- Over-crowding in class-rooms
- People with disabilities

Wichmann (2017) shows that the general population has an increased risk of death with extreme temperatures, with the elderly at significantly more risk. Other activity (e.g. working in hot or sun-exposed conditions) and location-specific (e.g. areas with low tree cover or exposed to the urban heat island effect) factors also contribute to health-related vulnerabilities. A final key determinant is access to and availability of skilled medical personnel and facilities.

The health effects of climate change are therefore determined by a complex interplay of contextual conditions, physical factors and local health systems (DoH, 2019b) and should therefore be considered alongside other indicators of vulnerability.

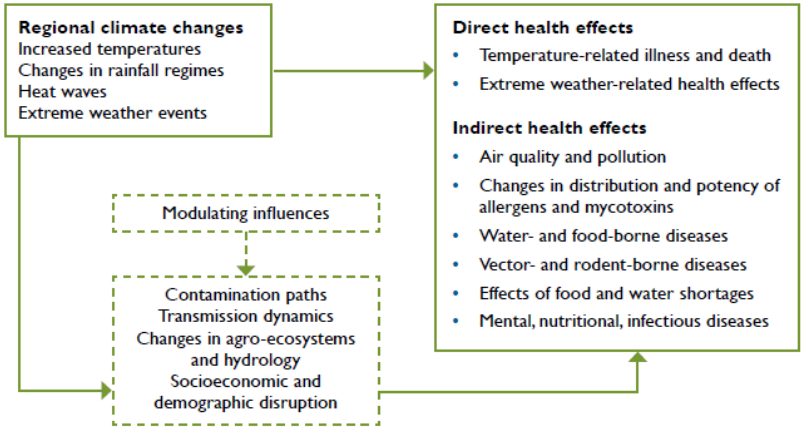

Figure 23: Direct and indirect health effects of climate change (Redrawn from World Health Organization, online at: WHO Climate Influences) (Davis, 2011)

The draft South African Health Sector Climate Change Adaptation Policy Framework (DoH, 2019a) warns about the following specific climate change linked health risks that can lead to overburdening of health systems, increased mortality, injuries, mental health illness or deterioration of pre-existing health conditions:

- Heat stress and resulting increased death rates from heart and respiratory diseases
- Burns linked to increased fire intensity and frequency
- Natural disasters that increase fatalities or injuries, including secondary and delayed onset consequences
- Exposure related to poor housing or living conditions, and insufficient access to basic services
- Diarrhoeal diseases because of contaminated water or lack of access to clean water
- Increased ranges and transmission seasons for vector-borne diseases such as Yellow Fever, Malaria, Chikungunya and Dengue Fever spread by mosquitoes, or tick borne diseases such as Lyme disease
- Increased respiratory illness due to exposure to ozone that forms due to methane emissions, or particular matter loads from fossil fuel burning processes

To reduce the overall risk, response measures need to work towards improved living conditions, universal, community level health care, much better disease surveillance (with some focus on climate change effects) and overall better control over disease control and outbreaks. This will require synergies between initiatives aimed at climate change response and public health.

It is also important to note that through joined mitigation of GHG emissions and general noxious air pollutants, for example through a reduction in emissions from fossil fuel burning, the reduction of overall health risk is greatly increased. Even seemingly unrelated mitigation actions can reduce people's sensitivity to health related risks, such as investment in NMT that encourages healthier lifestyles.

PROGRAMME AMBITION	**RESPONSIBILITY**
Outcome 11-1: Emphasis on disaster risk reduction and disaster response in informal settlements and poor urban and rural communities, especially during extreme weather events	Lead: Health Support: Human Settlements, Social Services
Outcome 11-2: Awareness raising on the importance of climate adaptation and involvement of affected communities in the planning and implementation of adaptation measures	**GCR FOCUS** • Cross-border sharing of skills and knowledge, joint health crisis response
Outcome 11-3: Integration between the health sector, disaster response services and the human settlements sector	**FINANCE AND FUNDING**
Outcome 11-4: Increased community health worker / NGO capacity	

	Government supported funding is the primary funding platform, but international adaptation funding may also be accessed for defined projects.

PRIORITY PROJECTS	IMPACT	MITIGATION TARGET ($kt\ CO_2e$)	TIMEFRAME	TARGETS	ROLE PLAYERS	FINANCE
1. Capacitation of the community-based Primary Health Care system	**QoL DRR**	N/A	<5	On-going implementation of Primary Health Care plan	Department of Health (DoH), Social Services, Municipalities	
2. Participate in National vulnerability and health system assessments or alternatively initiate Provincial programme	**QoL DRR**	N/A	<5	Annual vulnerability and health system assessments, either as part of National programme or as Provincial programme	DoH	
3. Generate surveillance data for climate-sensitive risk factors and diseases	**Eco QoL DRR**	**N/A**	**<5**	**Annual reporting on climate-sensitive risk factors and diseases**	**DoH, Medical Research Council**	

7 Critical projects for 2019/20-2024/25

7.1 Government projects

7.1.1 The role of Provincial Government

To follow through on the commitment to a more sustainable and more resilient economic system and social environment, the Gauteng City Region needs to commit to making social and physical transformation concrete on different levels of the social fabric and at different spatial scales, but within the scope of existing financial limitations. The intended outcomes should be a radical creation of an enabling environment and physical space along with a changing public mind-set.

There is a range of different roles provincial and municipal entities could take on in response to climate change. It is, however, particularly important that where government entities are identified as lead agents, they determine an appropriate role in a broader response programme but also on a project type level. The table below shows an overview of possible roles:

Table 16: Possible roles for government in climate change responses

Role	Instrument(s)	Goal (what can be achieved)	Affected sectors and parties
Leading by example	Ownership	Investment in more sustainable, lower carbon assets (buildings, vehicles, infrastructure, public lighting)	Government, contractors, suppliers
Partnering	Collaboration, finance and risk-sharing, ownership	Commitment, feasibility and realization of energy projects, better public-private relations, reduced vulnerability	Developers, real estate owners, government
Providing the right framework/conditions	Legal and (spatial and transportation) planning policies	Less constraints to develop renewable energy and sustainable transport projects	Developers, local government
Stimulator	Subsidies, targeted procurement, opportunities to innovate/ experiment	New possibilities to develop and invest in mitigation and adaptation measures (innovation and implementation)	Developers, companies, government
Spreading the message	Communication, campaigns,	Awareness and good will among citizens (support)and	Companies and citizens

Role	Instrument(s)	Goal (what can be achieved)	Affected sectors and parties
	knowledge exchange	companies (commitment)	
Regulation and enforcement	Legislation, control, check on implementation	Minimum environmental standards	Companies and citizens
Coordinator	Networking at the national and local level, information /data management	Connecting stakeholders and avoiding constraints and contradictions in policies	Government

The coordinating role of provincial government has been acknowledged in the draft of Climate Change Bill gazetted for comments (DEA, 2018). In section 8(9) it requests that "*A Provincial Committee on Climate Change is hereby established for each province in the Republic, which must be comprised of all relevant departments in a province and all Mayors of municipalities located within a province*". Therefore this intervention is prioritised and included as a priority action. It is further suggested that this committee is supported by the Office of Premier and MECs responsible for Environment and mayors of municipalities within GCR are invited as well. The regional rather than pure provincial coordination will help to ensure that work done in the Gauteng province can lead and support government interventions within the GCR, and that regional opportunities for economic transformation are realised.

