GREENBOOK
adapting settlements for the future

GREEN BOOK

ADAPTING SOUTH AFRICAN SETTLEMENTS TO CLIMATE CHANGE

FINAL TECHNICAL REPORT

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EXECUTIVE SUMMARY

Co-funded by the Canadian International Development Research Centre (IDRC) and the Council for Scientific and Industrial Research (CSIR), the Green Book is the result of a three-year initiative in which the CSIR collaborated with the National Disaster Management Centre (NDMC) and a number of stakeholders and reviewers in co-producing the methods and reviewing the research findings.

The ultimate goal of the Green Book is to contribute to resilient, sustainable and liveable South African settlements through climate change adaptation. To achieve this goal, the Green Book was developed as an online tool to support local government in South Africa with the planning and design of climate-resilient settlements. The interdisciplinary nature of the Green Book, which combines high resolution scientific evidence with adaptation solutions, makes this one of the most novel, innovative and information-dense research outcomes about disaster risk and climate adaptation planning on the African continent. The depths and scale of information provided in the tool, is unprecedented in South Africa.

Key advances and significant research findings include:

- A set of detailed projections of future climate change covering South Africa at an 8 x 8 km resolution – the most detailed projections of future climate change ever available for the entire country.
- New models have been developed and/or customised to quantify the impact of climate change on the exposure of South African settlements to various hazards (including drought, wildfires, inland floods and coastal flooding).
- A vulnerability assessment framework and set of indicators were developed to profile all 213 local municipalities in South Africa based on four unique statistically developed indicators, the 1637 settlements across South Africa based on six unique indicators, and two spatial multi-criteria indicators that captures vulnerability on a neighbourhood level. This is the first such an exercise globally.
- A population potential growth model was developed to forecast settlement growth across South Africa at a 1x1 km resolution – the first settlement population growth model to be developed on the African continent.
- Risk profiles that provide temporally dynamic risk profiles for each municipality and its settlements in South Africa for the present and a 2050 future. The municipal Risk Profile Tool is first of its kind in Africa.

- The menu of adaptation actions brings together planning and design actions that are appropriate for the South African context and local planning function. The Adaptation Actions Tool proposes a basket of mutually-reinforcing actions that are linked to each other so that no action is loose-standing, but supported.
- Climate change will continue to present a number of risks in particular to South Africa's water resources. The Green Book analyses the impact of climate change on ground- and surface water and translates them into the risks that municipalities will face with regards to water provision. Water-sensitive urban planning and design principles are integral to the proposed adaptation actions.
- The Green Book online decision-support tool is a first of its kind in the world (as far as can be established) given the level of detail, covering all municipalities in the country, integrating interdisciplinary scientific evidence, and combining adaptation actions that can be integrated into local plans.

The main output of the project is a website that can be found at: www.greenbook.co.za. The website contains general content such as background about the project, names of researchers, funders, stakeholders, and people and organisations involved in the co-creation of the content, as well as a depository containing all the project outputs. The research findings, the main body of the website, are structured into three components:

i. The first component is a series of interactive national story maps. The story maps provide information about the research methodology, findings and recommendations for 11 components of the project.
ii. The second component is the municipal Risk Profile Tool, which is an interactive tool that provides scientific evidence that assists municipalities to assess their current and future climate risks, socio-economic and other vulnerabilities, population growth pressure and the impact of climate change on hydro-meteorological hazards and key resources.
iii. The third component is the municipal Adaptation Actions Tool, which is an interactive platform that provides a range of planning and design actions for municipalities to adapt their settlements and environments to the likely impacts of climate change. Municipalities can select the most appropriate adaptation actions from the Adaptation Actions Tool Based on their risk assessment, and integrate these into their local planning tools and strategies to climate-proof their settlements, to reduce their exposure and vulnerability to hazards, and exploit opportunities for sustainable development.

Other outputs include 10 technical reports and two presentations that describe the research methods and findings in more detail, eight published conference papers, and a conference poster. Seven journal articles are in the pipeline, ranging from conceptualisation to submission to journals. The research team made 19 presentations at local and international conferences, and 22 formal presentations about the project as requested by forums, workshops, and committee meetings. The steering committee met 44 times with various stakeholders and interested parties during the course of the project, and 30 people from the public and NGO sectors peer-reviewed aspects of the Green Book.

Complementary to the Green Book is The Neighbourhood Planning and Design Guide (Red Book), developed by the CSIR for the Department of Human Settlements. The Red Book is aimed at built environment practitioners, and it supports the development of sustainable human settlements by providing practical information related to the planning and design of the services and infrastructure typically provided as part of a neighbourhood development project. Whereas the Green Book proposes a basket of mutually-supportive adaptation interventions to be integrated into a range of local planning instruments to adapt settlements to climate change risks in the future, the Red Book provides more detailed design guidelines for some of these interventions e.g. stormwater design. The Adaptation Actions Tool reference the Red Book, though the latter has not been released yet. Once it has, links to the appropriate sections can be added (also see https://greenbook.co.za/about-the-green-book.html).

In conclusion, one of the major achievements of the project is the coming together of an interdisciplinary team of more than 50 researchers, and their findings, to produce very technical results, packaged in a comprehensible way that is of great value to end users. It should also be noted that the project was led by three female researchers working full-time on the project, and more than 50% of the team was made up of women. Another achievement for the Green Book is the planned continuation of the Green Book Programme in Phase II. The Department of Environmental Affairs (DEA), the National Disaster Management Centre (NDMC) and Santam are committed to partner with the CSIR in Phase II of the Green Book. This phase will focus on rolling out the Green Book for implementation at municipalities most at risk, identifying gaps in research and development of this kind, and building the capacity of officials and departments to deal with climate change adaptation.

The Green Book has been received with much anticipation and enthusiasm by public, private and NGO organisations involved in the climate adaptation field. It has also received ample

exposure in the media, due to the novelty of the product. The CSIR is grateful towards the IDRC who made this project possible.

1 THE RESEARCH PROBLEM

This section describes the rationale for the project and any changes that may have occurred in the researchers' understanding of the problem. It reflects on the changes that have occurred in the aim, research questions and objectives over the course of the project, and provides an overview of the overall progress of the global project.

1.1 Rationale of the project

The rationale for the Green Book project has remained unchanged. Most South African settlements were planned in maladaptive ways, resulting in many people living in areas with low to no potential to make a living. The current development path that many settlements follow, continue to exacerbate the vulnerability and exposure of people and places to social, economic and environmental shocks. Simultaneously, climate change is threatening the livelihoods of many vulnerable people as well as the development gains made by local government in terms of infrastructure, service provision and economic growth (Van Niekerk et al., 2016). Since the project inception, the latest literature and evidence that have emerged further support the rationale for the Green Book, and highlight the value of the research and development that was done.

The rapidly changing climate is a key global challenge that needs action from all spheres of society. Environmental risks, namely extreme weather events, climate change mitigation and adaptation policy failure, and natural and man-made environmental disasters, are currently ranked among the top ten global risks in terms of likelihood and impact (WEF, 2019). The Paris Climate Change Agreement in 2016 was a commitment by countries to reduce greenhouse gas emissions such that global warming can be limited to well below 2°C above pre-industrial levels. The proliferation of weather-related disasters globally and the increases in associated damage in terms of geographical extent, size of affected population and economic costs, have necessitated proposals by the IPCC and climate vulnerable nations as represented by the Climate Vulnerable Forum (CVF) for a more ambitious target of limiting global warming to 1.5°C above pre-industrial levels (Masson-Delmotte et al., 2018).

The year 2017 was the costliest (US$353 billion) on record globally in terms of total economic losses due to natural disasters (Low, 2019). There was a reduction in 2018, but the losses

were still approximately 14% higher than the inflation-adjusted overall loss average of US$140 billion of the past 30 years. Of great concern in 2018 was the number of lives lost which tallied to 10,400, the third year in a period of five years in which the recorded death toll from natural disasters exceeded 10,000.

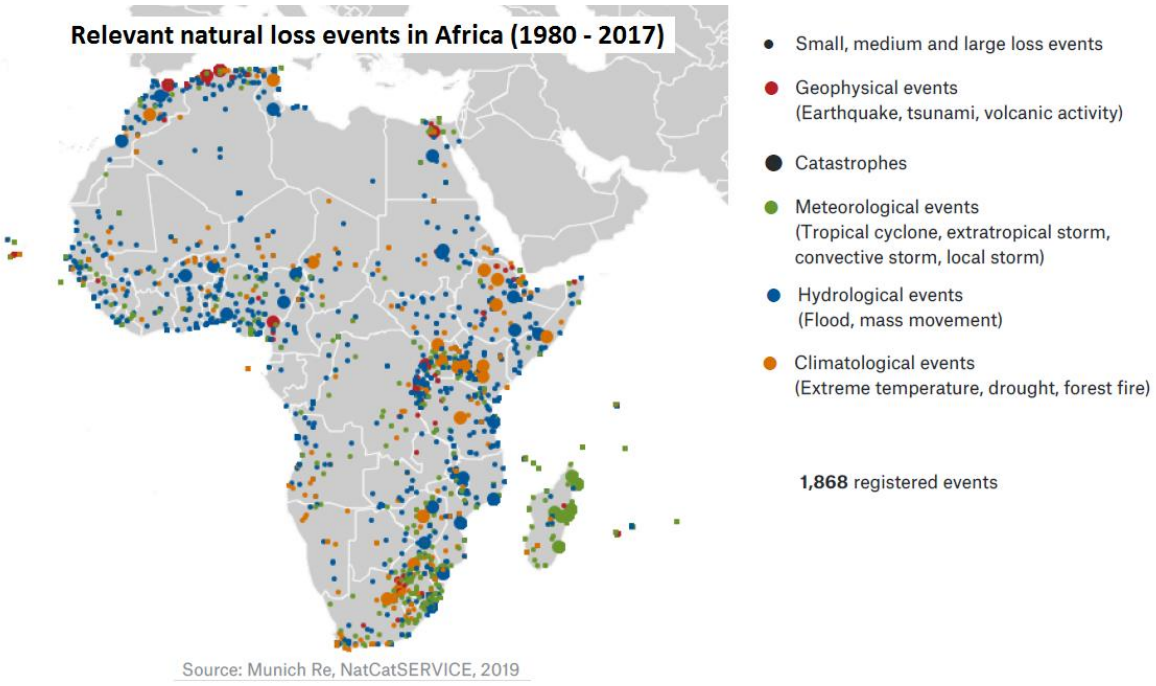

Figure 1: Loss incidents in Africa due to the occurrence of natural disasters,1980 - 2018 (Munich Re Group, 2019)

South Africa has not been spared from the impacts of climate related disasters in recent years as shown in the loss incidence map of Africa in Figure 1 (Munich Re Group, 2019). Extreme weather events observed over the region have resulted in increased frequency and intensity of fires, floods, hailstorms and droughts (Otto et al., 2018). The severe drought that threatened to leave more than 4.2 million residents and businesses in Cape Town without water between April and June 2018 was an indication of the vulnerability of the country to climate change. It was also a revelation that vulnerability to drought is as much a concern for urban areas as it is for rural areas. Cape Town received most of the media coverage, but other parts of South Africa were also gripped by the multi-year drought between 2015 and 2018, as vegetation greenness indices derived from satellite data revealed in 2015 that six of the nine provinces were experiencing drought conditions (Cho, 2016). The economic cost associated with the drought for the five month period from January to May of 2018 was in excess of R1.2 billion (AON, 2018), while the five month period from June to October 2017 is estimated to have cost more than R4 billion in terms of damages from the Knysna fires and storm-related flooding in Cape Town.

The South African situation is further complicated by the historically maladaptive ways in which settlements were planned, towards which there has been very little change due to the sluggish pace of spatial transformation in a country which is also faced with slowed economic growth and rising inequality. The injection of climate change into these complex and interconnected socio-economic challenges facing South Africa are a threat to the developmental gains made by the government over the past 25 years.

A need was identified for urban planning guidance on how to facilitate development and resilience when faced with complex challenges of increased exposure to climate hazards, sluggish economic growth and rising inequality. The Green Book was conceptualised in response to this, to offer a resource to South African local government to better understand their risk and vulnerabilities in relation to population growth, climate change, and exposure to hazards and the vulnerability of critical resources. In addition to this, the Green Book also intended to provide appropriate adaptation measures that can be implemented in cities and towns, so that South African settlements are able to minimise the impact of climate hazards on communities and infrastructure, while also contributing to developmental goals. The Green Book attempted to maintain this focus throughout the project, and though the project continued to evolve (as described below), the project's aim was to offer information and tools to support decision making in adapting South African settlements to climate change. The Green Book did not attempt to cover all aspects of vulnerability, risk or adaptation, but only those aspects that relate to the planning function of local government in built-up areas, and the impact of hydro-meteorological risks on settlements and climate related impacts on key resources. This focussed, evidence-base, top-down approach had many benefits, most importantly producing a valuable product within the set timeframe and being able to explain its purpose precisely, but also a few limitations: it did not consult local communities; it does not propose adaptation actions on a national or provincial level; it does not address the space between settlements; it does not propose funding mechanisms; and it does not include the most uncertain climate-related hazards such as hail, lightning and wind due to the huge uncertainty related to these events.

1.2 Evolution of the aim, objectives and research questions

In the project grant proposal to the IDRC it was stated that the aim of the proposed research project "is to develop planning and design guidelines to adapt South African settlements to climatic changes, called the 'Green Book', with specific focus on water sensitive design and management." The main objective was "to develop differentiated planning and design guidelines for South African settlements at risk (smaller than 2 million people) and in particular the adaptation of water management."

These research questions were revisited and slightly changed in the Inception Report to be:

i. "Based on downscaled climate change projections, hazard footprints and socio-economic profiling, what are the specific climate change risk profiles for different types of South African settlements?
ii. Based on existing adaptation plans and strategies, what are the most appropriate adaptation options for planning and designing settlements in the various risk profiles, based on experience with existing plans, local capacity constraints and a cost/benefit analysis?
iii. In what ways should existing policies and plans be adapted to reflect the findings of the Green Book?"

Thus, at the core of this project was a need to understand how South African settlements can be adapted to increase their resilience against the impacts of climate change. The specific objectives in support of the aim of the Green Book, as captured in the proposal were to:

1. Scope and assess existing adaptation strategies and plans developed and/or in use for South African cities and analyse downscaled climate change projections for South Africa to distinguish regional and local patterns of climatic changes (workstreams 1 and 2);
2. Adapt the existing Functional Settlement Typology (developed by CSIR for SACN and The Presidency) for the purpose of the study to make provision for informal settlements within towns and cities (workstream 3);
3. Identify potential high risk areas (hazard footprint) under a changing climate and develop a risk profile for different types of South African settlements by applying the climate projections and impact assessments to the settlement typology (workstream 4 and 5);

4. Develop a selection of appropriate, innovative adaptation options for planning and designing settlements in the various risk profiles (specifically for water management) which identify the associated costs and benefits, and gender-based implications (workstream 6); and,
5. Strengthen the capacity of key stakeholders to facilitate adaptation in South African settlements through engagement, targeted communications and training opportunities (workstream 7, 8 and 9).

The project aim, objectives and research questions have remained the same in essence throughout the project. However, as the finer detail of how this was to be achieved unfolded over time, and based on stakeholder engagement, initial research findings and lessons learnt in the project, the aim, objectives and questions evolved.

The main aim has become more encompassing and strategic to the extent that the Green Book aims to support long-term municipal planning with the development of climate resilient settlements through the implementation of the Green Book. The Green Book outcome is not a set of “planning guidelines” in book form as planned, but rather an interactive online planning support tool that provides evidence to inform planning and decision making. Also, the focus of the Green Book was originally only on municipalities with populations below 2 million, to be of greatest benefit for urban areas outside of the metropolitan municipalities as these typically have insufficient resources for spatial planning. Because all analyses and models were developed to cover the entire South Africa, the evidence developed as part of the Green Book is now available for all municipalities, including metropolitan municipalities. Any municipality, regardless of its population size, is able to use the Green Book and all its tools, resources and information, but smaller municipalities was always the primary audience. Furthermore, the importance of water-sensitive design and management was highlighted during the course of the project, as the City of Cape Town was at risk of being without water during 2017 because of a 3-year drought. In the Green Book, water is central to the analyses of climate related hazards, as well as the impact of climate change on municipal water resources such as groundwater and surface water. The proposed basket of adaptation actions is very conscious of water-sensitive urban design and planning, and ecosystem services therefore plays an important role in the planning and design of human settlements in South Africa, a water scarce country.

The table below indicates the research questions as per the approved Inception Report and the way in which the project addressed these questions, evolved over time. It is clear from the

table that the questions remained relevant, and all were answered through the project, but that the scope became bigger as the project evolved and technology and research capability made it possible to cover more detail and depth in the risk profiles of municipalities.

Original research questions	Evolved understanding of questions
i. **Based on downscaled climate change projections, hazard footprints and socio-economic profiling, what are the specific climate change risk profiles for different types of South African settlements?**	This question summarises objectives 1, 2 and 3 (workstream 2, 3 and 4) which was the bulk of the research work. The project completed all of these elements (downscaled climate change projections, hazard footprints and socio-economic profiling), but it did not evolve into "specific climate change risk profiles for different types of South African settlements" as an output because technology and research capacity made it possible for the Green Book to provide a risk profile for every municipality in South Africa that contains the detailed information of its customised vulnerabilities and risks. No typologies were thus developed for settlements or climate risk profiles. Settlements within a municipality are however able to compare themselves with one another in terms of their vulnerability indicators, population size and growth estimates. Once the neighbourhood level viewer is added to the website, they will also be able to see vulnerability and population growth hot spots within settlements.
ii. **Based on existing adaptation plans and strategies, what are the most appropriate adaptation options for planning and designing settlements in the various risk profiles, based on experience with existing plans, local capacity constraints and a cost/benefit analysis?**	This question addresses part of objective 1 and 4. The project did develop a menu of adaptation actions that are appropriate for implementation in South African settlements based on existing and planned adaptation plans and strategies. The adaptation actions are all available under the Adaptation Actions Tool on the website, and can be filtered to respond to a specific hazard(s), and/or a specific planning function. They have thus not been pre-selected per risk profile (as profiles were not clustered). This way municipalities can select their own actions, based on the local conditions and capacities, but with the ability to filter for all or any specific actions. Potential implications for costs and benefits were included under the description of every adaptation action.
iii. **In what ways should existing policies and plans be adapted to reflect the**	This question was supposed to be a general conclusion with recommendations in the Green Book. This question is partly addressed on the website through the guidelines on selecting

findings of the Green Book?	and prioritising adaptation actions (https://adaptationactions.greenbook.co.za/), as well as by the section on policy implications (https://www.greenbook.co.za/policy-implications.html). The Green Book will continue to think about this question in Phase II with the roll-out, training and capacity building of people working with these plans in local government.

With regards to the objectives, their essence remained the same throughout the project, but changed slightly to better match the evolved project research design and structure (and thus the order in which the workstreams were performed), and to reflect new learning, overcome challenges and take advantage of opportunities. The table below indicate the changed thinking about the objectives (the workstream numbers remained the same).

Original objective	Adaptation of objectives
1. **Scope and assess existing adaptation strategies and plans developed and/or in use for South African cities and analyse downscaled climate change projections for South Africa to distinguish regional and local patterns of climatic changes (workstream 1 and 2);**	The amended objective is to: "Analyse downscaled climate change projections for South Africa to distinguish regional and local patterns of climatic changes (workstream 2), and apply the projections to identify the likely spatial extent and implications of hydro-meteorological hazards on South African settlements and their key resources in future (workstream 4)." • The first part of the objective with regards to assessing adaptation actions was moved to objective 4. It turned out to be one workstream, as much of the work on the menu of adaptation actions could only be conducted once the hazards and vulnerability work were underway or completed. • Workstream 4, as part of objective 3 was moved to objective 1. This was done as the climate change projections were a direct input for the hazard modelling, and together they formed a unit of work. • Objective 1 states more explicitly what was done under workstream 4. Not only were potential high risk areas identified, but the likely extent of the exposure of settlements and implications for key resources was also determined.
2. **Adapt the existing Functional Settlement Typology (developed by**	The amended objective is to: "Profile all South African municipal and settlement vulnerability and population growth (workstream 3)."

