Introduction

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In recent years, South Africa has experienced an El Niño-related drought reported to be one of the worst meteorological droughts since 1904. The average rainfall in this drought period (late 2014–2016) was about 403 mm compared to 608 mm over the last 112 years (Manderson et al. 2016). El Niño is associated with the warming up of the Pacific Ocean, which is normally at a rate of 0.01% but has increased to a rate of 0.1% and the danger of exceeding the 1% critical threshold is imminent. The warming of the Pacific Ocean interrupts the usual weather patterns and affects the global climate. This could result in droughts in one region and intense storms in another (CPC 2015; Manderson et al. 2016:5). El Niño brings dry conditions to most of southern Africa (Makhubu 2015). The drought and heat conditions have impacted on the already dry and drought-stricken country, exacerbating existing vulnerabilities and affecting sectors such as water and agriculture. Provinces in the country, especially the Western Cape, Free State and the Northern Cape, have experienced water restrictions, widespread crop failure and substantial depletion of livestock. From late 2016, intense storms followed this drought, which resulted in flooding in some parts of the country including Gauteng, Mpumalanga, KwaZulu-Natal and Limpopo. The Western Cape winter rainfall region is, however, still suffering one of its worst droughts in decades. The frequency of extreme weather events has increased, as shown by the increased frequency of the El Niño (from 20 to 10 years), and some climate scientists have attributed this to climate change (Manderson et al. 2016; Pearce 2016). Although there may be debate about the factors influencing the frequency of extreme weather events there is evidence to show that these events have a detrimental impact on our lives and we cannot afford to be complacent.

The success of the first edition of the South African Risk and Vulnerability Atlas (SARVA), both as a publication and at COP17 (17th meeting of the 'Conference of the Parties' of the international treaty known as the United Nations Framework Convention on Climate Change), as shown by the feedback received, has prompted the production of this second edition with more chapters based on themes and case studies. While this publication still targets local government, it has been designed to appeal to other users including academia. We do however, acknowledge that more integration is needed in terms of balancing between the social and the physical impacts of climate and global change.

Nationally, there has been increased momentum in the implementation of the National Climate Change Response Policy. The Department of Environmental Affairs (DEA) increased its support to provincial governments and local municipalities so that they can conduct their own climate risk and vulnerability assessments, as well as to draw up climate change adaptation plans for local level climate change response, in line with the adaptation goals of the country. The increased momentum has also been evidenced by the implementation of the Climate Change Adaptation Monitoring and Evaluation framework and the completion of the Long-Term Adaptation Scenarios (LTAS) Phase 2 in 2014.

The second Global Change Summit co-hosted by the Department of Science and Technology (DST) and the National Research Foundation was held in December 2014. Various other sectors have also held meetings focussing on climate change,

such as the Understanding Urban Risk International Conference. Such engagements have created opportunities for cross-sectoral dialogue around issues including risk and vulnerability, mitigation, and adaptation and responses to global climate change. In 2016, the DEA commissioned the production of the Third National Communication and the Technological Needs Assessment as required by the United Nation's Framework for the Convention on Climate Change (UNFCCC).

South African Risk and Vulnerability Atlas

The *South African Risk and Vulnerability Atlas* was conceived by the DST in 2008 as a flagship programme under the 'Global Change Grand Challenge', which falls under one of the themes of the 'Innovation Towards a Knowledge Economy' plan. One of the themes in this programme focuses on the use of science and technology in responding to global change. It aims to enhance scientific understanding of global change and to develop innovative technologies to respond to global change, with an emphasis on climate change. The SARVA falls within this theme and was designed to ensure that existing knowledge on global change risks and vulnerability is made available for those who could benefit from its use.

Three products have since been developed under the SARVA: the online electronic spatial database, the Reading Risk SARV-GAP tool and the first edition of the SARVA, published in 2012.

The SARVA data platform provides data and information on the vulnerabilities and risks associated with global change, including climate change, for various sectors in South Africa. The portal, which is structured according to twelve different themes, contains theme-specific spatial data and case studies. The online portal is managed by the South Africa Earth Observation Network (SAEON) and can be accessed at http://sarva2.dirisa.org/. The Reading Risk SARV-GAP, which is an offline tool, was developed to cater to local government officials, especially those with limited reliable internet access. This tool can be accessed through the SARVA website (mentioned above). It offers information on the basic concepts of risk and vulnerability in the context of climate change to enhance the users understanding of the spatial and non-spatial information on the portal.