7.1.2 Priority projects

The prioritised projects for response programmes driven by government bodies are summarised in the table below. Detail panning of projects, including detail of staffing, funding and scale, must be done as part of existing government planning and budget cycles.

Table 17: Prioritised projects for provincial government

Response programme	Project description	Intervention type	Lead Department
Natural Resources	Review and implementation of biodiversity management plans and incorporation of results into development planning to achieve an increase in biomass, specifically through mesic grassland restoration and increased tree cover	Adaptation	GDARD
Agriculture and agro-processing	Farmer support – community level farmer training programme (conservation agriculture and ecosystem protection) and capacitation of extension officers for	Adaptation	GDARD

Response programme	Project description	Intervention type	Lead Department
	institutional support to improved land care		
	Support structural adjustments to agricultural systems – from product selection to processing facilities e.g. shift to heat tolerant crops and livestock breeds, including indigenous variants and species (e.g. antelopes replacing sheep and cattle) and aquaculture	Adaptation	
Disaster Risk Reduction and Management	Review and enhance early warning systems for: - Agriculture - Flooding and fire - Heat waves	Adaptation	Gauteng DRM Centre/COGTA
Water security	Research, pilot and implement Sustainable Urban Drainage Systems (SUDS) and Ecologically based Adaptation (EbA) approaches to stormwater management	Adaptation	GDARD
Buildings	Implement Gauteng Green Building Policy and MTSF target "To ensure that 50% of existing and new buildings have been built or upgraded using green technology by 2018/19". The implementation plan and functional M&E system should be completed by 2019 and annual reports on progress provided.	Mitigation &Adaptation	GDID
Human Settlements	No encroachment onto floodplains, protection and expansion of high value open spaces (use EIA, SDF and EMF, C-plan and bioregional plans)	Adaptation	GDARD
Health	Generate surveillance data for climate-sensitive risk factors and diseases	Adaptation	Health
Energy Supply	Identify financial models and funding mechanisms and support systematic implementation of wind and solar energy generation projects under 1	Mitigation	Energy office/ COGTA

Response programme	Project description	Intervention type	Lead Department
	MW and small-scale embedded generation		
Industry and mining	A sector support programme for Cleaner production processes for industry, including: - Best practice for primary aluminium smelting - Process integration - Best available production techniques - Bio-carbon reductants	Mitigation	Innovation Hub/GDED
Transport	Investment in public transport systems, especially mass transit (commuter rail and Bus Rapid Transit) along major corridors in urban areas and their integration	Mitigation	Gauteng Department of Roads & Transport
Waste	Projects for waste avoidance, recycling, reduction and reuse and strengthening of the regulatory framework	Mitigation	GDARD
Research	Vulnerability mapping using increased resolution and improved accuracy of climate change projections and localised contextualisation of impacts to ensure relevance and practicality, such as including information on vegetated areas for mapping heat stress impacts and provincial flood line data for mapping risk of flooding	Cross-cutting	GCRO
Green Procurement	Development of green procurement guidelines for Gauteng provincial departments (including a pilot)	Cross-cutting	GDARD
Governance/M&E	A Provincial Committee on Climate Change is established and MECs and Mayors from the GCR (including outside of Gauteng province) are invited to realise regional economic opportunities of leapfrogging to climate smart economy	Cross-cutting	Office of the Premier
	Update and enhance the Gauteng Climate Change register to be		GDARD

Response programme	Project description	Intervention type	Lead Department
	incorporated as provincial module in the National Climate Change M&E system		

7.2 Private sector actions

The below described interventions have been identified as the most important actions to be taken by the private sector in response to climate change. This has been selected, as for the government priority interventions, based on mitigation potential, cost effectiveness and additional benefits.

1. **Sourcing or generating renewable energy** will have the largest mitigation impact for most companies. Apart for the large emission mitigation potential, renewable energy and renewable energy technologies are becoming increasingly cost effective. Depending on the type of renewable energy and also the amount of energy and when this energy is used (off-peak or peak) renewable energy can be competitive with purchased energy, especially when taking future expected increases into account. Private companies can make the move from fossil fuel based energy to renewable energy in multiple ways;
    a. Purchase renewable energy from an independent power producer – the energy is generated elsewhere and 'wheeled' via the national or municipally operated grid
    b. Purchase renewable energy from an independent power producer which constructs its power plant on-site and makes use of the renewable energy sources available at the company's premises. The generated energy is distributed via a private (mini) grid to the company
    c. Generate own renewable energy. The company procures technology and installs a renewable energy generating facility by itself. The generated energy is distributed via a private (mini) grid to the company. Many large companies already installed solar PVs to minimise their electricity bill. The analysis by one of the major banks showed that recovery cost of such installations is around 5 years. Link to action 7 below.
2. **Change to energy efficient technology**: as found in the Mitigation Potential Analysis (DEA, 2014c), the potential for use of energy efficient technology in the private sector is very large and mostly with negative costs (cost savings). However, this does require investment and in some cases a write-off of earlier investments. It is recommended that private companies investigate the potential of changing to energy efficient technology within their company and look for funds specifically for these kinds of projects. The National Cleaner Production Centre of South Africa (NCPC-SA) has been running the Industrial Energy Efficiency (IEE) Project and have excellent support mechanisms.
3. **Energy efficient fleet**: private companies should, when replacing vehicles, focus on procuring energy efficient vehicles. This could include hybrids, dual fuel vehicles and electric vehicles for short-duration trips (which also comes with lots of promotional value).

4. To stimulate the **uptake of energy efficient building interventions and renewable energy, insurance and financial institutions providing bonds could offer preferential conditions when** solar water heaters, solar panels and roof/ wall insulation are purchased.
5. **Awareness of staff**; by campaigns on good practices at the company and at home.
6. **Waste management** – the private sector has a significant role to play in terms of the diversion of waste from landfill and supporting recycling infrastructure.
7. **Upscaling of industrial precinct planning** is needed which will move industrial centres close to the sources of employment, based on sustainability principals as promoted by the Green Building Council of South Africa (https://gbcsa.org.za/certify/green-star-sa/sustainable-precincts). The example of such precincts is the Tshwane Automotive City. Each precinct should attract an IPP to provide RE with tariffs lower than Eskom.