CSIR for SACN and The Presidency) for the purpose of the study to make provision for informal settlements within towns and cities (workstream 3);	• The Functional Settlement Typology was used as an input for the vulnerability work, but settlements were not classified in a typology based on their vulnerability, as it was possible to do a vulnerability assessment for every local municipality and its settlements in the country. • No extra category was added to the settlement typology. Informal settlements were identified as vulnerable spaces within settlements under the neighbourhood level vulnerability profile.
3. **Identify potential high risk areas (hazard footprint) under a changing climate and develop a risk profile for different types of South African settlements by applying the climate projections and impact assessments to the settlement typology (workstream 4 and 5);**	The amended objective is to: "Integrate the evidence to create current and future risk profiles for South African local municipalities and their settlements, providing information on vulnerability, population growth, climate, hydro-meteorological hazards, and impacts on key resources (workstream 5)." • The first part of the objective (workstream 4 - identify potential high risk areas under a changing climate) was moved to objective 1. • Objective 3 is solely about integrating all the evidence from objectives 1 and 2 into risk profiles per municipality (workstream 5).
4. **Develop a selection of appropriate, innovative adaptation options for planning and designing settlements in the various risk profiles (specifically for water management) which identify the associated costs and benefits, and gender-based implications (workstream 6); and,**	The amended objective is to: "Develop a menu of appropriate, mutually supportive planning and design adaptation actions based on the risks (workstream 1 and 6)." • It made sense to combine the original first part of objective 1 and objective 4 (workstream 1 and 6) as it formed one work package, namely to develop a menu of adaptation actions based on an assessment of already existing and planned adaptation actions in South Africa and elsewhere. • It also made sense to move it to the last of the research workstreams, as the actions are in response to the risk and vulnerability profiles put together under objective 3. • Originally it was thought that the outcome of workstream 6 would be the main Green Book product, but this changed over time as the importance and scope of the work in objectives 1-3 increased, and became important outputs in their own right.

	5. Objective 5 is an extra objective. It is to "Integrate all the research findings into one decision-support tool (workstream 6)." • Originally it was thought that the final product would be a set of guidelines for each type of risk profile, and that the scientific evidence (all the information contained in the risk profile) would form the backbone of the guidelines. However, as the scope and detail for objectives 1, 2 and 3 expanded, the wealth and depth of the findings became an achievement on their own. It became apparent that the output of objectives 1-3 is of great value to many stakeholders, and that it should be packaged as products on their own. • Thus, integrating all the research findings and packaging it in a way that is informative, user-friendly, supports municipal decision-making and is easy to mainstream into municipalities' own strategies and plans, became an achievement on its own. • This objective is therefore all about integrating and packaging the findings into the website, with its story maps and two tools.
5. **Strengthen the capacity of key stakeholders to facilitate adaptation in South African settlements through engagement, targeted communications and training opportunities (workstream 7, 8 and 9).**	The last objective did not change, it just became objective 6.

More information about each of these objectives, the methods for delivering them, and their outcomes are provided under Section 2.

1.3 Overall progress of the global project

The Green Book project has been completed in full to the satisfaction of the project steering committee. The aim was to develop a tool to support long-term municipal planning with the development of climate resilient settlements. The project was successful in developing such an online decision-support tool, which has so far received an overwhelming positive reaction

from all stakeholders. In as far as achieving all of the set objectives, the Green Book has achieved more than what it set out to do in all but the last objective.

Amended objective	Progress
✓ **Objective 1: Analyse downscaled climate change projections for South Africa to distinguish regional and local patterns of climatic changes (workstream 2), and apply the projections to identify the likely spatial extent and implications of hydro-meteorological hazards on South African settlements and their key resources in future (workstream 4)**	Expectations were met for workstream 2. Expectations for workstream 4 as set out in the proposal were met and exceeded. The project did not just identify high risk areas, but quantified the climate-related hazard risk for every municipality and settlement in South Africa, and the impact of climate change on key resources. The likely current and future extent of the exposure of every settlement is thus mapped.
✓ **Objective 2: Profile all South African municipal and settlement vulnerability and population growth (workstream 3).**	Expectations as set out in the proposal were met and exceeded as every municipality and its settlements were profiled. It is thus possible for every local municipality to look up their current vulnerability profile, see whether it has improved or worsened over time, and how they compare to other municipalities in the province and country. They can also see their extent of the future growth pressure they are likely to experience.
✓ **Objective 3: Integrate the evidence to create current and future risk profiles for South African local municipalities and their settlements, providing information on vulnerability, population growth, climate, hydro-meteorological hazards, and impacts on key resources (workstream 5).**	This objective has been met, and the depth and wealth of information as stipulated in the proposal, were exceeded, based on the outcomes of the first two objectives.
✓ **Objective 4: Develop a menu of appropriate, mutually supportive planning and design adaptation actions based on the risks (workstream 1 and 6).”**	The objective was met. It ended up being a smaller component of the work as envisaged in the proposal, and not the only final output per se, but on the other hand, all adaptation actions are linked to other actions in a typology to ensure none are loose-standing, but that they

	are mutually-reinforcing when integrated into local plans and strategies.
✓ **Objective 5: Integrate all the research findings into one decision-support tool (workstream 6).”**	This is a new objective.
✓ **Objective 6: Strengthen the capacity of key stakeholders to facilitate adaptation in South African settlements through engagement, targeted communications and training opportunities (workstreams 7, 8 and 9).**	This objective was partially met. The Green Book project team engaged many stakeholders and interested parties, but has not as yet conducted targeted roll-out and training of the Green Book. This is planned for Phase II of the Green Book in a new partnership.

The outputs, contributions and impacts of the Green Book are provided in detail in Section 3 and Annexure A of the report.

2 SYNTHESIS OF RESEARCH METHODS, RESULTS AND OUTCOMES

This section synthesises the purpose, research methods, and results of the Green Book project per objective (as adapted over the course of the project). It starts with a summary of the overarching research design, which is followed with a synthesised description of each of the objectives' purpose, research method and novel outcomes. The research methods are included here together with the results and outcomes, as the development of the interdisciplinary research methods is part of the achievement of the project, through co-production efforts.

2.1 The overarching research design

The Green Book project followed an interdisciplinary applied research methodology that combined various research techniques, analyses methods, models and approaches into a coordinated and coherent whole. The final output is a feat in inter-disciplinary research as it synthesizes and harmonised various domain disciplines into a unique product that is capable of addressing the South African local and national government's needs with regards to responding to the impending impacts that a shifting climate and urbanising population will have on our cities, settlements and key resources.

The comprehensive research methodology utilised in the Green Book can be classified as a mixed methods approach that integrates qualitative and quantitative techniques in the framework development, data collection, data analyses, indicator and model development processes. Some of the techniques utilised in this mixed-methods approach included desktop literature studies on theories and explorative best practice initiatives, multiple collaborative stakeholder engagement workshops, various statistical and mathematical techniques in the sourcing, alignment and processing of data, spatial data techniques in the indicator development processes, the utilisation of specialised geographical information systems to process and analyse the data, the use of advanced time series, qualitative techniques and causal models for forward projections and the use of advanced information dissemination tools to communicate and effectively visualise the results.

Many of the frameworks, concepts, indicators, tools, datasets and models needed to be able to address the project objectives wasn't readily available and or had to be developed and or

significantly enhanced for this purpose. The research team had to constantly develop, evolve and adapt the research methodology and as this was a research and development (R&D) project the consistent trial-and-error approaches ensured constant development, forward-moving and exploration into new emerging technologies.

Due to the cross-disciplinary nature and scale of this climate adaptation and risk profiling project, multiple domain experts where consulted which included research fields spanning climatology, demography, disaster risk sciences, environmental sciences, geography, informatics, urban planning, economics, computer sciences, ecology, architecture, anthropology, hydrology and statistics.

The Green Book integrates these various areas of specialised knowledge through its mixed research methods approach. The research is conceptualised from a strong disaster risk reduction and climate change adaptation science base and is grounded in the conceptual framework and definitions of the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change, Working Group 2 (Niang et al., 2014). A framework, approach and set of terminologies that places the concept of disaster risk at its centre. Figure 2 shows the conceptual framework of the Green Book project design. The following definitions apply:

- **Hazard**: Climate-related events (hydrological, climatological and meteorological hazards) that can possibly cause economic damage to and/or interruption of service in settlements as well as potential loss of life (e.g. floods, drought, wildfires, storm surges etc.).
- **Exposure**: Location and condition of exposed services, economic sectors, key commodities (e.g. agricultural commodities), and the associated infrastructure structures and services (e.g. water supply network) that could be adversely affected (e.g. poorly planned development within a hazard footprint, such as a flood plain).
- **Vulnerability**: Propensity to be adversely affected. The vulnerability of municipalities, settlements and neighbourhoods with regards to their inherent vulnerability (e.g. economic, physical, environmental socio-economic).
- **Adaptation:** Response mechanisms (e.g. planning or engineering) implemented with the aim of reducing the vulnerability and exposure of settlements and infrastructure with the ultimate aim of reducing the climate risk impacts, while contributing to developmental outcomes.

- **Risk:** Risk is defined as the risk of climate-related impacts that may harm a system. The risk of loss of lives, livelihoods, infrastructure, economic production emanating from the interaction between vulnerable communities, infrastructure and settlements that are exposed to a natural hazard.

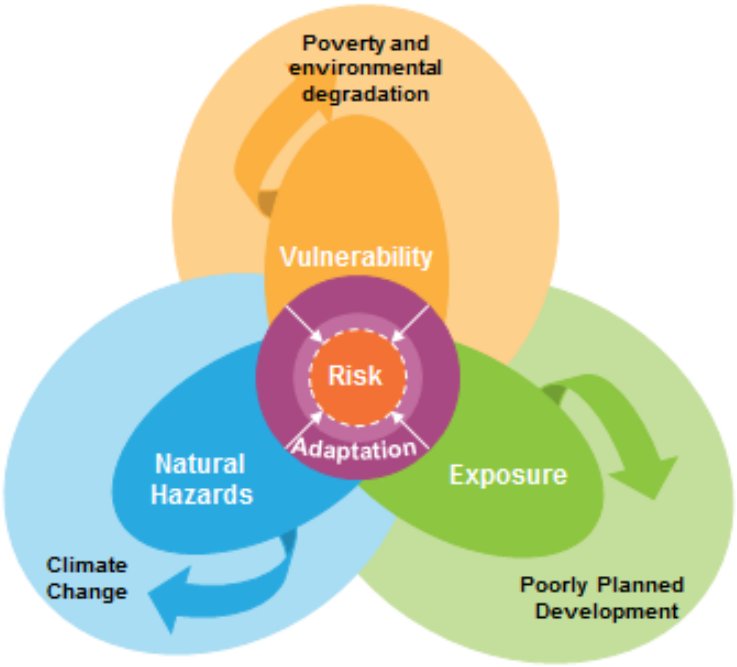

Figure 2: Green Book research design and terminologies (adapted from Niang et al., 2014)

With climate change comes changes in the intensity and frequency of natural hazards. In the past couple of decades scientific evidence has shown that the intensity and frequency of hydrological, meteorological and climatological hazards have increased, increasing the physical footprint of natural hazards such as droughts, wildfires, heat-waves, floods and storms. Development trajectories such as urbanisation and the response from the housing sector, the construction industry lacking in innovation and delivery, and the poor economic performance (slow GDP growth rate) have increased the vulnerability of many municipalities, increased their poverty levels, and reduced coping capacity in settlements and neighbourhoods. Development practices and land use management can also increase the exposure of vulnerable communities to natural hazards (e.g. allowing development in coastal setback-lines, not enforcing development controls, etc.). All of this has the potential to significantly increase the risk of loss of lives, livelihoods and economic assets. The role of adaptation planning is thus vital in reducing the exposure of municipalities, settlements,

neighbourhoods and infrastructure to the devastating impacts of climate-induced natural hazards.

In line with the above terminologies and definitions the research design of the Green Book was structured into six inter-dependent research workstreams (see figure 3), all with the purpose of producing quantitative scientific evidence, models, methodologies, frameworks, tools, datasets, maps and qualitative assessments to enhance the planning of climate resilient settlements.

Figure 3: Green Book inter-dependent research workstreams

Each stream utilised a series of research methodologies that were strongly supported through a co-production and co-development approach. This allowed for the inputs of multiple domain specific peers to test the scientific rigor, highlight caveats and constraints, reflect on the current thinking and relevance within a South African context, and to steer the research design, methodologies and findings towards being implementable and useable within local municipalities. The process was conducted through a series of four reference groups that consisted of members in academia, national government, implementation agencies, local authorities, NGOs and active role-players in the various disaster risk, climate adaptation, local government and planning domains. Their inputs were captured through individual engagement sessions, collaborative workshops, facilitated brainstorming sessions and peer-reviewing outputs.

The various research workstreams shared multiple key resources (e.g. data, people, facilities, model parameters, etc.) and all the streams were very closely linked and interdependent on each other (see textbox below for example). The project management team was closely involved and or managed these streams to ensure input and output datasets are in line with the overall aim and objectives. Regular brainstorming sessions, peer-to-peer discussions, scientific working sessions and domain relevant knowledge had to be harvested to ensure inter-disciplinary cohesion.

Example of inter-dependence amongst research streams

The delivery of the climate projections (*WS2) fed directly into the other research workstreams (WS4, WS5) as inputs, but was also influenced by the specific demand/needs for customised climate variables required in the hazard indices (WS4), and had to be customised to adhere to the requirements as part of the risk profiles design (WS5). The hazard indices were reliant on the settlement footprint boundary that was developed (WS3) and this was influenced by the design and conceptual understanding of the risk profile framework (WS5) and adaptation actions (WS1) framework. The climate projections (WS2) and the population projections (WS3) fed as input data into most of the WS4 impact studies (e.g. water demand/supply) but was reliant on the conceptual framework from WS5 as a basis. The various studies conducted as part of WS4 also utilised shared data sources, shared modelling outputs and in some cases shared model parameters. The selection of adaptation actions in WS1 was in response to the hazards identified in WS4, and can be filtered for municipal capacity as indicated in WS3.

*WS = workstream

2.2 Research methods, outcomes and novelty of results

2.2.1 Objective 1 (workstream 2)

Analyse downscaled climate change projections for South Africa to distinguish regional and local patterns of climatic changes

2.2.1.1 Purpose

Downscaling the climate change projections was the first step of the first objective. The main purpose of the workstream was to develop a set of high-resolution projections of future climate change over South Africa. The projections had to be of sufficient spatial and temporal detail to be of direct value in the Green Book climate change impact studies, hazard modelling and risk profiles and had to consider the range of uncertainty of modelling outputs from both low and high mitigation climate pathways. An important aspect of this work was to provide the

projections in suitable data formats to the various data users within the project, and to assist data users to appropriately interpret the data, including the uncertainties inherent to projections of future climate change. The variables were collaboratively agreed upon and fed into the various hazard studies (workstream 4), impact modelling studies (workstream 4) and municipal risk profiles tool (workstream 5).

2.2.1.2 Methods

The 8 x 8 km resolution projections were obtained by downscaling the CSIR's existing set of 50 x 50 km resolution CORDEX (Coordinated Regional Downscaling Experiment) projections of future climate change. This was done to incorporate many of the important topographic features of South Africa that directly affect climate, such as the eastern and southern escarpments. For each of the two emission pathways, 6 global circulation models (GCMs) that contributed to Assessment Report Five (AR5) of the Intergovernmental Panel on Climate Change (IPCC) were downscaled to a 50 km resolution over the globe, as part of the CSIR's contribution to CORDEX. The projections were analysed statistically and the implications for South Africa were discussed in a series of two peer-review reference group workshops. An uncertainty analysis was also presented through a comparison with the larger set of AR5 GCM projections.

For a detailed overview of the methodologies and models utilised please explore the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS2_ClimateChange_Report_2019.pdf

2.2.1.3 Outcome and novelty of results

A set of detailed projections of future climate change were generated. Covering South Africa at an 8 x 8 km resolution, these are the most detailed projections of future climate change ever available for the entire country. This is the first such an exercise on the African continent and the first time that climate projection has been downscaled for such a high resolution for two climate pathways considering six models that are representative of the South African climate. A series of 16 unique variables and multiple customised variables were developed throughout the course of the study. The impacts of the climate shifts are also displayed for each of the 1637 settlement and 213 local municipalities in South Africa.

The national results can be viewed in the interactive Climate Change story map located here: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=b161b2f892194ed5938374fe219

2e537. Local municipal results can be viewed in the Municipal Risk profile tool here: https://riskprofiles.greenbook.co.za

2.2.2 Objective 1 (workstream 4)

Apply projections to identify the likely spatial extent and implications of hydro-meteorological hazards on South African settlements and their key resources in future

2.2.2.1 Purpose

Profiling the climate-related hazards and the impacts of climate change on these hazards and key resources, was the second step in realising the first objective. Workstream 4 focussed on understanding the current hydro-meteorological hazards settlements are facing in South Africa, and considered the impact that climate change will have in future on the frequency and intensity of hazards such as flooding, drought, wildfires and coastal flooding. This stream also looked at the impacts that the various climate scenarios might have on South Africa's key resources such as surface- and groundwater availability, economic production and the agricultural sector specifically (as a proxy for food security).

2.2.2.2 Methods

No single approach, method or dataset existed that could be recommended or used for this study. Each of the various components utilised a series of statistical, mathematical and/or spatial modelling techniques to be able to effectively capture and model the various outputs. This workstream mostly utilised downscaled climate model outputs from workstream 2 and translated them to geographical hazard and impact studies. The population growth projections from workstream 3 were also used in the impact studies to determine the future demand for resources (e.g. population growth estimates used in water demand/supply and economic labour production). The settlement boundaries defined in workstream 3 also formed the basis for all the impact assessments conducted in this workstream. All components did a baseline as well as future assessment. A short summary of the methods used for each of the components of this workstream is discussed below, while detail is provided in each of the technical reports available on the website.

a) Coastal flooding: The impact of climate change on coastal zones

The goal of this component was to identify the coastal areas exposed to storm surge related flooding and sea level rise (as main sources for coastal risk in South Africa), and estimate the

degree and/or likelihood of exposure under current and future climate conditions This was done making use of a two-step approach:

i. Generating a coastal flood hazard index that consists of assessing the flood hazard exposure, generating elevation hazard risk assessment, generating coastal distance hazard risk assessment, and generating final coastal flood hazard index; and
ii. Performing a risk assessment for coastal settlements where the total spatial extent of each hazard risk class was assessed.

The approach was largely desktop-based and used existing geospatial information on topography and population characteristics. Flooding through rising water levels in the hinterland, e.g. through excessive rainfall and river flooding, was not assessed here, nor was the potential flood risk posed by tsunamis.

From the analysis the extent of risk zones in coastal areas, the buildings exposed in risk zones and the population affected in risk zones were determined. More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_CoastalFlooding_Report_2019.pdf

b) Flooding: The current state and implications of climate change

The purpose of this component was to conduct a flood risk assessment to identify the municipalities that are at risk of flooding. This component does not provide 50-year floodlines, but it does assess the flood risk for settlements based on the characteristics of the climate and the upstream water catchments, and the areas of each settlement that are potentially exposed to floods. The focus of this component is on floods generated by surface water (fluvial or river-related floods) but groundwater rises are important in some areas (e.g. the Cape Flats near Cape Town).