The first edition of the SARVA atlas contained chapters and case studies based on the themes on the portal and as defined in the National Climate Change Response White Paper. This second edition of the atlas differs from the first edition in several respects and comprises more chapters, which are more detailed and incorporate feedback received from the first edition.

The selection of the contributing authors to the second edition atlas was based on the experiences and knowledge that they brought to the book through their expertise in the different disciplines. The authors are diverse and include leading academics, scientists as well as social scientists. Unlike the first edition, this publication has been peer-reviewed, making it more scientifically credible. Other improvements in this publication include provision of the concept, meaning and understanding of the terms 'risk' and 'vulnerability' (Chapter 2). Chapter 3 highlights the risk and vulnerability of the socio-economic landscape and includes issues associated with the service delivery protests in the past few years. Chapter 4 explores the factors influencing global and climate change, such as the present-day climate. Chapter 5 presents the predicted changes in climate and provides evidence of increased concern regarding climate risk. Other specific sectors in this edition include the impact of climate on air quality (Chapter 6), on water (Chapter 7), on human health (Chapter 8), on the agricultural sector (Chapter 9) and on commercial forestry (Chapter 10). The book includes a chapter on the impact of climate change on biodiversity (Chapter 11), as well as a chapter on its impact on ecosystems such as coastal zones (Chapter 12), which is critical in terms of understanding global change. Chapters 13 and 14 illustrate the use of SARVA data by local government in response to global change, as well as its impact at the local level and its application in the business and insurance sectors respectively. The final chapter (Chapter 15) concludes the atlas by characterising trends of local disasters in the country.

The DST continues to fund research programmes under the Global Change Research Plan intended at building a climate change resilient society and projects aimed at transitioning South Africa towards a green and low-carbon economy. All these efforts contribute to the production of substantial amounts of information on climate change mitigation and adaptation. This publication is for decision makers in government, as well as for private and civil society and provides them with locally-produced knowledge on sector vulnerability to climate change as well as the drivers of sector vulnerability. The case studies showcase vulnerability to climate change in the sector at a local or grassroots level while other case studies highlight responses to climate change at the local level, in the different sectors. This information will increase the knowledge and understanding of the country's decision makers on climate change, its impacts and responses.

Acronyms

ADM	Amathole District Municipality
AEL	Atmospheric Emission License
AGCM	Atmospheric Global Circulation Model
AMCOW	African Ministers' Council on Water
AQMP	Air Quality Management Plan
AR4	Fourth Assessment Report of the Intergovernmental Panel on Climate Change
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
CCAM	Conformal-Cubic Atmospheric Model
CoGTA	Department of Cooperative Governance
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSIR	Council for Scientific and Industrial Research
CSIR GAP	Council for Scientific and Industrial Research, Geospatial Analysis Platform
CSIRO	Commonwealth Scientific and Industrial Research Council
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DJF	December to February
DoH	National Department of Health
DPCD	Department of Planning and Community Development
DST	Department of Science and Technology
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
FFC	Financial and Fiscal Commission
GCIS	Government Communication Information Systems
GCM	Global Circulation Model
GEOSS	Global Earth Observation System of Systems
GHG	Greenhouse Gas
ICLEI	Local Governments for Sustainability
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LED	Local Economic Development
LTAS	Long-Term Adaptation Scenarios Flagship Research Programme
MAR	Mean Annual Runoff
MDG	Millennium Development Goal
NCCRP	National Climate Change Response Policy
NFA	National Forests Act of 1998
NPC	National Planning Commission
NRE	Natural Resources and Environment (unit)
NWA	National Water Act (No. 36 of 1998)
PCIS	Principles, Criteria, Indicators and Standards
PM	Particulate Matter
RCM	Regional Climate Model
RCPs	Representative Concentration Pathways
SAAQIS	South African Air Quality Information System
SACN	South African Cities Network
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SARVA	South African Risk and Vulnerability Atlas
SDFs	Spatial Development Frameworks
SEI	Stockholm Environment Institute
SFM	Sustainable Forest Management
SRES	Special Report on Emissions Scenario
Stats SA	Statistics South Africa
SWPN	Strategic Water Partnerships Network
UGEP	Utilisable Groundwater Exploitation Potential
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UN-HABITAT	United Nations Human Settlements Programme
UNISDR	United Nations Office for Disaster Risk Reduction
WEF	World Economic Forum
WHO	World Health Organization
WRI	World Resources Institute