7.3 Cross cutting projects

7.3.1 Green procurement

The use of **existing procurement processes to promote sustainable products and buildings, by applying green procurement based on life cycle approach.** Government spending could stimulate a transition in the use of more sustainable products and services, by redirecting procurement towards more sustainable alternatives. It addresses SDG target 12.7 "Promote public procurement practices that are sustainable". One of the most significant impacts can be achieved by greening procurement for the infrastructure. Although there is some awareness with regard to sustainable government buildings, but still the majority of the buildings used by government (including rented buildings) are far from being sustainable. The progress in achieving GDID objectives in greening new and upgraded buildings (as described in section 7.5 above) needs to be reviewed. The Western Cape Province with support of the provincial treasury made significant progress in promotion of green procurement, including development of a guidebook for supply chain managers (WWF, 2018). In consultation with Provincial Treasury, the GDARD will develop Green Sustainable Procurement Guideline, facilitate interprovincial knowledge sharing, including identifying 'quick wins' and training of supply chain managers in selected provincial departments (preferably starting with GDID) for implementation of green procurement.

7.3.2 Research & Awareness

The required research is listed in Section 6 and current joint research on the socio-economic climate vulnerability mapping is described in Section 6.6.1.

The climate change awareness and capacity building interventions are also listed in Section 6, and included in all response programmes as more targeted awareness campaigns are required in each sector.

Furthermore, since 2018 different types of campaigns have been introduced by the GDARD:

- Annual Indaba
- School Awareness Campaign
- A Low Carbon Transport Initiative (in October transport month)

- Campaigns by Air Quality and Environmental Empowerment Directorates which include elements of Climate Change.

Those are supplemented by articles in internal and external media channels.

7.4 Monitoring and Evaluation

The NAS points out that "*There is a significant difference between an M&E system and a data collection, synthesis and reporting system. The M&E system is an analytical and experiential process, while the data collection system is an information management tool*." (DEA, 2019). 'M&E' refers to 'Monitoring and Evaluation', specifically in this case referring to the process of collecting data about the implementation of climate change responses and then improving the responses based on what an understanding of the data dictates. Monitoring of climate change responses at the provincial and municipal levels in the GCR therefore need to generate information on the progress of implementation, and also use the information to inform adjustments to the response actions. For example, if 'monitoring' finds that progress with emissions reductions is too slow, the 'evaluation' process should recommend increased efforts in specific sectors or at different scales.

The reporting of data on climate change responses is not only of value to the entities collecting the information, since nationally there needs to be collation of information for the purposes of national-level reporting against international commitments for climate change mitigation. It also provides an opportunity for shared learning, with information on both successes and failures providing valuable insights into how responses should be tailored to different situations and contexts.

As non-Annex I party to the UNFCCC, South Africa is required to measure and report on efforts to address climate change and the actual impacts of these efforts. This includes measurement of GHG emissions and the reduction thereof, the effects of specific mitigation actions, as well as the support received and still required (UNFCCC, 2014). Although this is mostly aimed at tracking national mitigation efforts, the four-yearly National Communication reports and Biannual Update Reports have to include a section on adaptation programmes and description of financial, technical and capacity-building needs (UNFCCC, 2014).

The National Communication reports must contain formation on five elements (UNFCCC, 2014):

- National circumstances and institutional arrangements
- A national greenhouse gas inventory
- A general description of steps taken or envisaged to implement the Convention, including programmes containing measures to facilitate adequate adaptation to climate change and programmes containing measures to mitigate climate change
- Other information considered relevant to the achievement of the objective to the convention
- Constraints and gaps, and related financial, technical and capacity needs identified

The Biannual Update Reports are very similar and in terms of reporting on mitigation actions and their effects, need to describe the mitigation actions, the implementation process, the applied methodologies, the anticipated and achieved outcomes, as well as the actual estimated emissions reductions.

Gauteng has a Climate Change Project register, based on the extract from the National Climate Change Response Database (NCCRD), which records all projects that has been carried out or planned within Gauteng. These projects includes all types of climate change interventions – mitigation, adaptation and cross-cutting. It is updated based on information provided at the Gauteng Climate Change Forum and collected through bilateral discussions between GDARD and other government and private sector organisations. The projects recorded in the Gauteng Climate Change Project Register will be integrated into the provincial module of the online National Climate Change Information System.

7.4.1 Monitoring emissions and mitigation responses

National GHG emissions reporting is informed by the National GHG Reporting Regulations Number 40762 promulgated on 3 April 2017 under National Air Quality Act, 2004. The main objective of these regulations is to introduce a single national reporting framework for the reporting and dissemination of information related to GHG emissions. Reporting of this GHG data will be done through the National Atmospheric Emissions Inventory System (NAEIS) managed by the South Africa Weather Service. Whilst the NAEIS is being customised to accommodate the reporting requirements of the GHG Reporting Regulations, DEFF is recording emissions from 595 facilities that meet the reporting thresholds specified in the regulations on an offline database (DEA, 2017).

M&E responsibilities of provincial government

To determine the success of its programmes and strategic interventions, provincial government requires information on;

1. Actual emissions and;
2. The impact of mitigating activities

GHG emissions

The current national GHG emission target, which is also translated to a provincial target, is a ‘fixed level goal’; absolute emission levels have been defined for target years. In this action plan, these fixed level goals have been compared to base year emissions in 2010 and to future emission scenarios. To track whether the province is going to achieve the set goal, it is recommended that provincial government determines its carbon footprint at least every 2 years following a combination of a bottom up and top down approach:

- **Bottom up approach**: it is recommended that provincial government requests GHG emission data for Gauteng from the South African Weather Services as reported in the SAAQIS database. This information is expected to cover most significant emissions taking place within the boundaries of the province. The following data sources which are required to calculate a complete GHG inventory are expected to be missing:

    - Emissions from ‘small scale’ fuel use in the commercial, residential, industry and energy sector. The threshold value for reporting in these sectors is 10 MW_{th} and emissions reporting is linked to declarations for the purposes of the Carbon Tax. This is not expected to be significant.
    - Emissions from private transport. This is expected to be a significant source of emissions which is not included.
    - Emissions caused by electricity use within the Gauteng province but which is generated outside of the boundaries of the province.
- **Top down approach**: to account for the emission sources which are expected to be excluded when using the emission data collected in the SAAQIS database, it is recommended that provincial government also calculates its carbon footprint following a top down approach. This top down approach is based on economic activity and explained in detail in Annexure A to this action plan. Using this approach, the emissions from transport and electricity use within the province can be calculated. The emissions from industry can also be calculated and used to compare the results from the SAAQIS reported emissions by industry. If needed, corrections can be applied.