The approach included disaggregating flood risk into two components, namely flood hazard and flood consequence. The flood hazard assessment was done by combining information on climate; observed floods; and the characteristics of water catchments that make them more or less likely to produce a flood. Flood consequence, or vulnerability to a flood, was determined by combining exposure, susceptibility and resilience. To do this, two main aspects were examined, namely:

i. The physical exposure of the settlements to a flood by identifying the areas which are within 10m of the elevation (level) of the river bed; and

ii. The socio-economic characteristics linked to the land cover classes found within that area (e.g. formal versus informal settlements) to identify the potential socio-economic impacts.

A Flood Hazard Index (FHI) was developed, which is based on the catchment characteristics and design rainfall, and was averaged at the quinary catchment level. More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_Flooding_Report_2019.pdf

c) Wildfires: The impact of climate change on wildfire

The objective was to determine the level of wildfire risk prevailing in the wildland-urban interface of settlements of South Africa. In addition, the objective was also to determine how the current number of high and extreme fire danger days that these settlements experience is likely to change under different climate change scenarios.

For this component the method followed in another study (Forsyth, Kruger & Le Maitre, 2010), which used mesozones (irregular polygons about 50 km² in area) as the basic assessment unit, was adapted to use 1 km wide buffers on the inside and outside of the settlement boundaries as the assessment unit. Two components to this assessment was added, namely fire occurrence information, and the projected changes in the occurrence of fire danger days.

The methodological process included:

- Defining the areas for assessing the hazard (i.e. wildland-urban interface);
- Characterising fuels and fire hazard;
- Quantifying the fire hazard for each settlement;
- Determining the consequence of a wildfire for each settlement;
- Determining the final level of social and economic consequences for each settlement;
- Assigning fire risk using a risk matrix;
- Using a record of fire occurrence between 2011 and 2016; and
- Accounting for the effect of climate change on fire danger days, for three time periods (baseline, near future and far future).

More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_Wildfire_Report_2019.pdf

d) Drought: The impact of climate change on drought

This component aimed to assess the impact of climate change on drought tendencies for South Africa. The study primarily used the Standardised Precipitation Index (SPI) to characterise the extent, severity, duration, and time evolution of drought (flooding) over South Africa. The SPI severity index was interpreted in the context of negative values indicating droughts and positive values indicating floods. The extent of moisture stress or loss due to global warming was also assessed using the Precipitation-Evapotranspiration Index (SPEI).

A significance test was conducted using a variant of the Mann-Whitney nonparametric procedure that explicitly accounts for variance adjustment caused by incidents of ties. More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_Drought_Report_2019.pdf

e) Economy: The impact of climate change on economic production and growth

The purpose of this component was to assess the impact of climate change on national and local economic output. The estimated impacts or effects were then used together with projected future temperature scenarios for South Africa to forecast possible economic losses due to climate change. Provincial level estimates were adapted to municipal economic structures to forecast losses at a municipality level for the forecast horizons of 2030 and 2050.

An econometric and forecasting methodology was used that can optimise the available data, while also catering for certain biases that may arise due to data issues. The model used to develop the econometric framework, is based on the well-known theoretical foundation of neoclassical economic growth models underpinned by economic production functions. The econometric model was estimated using a technique known as the System's Generalised Method of Moments. Before examining the results of the forecast of climate effects, a robustness check of the performance of the estimated model in forecasting was done.

More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_Economy_Report_2019.pdf

f) Agriculture, Forestry and Fisheries: The impact of climate change

The methodological approach for the study was subdivided in 4 main components:

i. Determining the contribution of agriculture, forestry and fisheries to the economy. The basic approach included a screening process to determine the most important areas

in terms of Gross Value Added (GVA) and employment for the agriculture, forestry and fisheries sector relative to the other sectors of the South African economy.

ii. Climate change scenario analysis using historical climate variables, as well as multi-model projections of future climates, to help identify specific climate-related risk factors for agriculture within specific regions.

iii. Crop and livestock suitability modelling indicating how the area suitable for crop production under the present climate conditions might shift or expand under the scenarios of future climate change.

iv. Impact assessment on local municipalities, using the climate change analyses in conjunction with the crop modelling outputs. The potential impacts of climate change over a specific area, or for a specific crop, were assessed to give more detail on how predicted climate changes translate into location/crop specific impacts.

More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_Agriculture_Report_2019.pdf

g) Surface Water: A water supply climate risk narrative

Under this component a first order assessment was done of the vulnerability of surface water supply to climate change for municipalities across South Africa. In order to get a high-level first order assessment of the relative climate change risks for water supply to different towns and cities across South Africa, a general risk equation was developed to determine the current and future surface water supply vulnerability that combines both climate change and development risks (i.e. demand based on an increase in population needs (this assumes assumptions regarding drinking water, industry, agriculture etc.)

The current vulnerability of individual towns was calculated based on the estimated current demand and supply as recorded across the country by the Department of Water and Sanitation's (DWS) All Towns study of 2011. The future vulnerability was calculated by adjusting the water demand for each town proportional to the increase in population growth for both a high and medium growth scenario.

The level of exposure was determined as a factor of the potential for increasing evaporation to result in increasing demands, and for changes in precipitation to impact directly on the sustainable yield from groundwater, and the potential for impacts on surface water supply. These were then multiplied by the proportion of supply from surface and groundwater for each town.

More information about the method is available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_SurfaceWater_Report_2019.pdf

h) Groundwater: The Impact of climate change on future groundwater availability

The main objective of this study is to identify potential high-risk areas under a changing climate. In relation to groundwater recharge, these high-risk areas include areas predicted to experience extensively low or high groundwater recharge potential values in response to changing temperatures, evaporation and precipitation.

The Vilholth GRiMMS (Groundwater Drought Risk Mapping and Management System) formulation (Vilholth et.al., 2013), which implemented a composite mapping analysis technique to produce an explicit groundwater recharge drought risk map, was adapted to formulate a series of potential groundwater recharge maps for the far-future across South Africa.

Following the output of groundwater drought risk maps, the impact of climate change on groundwater resources is illustrated through a set of "change in recharge" (Δ recharge) maps reflecting, in qualitative terms, the response of groundwater systems to climate-induced recharge patterns. Finally the future period 2031 to 2050 was compared with the historical period 1961 to 1990.

More information about the methods are available in the technical report: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS4_Groundwater_Report_2019.pdf

2.2.2.3 Outcome and novelty of results

This workstream resulted in several new models having been developed and/or customised for the South African landscape. It is the first time in South Africa that the impact of climate change (workstream 2) on every settlement (workstream 3) have been quantified for various hazards such as drought, wildfires, inland floods and coastal flooding (workstream 4). The outputs were applied at a national level to highlight high risk settlements but also on a local municipal level to highlight hazards and impacts per local municipality (as part of workstream 5).

In terms of the specific research components:

- The wildfire work extended beyond what was done in previous assessments by assessing the wildfire hazards and the economic consequences or vulnerability at the wildland-urban-interface of all settlements in the country. More information on this component is available here: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=a726c58f435141ba80b57fe21d3ec744

- As part of the flood risk modelling component, an alternative approach was used where widely available information on the characteristics of the catchment such as slope, soil type, land cover and design rainfall were used to estimate responsiveness to rainfall. This newly developed model was unable to deal with large (i.e. primary) catchments so the team divided the country into secondary catchments. They succeeded in doing so and also merged the outputs into large catchments so that we can look at settlements, for example, on rivers well downstream of the headwater catchments. This took much more effort and time than what was planned for, but the outcomes are of great value. More information can be found here: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=33d9a846cf104e1ea86ba1fa3d197cbd

- The impact of a changing climate and population growth for every settlement footprint across South Africa with regards to groundwater dependency was quantified and the results can be viewed here: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=73c7e05d7a1e4b0dbacc99b3709f7065.

- The impact of a changing climate, combined with projected population growth, on water supply in municipalities was quantified. This information offers local municipalities a better understanding of their current and future water supply vulnerability. The results can be viewed here: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=74fc5a7337f34460b7a09242d0770229

2.2.3 Objective 2 (workstream 3)

Profile South African municipal and settlement vulnerability and population growth

2.2.3.1 Purpose

Adapting settlements to be more resilient to the effects of climate change and climate variability calls for a thorough understanding of the hazards, risks, vulnerability and adaptive capacity within settlements. This section was concerned with establishing a base for understanding the inherent vulnerabilities within cities, and thus explored the social, economic, physical and governmental structures that make cities more or less vulnerable to the effects of climate change. The workstream also explored the potential shifts and development trajectories of South African settlements and developed methods, models and techniques to capture likely shifts in these.

This objective was realised in two steps:

a) Profiling cities/towns/settlements according to their social, economic, physical and governmental vulnerabilities; and
b) Projecting the socio-economic development trajectories of settlements to 2030 and 2050.

2.2.3.2 Methods

a) Profile city/town/settlement vulnerabilities

The objective followed a semi-quantitative indicator-based risk assessment method. An indicator-based risk method entails reducing a complex problem into key factors, identifying variables that characterise those factors and using mathematical and decision theoretic techniques to quantify and aggregate the variables into measurements that are intuitive, holistic and descriptive of the settlement's make-up. The research methodology was undertaken through 1) developing a vulnerability assessment framework, 2) sourcing, processing and collating data into the framework, 3) the creation of composite vulnerability indicators, and 4) the development and dissemination of vulnerability profiles. In order to develop this multi-dimensional and multi-scale vulnerability framework and the accompanying set of composite indicators a comprehensive research methodology utilising a series of techniques and methods was used. The research methodology utilised a mixed methods approach that considered the following:

- Comprehensive literature study on vulnerability concepts and definition.

- Best practice studies with regards to variable selection and composite indicator development.
- Vulnerability framework development was conducted in an iterative multi-stakeholder process, the process involved collaboration between domain experts in multiple disciplines and engagement with practitioners and policy makers involved through a series of interactive workshops.
- Various statistical and mathematical techniques in the sourcing and alignment of data.
- Spatial data techniques in the indicator development processes.
- The use of advanced information dissemination and storage tools.

For more detail on the technical development of this objective a technical overview presentation is provided here: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS3_ProfilingSettlementVulnerability_2019.pdf

b) Profile population growth projections

This step was executed through conceptualising and developing a growth/decline model for estimating growth and decline trajectories of settlements in South Africa. This was done through 1) designing the conceptual model, 2) sourcing input data, 3) building the model, 4) validating the model, and 5) linking the model to settlements. This was done using the following methods:

- Comprehensive literature studies.
- Model design.
- Collaborative workshops on parameterisation.
- Building the model in R scripting language.
- Validation of model with historical input data.
- Peer-review and testing with reference groups.

For more detail on the technical development of the population growth model a comprehensive methodology document can be accessed here: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS3_SettlementGrowth_Report_2019.pdf

2.2.3.3 Outcome and novelty of the results

The workstream resulted in a vulnerability assessment framework and set of indicators that can be used to profile 1) all 213 local municipalities in South Africa based on four unique statistically developed indicators, 2) all 1637 settlements across South Africa based on six

unique indicators and 3) two spatial multi-criteria indicators that captures vulnerability on neighbourhood level (500mx500m resolution). This is the first such an exercise globally.

This research workstream also developed a population potential growth model to forecast settlement growth across South Africa on a resolution of 1x1 sq. km., the first settlement population growth model to be developed on the African continent. The model boasts a 96% accuracy rate in the validation process.

The results can be viewed in the two interactive story maps located here:
Settlement Vulnerability: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=280ff54e54c145a5a765f736ac5e68f8
Growth Projections: https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=5180459a765c4e63bfb3fa527c7302b3
Municipal Risk Profile Tool: https://riskprofiles.greenbook.co.za

2.2.4 Objective 3 (workstream 5)

Integrate the evidence to create current and future risk profiles for South African local municipalities and their settlements

2.2.4.1 Purpose

This objective is linked to workstream 5 which involves the integration of workstream 2, 3 and 4 to create composite risk profiles for all South African municipalities and their settlements. In these risk profiles the outputs from other research workstreams were distilled and presented in a user-friendly way, with the main audience being municipalities. The purpose of the risk profiles are to inform long term planning and to support the development of risk and vulnerability assessments within local government. The risk profiles are also potentially useful to students, consultants, policy-makers, NGOs and researchers.

2.2.4.2 Methods

Workstream 5 utilised a geoinformatic-based risk assessment approach. The risk profiles represent overall exposure to the identified hazards. The profiles are represented in an interactive online dashboard showcasing distilled information for decision makers in a risk profile for each of the 213 local municipalities in South Africa. To assist in the planning

processes, the profiles not only consider the static risks of the current state of settlements but are forward-looking (2050), considering the future projections for population growth as well as the likely impacts that climate change will have on the extent and intensity of various hazards. They also provide information on the likely impacts of climate change on South Africa's water resources, economy and agriculture.

The municipal risk profiles combined the scientific information on climate change projections, hazard modelling, vulnerability profiling and population growth projections per municipality, and precede the Adaptation Actions Tool by providing risk factors that can be used to prioritise adaptation actions. The design and conceptualisation of this workstream was done through a series of multiple brainstorming and interactive workshops and sessions to identify the best possible information dissemination options and processes. The conceptualisation and design of the Risk Profile Tool was done as part of workstream 5, while the technical tool development was executed in workstream 6.

The conceptualisation and design process can be summarised as:

- Develop aims and purpose of the tool.
- Scope similar existing tools.
- Identify key data communication formats that can be used.
- Develop a draft concept risk profile tool.
- Explore the technical requirements and possibilities.

The process was iterative and the draft concept was refined as part of workstream 6.

2.2.4.3 Outcome and novelty of the results

The Green Book Risk Profile Tool (https://riskprofiles.greenbook.co.za/) forms part of the Green Book website. The tool provides temporally dynamic risk profiles for each municipality and its settlements in South Africa. These profiles provide information on vulnerabilities, population projections, exposure to climate hazards, and the impacts of climate change on some of our municipality's key resources. Information is available for the present and a 2050 future. The tool also links through to other sections of the Green Book website such as the story maps and the Adaptation Actions Tool.

The municipal risk profile tool is first of its kind in Africa. Although similar tools are available elsewhere, none of the platforms or tools the team were able to find, were as comprehensive

and information-dense as the Green Book Risk Profile Tool. Some examples of similar open-access online platforms or tools on various scales are:

- The Building Resilience in the Hindu Kush Himalayan Region platform, by Himalayan Adaptation, Water and Resilience (HI-AWARE) Research on Glacier and Snowpack Dependent River Basins for Improving Livelihoods and Climate Adaptation Services (CAS). The platform provides climate information and possible adaptation actions for the HKH region using Story Maps. It is available here: http://www.cas-platform.com/hi-aware/
- The Climate App that was developed to provide information for new and renovation projects with specific adaptation goals. The development of the App was supported by the Climate Changes Spatial Planning Foundation. It is accessible here: http://www.climateapp.nl/
- The US Climate Resilience Toolkit's Climate Explorer that offers customisable graphs and maps of observed and projected temperature, precipitation, and related climate variables for the entire United States. It is also accompanied by other tools to help build resilience to extreme events (https://toolkit.climate.gov/tools). It is accessible here: https://toolkit.climate.gov/

The settlement focussed risk and vulnerability contribution of the project, (focussing on all towns and settlements throughout South Africa in a relative data scarce context) was a mammoth task in terms of scale, scope, data requirements, innovations in analyses and modelling, sense-making and coordinated interdisciplinary teamwork. This involved conducting and integrating downscaled climate change modelling, modelling implications for potential climate change related hazard on settlements, and potential exposure in relation to multi-dimensional settlement vulnerability.

2.2.5 Objective 4 (workstream 1 and 6)

Develop a menu of appropriate, mutually supportive planning and design adaptation actions, based on the risks

2.2.5.1 Purpose

Workstream 1 formed part of objective 4 and involved scoping and assessing existing, local and global, urban adaptation strategies and plans to extract a range of appropriate, mutually supportive planning and design adaptation actions to be considered for implementation in South African settlements. The objective was achieved by developing a typology of locally

relevant planning and design actions that can be used to adapt South African settlements to reduce their vulnerability and exposure to climate risks and to exploit opportunities for sustainable development. These actions are to be integrated and mainstreamed into existing urban development strategies and plans, such as the spatial development framework and the integrated development plan.

2.2.5.2 Methods

A qualitative, iterative and exploratory approach was followed to develop a menu of adaptation actions that can be selected and integrated into existing or future municipal plans and strategies. The approach of assessing which adaptation actions to include was developed during a number of brainstorming sessions with the research team, and the interim results were tested with stakeholders. A reference group meeting was held to test the methodology and approach to this workstream in year 1, and then in year 3 the draft menu of adaptation actions were tested and further developed with officials from the City of Cape Town. It was decided that a quantitative cost-benefit analysis, as initially planned, was not feasible, as it would have involved full cost-benefit analyses of every action. This would have been too data intensive, requiring the estimation of the possible GDP savings for each adaptation strategy, the cost of each strategy (from the various scenarios) as well as balancing the time-discounted benefits. This would have taken too much time and resources for the various scenarios.

The development of the typology followed an iterative process where a menu of adaptation actions were reviewed and refined to reflect knowledge gained through further research and engagement of stakeholders and experts. The process followed was to:

i. Conduct a desktop analysis and review of existing adaptation measures. Domain experts assessed various existing and proposed plans to extract information and actions that could be of use and relevance to South African settlements. This included energy, water, stormwater, sanitation, solid waste, mobility and transport, food security, ecosystems, ICT infrastructure, health, etc. This process was complemented by a reference group which consisted of experts in the public, private and NGO sector. An extensive list of adaptation options and measures was developed based on the input of these domain experts.
ii. Although parameters were set for the selection of the actions to be included in the menu from the start, the combined menu of actions that were extracted from the domain experts' desktop analysis was so diverse, that it was necessary to redefine what were to be included and what not. Options were only included in the Green Book if they were:

- Linked to the mandate of local government,
- Suitable for urban areas,
- Associated with a local planning function,
- In support of good planning principles, and/or
- In support of GHG mitigation.

iii. The reduced menu of actions was then further refined by assigning a range of attributes to each action. This was done by reviewing the menu of adaptation actions in terms of each action's purpose. Three categories were identified, namely what local planning function is supported (spatial planning, land use management, environmental planning, landscape- and urban design, and engineering services and infrastructure provision); which climate change hazard(s) and/or impact(s) it addresses; and the type of climate change adaptation strategy (win-win, no regret, low regret). Under each of these categories a number of attributes were identified to further differentiate the actions.

iv. The draft menu of actions was tested with officials of the City of Cape Town. A few more actions were added, split or left out, based on their input.

v. The descriptions for all actions (81 in total) were completed based on a Dutch example (http://www.climateapp.nl/). This include a picture, and an overview of the action as well as the goals, benefits and co-benefits, costs and implications that need to be considered, and an example of where such an action was implemented (where available). Gender is addressed where possible under benefits and/or implications, depending on the action. Costs were addressed qualitatively, by proposing possible negative implications and requirements in terms of capacity and resources for implementation.

vi. Once the menu of actions was complete, all actions were linked to each other to be mutually beneficial or supportive. This was done using a matrix to create 'baskets' of actions that can be implemented together across scales, sectors and systems.

The actions can be filtered on the website in the Adaptation Actions Tool to be able to link the adaptation actions to the risk profiles and the capability of the municipalities to implement these. Actions can be filtered according to the specific climate change hazards and impacts, as well as the planning function, and/or the adaptation strategy. The menu of actions was developed through close cooperation with workstream 5.

More detail on the research methodology is available in the summary presentation: https://s3-eu-west-1.amazonaws.com/csir-greenbook/resources/WS1_AdaptationTypology_2019.pdf.

2.2.5.3 Outcome and novelty of the results

The menu of adaptation actions was developed as an online tool, https://adaptationactions.greenbook.co.za/, and can be found on the Green Book website. The novelty of the menu of adaptation actions is that it brings together local planning and design actions that are appropriate for the South African context and planning function. Stand-alone adaptation actions would not be able to bring about immediate and long-term change in support of resilience. The Adaptation Actions Tool is therefore novel because it proposes a basket of mutually-reinforcing actions that are linked to each other so that no action is loose-standing, but supported. For example, when a land-use management adaptation action is proposed, it is supported by a spatial planning action as well as an urban design action. This way the actions identify a space where adaptation needs to take place (through spatial planning), it protects that space (through land use management), and it sets a design principle to follow when that space is developed (landscape- or urban design).

The adaptation actions have a specific focus on water-sensitive urban design, given water scarcity, but also the propensity for urban flooding to occur in many South African settlements. This focus is not explicit, but integrated into the many soft adaptation actions. Where gender and equity could be promoted through an adaptation actions, this is described under to goals or benefits of such an action.

The adaptation actions need to be integrated into the many everyday planning functions, plans and processes of local municipalities. Municipalities can select the most appropriate actions to be integrated into their local urban planning strategies and plans, based on the risks in their profile. The adaptation actions were developed with the emphasis on easy integration into local spatial plans, development plans and sector plans, to reduce exposure to hazards, and contribute to liveable and resilient settlements. This way, “climate-awareness” in spatial planning can be increased, thereby increasing the capacity to manage climate change and reduce exposure to risk.

2.2.6 Objective 5 (workstream 6)

Integrate all the research findings into a decision-support tool

2.2.6.1 Purpose

The purpose of this objective (workstream 6) is to align and integrate the outputs of all the previous workstreams into a decision-support tool that is readily accessible, and easy to navigate. The outcome of this is to be an online, open access tool that will help municipalities understand their hydro-meteorological risk profile so as to influence spatial planning and infrastructure investment at a local level by also providing climate change adaptation actions to reduce the risks of vulnerable people and sectors.

2.2.6.2 Methods

From the onset of the project a hard copy and a website were planned. The website was to host a copy of the information contained in the hard copy, but then with links to relevant other projects such as the Red Book. Over time, the project team came to realise that the wealth and depth of information that was generated by the project could not be contained in a hard copy. Permission was granted by the IDRC to develop the Green Book as an online tool only.

The process that was followed to develop the Green Book website and tools include the following steps:

- Develop the outcomes of what the website and tools should achieve.
- Identity and scope similar tools and resources to learn from their look and feel and functionality.
- Conceptualise the different components of the Green Book, namely the main website, the story maps, the Risk Profile Tool and the Adaptation Actions Tool.
- Share the concept with web developers and adapt according to technical possibilities.
- Develop draft website, story maps, Risk Profile Tool and the Adaptation Actions Tool.
- Create and revise content and datasets to feed into website and tools.
- Review and test draft website, story maps, Risk Profile Tool and the Adaptation Actions Tool.
- Finalise website, story maps, Risk Profile Tool and the Adaptation Actions Tool.

The development of the Green Book website and its tools was an iterative process. As each section was finished on a test site, feedback was provided to the web developers based on reviews and tests by the project team as well as others.

2.2.6.3 Outcome and novelty of the results

The outcome is the Green Book online decision-support tool that is a first of its kind in the world (as far as can be established) given the level of detail, covering all municipalities in the country, integrating interdisciplinary scientific evidence, combined with adaptation actions that can be integrated into local plans, available at www.greenbook.co.za.

The Green Book is structured into three main components. The first component is a series of 11 interactive national story maps. It was decided to provide the user with an overview of the scientific research findings of the Green Book project in the form of story maps. Several dissemination options were investigated, and it was decided that an emerging technology called story maps met the criteria of 1) being informative, 2) combining the use of info-graphics and visual images to communicate effectively, 3) enhancing the message through graphic design, and 4) using a platform that can include all of the above (info-graphics, messages, visuals) while automatically drawing in data from a database. This also allowed the team the opportunity to obtain new skills and several team members were trained in the use of the story maps.

Evidence is provided on:

- The vulnerability of South African local municipalities, settlements and neighbourhoods,
- Urban growth projections for South African settlements,
- The current South African climate and climatic shifts projected towards 2050, and
- The implications of these shifts for some of South Africa's hydro-meteorological hazards and resources.

The story maps also provide information on the research methodology, findings and recommendations, as well as a link to the technical reports and interactive datasets. The 11 story maps can be accessed here: https://greenbook.co.za/story-maps.html.

The second component is the municipal Risk Profile Tool, an interactive tool that grounds the adaptation process in scientific evidence of the risks each local municipality in South Africa is likely to face under a changing climate by 2050. The Risk Profile Tool provides temporally dynamic risk profiles for each municipality and its settlements in South Africa. These profiles provide information on:

- Vulnerabilities,

- Population projections,
- Exposure to climate hazards, and
- The impacts of climate change on some of our municipality's key resources.

The Risk Profile Tool is available at https://riskprofiles.greenbook.co.za/.

The third component is the municipal Adaptation Actions Tool, an interactive platform to support adaptation planning in local municipalities. The Adaptation Actions Tool provides a range of planning and design actions for municipalities to consider:

- To adapt their settlements and environments to the likely impacts of climate change,
- To climate-proof their settlements, and
- To reduce their exposure and vulnerability to hazards, and thus the risk for disaster.

Guideline on how to select and prioritise adaptation actions are also provided on the website. The Adaptation Actions Tool is available at https://adaptationactions.greenbook.co.za/.

With the evidence and planning support provided by the Green Book, local municipalities will be able to plan for current needs, as well as to prioritise interventions to adapt their settlements to future climatic changes through effective forward planning.

2.2.7 Objective 6 (workstreams 7, 8 and 9)

Strengthen the capacity of key stakeholders to facilitate adaptation in South African settlements through engagement, targeted communications and training opportunities

This objective has not changed at all. All but one aspect of this objective was addressed in the duration of the project. Because the scope extended on a number of workstreams, the final products were delayed and not enough time was left to address the formal capacity building and training component of the objective, though this happened informally through stakeholder consultation and information dissemination. The research team acknowledges the value of this objective and has canvassed a number of stakeholders who would be able to support the roll-out of the Green Book through training of local government officials and professionals in Phase II of the project, post March 2019.

Throughout the project, the project team engaged with stakeholders and experts within national government, local government, NGOs, industry and academia. Engagement was done as part of the peer-review and co-production process and as part of the process to disseminate findings and to secure buy-in and support. Co-production was mainly achieved through reference groups, in which members contributed to the research design, peer-reviewed the content, validated the outputs, shared lessons learnt from their own experiences, and gave their support to information dissemination and raising awareness. More information on this process is available on the Green Book website (https://greenbook.co.za/co-production-peer-review.html). Ad-hoc presentations to stakeholders were done when requested, and where the opportunity arose.

2.2.7.1 Workstream 7: Communication and dissemination

Disseminating the knowledge and understanding generated in the Green Book is crucial to the project. Dissemination involves making known and available data, results of the research and its application, as well as its point of departure, questions and perspectives. The communication and dissemination of research is crucial for contributing to the latest developments in research. It serves as a progressive method of receiving feedback, and allows for various groups outside of the research and academic world, including public bodies, to be reached.

Throughout the project the Green Book team disseminated information about the method (and tested it with peers), initial findings and the value of the Green Book concept. The team also presented the Green Book at various local and international conferences. With the launch of the Green Book in March 2019, the project received widespread media attention throughout the country in print, radio, online and video media.

See Annexure A with a list of all the presentations made, media statements and conferences attended.

2.2.7.2 Workstream 8: Stakeholder engagement

Stakeholder engagement was, and continue to be important to the success of the Green Book and is a mutually beneficial function. It was essential to ensure that the final product is well-informed and that it addresses the needs of the users, as well as securing their buy-in by providing stakeholders the opportunity to contribute to the Green Book's development.

The Green Books stakeholder engagement objectives were to:

- Identify and engage stakeholders;
- Secure the commitment of a defined group of stakeholders to the project aims;
- Provide effective communication, facilitation, coordination and other supportive conditions to achieve the best outcomes from stakeholder engagement; and
- Encourage an environment where stakeholders can learn, understand, contribute and implement the Green Book's strategies and guidelines to achieve the desired outcomes in the South African planning and policy space.

Potential stakeholders were identified at the onset of the project and the list continued to evolve and expand as the project progressed and networks grew. Stakeholders have been engaged at multiple levels, to varying degrees, and different methods were used to inform, consult, involve or collaborate with stakeholders at the various stages of the Green Book project. This includes formal engagements to inform government departments and other important stakeholders of the Green Book and/or its progress; attending conferences, seminars and workshops; interviewing adaptation project champions and experts in the fields of adaptation, planning, local government etc.; hosting reference groups to provide strategic and specialist guidance for each of the workstreams; and involving peers in the reviewing of the methods and outputs.

Formal engagement was done through:

Reference groups

Experts in various disciplines were selected as reference group members to contribute to the research design, peer-reviewed the content, validated the outputs, shared lessons learnt from their own experiences, and gave their support to information dissemination and raising awareness. There were four reference groups and 16 members in total. Members of the reference groups were expected to sit in on one workshop to advice on the scope and methodology for the different project components and then, towards the end, to review the outputs that were developed under each component. They thus participated and contributed to the development of the methodology, and remained aware and informed of evolving priorities and plans during the development of the Green Book.

Peer-reviewing

Peer reviewers (31 in total) reviewed the content, validated the outputs, and supported dissemination and awareness raising. This was necessary because of the novelty of every

step in compiling the Green Book. None of this research had been undertaken on this scale for the whole country before. Draft chapters and other outputs from various workstreams were reviewed and subsequently amended and/or expanded. There were more peer-reviewers than reference group members.

Stakeholder engagements

The purposes of stakeholder engagements were to obtain buy-in in support of implementation, to obtain support for the outputs and their use, and to provide opportunities for stakeholders to influence the content. The collaboration and stakeholder engagement process has evolved throughout the project and has continued to add more value to the project and its outputs. The stakeholders consulted included national, provincial and local government, the private sector and NGOs. From these engagements we received:

- Support for the project.
- Suggestions for peer-reviewers.
- Suggestions of other stakeholders to consult.
- Information on other relevant initiatives and case studies.
- Invitations to serve on technical committees.
- Opportunities to disseminate information and findings about the Green Book to their constituencies (see impact report for stakeholder engagements for more details).

A complete list of peer-reviewers, reference group members and stakeholders consulted are captured in Annexure A of the report, and also on the website.

2.2.7.3 Workstream 9: Training and capacity building

This is the only workstream under the project that was not fully met. It remains however an important objective, and is thus the focus of the second phase of the Green Book programme.

The Green Book's training and capacity building objectives were to:

- Train urban planners, environmentalists, disaster managers and engineers to be well positioned to apply the guidelines outlined in the Green Book;
- Capacitate educators to train planning, environmental, disaster risk reduction, economic and engineering students in adapting urban settlements to the risks associated with climate change; and
- Expand the research focus area and the capacity of researchers at the CSIR and partners in the area of climate change adaptation.

Because the scope of a number of the workstreams expanded, the final products were delayed and not enough time was left to address the formal capacity building and training component (the first two bullets under this workstream's objectives), though this happened informally through stakeholder consultation and information dissemination. The research team acknowledges the value of this objective and has canvassed a number of stakeholders who would be able to support the roll-out of the Green Book through training of local government officials and professionals.

The part of this objective that promotes the 'research focus area and the capacity of researchers', was successful. Researchers involved in the Green Book project (both junior and senior), have become much more aware of the impact of climate change, and in particular on settlements, as this was a 'new' focus area for many of the researchers working in the Natural Resources and Environment Unit of the CSIR. Water scarcity has become a very important topic in South Africa given the number of severe droughts we have experienced over the last number of years. Many CSIR researchers are better equipped as a result of working on aspects of the Green Book, to participate in discussions around water. Researchers are now more likely to raise issues of climate change and water scarcity in workshops, seminars and meetings with stakeholders. The project has also advanced a number of researchers' skills on spatial modelling and dealing with large datasets. The Green Book team integrated information, data, techniques, perspectives, concepts and theories from multiple areas of specialised knowledge to advance and integrate an understanding of risk, vulnerability and adaptation using a holistic approach.

The capacity building of junior researchers in particular was facilitated through mentor-protégé relationships between junior and senior researchers and through peer-to-peer learning. The following mentor-protégé relationships were set up or emerged organically:

Mentor	Protégé	Subject/field
Willemien van Niekerk	Amy Pieterse	Urban planning and climate change adaptation, project management and administration
Alize le Roux	Kathryn Arnold	Geo-informatics, risk and vulnerability
Alize le Roux	Chantel Ludick	Geo-informatics
David le Maittre	Ilse Kotzee	Flood modelling

A major form of capacity building was through supporting post-graduate studies and supervision. The following people are furthering their qualifications by conducting research related to the Green Book:

Person	Degree	Supervisor	Progress
Laura Wools	Msc Geo-information Science, Wageningen University, the Netherlands	Alize le Roux	Laura completed her internship obligations with the CSIR on 31st March 2017. She spent 4 months building capacity on town growth modelling as part of the WS3 town growth modelling component. She received her MSc Geo-information Science degree at the Wageningen University in Netherlands.
Brenna-Leigh Robertson	Masters in Disaster Management at the University of the Free State	Willemien van Niekerk	Brenna-Leigh completed her mini-dissertation successfully and graduated in 2018 from the University of the Free State, South Africa.
Amy Pieterse (staff member)	Masters in Urban and Regional Planning at the University of Pretoria, South Africa	Willemien van Niekerk	Planned date of submission is August 2019.
Kathryn Arnold (staff member)	Msc Geomatics, University of Cape Town, South Africa	Alize le Roux	Planned date of submission is December 2019.

3 PROJECT OUTPUTS, CONTRIBUTIONS & IMPACTS

This section of the close-out report highlights the main project output, the contribution to knowledge that this project represents from a scientific, developmental and/or policy perspective, as well as the uptake of the project results by various stakeholders and other impacts that the project have already seen.

3.1 Project output

3.1.1 Main output

The main output is the Green Book online interactive tool to support long-term municipal planning with the development of climate resilient settlements, available at www.greenbook.co.za. The Green Book looks forward to the year 2050 by projecting settlement growth combined with quantitative, scientific evidence of the likely impacts that climate change will have on South African towns and cities. Every settlement risk profile is linked to customisable adaptation actions, to be considered for integration into local plans and strategies that are to be implemented.

The ultimate goal of the Green Book is to contribute to resilient, sustainable and live-able settlements through climate change adaptation. The Green Book website is a novel information-rich web-based information source and is structured into three main components.

The first component is a series of interactive national story maps. There are story maps available for all the components that make up Workstreams 2, 3 and 4. There are story maps for coastal flooding, floods, wildfires, drought, settlement vulnerability, urban growth, climate change, the economy, agriculture, forestry and fisheries, surface water, and groundwater. Users are able to browse through these story maps to learn more about the research methodology, findings and recommendations, as well as to access the technical reports and interactive datasets. The 11 story maps can be accessed https://greenbook.co.za/story-maps.html.

The second component is the municipal Risk Profile Tool, an interactive tool that grounds the adaptation process in scientific evidence of the risks each local municipality in South Africa is likely to face under a changing climate by 2050. The Risk Profile Tool provides temporally

dynamic risk profiles for each municipality and its settlements in South Africa. These profiles provide information on vulnerabilities; population projections; exposure to climate hazards; and the impacts of climate change on some of South Africa's municipality's key resources. The Risk Profile Tool is available at https://riskprofiles.greenbook.co.za/.

The third component is the municipal Adaptation Actions Tool, an interactive platform to support adaptation planning in local municipalities. The Adaptation Actions Tool provides a range of planning and design actions for municipalities to consider, to adapt their settlements and environments to the likely impacts of climate change, to climate proof their settlements, and to reduce their exposure and vulnerability to hazards, and thus the risk for disaster. With the tool, guidelines for selecting and prioritising adaptation actions to the local municipal context (https://greenbook.co.za/adaptation-support.html). The Adaptation Actions Tool is available at https://adaptationactions.greenbook.co.za/.

In addition to these three major components of the Green Book website there is also a video available that provides an overview of the website and short tutorials on each of the three components discussed above. Information is also available on what adaptation planning is, and why it is important, an adaptation support page where information is provided on how to deal with uncertainty, the mechanisms that support adaptation implementation, and guidelines for the selection and prioritisation of adaptation actions.

Under the general content more information is provided on how the Green Book was co-produced with stakeholders, and the peer-review process that was followed. In addition to the stakeholders and peer-reviewers involved in the project, close to 50 researchers contributed to the Green Book. The research team was made up of researchers from multiple domains and disciplines, and their names and disciplines are listed on the website. There is a page with the funders and partners on the project to learn more about the organisations that funded the project, the collaborative partner, and project consultants. There is also a section on the climate change adaptation and disaster risk reduction policy environment and the role of the Green Book in it. This information is available from https://greenbook.co.za/policy-implications.html.The Green Book has produced a number of written resource documents such as research reports, presentations and papers, all available on the website.

3.1.2 Other output

As outlined in the IDRC's open access policy, full social and economic benefits of research in support of development should be available to everyone who could use it – and build on it –

to improve people's lives. The project supports this policy fully. The research done as part of the Green Book and its main output, was done to support South African local government to be able to build resilient and sustainable cities and towns. It is for this reason, as well as the policy as set out by the IDRC, that the Green Book website is available online, accessible by all. All technical reports, papers and presentations are accessible through the website (https://greenbook.co.za/resources.html). Journal articles, once they have been published and cleared of any embargos will also be linked to the Green Book. Open access journals will however be pursued, if they are accredited with the South African Department of Higher Education.

Quantitative and qualitative data was collected and created during the term of this project. A lot of the value of the project lies in the way dense data and information has been communicated. The Green Book offers distilled and dense, but still digestible information and evidence that can be used by local municipalities and other users to inform decision-making around development and planning, or to further other research endeavours. Various datasets from the project have already and will be shared for further use by original and other researchers, stakeholders, students, etc. Only the research team has access to the raw or working data through the internal repository. The project team is looking to host datasets externally through the South African Environmental Observation Network (SAEON), and are currently exploring how this will be executed. All data collected, created and disseminated during the project will be factual data and therefore not subject to copyright.

Annexure A provides an overview of all the project outputs in various categories. The most significant outputs are the following:

1. The Green Book website itself with all the information and the two tools. The story maps and the two tools by themselves are significant output.
2. The partnership and other potential research projects that have/are emerging as a result of the Green Book. This can mostly be ascribed to the continued stakeholder consultations, and presentations of interim findings.
3. The conference presentations made at Adaptation Future 2018, DMISA 2018 and ISOCARP 2018. The Green Book findings were presented, and many people showed interest on the work.

A summary of all the output include:

i. Publications:
   - For each of the workstreams a technical report or presentation was written. There are 12 technical reports/presentations in total, available on the website.
   - The project committed to two published conference papers in the proposal. The research team has published eight conference papers so far.
   - The project committed to two journal articles by researchers and two by masters students having completed their dissertations. No journal articles have as yet been published, but seven are in various stages of being drafted or submitted. The articles are late in being submitted due to the research components and masters studies taking longer than anticipated. Researchers are only now in a position to report on the findings.

ii. Presentations:
   - The research team made 19 presentations at local and international conferences thus far. Of these, seven were international conferences, six were regional conferences (southern Africa), and six were local conferences.
   - The research team made 22 formal presentations about the project during its various stages at forums, workshops, and committee meetings.

iii. Stakeholder engagements, co-production and peer review:
   - The steering committee met 44 times with various stakeholders and interested parties during the course of the project. This was to inform stakeholders of the project, its progress or initial findings, to leverage buy-in and support for the roll-out and uptake of the project, and to gain access to information and/or people to peer-review the work.
   - In total, 31 people from the public and NGO sectors peer-reviewed aspects of the Green Book, be it research method/process or the output of the research. Many of the peer reviewers also formed part of the references groups.
   - Members of the steering committee serve(d) on seven technical committees/ advisory bodies/ working groups during the course of the project in light of the work done for the Green Book project.

iv. Media and external exposure:
   - Four externally published reports made mention of the Green Book (this was before the launch).