Mitigation actions

The actual emissions inventory is used to determine whether provincial government is going to achieve its fixed level goal of between 139 and 215 $MtCO_{2eq}$ by 2025-2030. However, it is very important to know the impact of mitigation actions, as emissions might have developed in a different way than expected, for example due to increased industrialization, disruption of existing emission reducing incentives and economic growth. To determine the success of programmes and interventions, and also to obtain insight into why (fixed level) mitigation goals are or aren’t being achieved, provincial government needs to compare the anticipated policy impact (difference between ex-ante baseline emissions and anticipated emissions under policy directives) to the actual emissions trajectory (actual evolution of ex-post baseline scenario vs. ex-post observed emissions). This approach of reconstructing ‘baseline emissions’ has been developed by the World Resources Institute and is increasingly used to determine the success of interventions. The national GHG trajectory of PPD to be used in this methodology is specifically mentioned in assessment of the proposed Climate Change Bill (Department of Planning, 2017)

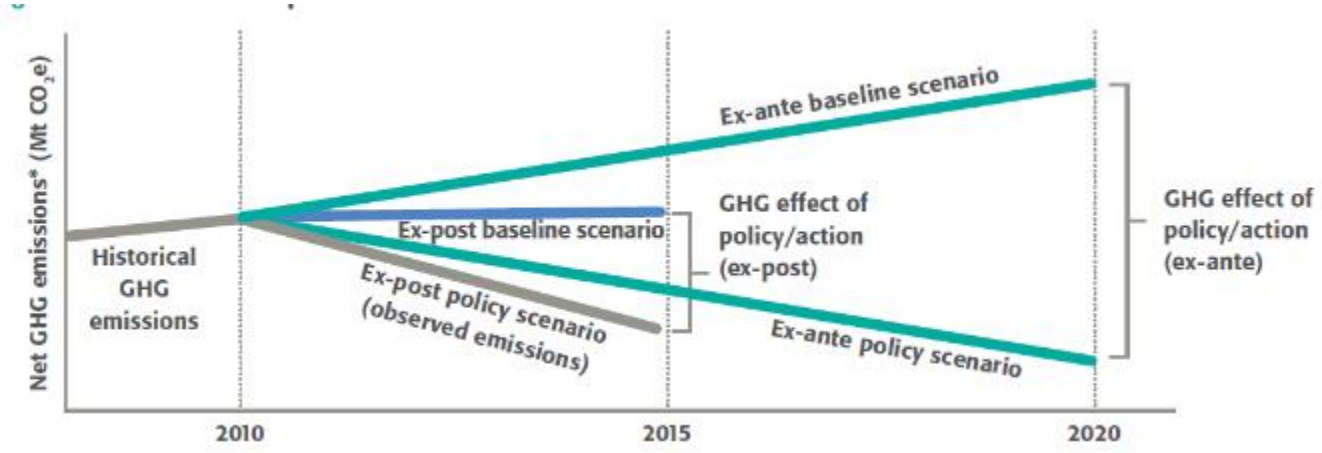

Figure 24: Determining the GHG effect of policies and actions (Source: the 'Policy and Action Standard' (WRI))

To evaluate impact of mitigation actions the use of indicators based on readily available data should be considered. For example, since accurate GHG data in transport sector is difficult to get within provincial boundary (particularly because Gauteng crossed by a number of major national and international highways utilised by both, passenger and freight transport, outside of province) it is suggested that number of private cars/population and GCRO's Quality of Life Survey data on modal split could be used to indicate progress in shifting from private to other forms of transport.

Apart from providing context to the emission profile of the province, the information on mitigation actions is required by national government as part of national and international reporting requirements.

Developing a provincial M&E system

In addition to the recommendations given to improve actual emissions and mitigation actions tracking some specific M&E system components that will enable and facilitate a coherent reporting process are:

- Assigning of responsibility to a competent unit within GDARD and rate performance through existing performance management processes
- Developing set of SMART indicators for monitoring progress in implementation of this Strategic Plan
- Quarterly or annual data collection and analysis
- A centrally coordinated database
- Annual reporting
- Dissemination and public release of reports

7.4.2 Monitoring of adaptation responses

Arguably, reporting on mitigation interventions is much easier that adaptation, mostly due to the qualitative nature of adaptation action impacts and the long timeframes over which the adaptation responses find effect. Other difficulties in monitoring and reporting for adaptation include (Bours, McGinn, & Pringle, 2013):

- Uncertainty about the nature, scale and spatial variability of climate change effects that translate into uncertainty about the impact of adaptation measures
- Constantly changing contexts and situations
- The need to measure slow onset climate change and non-events
- The inappropriateness of universal indicators
- Differentiating between, or defining, contribution, attribution and additionality
- Disagreement over definitions and terms

In general, to overcome these difficulties, a monitoring system needs to be flexible enough to adjust to changing circumstances and to effect iterative improvements over time. It should therefore start with clear definitions of intended or envisaged outcomes that will be used as reference, and against which progress can be measured. These outcomes naturally need to be framed as effects that create socio-economic and social-ecological resilience in the face of shocks and that steer broad development trajectories in appropriately sustainable directions (Bours, McGinn, & Pringle, 2013). The outcomes also need to be matched to temporal and spatial scales, made relevant to specific entities involved or interested in either the implementation or measurement actions.

Due to the long time period over which effects will be seen, and sometimes long lead times, measurement of process rather than outcome will be important. This implies that specific procedural indicators of progress need to be identified that will show that the roll-out of the adaptation actions are in fact on course.

This should also be matched to reporting that aims at early detection of maladaptation or unintended consequences. Should problems be identified, the process can be adjusted in time to avoid bigger problems. Necessarily this, and the need to adjust the monitoring, reporting and evaluation system to changing administrative contexts, mean that a reflective system is required that can be adjusted and improved over time as conditions and circumstances dictate.

Central to monitoring and reporting of climate change adaptation responses is the tracking of general progress towards achieving the adaptation outcomes identified in this overall climate change response strategy. Appropriate indicators for the different outcomes would need to be identified as guidance for the reporting process. These indicators, as suggested in the response programmes, are at first likely to relate to process steps and system components rather than actual outcomes, given that the adaptation outcomes are difficult to relate directly to intervention actions and only manifest over long time periods.

Nevertheless, overall progress must also be measured and reported on through the DAOs identified in Section 4 of this strategy as part of an overall, standardised, national M&E system for adaptation responses. In the context of this action plan, the monitoring must focus on understanding the progress made by Gauteng province towards achieving Gauteng Adaptation Outcome (a resilient, low-carbon economy, improved human well-being, functional ecosystems and reduced disaster risk) for each of the prioritised response programmes. The evaluation component will focus on understanding the effectiveness of responses.

A table provided as ANNEXURE D: Adaptation Monitoring and Evaluation through tracking of DAO summarises how the monitoring and evaluation will be undertaken for each of the prioritised response programmes in Gauteng. **Where possible the data and indicators used**

for the Gauteng Environmental Outlook will be used for main adaptation response programmes which overlap significantly with the sectors in the Outlook.

7.4.3 Integration of Reporting Systems

Proper monitoring and reporting of climate change mitigation and adaptation data requires a coherent system of data collection within the National, Provincial and Municipal administrative structures. However, it need not result in new structures being created or more onerous reporting requirements being imposed. Instead, existing monitoring and evaluation arrangements should be used as far as possible.

A range of relevant reporting mechanisms identified for possible relevance to a climate change response plan include:

- National Climate Change Response database (NCCRD). It is supplemented by Gauteng Climate Change Projects Register established by GDARD.
- SA Response and Vulnerability Atlas (SARVA) which will incorporate NCCRD.
- Monitoring and evaluation taking place in the offices of the Premier or Mayors, tracking service delivery related planning and performance – with specific emphasis on the Service Delivery and Budget Implementation Plan (SDBIP) and Built Environment Performance Plan (BEPP) reporting that, from 2018 onwards, require reporting against a number of climate change and resilience indicators. This includes (National Treasury, 2017):
    - EE4.11 Total renewable energy capacity available through IPPs
    - EE4.12 Installed capacity of embedded generators on the municipal distribution network
    - ENV6.1 GHG emissions per capita
- MTEF and Annual Performance plans by provincial and national government.
- Data collection and reporting by StatsSA – such as the Community Surveys and census programme. It is supplemented in Gauteng by the Quality of Life survey of the GCRO.
- The South African Air Quality Information System (SAAQIS) and National Atmospheric Emissions Inventory System (NAEIS).

Annual Integrated Development Plans (IDP) can be used to monitor the planning processes of local government. GDARD piloted Climate Change IDP review tool to assess the level of mainstreaming of climate change into municipal IDPs. It helped with the consistent quantitative and comprehensive analysis which resulted in giving each IDP a score that could be tracked spatially across province and temporally. This tool was reviewed and incorporated in a wider Gauteng IDP Environmental Toolkit used by GDARD for the annual IDP evaluation and available on request.

The National Waste Information system supplemented by the Gauteng Waste Information System (GWIS). GWIS is governed by the Gauteng Waste Information System Regulations which provides information relating to waste management facilities, quantities of waste produced and transfer of waste within the province and between other provinces. These systems can be progressively improved to the point where it also complies with IPCC requirements for the calculation of waste related GHG emissions.

There are a number of existing international external reporting systems specifically aimed at tracking climate change response related data, such as carbon emissions declarations (The C40 Climate Risk and Adaptation Framework and Taxonomy (CRAFT) reporting framework, Carbon*n*, The Carbon Protocol of South Africa, Carbon disclosure project (CDP) or reporting to the UNFCCC). The National Business initiative (NBI), which is responsible for the CDP reporting is also reporting to the UNFCC on "We Mean Business" partnership which showcasing best practice examples of climate action from within South Africa. There are also monitoring systems of development organisations and NGOs on mitigation and adaptation projects they've supported (UNDP, GEF, GCF, UNDP, WWF, etc.).

Local government and NGOs using international reporting standards to access climate change finance and technical support. These reports need to be reviewed to identify the projects in Gauteng and the ways of integrating their information into the Gauteng Climate Change Register.

The National Climate Change M&E Information System is likely to become a key structural element in this field, as it will set the overall standards for national reporting of emissions and adaptation outcomes. The system is envisaged as a web-based platform that collates data from a range of sources for the purpose of specific reporting formats[9]. Ultimately the information will populate the national Climate Change Report, UNFCCC reporting, GHG Inventory and others (see Figure 25).

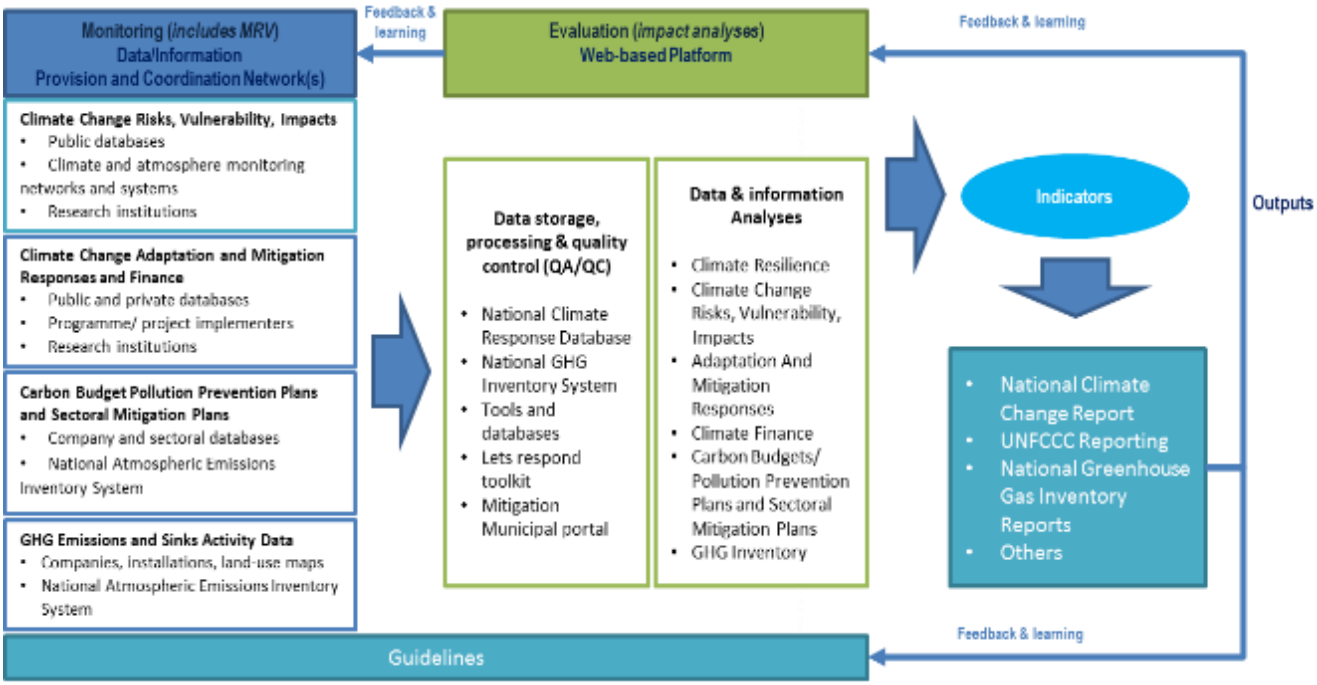

Figure 25: Overview of the climate change information System (Presentation by DEA on "*DEA Climate Change Information Systems*", Jan 2018)

It is recommended that provincial government expands its existing Gauteng Climate Change Register with the following:

[9] Currently being developed as ccis.environment.gov.za

- Negotiate with the Carbon Disclosure Project (CDP) South Africa for a way to obtain information on industry interventions occurring within the Gauteng Province.
- Request development organisations and NGO's to submit information on mitigation and adaptation projects they've supported developing and implementing. These are most likely to be community, rural or agriculture-based projects. GDARD will use its annual Climate Change Indaba for re-introducing the now discontinued civil society-driven Climate Champion Awards. The nomination for the award will require quantitative information that will be captured in the system.
- Use information from IDP review to identify and record projects and initiatives planned by local government.

8 Way Forward

The Gauteng Department of Agriculture and Rural Development should take ownership of the Gauteng City Region Climate Change Response Strategy and Action Plan as the lead developer and coordinating entity. However, the strategy is developed with the goal of harmonized and focused uptake by all lead agents. The successful implementation of the action plan and intervention programmes will be the responsibility of the lead agents who hold mandates to spearhead change within a sector.