- The research team is aware of 40 media statements, radio interviews or YouTube videos about the project. Most were released just before and after the launch of the Green Book in March 2019.

v. Partnership and proposals emanating from the project:
   - A number of collaboration/partnerships/funding arrangements have emanated from the work on the Green Book. The most important one is the partnership for Phase II of the Green Book to focus on the roll-out, training and capacity building components (more information is provided under 3.2.6).
   - The Green Book has received many data requests thus far. The project cannot supply the raw data when this is requested, as the data was gathered with a very specific goal in mind. The Green Book has supplied data to seven public projects. The most significant request came from the Gauteng Province for inclusion in their Climate Change Strategy, a draft of which has been published for comment. The other requests for data are still being integrated into the various projects.
   - A number of proposals (8 thus far) were submitted based on work done and capabilities that were developed or honed during the Green Book project. Thus far one was successful, a few were unsuccessful, and the outcome of others are still unknown.

See Annexure A for a detailed list of all the outputs.

3.2 Knowledge contributions, uptake and impact

South Africa produces internationally recognised research in climate modelling, climate change impacts and adaptation, which amounted to an estimated 35% of all scientific publications produced between 2006 and 2015 (ASSAf, 2017). The bulk of this research (86%) was produced by universities, especially the top tier research universities while science councils contributed 12%, of which half was produced by the CSIR. South Africa has capabilities to produce both statistically and dynamically downscaled climate projections. Given the focus of the Green Book on producing settlement planning guidelines, it was necessary to tap into these capabilities to provide information necessary in the assessment of current climate adaptation strategies and plans. The research undertaken in the Green Book project contributes to knowledge about current and future climate impacts in the built environment and in the development of cross-sectoral risk and vulnerability-based adaptation

responses. Both these areas were identified as gaps in terms of climate change research in southern Africa (Ziervogel et al., 2014).

When presented with the Green Book at stakeholder engagements, training sessions, conference presentations, and at the launch, stakeholders, the media, other researchers, consultants, etc. were all appreciative of the value and depth of the information provided on the website, as well as the usefulness of the tools ("this is an amazing resource" – Derek Morgan, consultant; "brilliant tool" – Alain Mathieu, consultant; "Impressive" – Harold Guiob, Namibian official). Local government officials have noted how much easier the information on the Green Book website will make it for them to conduct local risk and vulnerability assessments ("you have done our work for us" – local government official). There has even been interested from neighbouring countries to develop something similar (James Mutandwa, Zimbabwe; Harold Guiob, Namibia; Fred Dubee, China).

The rest of this section describes the actual and potential value, uptake and impact of the Green Book and its findings.

3.2.1 Scientific contributions and uptake

The Green Book has made a number of novel and ground-breaking scientific advances in the fields of climate change, risk and vulnerability, as described under each objective in Section 2. The evidence and proposed adaptation actions can assist with the prioritisation of interventions by local government to adapt settlements to climate change. The evidence and trend analyses can assist national government to identify and prioritise disaster risk reduction coordination and support in municipalities most at risk.

The science and evidence produced as part of the project has already made a number of contributions to other initiatives and projects, the uptake of which is discussed here. It was possible to make these contributions before the products were finalised mainly due to continuous stakeholder engagements and presentations at workshops and conferences that ignited the interest in the Green Book and its interim findings.

The downscaled climate change projections and most likely implications for the respective sub-national regions in South Africa formed part of the evidence base, and national spatial shapers considered in developing a spatial vision and ideal spatial development pattern for the Draft National Spatial Development Framework, 2018. The population growth projections and outputs of the settlement growth modelling also formed part of the evidence base and

national spatial shapers considered as spatial scenario in the Draft National Spatial Development Framework, 2018 – thus directly informing national adaptation.

The development of a multi-scale and multi-indicator vulnerability framework provided the foundation for SAEON and DEA to consider embarking on the development of the first official national vulnerability framework for South Africa, to be developed in the latter half of 2019.

The settlement and towns-specific population growth scenarios developed through the downscaled population projections and national settlement growth model, has already been utilised to inform the South African Local Government Association's (SALGA) small town regeneration and regional cross-border development initiatives in the Bojanala District. The 'without intervention' town growth scenarios clearly illustrate the potential impact and value of the national results to inform regional development scenarios, highlighting the extent and risks associated with existing development and policy challenges. Both the State of Towns Report to be published by SALGA and the CSIR, the State of Cities Report to be published by the South African Cities Network will consider policy and governance implications highlighted by the settlement growth scenarios.

3.2.2 Policy contributions and potential impact

Often science is scantily used to shape public policy, but environmental governance in South Africa strongly relies on effective interfacing of science with policy (ASSAf, 2017). The co-production of R&D in climate science and technology has been driven largely by the need to use the available environmental research infrastructure effectively given scarce financial resources and specialised skills. It is important to consider the latest activities in the policy environment to get a sense of priorities in the next five to ten year period during which the Green Book is intended to have impact.

There are several key legislative documents, dating back to 1998, that outline policy based priorities in anticipation of a warmer climate future in the country (ASSAf, 2017). Some of the most recent documents that are pertinent to the Green Book include, firstly, the Climate Change Bill and the National Climate Change Adaptation Strategy (DEA, 2017a, 2018), which set out the government's directives pertaining to adaptation to climate change impacts, resilience and sustainable development. Then there is the Carbon Tax Bill (Treasury, 2018) which comes into effect in June 2019 and the Draft Green Transport Strategy 2017-2050 (DoT, 2017) that was signed into law in October 2018 as policy instruments to drive transition of the South African economy towards a low carbon development path and encourage transit-

oriented development in urban areas. Lastly, there is the Draft White Paper on Science, Technology and Innovation (DST, 2018) focusing on directives pertaining to investments in climate change R&D for the benefit of stimulating eco-innovation and the long-term transition to a green economy. These recent legislative gains have been made on the back of earlier strategic plans, namely the National Development Plan (Vision 2030), the Medium-Term Strategic Framework 2014-2019, the National Climate Change Response White Paper (2011), the Spatial Planning Land-use Management Act (2013) and the amended National Disaster Management Act (2002). The Green Book is intended to support implementation of these policies by providing spatially disaggregated information on sectoral climate change risk and vulnerability, suitable adaptation options, and in developing capacity in urban planning and related fields.

Monitoring and evaluation of climate adaptation policies, strategies and plans is an important issue starting to attract attention worldwide (Zommers & Alverson, 2018). The Climate Change Bill is explicit about the establishment of a National Climate Change Response M&E system (DEA, 2018). The system is already under development and consists of tracking responses related to climate mitigation and to climate adaptation separately (DEA, 2017b). The success of the system, especially in urban areas, will also depend on close coordination between the departments of Human Settlements, Energy, Transport and Environmental Affairs. The Academy of Science South Africa (ASSAf) is playing a role in evaluating the skills aspects which can be related to climate policy outcomes and impacts through their biennial review of the state of climate science and technology R&D in South Africa (ASSAf, 2017).

As the project progressed and the team engaged with multiple stakeholders, it was realised that the research inputs and outputs of the Green Book can have far-reaching policy implications. Some of the policies and national strategies mentioned above, and how the Green Book can support legislative compliance as well as implementation, are discussed in more detail:

- Climate Change Bill, 2018: Can support provincial and local climate change response assessments and implementation plans by providing risk and vulnerability profiles, information to prioritise areas most at risk, and appropriate adaptation actions.

- National Climate Change Adaptation Strategy, 2018: Can support adaptation planning at national, provincial and at local level in particular, by providing detailed information for risk and vulnerability assessments, appropriate adaptation actions, and guidelines.

The Green Book can also support capacity building and awareness with a particular focus on local government by potentially offering technical training, and capacity building to mainstream climate change adaptation into planning. South Africa's Intended Nationally Determined Contribution (INDC) as part of the Paris Agreement, 2016: The Green Book supports the national priorities that emphasise its overriding priority to address poverty and inequality and considers the circumstances that guide the country's sustainable development trajectory. The vulnerability indicators shows those places with the highest poverty and inequality, and win-win adaptation actions were developed to not burden municipalities with costly infrastructure projects where poverty reduction is most needed. Adaptation actions will benefit GHG mitigation. It also addresses some of the INDC goals, e.g. the vulnerability assessment.

- Spatial Planning and Land Use Management Act (SPLUMA), 2013: The Green Book provides evidence in support of forward planning and can support the development of national, provincial, regional and local spatial development frameworks. Evidence from the Green Book has already served as input to the development of the National Spatial Development Framework, as required by SPLUMA and as an implementation tool of the 2030 National Development Plan.

- Disaster Management Act and Amendment, 2002: Can support compliance in terms of providing evidence for risk assessments and mapping, also providing adaptation measures to reduce risks.

- Department Science and Technology's Global Change Grand Challenge Programme: Can support research under knowledge challenge no.3, i.e. research on preparing for rapid change and extreme events, and planning for sustainable development. The Green Book also addresses the Global Change Research Plan's priority to address very unique local needs and working in areas of national comparative advantage, by focusing on settlements with population concentrations becoming more vulnerable to the impacts of climate change and extreme events, and doing this in a cross-disciplinary style.

The most notable contribution to national policy by the project was to the Draft National Spatial Development Framework 2018, as discussed earlier. The NSDF was developed in response to the requirements as set out in the Spatial Planning Land Use Management Act of 2013 and

as an implementation tool of the National Development Plan (Vision 2030) and the Integrated Urban Development Framework. The CSIR was part of a team of researchers, academics and consultants who compiled the NSDF, and the climate change projections was ready in time to be integrated into the NSDF. The NSDF directs public investment in South Africa spatially, thus it is a very significant instrument that prioritises public interventions and investment in specific places in the country. The Green Book climate change projections are the most detailed projections available in the country, and is thus of value to guide future investment.

The findings in the Green Book has potential implications for future policy development in South Africa, for example to:

- Suggest the need to take ambitious and urgent action to reduce greenhouse gas emissions to mitigate more severe impacts of climate change.
- Advocate for greater urgency to implement the informal settlement upgrading programme. Extreme events and temperatures will make shack dwellings unliveable.
- Enforce planning regulations and building codes and regulations in all parts of settlements.
- Empower, and reinforce the role of professionals signing off on plans for township establishment, housing, infrastructure, and roads and transport.
- Raise awareness of the responsibility for climate change adaptation and disaster risk reduction in traditional areas.
- Lobby for officials across spheres to be held accountable and liable for planning decisions when it places people at risk – threatening health, lives and livelihoods.
- Integrate climate change adaptation monitoring and evaluation into performance indicators across various departments and across various disciplines.
- Continually invest in new building technologies and construction materials that promote adaptation, and discourage the use of unsustainable materials.
- Address future food and water security in settlements.
- Motivate for larger budgets for emergency housing programmes and for internally displaced people due to climate change and extreme events.
- Incentivise for adaptation, e.g. together with the insurance industry.

Stakeholders involved in the Green Book are aware of these potential policy implications, but an effort by the CSIR and other role-players will have to be made to see these policy changes through. The policy briefs written as part of the Green Book project is an effort at raising the awareness of some of these policy implications.

3.2.3 Research and capacity building impact, and training potential

The Green Book has achieved to build the research capacity of junior and senior researchers (more than 50% of the team was made up of women) within the CSIR in areas such as climate change adaptation, settlement planning and design, modelling, projections and working with large datasets. One of the major achievements of the project is the coming together of an interdisciplinary team of researchers, and their findings, to produce very technical results, packaged in a comprehensible way that is of great value to the public and private sector. Between data from modelling, forecasting, projections and indicators, a bridge was built to produce information, conclusions and recommendations that are implementable. The success can also be ascribed to the co-creation of methods and knowledge through collaboration and consultation with many stakeholders and specialists.

The Green Book project enhanced knowledge sharing, networks and collaboration that can contribute to adaptation efforts moving forward – especially across disciplines, departments, institutions, civil society, private sector, etc. It is also ploughing back into the public domain by sharing of the results and experience in national and global fora, technical working groups and committees. The team has made significant efforts to make data available to others, sought and responded to requests for data, information and/or collaboration.

The Green Book has much research, training and capacity building potential to be realised. For example, the Green Book is rich in data that could be mined or used for future research – by the research team or others, since the results are publicly available. The Green Book is ready to be rolled-out to municipalities, and provide training to officials on how to use the Green Book tools and implement the adaptation actions into their local planning functions. Many requests for training have already been received.

Information from the Green Book and its tools have the potential to be taken up into curricula for the education of urban planners, geographers, engineers, environmentalists, landscape architects, architects, property economists, etc., and for continuous professional development courses in these various disciplines for experienced professionals.

3.2.4 Potential developmental impact

Climate change adaptation has much in common with local planning practices, especially spatial planning, land use management and urban design. There are many linkages and overlaps that can facilitate the creation of resilient settlements in South Africa. The integration

of the risk and vulnerability profile in the Green Book with a settlement's risk and vulnerability assessments has the potential to:

- Increase the 'climate-awareness' of spatial planning and increase the capacity to manage climate change and reduce exposure to risk.
- Inform strategic spatial planning of high risk areas that in return informs land use planning and the prioritisation of investments in climate change adaptation for the risk to be reduced.
- Inform land use planning and applications of the long-term risk and vulnerability, when considering changes to land uses.
- Identify those marginalised communities who live in areas at risk to extreme events that need to be prioritised.
- Flag if urban consolidation and growth outpaces the supply of water and other resources.

The implementation of the proposed adaptation actions in the Green Book has the potential to:

- Bring incremental and transformative change through climate change adaptation planning by integrating short-, medium-, and long-term adaptation actions, while protecting past development gains.
- Encourage the continuous maintenance of infrastructure and ecosystems to climate-proof cities and to increase adaptive capacity to mitigate the impact of floods, storm surges and other hazards.
- Assist with the planning for service delivery at a neighbourhood level by introducing relevant factors that should be considered to determine the type and level of service that are provided, and the associated systems and infrastructure that will have to be designed in future.
- Promote building regulations and codes that are realistic and risk-compliant, and enforced in all parts of a settlements to protect people's health, lives and livelihoods in cases of extreme events.
- Promote the investment in new building technologies that factor into account the impact of climate change on building materials and practices.
- Inform the design of dwellings, infrastructure and services in an informal settlement upgrading to withstand hazards such as heavy rain or high temperatures and adhere to appropriate building standards.

- Propose actions to prioritise the special needs of women, children, and the elderly among others when adapting settlements to climate change.
- Complement existing planning guidelines such as *The Neighbourhood Planning and Design Guide* (the Red Book) to make South African settlements more liveable and sustainable.

For the Green Book to have the desired impact on development as listed above, it needs to be incorporated into the roll-out and training programme in Phase II.

3.2.5 Potential uptake by the private sector

Public sector stakeholders were engaged extensively during the development of the Green Book, but it is also important to consider the private sector in considering climate change impacts and adaptation. Business will be directly affected by a shift to a low carbon economy as well as increased probabilities of incurring large losses as a result of extreme weather events. Private sector investments in climate change R&D have mainly been in the form of propriety technology development. They are, however, users of publically produced research and recently there is willingness, especially from the insurance industry, to form partnerships in seeking solutions to some of the climate change challenges. It seems reasonable to assume that more of these partnerships will be formed as carbon tax comes into effect and as the transition to low carbon development and circular economy gains momentum. The insurance penetration rate in South Africa is low compared to developed countries, hence partnering with the private sector on climate change adaptation planning seems to be a more sustainable solution than continuously increasing premiums as affordability will likely become a real barrier in the long-term. The Green Book's impact can therefore be extended to the private sector to support plans to strengthen business resilience to climate change.

3.2.6 Phase II partnership and other (potential) projects

A partnership has been established to continue with work on the Green Book and, most importantly to support the roll-out and training on the Green Book. The partnership is a result of relationships that developed during the Green Book project and includes the CSIR, the National Disaster Management Centre (NDMC), the Department of Environmental Affairs (DEA, now DEFF), and Santam. All members of the partnership are committed to support continued research and development, implementation through training and capacity building, and maintaining and updating the website and tools.

To adequately capacitate decision-makers to effectively plan for and reduce their risk exposure, Santam in collaboration with the CSIR and the NDMC will join forces to pilot and refine the Green Book training and establish a roll-out and implementation plan for all local municipalities. As part of Santam's shared value contribution and in an effort to reduce and mitigate insured risk, the Partnership for Risk Reduction (P4RR) assists municipalities with building capacity in combating the risks of hydro-meteorological hazards within vulnerable communities. The P4RR has through this effort formed formal partnerships with 7 district municipalities (35 local municipalities) and have had working relationships with an additional 3 metros (City of Johannesburg, Ekurhuleni and Tshwane) and 9 local municipalities. In an effort to leverage this momentum and ensure proactive disaster risk reduction, Santam will partner with the CSIR's Green Book project to facilitate the identification of climate risks and embedding the appropriate adaptation responses into these high risk municipalities' planning processes, instruments and policies. The ultimate aim of the piloting of the Green Book would therefore be to build enduring municipal capacity to deal with and reduce the exposure and impacts of hydro-meteorological hazards and expected climate change on settlements.

The uptake and ultimate embedment and mainstreaming of the evidence produced in the Green Book take high priority. In order to support disaster risk reduction (DRR) to its fullest extent the evidence should ideally inform and be embedded in municipal policies, plans and processes. This can range from mainstreaming into Disaster Risk Plans (DRPs), Climate Action Plans (CAPs), Integrated Development Plans (IDPs), and Spatial Development Frameworks (SDFs) to embedding the scientific evidence in the municipal Decision Support Tools (DSTs), indicative risk profiles or GIS supportive systems. Consistent engagement with the users will ensure a detailed R&D plan is put forward to commission research and development in missing elements to enhance and extend the Green Books' planning support offerings. Through hands-on training sessions the team will record the users' experience, missing R&D elements and to what extend various aspects addresses the relevant need.

Currently a multi-year programme is being developed for the Department of Environment, Fisheries and Forestry (DEFF, previously DEA) to secure funding for the roll-out and training of the Green Book to sector departments on a national and provincial level. DEFF needs to canvas other organisations for this funding.

After the launch of the Green Book other stakeholders have also been invited to collaborate with the CSIR on expanding the scope of the Green Book, updating the research results, or other spin-off projects. A list of these discussions are provided in Annexure A (under 5.4 Strategic Discussions). The Green Book team is currently in discussion with many

stakeholders, the most promising being National Treasury, the City of Tshwane/C40, the Presidential Infrastructure Coordination Committee (PICC), and SAEON.

4 PROBLEMS AND CHALLENGES

The Green Book project has been completed successfully, on time and within budget. The Green Book project has achieved more than what it set out to do, but however successful the project, it was not without its problems and challenges. These problems and challenges are described below.

Problems and challenges with datasets

Providing climate change datasets to a variety of users, with different technical levels of expertise in handling large datasets, and with different application models requiring various data input formats, proved to be a time-consuming endeavour. For example, the economic analyses used flat file structures whereas the hydrological water supply study used spatially rich .netcdf files. Interpreting the requirements, processing, aggregating, reformatting the variables and transferring the data proved time-consuming and cumbersome. Originally 16 variables were selected to anticipate the expected climate variables that might be needed for conducting impact and hazard studies but since many of these models were built during the course of the project the original 16 variables had to consistently be revised and revisited. Different skills amongst the data users and different modelling techniques used, required several discussions and trail-and-error approaches in formatting, aligning and processing the various required datasets.

Lack of appropriate data, frameworks and models

When the Green Book started there was no measuring framework, indictors or data available on the dimensions of vulnerability within municipalities, settlements and neighbourhoods. The framework had to be developed through an interactive process to ensure buy-in from national stakeholders. This process was time-consuming and the peer-review process took a long time. There were also significant data challenges in terms of sourcing, processing and realigning the required data, and many new methodologies and processing techniques had to be developed.

Most publically available future population estimates are at a global scale and are non-spatial in nature at a national scale. In order to provide planning support that is sensitive to the local context, local projections are required, and since no model existed the team had to develop a new spatial allocation model. The development of this model was time-consuming and had to go through several peer-review processes and validation studies. Owing to the data scare

environment, significant innovation was needed to develop an accurate and relevant population distribution model.

Furthermore, certain domains did not agree with stochastic, probabilistic modelling and/or approaches, and preferred using their own set of mathematical or statistical techniques for problem solving, in some cases with limited spatial understanding. This meant that the spatial translation and interpretation for the risk profiles had to be done/supported by members of the project steering committee.

Challenges with the hydrological modelling component

A particular challenge arose when the project team for the hydrological modelling for water supply/availability did not deliver. During the first phase of the project little progress was made and many deadlines were missed. One of the domain experts also passed away. The steering committee had to appoint an external consultant to complete the work, but this delayed the work on the final output, and was the last deliverable to be completed. This required flexibility, adaptation of project plans, finding alternative resources willing to step in at such late stage, and subsequently innovation and dedication from the new team and management team.

Complexity of the interdependency of workstreams

The nature of the project was that most workstreams were dependent on the output of another to be able to conduct the work that was required to meet the objective. Delays in one workstream had an effect on all the other workstreams. The delay in supplying the climate change projection data in the formats required by the domain experts delayed some of the project components by a year. The project steering committee had to tirelessly facilitate the provision of data between research teams. Ultimately the result was that the final output was completed much later than planned for, and the roll-out and training of the Green Book had to be rescheduled for a second phase with new partners.

It was the intention that the adaptation actions be developed in response to the risk profile and integrated per local municipality, but the delay in the timely delivery of the vulnerability profiling, population growth projections and hazard modelling, delayed the integration of data into the risk profiles. The work on developing the adaptation actions could not wait for the risk profiles to be completed, therefore it was developed as a separate loose-standing output in the Adaptation Actions Tool. The result is that the adaptation work may have lost some of its impact, but it may still prove to be of much value as a loose standing, customisable tool.

Lack of shared understanding of concepts

Working on an interdisciplinary project had many benefits, but also challenges – one which is a shared understanding of concepts and terminology. The various domains have their own understanding of terminologies and definitions, therefore developing a shared language and understanding of the vision took significantly more time than anticipated.

Some domain experts struggled to come to terms with what is meant by settlement planning at a city-wide scale, and some experts in planning struggled with what is meant by adaptation planning. It seemed to be quite a challenge for many of the domain experts to provide a concise, but value-adding overview of the wide range of adaptation actions relevant to settlement planning from the in-depth literature studies and case study work undertaken. It also proved to be a significant conceptual challenge to process, simplify and structure this information, to provide decision-makers with access to the various adaptation actions relevant to various contexts and conditions. The core team putting together the adaptation actions had to translate these diverse and unrelated actions into a typology that is relevant to the local planning function, appropriate for urban areas in South Africa and that are implementable. This meant sifting and synthesising more than 30 desktop analyses into a user-friendly Adaptation Actions Tool.

Internal administrative and IT infrastructure challenges

The CSIR's procurement processes were experienced as cumbersome, significantly delaying progress in some cases. For example, to appoint the website developer as a sub-contractor took about six months, and three advertising cycles. This challenge was overcome by shortening the duration of their contract to complete the website in time. Many people in the research team had to work overtime to finish the work due to these delays.

The internal IT infrastructure proved a challenge as it was not capable of handling the functionality required by the Green Book website. The infrastructure was very instable a few months before the launch of the Green Book, and it took several IT people to troubleshoot solutions. It also meant the research team had to redo large parts of the publishing work on the website, which delayed the final deliverable. The website still experiences problems with the webmap server, which is often down or overloaded, but the matter is being looked into.

It should be mentioned that the project obtained research ethics clearance from the CSIR's Research Ethics Committee in January 2017, but there were no challenges related to research ethics.

5 ADMINISTRATIVE REFLECTIONS AND RECOMMENDATIONS

This section reflects on the general and useful lessons that can be derived from the Green Book project, for the benefit of future projects. It also considers what could have been done differently as a result of this experience. It furthermore reflects on the IDRC project administration in relation to the scope, budget and timeframe of the project.

5.1 General and useful lessons learnt

The Green Book project provided a unique opportunity for experimentation and innovation in terms of domain specific modelling of potential climate change implications, development of a typology of appropriate climate change adaptation actions, and integrated, interdisciplinary modelling and risk profiling within the Global South. In reflection on the project and the outputs achieved, members of the steering committee, various junior researchers and a number of researchers from the team reflected on questions such as: What has the team managed to do particularly well and why? What made these achievements possible? What were some of the biggest challenges that we could learn from? Are there things that in hindsight could have been done better?

What were some of the success factors in the project?

The steering committee maintained a focussed outlook about what the project aims to achieve, and what it is not. The project consulted with many stakeholders and peer-reviewers and this did have an impact on the scope of the Green Book to the extent that the scope in some of the workstream changed, but hard decisions had to be made and stood by at times to keep the project on track (e.g. to finalise a component, even though the researcher would have wanted to do more). We also replanned the project and reallocated budgets every six months to adapt for any changes, delays or challenges. This made it possible to complete the project in time and within budget, with a well-known, information rich product, which too few research projects achieve.

A major advantage for the Green Book project was the prior and good working relationships that existed between many of the domain experts who have in the past worked together on other projects. It was relatively easy to put a project team together as researchers knew about each other's capabilities, and everyone was optimistic and passionate about working on the

Green Book. Basically all the expertise needed for the Green Book was found within our organisation. The deeply embedded domain expertise, as well as experience and expertise in applied science and inter-disciplinary application of natural and social science was thus another advantage. A few senior researchers were in the end not able to work on the project themselves due to other project pressure, but they trained other and junior researchers to do the work, and this meant that the capacity of researchers within the climate change modelling and adaptation fields in the CSIR grew.

One of the strong points of the project design and execution was the external peer-review and stakeholder buy-in process. The process of extensive engagements, one-on-one discussions and ongoing interactions with potential users, government stakeholders and relevant role players, is regarded as a critical success factor to create awareness and buy-in for the project output. The various engagements with external stakeholders were very inspirational, highly motivating and provided a clear indication of the relevance and the urgency for the outputs of the project.

At about the time when all the findings were supposed to be integrated into the risk profiles, a two day mini-conference was held where everyone leading a work component presented their work to all the others. In their feedback, researchers indicated that this is when they finally understood the vision of what the end product wants to achieve, coupled with an increasing realisation (and sense of inspiration) of how powerful the collaboration between researchers is. Before this they felt like they were ‘muddling through’ in a period of confusion, even though there was an initial excitement to be part of the project and a shared perspective amongst domain experts. Such moments of coming together and sharing results proved to be of great value, but because we were located in different cities across the country, it was not done more frequently (twice in the duration of the project). Skype sessions had its limitations.

The Green Book was originally planned as a hard copy (with a website), divided into chapters that describe each of the outcomes of the workstreams. As the work progressed we realised the wealth, depth and complexity of the research findings cannot be printed in hard copy, for one, the book would become very thick, and two, the dynamic and layered nature of the information is hard to portray in a static copy. Deciding to only develop an interactive, online, decision-support tool with general information, story maps, a Risk Profile Tool and an Adaptation Actions Tool proved to be a very good decision. In this way it is freely available to anyone, can be updated, and is user-friendly. To do this required an adaptation within the

project team, the project planning, as well as motivation to the IDRC for amending the project outputs.

Another critical aspect was the steering committee's tenacity, dedication, passion, and willingness to collaborate and continue to drive the project through innovation. The steering committee had a strong set of mutually supportive qualities, for example strong visioning and conceptualisation, excellent technical and spatial sense-making, efficient project management and decision-making, excellent communication and stakeholder engagement, strong financial and human resource and project planning capabilities. These capabilities, coupled with the passion for climate change adaptation and to create a space for others to innovate, grow and support the processes required to find creative solutions, as well as deliver on project outputs whilst keeping domain expert motivated, were possibly some of the biggest reasons for the success of the project. The loyalty and commitment to offer a consolidated approach to the broader project team and stakeholders provided a significant point of stability within a process influenced by a magnitude of aspects and people.

Personal growth, learning and innovation

The project provided individual researchers exposure to, but also in-depth engagement with climate change as knowledge field, and exploration of climate change implications within their specific field of expertise. For many, this exposure provided significant growth opportunity in their fields of work regarding implications of climate change for hazard exposure. Team members responsible for hazard modelling also indicated their growth in technical aspects related to innovations in modelling approaches, learning to work with certain data types and files, and application in settlement related contexts.

Many researchers have not worked on a settlement level before, or in the domain of urban planning and design. This challenged them to think differently about their work, and how it applies to settlement dynamics. Other researchers have never worked in the field of climate change adaptation, and had to grow in their understanding of climate change, its impacts and the adaptation of settlements to these impacts. Some researchers have also indicated that working with large datasets was a first for them, and they had to grapple with data formats, data sharing and aligning data. Another capability that many researchers had to develop was the spatial representation of research findings. The use of visual profiling of settlement vulnerability and hazard implications, as well as the use of story maps to support effective communication of the project results and methodologies, are regarded as very powerful, and an area of learning for many of the specialists on the project team.

To experienced researchers the project seemed to have stood out in terms of the opportunities it provided to make a meaningful contribution. Many mentioned that they would have liked to do more, or would like to now build forward and improve their results.

Many of the younger team members described the project as providing an incredible opportunity, but also a massive challenge and learning curve. Benefits were said as ranging from being exposed to working with a big multidisciplinary team/other experts, who were passionate, dedicated and committed to add value to a body of knowledge, but more so to support development decisions and settlement planning that would benefit the most vulnerable in society. The exposure to external stakeholders in the field, as well as to the processes of external reference groups and robust reviews, were regarded as extremely beneficial. Specific mention were also made of opportunities:

- For exposure to the climate change and related knowledge fields and networking in the field, through international and local interactions with other experts at conferences. This was said to provide opportunities to see the relevance, as well as innovations within the project and served as source of inspiration.
- To conduct research and make progress with relevant Masters studies in the field. Even though this was also mentioned as a challenge given the work load and pressures, the opportunity for focus the project provided was highly supportive for progress and significant learning within relevant Masters' studies, as well as on a technical level.
- To actively contribute to the project, to be able to share innovative ideas, and make contributions that were regarded as valuable.

What would we have done differently?

In hindsight, the steering committee should have involved the managers of the various researchers in the project to commit to project output and deadlines. This could have provided leverage or project finance tools to enforce delivery and avoid non-performance. In this regard a practical lessons to take forward, is the setting in place of project specific protocols for retracting funding and also clear mechanisms for dispute resolution for negotiating non-delivery from 'internal teams'.

More attention and time could have been given to develop a shared understanding of concepts, scale, spatial representation, and data formats. This would have helped to work towards a common goal, and shorten the time spent on finding solutions afterwards to use the

output or integrate it into the risk profiles. Protocols for providing other research groups with data should have received particular attention.

5.2 Recommendations to the IDRC

Our experience working with the IDRC was of a very positive and constructive partnership between the Green Book steering committee and our programme officer(s). Our programme officer(s) guided the Green Book steering committee from the proposal phase right up to writing the close-out report on the best way to approach some of the topics, whom to consult with as important stakeholders, bringing us into contact with other projects and people working in this research field, and often proposing an angle that we have not thought of. Our programme officer was always quick to respond to requests for information, clarity or otherwise. The Green Book project steering committee endeavoured to respond speedily to all requests by the IDRC for information, suggestions for sources of information, the involvement of stakeholders, participation in conferences, and meetings with other projects. We appreciated being guided, but having the responsibility and independence to make our own decisions.

Because the Green Book was identified as a low risk project by the IDRC, we only had to report our progress once a year in a technical report. We found the administrative burden on our project light, and are appreciative of this.

The original call for proposals by the IDRC for Cities and Climate Change was broad enough in scope to allow the CSIR to respond in a well-defined proposal that brought together many of our strengths: interdisciplinary collaboration, settlement modelling and profiling, downscaling climate change projections, hazard modelling, as well as developing guidelines. It provided us the space to develop new capabilities and novel research based on our existing capabilities.

Though we were pressed for time to deliver on the final product, and could have done more to train people on the use of the Green Book, three years were adequate to reach our objectives. It was possible to keep continuity among the steering committee and researchers working on the project in a time when lot of things changed at the CSIR. It was also possible to keep stakeholders interested in the project, and they were happy to wait a year or so for the final output, otherwise they might have lost interest.

In terms of the budget, we had to source alternative funding for the project, as the IDRC grant did not cover our overheads. It also would not have been sufficient to cover the costs of involving as many researchers in the project, or three members of the steering committee to work on the project fulltime for three years. The CSIR funded the project for just more than 50%, which covered most of the HR and overhead costs. This funding was secured through an internal competitive bid in which the Green Book came out as the top proposal.

Overall we have found the IDRC grant generous, the project administration helpful, the administrative burden light, and most important of all, it allowed us to do a research project in South Africa that would not have been possible otherwise. The Green Book has seen an overwhelmingly positive reception among public, private and NGOs involved in the climate adaptation field. We are very grateful towards the IDRC who made this possible.

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ANNEXURE A: PROJECT OUTPUT

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1 PUBLICATIONS

1.1 Research reports

For all the technical and research components that made up the project, namely workstreams 1 to 4, there are detailed technical reports available. The technical reports for workstream 1 and for the vulnerability component of workstream 3, have been written up as journal articles. Currently on the website, summary presentation of the methodology and findings are provided which will be replaced by the published articles once these are available.

Workstream	Technical report title
Workstream 1: Developing a typology of climate change adaptation actions.	Green Book - Developing a typology of climate change adaptation actions. Available here.
Workstream 2: Downscaling climate change projections.	Green Book – Detailed Projections of Future Climate Change over South Africa. Available here.
Workstream 3: Settlement profiling and growth projections.	Green Book - Projecting the future growth of South African Settlements: Developing a concept model for town growth forecasting in South Africa. Available here.
	Green Book - Profiling the vulnerability of South African settlements. Available here.
Workstream 4: The impact of climate change on hazards and resources.	Green Book – Climate change impacts on agriculture, forestry and fisheries. Available here.
	Green Book – Coastal Flood Hazard Assessment. Available here.
	Green Book – The Impact of Climate Change on Drought. Available here.
	Green Book – The economic effects of climate change on settlements. Available here.
	Green Book – The impact of climate change on flooding. Available here.

	Green Book – The impact of climate change on groundwater availability. Available here.
	Green Book – The impact of climate change on surface water supply. Available here.
	Green Book – The impact of climate change on wildfires. Available here.

1.2 Conference papers

The following conference papers and posters based on work done for the project have been published. All the conference papers and posters are available on the website here.

Van Niekerk, W., Duncker, L., Maditse, K.; Davis, C & Pieterse, A. 2018. Water Sensitive Urban Planning as Adaptation Strategy. Conference Proceedings: 54th ISOCARP Congress. 1 – 5 October, Bödo, Norway.

Le Roux, A., Van Niekerk, W., Arnold, K., Pieterse, A. & Davis, C. 2018. What to adapt for? Climate change risk profiles for South African cities. A poster presentation at the IPCC Cities and the Science of Climate Change Conference, Edmonton, Canada, 5-7 Mar 2018.

Pieterse, A., van Niekerk, W. & du Toit, J. Forthcoming. Creating resilient settlements through climate change adaptation planning, Conference Proceedings: Planning Africa Conference 2018, South African Planning Institute. 15 – 17 October 2018, Cape Town.

Gibberd, J. 2017. Pre-design considerations for urban climate change adaption and mitigation strategies, Smart Sustainable Cities and Transport Seminar, CSIR Knowledge Commons, Pretoria, 12-14 July 2017.

Gibberd, J. 2017. Social Resilience in Urban Areas, 11th Built Environment Conference, Durban South Africa, 6- 8th August 2017 Durban, South Africa.

Gibberd, J. 2017. Water Resilience in Urban Areas, 11th Built Environment Conference, Durban South Africa, 6-8th August 2017 Durban, South Africa.

Van Wyk, L., 2017, Cultural and heritage sensitive adaptation measures and principles in climate change adaptation plans for South African metropolitan cities, Smart Sustainable Cities and Transport Seminar, CSIR Knowledge Commons, Pretoria, 12-14 July 2017.

Van Wyk, L., 2017, Key principles for adapting South African settlement patterns to climate change, Smart Sustainable Cities and Transport Seminar, CSIR Knowledge Commons, Pretoria, 12-14 July 2017.

1.3 Journal articles

The following journal articles are in the pipeline for submission in 2019:

Title	Responsible person	Co-authors	Journal	Status
CSIR launches novel online climate risk profiling tool: The Green Book	Willemien van Niekerk	Alize le Roux, Amy Pieterse	South African Journal of Science (news article)	Published 29 May 2019
The winter rainfall region drought - evolution, impacts and implications	Emma Archer	Willem Landman, Mark Tadross, Johan Malherbe, Simone Pretorius	Climate Risk Management	Final draft to be submitted by May 2019.
A practical decision support tool for improved flood management	Ilse Kotzee	David Le Maittre	Journal of Disaster Risk Studies (Jàmbá)	Draft article.
Technical Paper with GIS focus on coastal flooding risk	Melanie Luck-Vogel	Alize le Roux, Jessica Eichhoff, Andre Theron, John April	Journal of Disaster Risk Studies (Jàmbá)	Draft article.

Livestock projections over SA	Daleen Lotter	Emma Archer	Climate Risk Management	Draft article.
Intra Settlement Growth model. Constructing a model for predicting the growth and decline of settlements across South Africa	Alize le Roux	Mans G, Makhanya-Khuluse S, Wools, L; Van Tonder, L; Arnold, K	International Journal of Geographical Information Science	Final draft to be submitted by May 2019.
Creating a vulnerability framework for measuring the various dimensions and scales of vulnerability in South African settlements	Alize le Roux	Kea Maditse; Elsona van Huyssteen; Gerbrand Mans; Willemien van Niekerk	Journal of Disaster Risk Studies (Jàmbá)	Final draft to be submitted by May 2019.
Developing a typology of climate change adaptation actions	Amy Pieterse	Willemien van Niekerk; Claire Davis-Reddy	International Journal of Climate Change Strategies and Management	Final draft to be submitted by May 2019.

2 PRESENTATIONS

2.1 Conference presentations

The following conference presentations were made during the project, based on research done as part of the project. All the conference presentations are available here.

Event	Date	Title and notes on presentation
African Capital Cities Sustainability Forum	26 Jun 2019	Presenting on the Green Book as planning support tool during the Planning for Resilient Cities Seminar.
4th European Climate Change Adaptation Conference. 28 – 31 May 2019, Lisbon	28 May 2019	The Green Book: Planning support tool for identifying and adapting South African settlements at risk to the impacts of climate change. By Alize le Roux, Willemien van Niekerk and Amy Pieterse. Presented by Alize le Roux.
Out-Of-The Box Human Settlements Conference. 24 October 2018, Pretoria.	24 Oct 2018	A likely 2050 future: Risk trajectories of South African settlements. By Alize le Roux, Kathryn Arnold, Chantel Ludick, Willemien van Niekerk, Amy Pieterse, David le Maitre, Greg Forsyth, Melanie Luck-Vogel, Francois Engelbrecht, Asmerom Beraki. Keynote presentation by Alize le Roux.
Fourth Biennial Conference of the Southern Africa Society for Disaster Reduction (SASDiR), 17 – 19 October 2018, Umhlanga.	18 Oct 2018	Planning support tool for identifying and adapting South African settlements at risk to the impacts of climate change. By Le Roux, A., van Niekerk, W. Le Maittre, D., Forsyth, G., Lück-Vogel, M. Engelbrecht, F., Ludick, C., Arnold, K. Lötter, D. & Beraki, A. Presented by Alize le Roux.