A strategy for the 'City Region' will remain elusive if boundaries are unclear and a unified voice (from 5 provinces) regarding energy, transport, water and human well-being is absent.

The general approach to implementation of this Strategic Plan should be process-oriented in order to:

- Find increasing alignment between this plan and guidance strategies of specific sectors of implementation, particularly Gauteng Green Economy Programme, and
- Refine the list of required actions by either committing to the suggested actions/projects or finding replacement actions that can achieve the same outcomes or targets (e.g. swop wind power for solar PV installations).

To ensure this widespread uptake of the strategy and intervention programmes, the following actions are envisioned:

1. **Immediate actions** are recommended under Section 7, and these should be embarked upon to 'get the wheel rolling' in respect of climate change response, starting from establishment of the Gauteng Committee on Climate Change.

2. **Communication and distribution** of the GCR Climate Change Response Strategic Plan should take place once it is approved by provincial EXCO.

3. **Engagement** between GDARD and the 'lead agents' within sectors should take place to align planned interventions and agree on these planned interventions and target dates thereof. During these engagements, GDARD could provide more insight in the suggestions made in the programme and when required provide connections between different lead agents and organisations, for example when financing is required. Furthermore, Implementation Plan will be developed in consultation with the 'lead agents' and all key stakeholders.

4. **Monitoring and Reporting** of GHG emissions and emissions reduction, as well as performance against the stated adaptation and cross-cutting intervention actions. Annual performance reporting is required from all "lead agents".

5. **Review** of the strategy and action plan on an annual (performance review and corrective measures) and 5-year (strategic review of policy alignment) basis in order to identify corrective measures and identify alternative solutions that can achieve the identified targets.

Climate change response actions will be given impetus through political, administrative and financial support. Linked to the Provincial Budget Speech of July 2019 on the pronounced climate change and sustainability agenda, GDARD has listed ten priority climate

change actions which will be implemented in the next five years. Ten priority climate change actions are as follows:

1. Projects for waste avoidance, recycling, reduction and reuse and strengthening of the regulatory framework.

2. Establishment of solar parks in public properties.

3. Renewable energy in new public infrastructure projects (Schools, Hospitals, Nature Reserves etc.).

4. Waste to energy conversion projects such as landfill gas and waste heat utilization.

5. A sector support programme for Cleaner production processes for industry, including: Process integration, Best available production techniques and Bio-carbon reductants as coal replacement.

6. Roll-Out of Electric Vehicles for all Gauteng Government Fleet.

7. Rollout of electric vehicles infrastructure (vehicle charging facilities).

8. Investment in public transport systems, especially mass transit (commuter rail, Gautrain and Bus Rapid Transit) along major corridors in urban areas and their integration.

9. Non-motorised transport infrastructure (e.g. bicycle lanes).

10. Sustainable water practises such as Use of Alternative water sources (e.g. ground water), Water conservation, Rain water harvesting, Grey water harvesting and Sustainable urban drainage systems.

These ten priority climate change actions have been embedded in the response programmes that have been outlined in the Gauteng City Region Climate Change Response Strategy and Action Plan (in Section 6).

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ANNEXURE A: Gauteng Greenhouse Gas Inventory (as separate document)

Refer to the report:

GDARD. (2017). Gauteng City Region Over-Arching Climate Change Response Strategy 2017: Climate Change Mitigation (Draft October 2017). Report for the Gauteng Department of Agriculture and Rural Development (GDARD).

Available from the Directorate: Environmental Policy, Planning and Coordination, Gauteng Department of Agriculture and Rural Development.

ANNEXURE B: Adaptation Strategy for Agriculture (as separate document)

Refer to the report:

GDARD. (2017). Gauteng City Region Over-Arching Climate Change Response Strategy 2017: Adaptation Strategy for Agriculture in Gauteng (Draft October 2017). Report for the Gauteng Department of Agriculture and Rural Development (GDARD).

Available from the Directorate: Environmental Policy, Planning and Coordination, Gauteng Department of Agriculture and Rural Development.

ANNEXURE C: Climate Change Finance (as separate document)

Refer to the report:

GDARD. (2017). Gauteng City Region Over-Arching Climate Change Response Strategy 2017: Climate Change Finance (Draft October 2017). Report for the Gauteng Department of Agriculture and Rural Development (GDARD).

Available from the Directorate: Environmental Policy, Planning and Coordination, Gauteng Department of Agriculture and Rural Development.

ANNEXURE D: Adaptation Monitoring and Evaluation through tracking of DAOs

Table 16: Data and information required to monitor and evaluate inputs/enablers for effective adaptation

Generic or universally applicable provincial DAO	Data/ information required to monitor progress	Data/ information required to evaluate the effectiveness of responses		
		Adaptation priorities not addressed/effectively addressed	Adaptation priorities partially (effectively) addressed	Adaptation priorities fully addressed/ effectively addressed
G1. Climate change adaptation fully integrated into provincial and municipal planning processes, including governmental, sectoral and multi-sectoral planning.	Number of provincial climate change policies, plans, strategies, legal framework, programmes in prioritized sectors at operational and strategic level. Number of provincial policies, plans, strategies, legal framework, programmes and projects which have integrated climate change issues in prioritized sectors at operational and strategic level.	Legal frameworks, plans/strategies, policies, programmes and projects not informed by existing risk and vulnerability profiles that include climate risks and impacts.	Legal frameworks, plans/strategies, policies, programmes and projects informed by risk and vulnerability profiles that include climate risks and impacts.	Implementation of legal frameworks, plans/strategies, policies, programmes and projects - informed by risk and vulnerability profiles that include climate risks and impacts - to reduce vulnerability in risk and vulnerability profiles and enhance capacity to respond to climate change impacts.
G2. Appropriate processes and mechanisms for coordinating	Number of provincial prioritized sectors with dedicated climate change champions/nodes/units	No dedicated political/administrative champions, capacity, structure (i.e.	Political/administrative champions designated but with no capacity, structure	Political/administrative champions designated, and capacity, structure

climate change adaptation in province and municipalities.	Number of provincial prioritized sectors with dedicated climate change funding Number of provincial prioritized sectors with training programmes/projects on climate change Number of provincial prioritized sectors which have included climate change as agenda item in operational and strategic committees/forums Number of provincial prioritized sectors which have implemented the climate change action plan from operational and strategic committees/forums	organogram with climate change key performance indicators or Board-level oversight of climate change) or funding (including monetary incentives); no inclusion of climate change items in existing administrative and political forums/committees in businesses, sectors, provinces and municipalities.	(i.e. organogram) or funding; inclusion of climate change items only by request in existing administrative and political forums/committees.	(i.e. organogram/Board-level oversight) and dedicated funding; climate change standing item in administrative and political provincial, municipal and sector forum/committee agendas.
G3. Accurate weather forecasting, seasonal predictions, climate projections and effective early warning systems for extreme weather and other climate-related events provided for province and municipalities.	Availability of provincial: (i) historical climate trends, (ii) fine-scale projections, forecasts (seasonal to inter-annual and intra-seasonal variability), and (iii) early warning systems for provincial and municipal use Dissemination and communication platforms for weather and climate-related events (e.g. SMS and media) Evidence of utilisation of data/information products by end-users Maintenance and enhancements of monitoring and forecasting facilities/networks.	No dissemination and utilisation of weather and climate-related information. Lack of monitoring and forecasting facilities/networks.	Dissemination but no utilisation of weather and climate-related information. Monitoring facilities/networks exist but are not well-maintained or enhanced.	Dissemination and utilisation of weather and climate-related information at provincial, municipal and community levels. Monitoring facilities/networks exist and are maintained and enhanced.
G4. Capacity development	Number of provincial capacity development programmes (including students, staff, researchers	No capacity building programmes (including	Attendance of capacity building	Capacity building programmes