Fourth Biennial Conference of the Southern Africa Society for Disaster Reduction (SASDiR), 17 – 19 October 2018, Umhlanga.	18 Oct 2018	A Practical decision support tool for improved flood management. By Kotzee, I.& Le Maitre, D. Presented by Ilze Kotzee.
Fourth Biennial Conference of the Southern Africa Society for Disaster Reduction (SASDiR), 17 – 19 October 2018, Umhlanga.	18 Oct 2018	Coastal settlements and climate change: A pragmatic approach to determining settlements at risk of coastal flooding. By Lück-Vogel, M., Le Roux, A. Eichhoff, J., Theron, A.K. & April, J. Presented by Melanie Lück-Vogel.
Planning Africa Conference, South African Planning Institute, 15 – 17 October 2018, Cape Town	16 Oct 2018	Creating a vulnerability framework for measuring the various dimensions and scales of vulnerability in South African settlements. By Van Huyssteen, E., Le Roux, A. Maditse, K. Presented by Elsona van Huyssteen.
Planning Africa Conference, South African Planning Institute, 15 – 17 October 2018, Cape Town	16 Oct 2018	Creating resilient settlements through climate change adaptation planning. By Pieterse, A., van Niekerk, W. & du Toit, J. Presented by Amy Pieterse.
54th ISOCARP Congress 2018. 1-5 October 2018, Bodo, Norway.	3 Oct 2018	Place-based adaptation solutions for South African settlements. By Willemien Van Niekerk, Amy Pieterse and Alize le Roux. Presented by Willemien van Niekerk.
54th ISOCARP Congress 2018. 1-5 October 2018, Bodo, Norway.	3 Oct 2018	Water sensitive urban design as adaptation strategy. By Willemien Van Niekerk, Amy Pieterse, Louiza Duncker, Kea Maditse and Claire Davis. Presented by Willemien van Niekerk.
Disaster Risk Reduction 2018 Conference. Disaster Management Institute of Southern Africa, 19 – 20 September 2018, Benoni.	19 Sep 2018	Planning support tool for identifying and adapting South African settlements at risk to the impacts of climate change. By Le Roux, A., van Niekerk, W. Le Maittre, D., Forsyth, G., Lück-Vogel, M. Engelbrecht, F., Ludick, C., Arnold, K. Lötter, D. & Beraki, A. Presented by Alize le Roux.

Adaptation Futures 2018: 5th International Climate Change Adaptation Conference, 18 – 21 June 2018, Cape Town	20 Jun 2018	Place-based adaptation solutions for South African settlements. By Van Niekerk, W., le Roux, A., Pieterse, A. Presented by Willemien van Niekerk.
Adaptation Futures 2018: 5th International Climate Change Adaptation Conference, 18 – 21 June 2018, Cape Town	19 Jun 2018	Opportunities and challenges for disaster risk reduction and climate change adaptation coordination within the South African intergovernmental planning system. By Pieterse, A., van Niekerk, W., van Huyssteen, E. & Bruwer, A. Presented by Amy Pieterse.
Green Buildings and Infrastructure Conference, as part of Sustainability Week. 7 June 2018, Pretoria.	7 Jun 2018	The Green Book: Adaptation actions for South African settlements at risk of climate change. By Willemien van Niekerk, Alize le Roux and Amy Pieterse. Keynote presentation by Willemien van Niekerk.
Resilient Cities 2018, The 9th Global Forum on Urban Resilience and Adaptation. 26-28 April 2018, Bonn, Germany.	27 Apr 2018	Stakeholder engagement, collaboration and co-development of the Green Book project: Approached and lessons learnt. By Amy Pieterse and Willemien van Niekerk. Panel presentation by Amy Pieterse.
IPCC Cities and the Science of Climate Change Conference, 5-7 March 2018, Edmonton, Canada.	6 Mar 2018	What to adapt for? Climate change risk profiles for South African cities. A poster presentation. By Alize le Roux, Willemien van Niekerk, Kathryn Arnold, Amy Pieterse & Claire Davis. Presented by Elsona van Huyssteen
Smart & Resilient Cities & Transport Seminar, hosted b UP/CSIR/TUDelft, Pretoria.	12 Jul 2017	A Review of Cultural and Heritage Sensitive Adaptation Measures in Climate Change Adaptation Plans for South African Metropolitan Cities. By Llewellyn van Wyk

Smart & Resilient Cities & Transport Seminar, hosted by UP/CSIR/TUDelft, Pretoria.	12 Jul 2017	Key Principles and Goals for Adapting South African Settlements to Climate Change. By Llewellyn van Wyk
Smart & Resilient Cities & Transport Seminar, hosted by UP/CSIR/TUDelft, Pretoria.	12 Jul 2017	Pre-design considerations for urban climate change adaption and mitigation strategies. By Jeremy Gibberd
Local climate solutions for Africa 2017 (LoCS4Africa): Water and Climate Congress, hosted by ICLEI, Johannesburg.	23 Mar 2017	The Green Book. By Jeremy Gibberd
Liveable Cities Forum	13 Sep 2016	The Green Book. By Willemien van Niekerk

2.2 Project presentations

The following presentations were made during the project in support of dissemination of the project findings. The presentations are available here. Not all presentations have been made available on the website to avoid duplication.

Event	Date	Title and notes on presentation
African Capital Cities Sustainability Forum	26 Jun 2019	Presenting on the Green Book to approximately 60 African City Mayors.
Green Book Launch – Stellenbosch	14 Mar 2019	Green Book: Adapting South African Settlements to Climate Change. Presented by Willemien van Niekerk and Amy Pieterse.

Disaster Management Awareness And Advocacy Working Session, NDMC, 12-13 March 2019, Durban	13 Mar 2019	Green Book: Adapting South African Settlements to Climate Change. Presentation to Disaster Management Awareness And Advocacy Working Session, hosted by the NDMC, SALGA, and the Department of Cooperative Governance and Traditional Affairs. Presented by Willemien van Niekerk
Green Book Launch - Pretoria	8 Mar 2019	Green Book: Adapting South African Settlements to Climate Change. Presented by Willemien van Niekerk, Alize le Roux and Amy Pieterse.
National Capacity Building Coordinating Forum, National Disaster Management Centre	26 Feb 2019	Green Book: Adapting South African Settlements to Climate Change. By Mans, G., Pieterse, A. Le Roux, A., van Niekerk, W. Presented by Gerbrand Mans.
DEA Local Government Support Forum	27 Nov 2018	Green Book: Adapting South African settlements to the impacts of climate change. By By Pieterse, A., Van Niekerk, W., le Roux, A. Presented by Amy Pieterse.
KwaDukuza Local Municipality	14 Nov 2018	As part of the ICLEI Urban LEDS Project, the local risk profile information was used to support the adaptation response planning process in the KwaDukuza Local Municipality. The risk profile information was presented and facilitated by Rebecca Cameron from ICLEI.
Steve Tshwete Local Municipality	6 Nov 2018	As part of the ICLEI Urban LEDS Project, the local risk profile information was used to support the adaptation response planning process in the Steve Tshwete Local Municipality. The risk profile information was presented and facilitated by Rebecca Cameron from ICLEI.
Department Environmental Affairs, Climate Change Adaptation Technical Working Group	21 Sep 2018	Green Book: Adapting South African settlements to the impacts of climate change. By By Pieterse, A., Van Niekerk, W., le Roux, A. Presented by Amy Pieterse.

Presentation to SEA, SALGA & SACN	26 Sep 2018	Planning support tool for identifying and adapting South African settlements at risk to the impacts of climate change. By Van Niekerk, W. Le Roux, A., Pieterse, A., Arnold, K., Ludick, C. Presented by Willemien van Niekerk
Department Human Settlements' Science, Technology and Innovation for Sustainable Human Settlements Roadmap (STI4SHS)	Sep 2018	Risk trajectories of South African settlements, and initial findings from the Green Book for all 9 Provinces. By Le Roux, A., Arnold, K., Ludick, C., Le Maittre, D., Forsyth, G., Lück-Vogel, M., Engelbrecht, F., Lötter, D., van Niekerk, W. & Beraki, A. Presentations made by Peta de Jager.
CSIR Green Book Project: Knowledge sharing session	2 Aug 2018	Engaging relevant stakeholders on project findings. Attended by the: University of Pretoria, Department pf Cooperative Governance and Traditional Affairs and South African Cities Network. By Alize le Roux
South African Insurance Association: General meeting	17 July 2018	The Green Book. Adaptation actions for South African settlements at risk of climate change. By Alize le Roux
Department of Environmental Affairs (DEA)	18 July 2018	The Green Book. Settlement risk profiles. By Alize le Roux
South African Insurance Association: Technical committee	25 July 2018	The Green Book. Adaptation actions for South African settlements at risk of climate change. By Alize le Roux
The Green Book mini-conference, Pretoria.	21 Feb 2018	Presentations by all 6 workstreams to the research team, IDRC, partners and managers on the work done during the first two years of the Green Book project. By Willemien van Niekerk, Francois Engelbrecht, Alize le Roux, Jean-Marc Mwenge Kahinda, Greg Forsyth, David le Maitre, Daleen Lotter, Claire Davis, Amy Pieterse, Melanie Luck-Vogel & Nicholas Ngepah.

Presentation to National Planning Commission Lekgotla and Minister Radebe (Minister in the Presidency) on the development of the National Spatial Development Framework for South Africa, Pretoria.	10 Feb 2018	The National Spatial Development Framework (NSDF) is being prepared by the Department of Rural Development and Land Reform and the Department of Monitoring and Evaluation in The Presidency. The CSIR is part of the EUP Team that supports this process. The Draft 1 of the NSDF outlines challenges related to sustainable urbanisation and references the Green Book's population projections and expected implications of climate change on urban and rural development. By Prof Mark Oranje
Project Steering Committee Work Session: Draft 1 National Spatial Development Framework for South Africa, Pretoria.	9 Feb 2018	The National Spatial Development Framework (NSDF) is being prepared by the Department of Rural Development and Land Reform and the Department of Monitoring and Evaluation in The Presidency. The CSIR is part of the EUP Team that supports this process. The Draft 1 of the NSDF outlines challenges related to sustainable urbanisation and references the Green Book's population projections and expected implications of climate change on urban and rural development. By Prof Mark Oranje
Built Environment Tearoom Session, Pretoria.	1 Sep 2017	The Green Book project. A presentation made on the Green Book project to which the whole of the CSIR Built Environment was invited. By Willemien van Niekerk
Veldfire risk to communities living in the wildland-urban interface. Risk Symposium on Changing Climate, Changing Risk, 31 Jul - 1 Aug 2017, Belville, Cape Town.	31 Jul 2017	Organised by the Western Cape Disaster Management Centre (WCDMC) in collaboration with Santam Ltd, South African Weather Services and Western Cape DMISA. Presentation by Greg Forsyth.
Disaster Management Workshop, Pretoria.	13 Jul 2017	A presentation on the CSIR's capabilities to do urban risk and vulnerability analyses to the disaster managers of Gauteng. By Willemien van Niekerk

2nd Coastal Spatial Planning Working Group Meeting, Cape Town.	3 Mar 2017	The Green Book. By Melanie Luck-Vogel
2nd Coastal Spatial Planning Working Group Meeting, Cape Town.	3 Mar 2017	The Green Book. By Melanie Luck-Vogel

3 STAKEHOLDER ENGAGEMENT, CO-PRODUCTION AND PEER-REVIEW

3.1 Stakeholder consultations

The following stakeholders have been consulted during the Green Book:

Stakeholder	Person(s)	Date	Notes on engagement
City of Tshwane and C40 cities	Lutske Newton Nicci Mander	18 Feb 2019	Met with the City, their C40 representatives and our colleagues from CSIR NRE regarding previous work done for the City's vulnerability assessment and discussed updating this work based on the Green Book framework. Shared Green Book work.
DEA, Santam, NDMC	John Lomberg Ané Bruwer David Madurai	13 Feb 2019	Reached agreement between CSIR, DEA, NDMC and Santam to partner on phase II of the Green Book. Agreed that the

	Tlou Ramaru Faith Nkhola Lindelani Mudau		partnership will be announced at the Green Book launch and set up a steering committee.
Multiple stakeholders part of the Science, Technology & Innovation for Sustainable Human Settlements Roadmap (STI4SHS) KZN Provincial Workshop	Department Human Settlements Housing Developing Agency Ethekwini Municipality UKZN	18 Jan 2019	Provincial risk trajectories and profiles shared with stakeholders in the KZN province as part of the Roadmap for Science, technology and innovation for sustainable human settlements.
SANBI	Sagwata Manyike Hulisani Magada	15 Jan 2019	Presented the draft Green Book outputs and discussed possible future collaboration.
Santam	John Lomberg	18 Dec 2018	Discussion with Santam on Green Book, collaboration opportunities and need for investment and roll-out. Discussion to securing buy-in for phase II of the Green Book.
Department of Science and Technology	Henry Roman Tsepang Monsiea Tiyani Ngoveni	12 Dec 2018	Presented the draft Green Book outputs and discussed possible future collaboration with DST as a research and development partner. Also discussed the collaboration with the DST funded SARVA (currently managed by SAEON). ….
Multiple stakeholders part of the Science, Technology & Innovation for Sustainable Human Settlements Roadmap (STI4SHS)	National Department Human Settlements DST MP DHS	28 Nov 2018	Provincial risk trajectories and profiles shared with stakeholders in the Mpumalanga province as part of the Roadmap for Science, technology and innovation for sustainable human settlements.

Mpumalanga Provincial Workshop	Provincial DHS SALGA MP CoGTA Housing Developing Agency		
Department Environmental Affairs	Alinah Mthembu Faith Nkhola Lindelani Mudau	23 Nov 2018	Presented the Green Book website concept and draft story maps to DEA as a first step to securing buy-in for phase II of the Green Book.
City of Tshwane and C40 cities	Samuel Chademanda	22 Oct 2018	Introduced the Green Book and discussed ways in which we can provide mutual support
ICLEI Africa	Meggan Spires Rebecca Cameron	11 Oct 2018	Discussion on Green Book findings and tools and collaboration opportunities. Identified opportunities for testing the research findings in two of Urban LEDS Phase 2 - Municipalities.
CoGTA	Stefanie Chetty Lerato Phokobye Kholofelo Sepuru	3 Sep 2018	Information sharing and collaboration opportunities. Knowledge Sharing Session on the Green Book and how the project can support the IUDF and other initiatives in CoGTA
Multiple stakeholders part of the Science, Technology & Innovation for Sustainable Human Settlements Roadmap (STI4SHS) Free State Provincial Workshop	National Department Human Settlements Housing Developing Agency – Free State UFS Several local Municipalities	5 Oct 2018	Provincial risk trajectories and profiles shared with stakeholders in the Free State province as part of the Roadmap for Science, technology and innovation for sustainable human settlements.

	SALGA Mangaung Metro		
Multiple stakeholders part of the Science, Technology & Innovation for Sustainable Human Settlements Roadmap (STI4SHS) Northern Cape Provincial Workshop	DHS SALGA NC SALGA Frances Baard DM CoGTA NC DWS	7 Sept 2018	Provincial risk trajectories and profiles shared with stakeholders in the Northern Cape province as part of the Roadmap for Science, technology and innovation for sustainable human settlements.
Multiple stakeholders part of the Science, Technology & Innovation for Sustainable Human Settlements Roadmap (STI4SHS)	NDHS DST TIA DWS UP WRC City of Tshwane SALGA	4 Sep 2018	Provincial risk trajectories and profiles shared with all 9 provinces through the Department of Science and Technology project.
SACN, UP, CoGTA	Peter Magni Mark Oranje Stefanie Chetty Liteboho Makhele Litha Sibayi	2 Aug 2018	Information sharing around the settlement vulnerability profiling and population projections and high level findings of the Green Book
Department Environmental Affairs	Alinah Mthembu Faith Nkohla	18 Jul 2018	Knowledge sharing session on risk profiles and vulnerability indicators.

	Mikateko Sithole		
South African Insurance Association – Insurance Technical Committee	Representatives from various industry partners e.g. Hollard, Santam, King Price, OldMutual etc.	25 Jul 2018	Information sharing on the Green Book project, high level findings for the Western Cape Province and getting support and buy-in from the industry. Specific focus on risk assessment.
South African Insurance Association	Representatives from various industry partners e.g. Hollard, Santam, King Price, OldMutual etc.	17 Jul 2018	Knowledge sharing session and awareness raising about the Green Book aim, objectives and high level findings.
SANBI VU, Amsterdam, NL	Jeanne Nel Amanda Driver	12 Jun 2018	Discussion around how aspects of the Green Book (specifically the vulnerability Workstream 3) can support the Cities and Ecosystems accounting discussions.
TuDelft	Dr Franklin van der Hoeven	April 2018	Met with Dr Franklin van der Hoeven to gain insight and lessons learnt from the Knowledge for Climate Programme, which is the only project that we similar to the Green Book in terms of scope and content. He shared lessons from the programme, specifically related to information sharing and dissemination.
City of Cape Town	Amy Davison Barry Coetzee	20 Apr 2018	Co-development of adaptation actions in a workshop format.

	Charlotte Powell Margie Murcott Nosiphe Mnyazi Tamsin Fraghar		
SAEON	Wim Hugo Asiphe Amelia	26 Mar 2018	SAEON-CSIR Green Book Working session. Streamlining initiatives and data sharing.
SAEON	Wim Hugo Hayden	13 Mar 2018	SARVA-Green Book Collaboration and progress meeting.
NDMC	Mark van Staden	21 Feb 2018	Discussed the results from the flood modelling with the NDMC. They have a strong interest in this approach to flood risk modelling.
City of Cape Town	Tamsyn Faragher Amy Davis Richard Nell	16 Feb 2018	The reviewers of some of the Green Book chapter had questions and comments, and wanted to engage further with us on the matter. They were very enthusiastic about the Green Book and noted their willingness to be included in future peer-review.
SAEON	Wim Hugo	7 Dec 2017	Consultant to various government departments on the hosting of data.
Department of Rural Development and Land Reform	Mfanafuthi Gama	29 Nov 2017	DRDLR is very interested in the work we are doing on the Green Book. They share good practice and invited us to participate in their rural climate change programmes.
Department of Science and Technology	Henry Roman Magamase Mange	22 Sep 2017	DST indicated they are willing to serve as peer reviewers, and is very interested in the data.

Department of Environmental Affairs	Vernon Baloyi	11 Sept 2017	We met with DEA to specifically discuss the work on the vulnerability indicators. They are very interested to gain access to our work on this part of the Green Book.
Pegasys	Sheenagh Bruce Mvuyisi April	29 Aug 2017	Pegasys is a consultant to National Treasury, and responsible for updating the BEPP indicators.
National Treasury	Anthea Stephens	16 Aug 2017	Treasury was very interested in our work and invited us to participate in their BEPP indicators workshop.
National Disaster Management Centre	Mmaphaka Tau Ane Bruwer	3 Aug 2017	We informed the new head of the NDMC about the project and their obligations towards providing data, as well as
Development Bank of South Africa	Ruan Kruger Julie Clarke Bernhard	12 Jul 2017	DBSA would like to get involved as peer-reviewers of the project, training local planners, and could provide support in the preparation of a pilot project for future funding.
Department of Environmental Affairs	Vhalinavho Khavhagali Mikateko Sithole Faith Nkohla	4 Jul 2017	There are many aspects that DEA is interested in, and they would like to be closely involved in the project. They have since been inviting us to various workshops.
South African Local Government Association (SALGA)	Intelligence Chauke	18 May 2017	SALGA has shown sincere interest in the Green Book, would endorse it and would like to explore an MOU or partnership
USAID	Haily Smith Christopher Perine	9 May 2017	USAID is doing climate change work in South Africa, and we shared our work with each other.
About 100 national, provincial and local coastal stakeholders &		5 workshops in 2017	While the coastal metropoles and some coastal districts have been conducting local coastal risk assessments on their own account during the last years, a coastal flood hazard exposure

managers for DEA's National Coastal Assessment project			assessment is still urgently needed for most other parts of the SA coast. This need was expressed inter alia during the 5 workshops for the DEA NCA project. Uptake of the products from the Green Book is very likely in this project.
City of Cape Town	Helen Davies Margie Murcott Amy Davison Mikhyle Moos	15 Sep 2016	Introduced the project and invited the City to engage and participate in the project as a valued stakeholders. The City provided input and suggestions related to understanding end-user needs, and content that can be included.
Conservation South Africa	Sarshen Scorgie	15 Sep 2016	Introduced the project and invited Conservation SA to engage and participate in the project as a valued stakeholders. Valuable suggestions were provided in terms of other stakeholders to include, other work that has been done that can support the Green Book.
University of Cape Town, Climate Systems Analysis Group (CSAG)	Gina Ziervogel Sue Parnell Alice McClure Anna Steynor Chris Lennard	15 Sep 2016	Introduced the project and invited the group to engage and participate in the project as a valued stakeholders. Valuable suggestions were provided in terms of approach, content, available data and communication of findings.
Western Cape Disaster Management Centre	Nabeel Rylands	14 Sep 2016	Introduced the project and invited WC Province to engage and participate in the project as a valued stakeholder. Nabeel provided suggestions in terms of approach and content.