programmes in province and municipalities informed by locally-specific adaptation research.	and institutions) addressing climate change adaptation Coverage of provincial adaptation research and training being undertaken and financed Uptake of provincial research outcomes Number of provincial human capacity trained in adaptation Collaboration and partnerships between sectors, businesses, provinces, municipalities and researchers Incorporation of climate change issues into school curriculum.	research), collaboration and partnerships to address climate change adaptation and no incorporation into school curriculum.	programmes but no utilisation, collaboration and partnerships to address climate change adaptation and no incorporation into school curriculum.	(including research and utilisation), collaboration and partnerships to address climate change adaptation, incorporation into school curriculum, and utilisation to inform policy and decision-making.
G5. Development and implementation of new technologies or knowledge on climate change adaptation for province and municipalities.	Number of provincial new technologies, research and knowledge adopted (including indigenous knowledge systems) Provincial adaptation challenges and opportunities on technologies, research and knowledge	Lack of awareness/understanding of newly developed technologies, research and knowledge leading to poor or no application.	Awareness/ understanding of technologies, research and knowledge but no implementation and utilisation.	Evidence of implementation and utilisation of technologies and knowledge (e.g. 100 households now have rainwater harvesting devices and have received training on how to use and maintain them).
G6. Climate change risks, impacts and	Number of provincial risk profiles and vulnerability assessments and measures/actions to address the	No risk and vulnerability profiles.	Risk and vulnerability profiles identified.	Risks, impacts and vulnerabilities

vulnerabilities identified and addressed.	identified risks, impacts and vulnerabilities in prioritised sectors			addressed in policies, plans and actions.
G7. Reduction in non-climate pressures and threats in province and municipalities.	Data on land use and land use change, population demographics, pollution, water quality and siltation of dams, protection and enhancement of natural resources and other environmental assets, service delivery protests, non-maintenance of infrastructure, and socio-economic status/factors.	Findings from surveys and datasets (e.g. green/blue drop status, community satisfaction surveys, STATSSA census of socio-economic indicators etc.) will be used for this purpose.		
G8. Secure food, water and energy production and supplies in province and municipalities take climate change considerations into account.	Number of provincial climate smart agriculture, conservation agriculture, and water conservation and demand programmes/projects.	No climate resilient measures/actions implemented to ensure secure food, water and energy.	Climate resilient measures/actions implemented to ensure secure food, water and energy.	Evidence of secure food, water and energy in communities as a result of implementing climate-resilient measures.

Desired Adaptation Outcomes for priority sectors

The DAOs identified by DEFF relate to so-called ‘at risk’ sectors and for disaster risk reduction and management. These are Water, Agriculture and Forestry, Health, Biodiversity and Ecosystems, Human Settlements, Food Security, Energy Security, Buildings and Transport, as well as Disaster Risk. DAOs for each of these, except Food Security, are listed in the tables below, following consideration of the national list of DAOs against the primary strategic outcomes of this strategy and the strategic analyses done to identify the climate change related weaknesses of the GCR. Food Security DAOs are not specified for the GCR as they are deemed sufficiently covered within the Agriculture and Human Settlements sectors.

Table 17: DAOs for the Agriculture Sector

DEFF reference	Desired Adaptation Outcome [as related to generic DAOs]
A1	Climate resilience integrated into agriculture development plans (e.g. in relation to job creation, food security and livelihoods, and synergies or competing objectives between adaptation and mitigation) [G1 & G2].
A2	New opportunities, areas and crops utilised sustainably by the agriculture sector and negative impacts of existing practices reduced (informed by climate vulnerability/risk assessments) [G5, G6 & G7].
A3	Stakeholders in the agriculture sector better understand climate change and need for adaptation (through education and awareness programmes, linked to agriculture extension activities) [G4].
A4	Farmers alerted to adverse weather conditions by early warning systems, and provided with up-to-date climate information and decision-support tools to assess vulnerabilities and inform management decisions [G3].
A5	Uptake of 'climate-smart agriculture' in primary production and as agro-processing (with higher yields, lower GHG emissions, and more resilience to climate change - guided by research into water, nutrient and soil conservation, emissions reduction, climate-resistant crops and livestock, and new production, ownership and financing models) and 'conservation agriculture' (sustainable nature-based approaches - based on indigenous knowledge and sympathetic use of ecosystem services) [G5, G7 & G8].
	The preservation of high potential agricultural land for food production, along with the surrounding natural areas that provide critical support services such as pollination and soil conservation

Table 18: DAOs for the Disaster Risk Reduction and Management Sector

DEFF reference	Desired Adaptation Outcome [as related to generic DAOs]
	Emphasis to shift towards disaster risk reduction (including ecosystem-based approaches like alien clearing and wetland protection/ rehabilitation with job creation co-

	benefits) with appropriate capacity building (skills and resources) in disaster risk management units
D1	Early warning systems and new communication technologies used to alert vulnerable communities to weather and climatic events and associated impacts (e.g. pest infestations) [G3].
D2	Regional early warning systems established and shared with neighbouring provinces [G3].
D3	Risk and Vulnerability Service Centres (university-based) provide information to resource-constrained communities [G3].
D4	Seasonal climate forecasts used by key stakeholders (e.g. water and agricultural sectors) [G3].
D5	Disaster risk reduction/management information used by provinces and municipalities to inform climate change adaptation planning [G3].
D6	Awareness-raising, technology transfer and capacity-building (including proactive funding) to prevent or reduce impact of disasters facilitated through social networks (e.g. community organisations, NGOs, women's and farmers' organisations, and the Adaptation Network) [G4].
D7	Support mechanisms help recovery of disaster-hit areas and people, particularly the poor (e.g. reactive funding and micro-insurance) [G2].

Table 19: DAOs for the Water Sector

DEFF reference	Desired Adaptation Outcome [as related to generic DAOs]
W7	Integrated water resources management that is current, feasible and adequate, and that ensures that the water sector has resources (i.e. human, legal, regulatory, institutional, governance, and financial) and capacity to properly address climate change challenges [G1].
W1	Climate change adaptation fully integrated into planning processes in water-dependent sectors (e.g. agriculture, mining, industry, economic development, health, spatial planning, and science/technology) [G1 & G3].
W2	Capacity development programmes in water-dependent sectors informed by water-related adaptation research (e.g. high quality data and tools to analyse data) [G4].