Stellenbosch University, Research Alliance for Disasters and Risk Reduction (RADAR)	Ailsa Holloway Gillian Fortune Robyn Pharaoh	14 Sep 2016	Introduced the project and invited RADAR to engage and participate in the project as a valued stakeholder. RADAR provided suggestions in terms of approach and content.
Department of Cooperative Governance and Traditional Affairs	Modjadji Malahlela	25 Jul 2016	Introduced the project and invited CoGTA to engage and participate in the project as a valued stakeholder.

3.2 Peer-reviewers

The following people and organisations have served as peer reviewers for the pieces of work done on the Green Book. The peer-reviewers and reference groups serve as co-developers of the methodologies of the various workstreams, and they also provide comments on and suggest changes to the findings.

Name	Organisation	Sector	Workstream
Amy Davison	City of Cape Town	Local government	1
Ane Bruwer	National Disaster Management Centre	National government	1
Ashraf Adam	South African Local Government Association	Government body	3
Chris Jack	University of Cape Town	Academic/research	2
Chris Lennard	University of Cape Town	Academic/research	2
Coleen Vogel	WITS University	Academic/research	2, 4
Denis Hughes	Rhodes University	Academic/research	4
Ed Filby	City of Cape Town	Local government	1

Frances van der Merwe	Western Cape Province: Department of Environmental Affairs and Development Planning	Provincial government	1
Hassen Mohamed	The Presidency, Department of Performance Monitoring and Evaluation	National government	3
Helen Davies	City of Cape Town	Local government	1
Henry Roman	Department of Science and Technology	National government	1
Hilary Price	City of Cape Town	Local government	1
Ian Gildenhuys	City of Cape Town	Local government	1
Julie Clarke	Development Bank of South Africa	Funding organisation	1
Mark Oranje	University of Pretoria	Academic/research	3
Meggan Spires	ICLEI Africa	NGO	1
Mikateko Sithole	Department of Environmental Affairs	National government	1
Mike Wallace	Western Cape Province	Provincial government	6
Nabeel Rylands	Western Cape Province: Disaster Management	Provincial government	4
Peter Magni	South African Cities Network	NGO	1, 3
Priscilla de Comarmond	City of Cape Town	Local government	1
Rebecca Cameron	ICLEI Africa	NGO	1
Ruan Kruger	Development Bank of South Africa	Funding organisation	1
Sarshen Scorgie	Conservation SA	NGO	1
Sizo Sebake	CSIR	Academic/research	1
Sue Parnell	University of Cape Town	Academic	3

Tamsin Faragher	City of Cape Town	Local government	1
Vhalinavho Khavhagali	Department of Environmental Affairs	National government	1
Wandile Nomqupu	Water Research Council	Academic/research	4

3.3 Technical committees/advisory bodies/working groups

The project steering committee members are serving on the following technical committees, advisory bodies and working groups as a result of the project work:

Body	Researchers involved	Notes on body
Built Environment Performance Plans (BEPP)	Willemien van Niekerk Amy Pieterse	Revising the BEPP indicators for National Treasury
Cities Resilience Programme	Amy Pieterse	Department of Environmental Affairs
National Adaptation Strategy	Willemien van Niekerk	Revising the NAS for the Department of Environmental Affairs
National Climate Change Committee	Willemien van Niekerk	Department of Environmental Affairs
National Framework for Climate Services	Alize le Roux	Framework for establishing data custodians for climate related assessments, Department of Environmental Affairs
SARVA Working Group 3	Alize le Roux	Working group on SARVA framework, information sharing, baseline of important stocks, increase

		visibility and usability of SARVA, roll out to decision makers
Climate Change Adaptation Technical Working Group	Amy Pieterse	Department of Environmental Affairs

4 MEDIA AND EXTERNAL EXPOSURE

4.1 External publications

The following documents have been published with reference made to the Green Book:

Department of Planning, Monitoring and Evaluation. 2018. Draft National Spatial Development Framework. Available from: https://www.dpme.gov.za/keyfocusareas/gwmeSite/The%20PME%20Forum%202018/FINAL-DRAFT-NSDF-September-2018-B-1.pdf

Science Technology & Innovation for Sustainable Human Settlements (STI4SHS) Roadmap. 2018. Provincial Consultative Workshop Reports for all 9 provinces. Available from: http://www.sti4shs.co.za/documents

USAID. 2018. Building urban resilience to climate change: A review of South Africa. Pp 18-20, 23-25, 36, 43. Available from: https://www.climatelinks.org/sites/default/files/asset/document/180327_USAID-ATLAS_Building%20Urban%20Resilience%20to%20CC_South%20Africa_to%20CL_rev.pdf)

Department of Environmental Affairs. 2016. South Africa National Adaptation Strategy draft for comments. p 48 Available from: https://www.environment.gov.za/sites/default/files/docs/nas2016.pdf

4.2 Interviews and media statements

The following interviews and news articles have appeared in local and international media about the project:

Publisher	Date	Notes on publication
WeADAPT	1 Jul 2019	The Green Book: Adapting South African settlements to climate change, online at https://www.weadapt.org/knowledge-base/cities-and-climate-change/the-green-book-adapting-south-african-settlements-to-climate-change
Industry News	12 Jun 2019	A tool for adapting settlements: CSIR launches The Green Book. https://www.specifile.co.za/news/csir-green-book/
Carte Blanche	29 Apr 2019	Devastating floods wreak havoc in KZN https://www.youtube.com/watch?v=J1MSsManFMA
Building and decor	15 Apr 2019	CSIR launches the Green Book: a tool for adapting settlements in light of climate change
Brandlive.co.za	29 Mar 2019	A 25 minute podcast with Kgauhelo Dioka on CSIR Engage, Episode 2 about the Green Book at http://brandlive.co.za/podcast/csi-enage-x-episode-2/ or https://youtu.be/yfHBprkPz0g
CSIR Connect	29 Mar2019	WATCH: Launch of the Green Book - An online tool to assess climate change impact for efficient planning https://streaming.csir.co.za/View.aspx?id=9195~4y~AsgpJYFg
Climate and Development Knowledge Network (CDKN)	22 Mar 2019	Novel tool unveiled for climate risk profiling and adaptation. https://cdkn.org/2019/03/news-novel-tool-unveiled-for-climate-risk-profiling-and-adaptation/?loclang=en_gb

On Point - SABC News	22 Mar 2019	CSIR launches online climate risk profiling and adaptation tool. https://www.youtube.com/watch?v=giN58Xw--0o
Public Eye Maritzburg	15 Mar 2019	CSIR launches online climate risk profiling and adaptation tool.
Brakpan Herald	15 Mar 2019	CSIR launches online climate risk profiling and adaptation tool.
Joburg East Express	15 Mar 2019	CSIR launches online climate risk profiling and adaptation tool.
Rekord (Pretoria Central)	15 Mar 2019	CSIR online tool will fight climate change. Page 8.
Rekord Online	15 Mar 2019	CSIR launches online climate risk profiling and adaptation tool.
TshWi-Fi	15 Mar 2019	CSIR launches online climate risk profiling and adaptation tool.
Oudtshoorn Courant	14 Mar 2019	Green Book readies municipalities for climate change.
Knysna Plett Herald	14 Mar 2019	Green Book readies municipalities for climate change.
Mossel Bay Advertiser	14 Mar 2019	Green Book readies municipalities for climate change.
Graaff Reniet Advertiser	14 Mar 2019	Green Book readies municipalities for climate change.
George Herald	14 Mar 2019	Green Book readies municipalities for climate change.
Suid-Kaap Forum	14 Mar 2019	Green Book readies municipalities for climate change.
Smile FM	13 Mar 2019	The Green Book. Interview with Willemien van Niekerk. Snippets played during news, every hour. Duration: 00:00:41.
Bizcommunity	12 Mar 2019	Green Book readies municipalities for climate change.
India Environmental Portal	12 Mar 2019	South Africa: Green Book readies municipalities for climate change. http://www.indiaenvironmentportal.org.in/content/461929/south-africa-green-book-readies-municipalities-for-climate-change/
Prevention Web	11 Mar 2019	South Africa: Green Book readies municipalities for climate change. https://www.preventionweb.net/news/view/64169
SANews	11 Mar 2019	Green Book readies municipalities for climate change.

ITWeb	11 Mar 2019	CSIR offers online climate risk profiling tool.
Pretoria News	11 Mar 2019	Tool to help address impact of change. Page 2.
All Africa	11 Mar 2019	South Africa: Green Book Readies Municipalities for Climate Change. https://allafrica.com/stories/201903110804.html
World Association for Disaster and Emergency Medicine	10 Mar 2019	South Africa: Green Book readies municipalities for climate change. https://wadem.org/feed-items/south-africa-green-book-readies-municipalities-for-climate-change/
SA FM	10 Mar 2019	Focus on the Green Book Project initiated by the CSIR. Interview with Willemien van Niekerk. Duration: 00:08:44.
Engineering news	8 Mar 2019	CSIR launches tool to help municipalities assess their climate risks.
Polity	8 Mar 2019	CSIR unveils novel online climate risk profiling and adaptation tool.
CSIR	8 Mar 2019	CSIR unveils novel online climate risk profiling and adaptation tool
Augstus Consulting	7 Mar 2019	SA to unveil first-of-a-kind tool to tackle climate change.
The Citizen	6 Mar 2019	SA to unveil groundbreaking online tool for municipalities to respond to climate change.
Investing.com	6 Mar 2019	SA to unveil first-of-a-kind online tool for municipalities to respond to climate change.
IOL	6 Mar 2019	SA to unveil first-of-a-kind tool to tackle climate change.
Find All News	6 Mar 2019	SA to unveil first-of-a-kind tool to tackle climate change.
Infrastructure News and Service Delivery	6 Mar 2019	Online tool set to help municipalities respond to climate change.
The Adaptation Network South Africa online newsletter	Aug 2017	A news article on what the Green Book is, at http://www.adaptationnetwork.org.za/2017/08/green-book-adapting-south-african-settlements-climate-change/

News article on the CSIR website	27 Jan 2017	Development of the Green Book on human settlement adaptation for climate change on track, at https://csir.co.za/development-green-book-on-human-settlement-adaptation-climate-change-on-track
Project information on the CSIR website	Jan 2017	CSIR and partners develop climate change adaptation guidelines for SA settlements, at https://csir.co.za/csir-and-partners-develop-climate-change-adaption-guidelines-sa-settlements

5 PARTNERSHIPS, PROPOSALS AND STRATEGIC DISCUSSIONS EMANATING FROM THE GREEN BOOK

5.1 Collaboration/partnerships/funding

The following partnerships, alliances and funding arrangements have been established during the course of the project, based on the work done for the Green Book project:

Organisation/project	Researchers involved	Notes on body
National Treasury, Cities Support Programme	Amy Pieterse, Willemien van Niekerk, Gerbrand Mans	Providing technical support to all metropolitan municipalities over three years to integrate climate responsiveness and resilience into their planning process.

City of Tshwane	Willemien van Niekerk, Alize le Roux	Supporting the City of Tshwane in completing their Climate Action Plan as required by C40.
Green Book Phase II Partnership: CSIR, DEA, Santam and NDMC	Green Book project management team	Partnership established to support the implementation of the Green Book through capacity building and training in national and local government; identifying research gaps and needs, maintaining and updating the website and tools.
DEA's national coastal assessment project	Melanie Luck-Vogel, project leader of NCA	Sourcing on NCA stakeholders for input and comments on hazard exposure map; also source of co-funding for map development
Operation Phakisa: OCIMS	Melanie Luck-Vogel, leader of coastal flood decision tool development	Using OCIMS stakeholder input for user requirement assessment
Stellenbosch University, Centre for Geographical Analysis CGA	Melanie Luck-Vogel, project collaboration	Collaboration on GIS assessment of coastal flood hazard exposure (and further coastal pressures) in the NCA project
Santam	Greg Forsyth, project collaboration	High fire risk areas in the Western Cape.

5.2 Data request

The following data request have been received during the project:

Client/project	Date	Notes on request for data
WITS University	Jan 2019	Risk profiles and adaptation options extractions for Johannesburg Metropolitan

ICLEI-Urban LEDS	Nov 2018	Risk profiles and adaptation measures for two Municipalities as part of their climate response plans
Private consultants to Gauteng Province	Nov 2018	Data requested for stormwater runoff modelling for Gauteng.
City of Tshwane	Oct 2018	Population projections data request to inform climate change mitigation and adaptation planning process.
SAEON	March 2018	Sharing the DataCUBE database developed for the Green Book vulnerability profiling
National Spatial Development Framework by the Department of Rural development & Department of Public monitoring & Evaluation	Jan 2018	The climate change projections as well as the demographic downscaled projections of growing/declining towns as well as the growth/decline projections on national, provincial and local municipality level are used by the strategic National Spatial Development Framework currently underway. This is a key national planning document.
Department of Environmental Affairs	Sept 2017	The national department requested data on the vulnerability indicators
Gauteng Province	Jun 2017	Gauteng Province requested access to the downscaled climate change data to be incorporated into their updated Climate Change Strategy

5.3 Project proposals

The following proposals emanated from the project and have been submitted resulting from work done on the project:

Client	Date	Proposal
City of Tshwane/ C40	Jul 2019	Developing two concept notes. 1) Downscaling GB to Metro-level (Climate R&V support) and supporting the climate adaptation plan (CAP) as part of C40 programme. 2) Developing a long-term modelling concept note (integrated assessment modelling initiative)
National Treasury: Cities Support Programme	Jun 2019	Integrating climate-responsiveness and resilience into the Built Environment Performance Planning process
Santam	Jun 2019	Green Book Phase II Piloting and roll-out. Concept note submitted for Santam contract.
GIZ/Department of Environmental Affairs	Jan 2019	Proposal was submitted to develop a National Risk and Vulnerability Framework for the Department of Environmental Affairs
Department of Rural Development and Land Reform	Nov 2018	Proposal was submitted to conduct district level risk and vulnerability assessments and to develop adaptation plans for 3 districts.
National Research Foundation	Sep 2018	Proposal submitted to the NRF as part of the SASSCAL phase 2 programme, to further develop the Green Book to include traditional settlements and to develop adaptation actions specific to traditional areas.
GIZ/Department of Environmental Affairs	Jul 2018	Proposal submitted to conduct a South African cities preparedness assessment to address climate change challenges and build climate change resilience.

GIZ/Department of Environmental Affairs	Jul 2018	Proposal submitted to do more detailed analysis of coastal risk and vulnerability for South Africa.
Western Cape Province	Mar 2018	To use the flood risk data for the Western Cape Province in a project for the provincial Department of Environmental Affairs and Development Planning. We are currently preparing a bid to secure this project and have suggested using the flood risk dataset in our bid document.
CSIR	Feb 2018	A proposal was submitted to the CSIR long-term Thematic Programme to fund a three-year research programme on the Climate-Urban-Health Nexus (CLUHN): Projecting urban health futures in South Africa under climate change. This proposal stems from the work done on the Green Book and the cooperation between the Built Environment and the Natural Resources and Environment units.
City of Joburg	2017	A proposal was submitted to the City of Johannesburg on revising their sanitation policy: for climate change to feature in the new policy.

5.4 Strategic discussions

The following strategic meetings and workshops have been held since the Green Book project grant funding came to an end, to pursue continued research and development of the Green Book, spin-off projects, and requests for support from various stakeholders:

Stakeholder	Date	Prupose and way forward or outcome
SASRIA	15 Apr 19	Collaboration opportunities and sharing GB tool and value for insurance industry
Risk Insurance Industry	16-17 Apr 19	Risk protection gap laboratory: senior stakeholders within and beyond the general insurance industry to move forward the UN Principles for Sustainable Insurance in South Africa. Mapping the insurance risk protection gap. Resulted in position statement and several individual follow-up meetings and actions
SANBI/DEA Bilateral	23 Apr, 7 May, 15 May 19	Meeting with SANBI's Green Climate Fund Project management team and DEA's Climate adaptation response team on GCF investment priorities and allignment. Currently providing inputs to GCF investment concept note i.t.o GB contribution to DRR space.
Department of Environment, Forestry and Fisheries	29 Apr 19	Green Book Phase II partnership meeting. Need to develop a phase II training roll-out Programme for sector and municipal capacity building based on the Green Book.

PICC	2 May 19 & 3 Jun 19	Follow-up meeting: Discussing way forward on Green Book dissemination to Senior political principals. Presentation prep for PICC council and possible case study demonstration. Political support for Green Book as planning support tool and stimulating investment in DRR & CCA R&D
South Africa Insurance Association	7 May 19	Collaboration opportunity for GB and Insurance industry. Scehudling high-level presentations to Executives in Insurance industry
City of Tshwane	10 May 19 & 21 Jun 19	Programme and objectives for seminar on Resilient Cities as part of Sustainability Week and the African Capital
Newton Fund	22 May 19	Collaboration discussion on CSIR GB and CSIR climate modelling and Newtond Fund initiatives
Department of Environment and Forestry	24 May 19	Exploring ways in which the Green Book adaptation actions can be used in the National Climate Information Services Database.
SAEON	24 May 19 & follow-up meetings	CSIR involvemnet in SARVA 3. CSIR/DST/SAEON position statement on RV framewrok development. Green Book/SARVA synergies. Concept note development in progress.
Club of Rome	27 May 19	Discuss how the CSIR and the Club of Rome can support each other on the climate change agenda.
CSIR Smart Places	31 May 19	Strategic discussion within cluster to identify opportunities and ideas around the Nationa Climate Change Adaptation Strategy.
National Disaster Management Advisory Forum	6 Jun 19	Presentation to NDMAF. Awereness rasising about the GB as Planning support tool and tabled the motion of investment in R&D for sectors into DRR & CCA. Follow-up discussions nessesary

National Treasury and World Bank	10-11 Jun 19	Programme alignment within NT Cities Support Programme (CSP) on Climate Response and Resilience, between CSIR and World Bank Component. Presented Green Book to World Bank Team. Formed part of World Bank Scoping Mission where we together met with Ekurhuleni, Johannesburg and Tshwane.
Chemonics International	11 Jun 19	Purpose was awereness raising on the ability of Smart Places to address complex climate impact problems/solutions. Opportunity for uptake of capability in other countries. Collaboration discussions will be scheduled to explore project oppertunities
C40 Cool Cities Network	11 Jun 19	Meeting with C40 Cool Cities Network to present work done on urban heat.
Institute of Risk Management South Africa (IRMSA)	14 Jun 19	Risk intelligence committee meeting. Presentation to executive committee for Inputs to 2020 annual risk report.
Newton Fund / Met Offices (UK)	17 Jun 19 & 15 Jul 19 (tbc)	Currently providing inputs to their investment plan and on CSIR service partnership possibilities in climate modelling and downstream climate services. Met office to visit CSIR (high-level delegation) TBC
Santam, University of Cape Town	19 Jun 19	Sharing between the Green Book and the Santam Partnership for Resilience Programme on how to support municipalities to reduce risk. Will continue to explore opportunities for collaboration.