W4	Water security and resource protection enhanced by adaptation of catchment and water management practices (e.g. investment in water conservation and water demand management) [G8].
W5	New and unused water resources utilised sustainably in areas of water stress (e.g. groundwater, effluent re-use, and desalination - with cost-benefit and maladaptation risk assessments undertaken) [G5].
W6	Vulnerable communities, sectors and infrastructure more resilient to water-related climate change impacts, and aware of the benefits of water use efficiency and demand management, and the utilisation of multiple water sources (especially rainwater harvesting and use of grey water) [G6].
W8	Efficiency and effectiveness of water-related climate change adaptation policies and programmes monitored and evaluated over short, medium and longer-term time scales [G1 & G2].
W9	Non-climate pressures and threats to water quality and availability reduced (particularly where these compound climate change impacts) [G7].
	Groundwater recharge and DRR through use of green infrastructure (i.e. protection of watercourses, wetlands and aquatic habitat)
	Improved surface and groundwater quality

Table 20: DAOs for the Human Settlements Sector

DEFF reference	Desired Adaptation Outcome [as related to generic DAOs]
URBAN	
U1	Opportunities presented by urban densification leveraged into building climate-resilient urban infrastructure and promoting behavioural change (through urban/spatial planning, growth management, and efficient resource use) [G2].
U2	Low-cost housing design (new-build and in-situ upgrades) avoids at-risk locations (flood-prone areas, pollution, unstable ground) incorporates climate-resilient technologies (e.g. thermally efficient, water-sensitive, and flood resistant) and, where possible, provides easy access to employment and services via affordable lower-carbon public transport systems [G5].

U3	Resilience of towns and cities to climate change assessed and priorities for adaptation interventions identified (through development of information systems and monitoring and evaluation schemes, and enhancement of existing decision-support tools for urban/spatial planning) [G6].
U4	Urban design and infrastructure planning is water-sensitive and uses nature-based solutions where possible (i.e. addresses water supply constraints and extreme weather events, and minimisation of pollution, erosion and disturbance) [G8].
U5	Climate information integrated into medium and long-term spatial development plans (through downscaling of climate models to provincial and local levels, and provision of hazard maps and disaster risk reduction/management plans) [G3].
U6	Impacts of climate change and need to sustain ecosystem services addressed in urban land-use/infrastructure planning; land-use zoning regulations enforced as appropriate [G1 & G7].
FS6	Food security improved by community food production schemes (e.g. food gardens) and food storage/supply facilities [G1 & G6].
	Stakeholders in the Human Settlements sector better understand climate change and need for adaptation (through education and awareness programmes) [G4].
RURAL	
R1	Small-scale and subsistence farmers aware of potential climate change risks and supported in development of locally-specific adaptation interventions (e.g. on-farm demonstration of water harvesting and experimentation with crop rotation that prioritise indigenous knowledge) [G4].
R2	Rural communities design and implement economic and livelihood diversification programmes that address climate change issues [G1 & G1].
R3	New technologies developed for climate change adaptation in rural areas (e.g. low water-use irrigation systems, rainwater harvesting, and drought-resistant seed varieties) [G5 & G8].
R4	Increased resilience of rural communities most vulnerable to climate change impacts (through adaptation programmes and disaster risk reduction/management plans, which include enhancing knowledge of sustainable resource use and optimising ecosystem services) [G6].

HEALTH	
H1	Incidence of respiratory diseases resulting from climate-related factors reduced through improvements in air quality (e.g. reductions in particulate matter, ozone and sulphur dioxide) [G7].
H2	Food security and robust nutritional policies integrated into health adaptation strategies (nutritional status of individuals a key factor in building resilience to environmental health threats) [G1 & G8].
H3	Public more aware of health risks of extreme temperatures and appropriate responses (through regulation and campaigns to improve ventilation and promote 'avoidance behaviours' that minimise exposure) [G4].
H4	Implementation of 'heat-health' action plans (including emergency medical services, improved climate-sensitive disease surveillance and control, safe water, and improved sanitation) [G1].
H5	Better knowledge of and information on linkages between disease and climate change (strengthened by scientific research) [G4].
H6	Health data capture systems record spatial and temporal climate-related data and provide information to multiple-risk systems (e.g. South African Risk and Vulnerability Atlas - SARVA) [G1].
H7	Bio-safety component of malaria control strategy improved (whilst current strategy has reduced malaria outbreaks, concerns remain about long-term effects of DDT on environmental and human health) [G7].
H8	Public better informed about climate-related implications of vector-borne and water-borne diseases (through more-effective awareness programmes) [G4].
	Integration between the health sector, disaster response services and the human settlements sector
	Increased community health worker / NGO capacity

Table 21: DAOs for the Energy Sector

DEFF reference	Desired Adaptation Outcome [as related to generic DAOs]
ES1	Climate-related risks integrated into strategies and plans for climate-resilient energy production systems and supply infrastructure [G1 & G2].

ES2	Early warning systems and disaster management information used to improve climate resilience of energy production systems and supply infrastructure [G3].
ES3	Progress towards climate-resilient energy production systems and supply infrastructure informed by transfer and use of knowledge and innovation [G1, G4 & G5].
ES4	Efficiency of water-use in energy production systems optimised [G6].
ES5	Climate resilience of energy sector compatible with protection and enhancement of natural resources and other environmental assets [G7].
ES6	All citizens (and industries) have access to secure energy supplies that take climate change considerations into account [G8].
	Strengthened community resilience through more diversified and decentralised energy systems (including the utilisation and expansion of renewables as well as smart and mini grids, with associated job creation), and energy efficiency measures for housing
	Revised electricity supply and revenue collection system that accommodates net metering and feed-in tariffs

Table 22: DAOs for the Buildings and Transport Sectors

DEFF reference	Desired Adaptation Outcome [as related to generic DAOs]
BTI1	Climate-related risks integrated into adaptation strategies and plans for climate-resilient buildings and transport infrastructure and into wider planning processes, with co-benefits optimised [G1 & G2].
BTI2	Early warning systems and disaster management information used to improve climate resilience of buildings and transport infrastructure [G3].
BTI3	New technologies, tools, methods and resources used to increase climate resilience, including reduced energy and water footprint, of buildings and transport infrastructure [G1, G4 & G5].
BTI4	Climate-resilient buildings and transport infrastructure benefit all communities, especially those most vulnerable to climate change [G6].
BTI5	Climate resilience of buildings and transport infrastructure compatible with protection and enhancement of natural resources and other environmental assets [G7].

GAUTENG PROVINCE
AGRICULTURE AND RURAL DEVELOPMENT
REPUBLIC OF SOUTH AFRICA

Gauteng Department of Agriculture & Rural Development
56 Eloff Street, Umnotho House,
JOHANNESBURG 2000
http://www.gauteng.gov.za