CHAPTER 1

Risk and vulnerability to global and climate change in South Africa

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Introduction

The Intergovernmental Panel on Climate Change (IPCC) defines 'vulnerability' as 'the degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes' (IPCC 2007: 883). This definition assumes vulnerability and its impacts to be mainly physical causes. The definition by Schneider et al. (2007) refers to vulnerability as the 'degree to which aforementioned earth systems are susceptible to and unable to recover from and cope with climate and global change'. This definition considers coping as a part of the vulnerability process.

The issue of vulnerability is usually spoken of in the same context as the element of risk where risk can be the result of climate change or variability. Climate risk includes droughts, floods, heat waves and other extreme climate events to which people, ecosystems and economic sectors are exposed. 'Exposure' is regularly defined as the character, magnitude and rate of climate variation and change to which a system is exposed (Climate-ADAPT n.d.). Human exposure to climate change and variability is often exacerbated by human activities such as urbanisation and deforestation, as well as development in high-risk areas, which increases the vulnerability of ecosystems to change.

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The concept of vulnerability originated from the field of disaster risk management and is defined by UNISDR as 'the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards' (UNISDR 2009). This definition considers the social factors that affect the different population groups, which are often differentiated by income, socio-economic status and even the type of livelihoods. This type of vulnerability is often dynamic and complex, changing over time. Vulnerability is, therefore, considered an inherent characteristic of a social system or societal group (UNISDR 2009, 2011).

In the field of climate change, the definition of vulnerability has also evolved from the early assessment reports, which focused more on the susceptibility of a system to harm, to adopting a risk approach (Davis et al. 2017). The *IPCC Assessment Report 5* defines vulnerability as 'the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt' (Field et al. 2014: 5). This definition considers the ability of an affected system to adapt to or to cope with change. However, almost all definitions of vulnerability consider three key elements: exposure, sensitivity and adaptive capacity. Figure 1.1 gives a description of these elements/components.

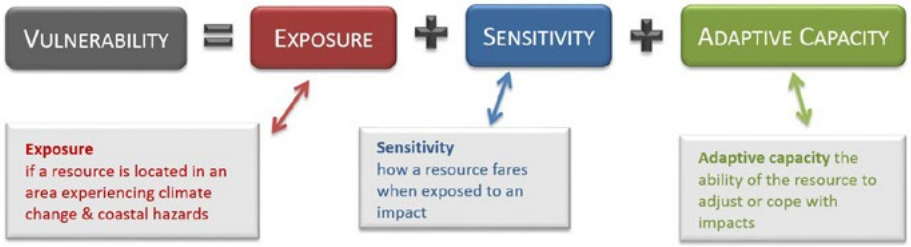

Figure 1.1 The components of vulnerability (Source: NPS 2017)

Understanding risk and vulnerability

Understanding risk and vulnerability to both global and climate change require a multi-dimensional approach due to the complexity and concurrent nature of all the factors that need to be considered (SARVA n.d.; IPCC 2007). Vulnerability should therefore also consider factors such as social, economic, political, cultural and institutional among others (SARVA n.d.; Davis et al. 2017). Given this complexity, there is no prescribed formula or procedure for doing vulnerability assessments, since of vulnerability is dynamic. Many of the earth's social, economic and natural systems face increased risks from climate change and variability, thus turning the focus more towards the impacts of and adaptation to these changes.

Exposure

Exposure to hazards is the nature and extent to which a population or system experiences climate-induced, environmental, socio-political, and/or external stress (IPCC 2012). The characteristics of these stresses include the magnitude, frequency, duration and extent of the hazard. The hazards for climate-induced stress would include increases in temperature, increases in the occurrence and intensity of extreme climate events, such as droughts and floods, sea level rise, coastal hazards and changes in rainfall and temperature (UNDP 2010; NPS 2017). For example, agriculture, forestry, water, or biodiversity (both terrestrial and marine) are systems that will be affected by projected changes and variability in climate (Lavelle et al. 2012). The magnitude and rate of exposure are very crucial in assessing the level of vulnerability (UNDP 2010; Lavelle et al. 2012).

Sensitivity

Sensitivity is based on the understanding of how resilient the system is to changes in climate variables as well as the current physical state and location of the systems in question, which increases or reduces their sensitivity to climatic changes (Adger 2006; UNDP 2010; Bronkhorst et al. 2012). Sensitivity is important in assessing the social vulnerability of societies or communities to climate change and variability.

Adaptive capacity

Adaptive capacity is based on information about the activities that the different sectors are engaged in to adapt or reduce their vulnerability to climate change. The adaptive capacity would include policies and institutional or legal instruments, finance and capacity that are available to tackle climate change (Adger 2006; IPCC 2007; SEI 2014). For example, in South Africa, adaptive capacity is strongly influenced by social factors such as poverty, unemployment and types of housing, with informal settlements posing high risks to extreme weather events. In such cases, reducing inequality and enhancing basic services could significantly reduce vulnerability to climate change and extreme events.

Climate change and disaster risk reduction

The concept of exposure and vulnerability are closely linked to disaster risk reduction and management and both adaptation and disaster risk reduction need to be understood in the context of broader socio-economic development (see Figure 1.2 below).

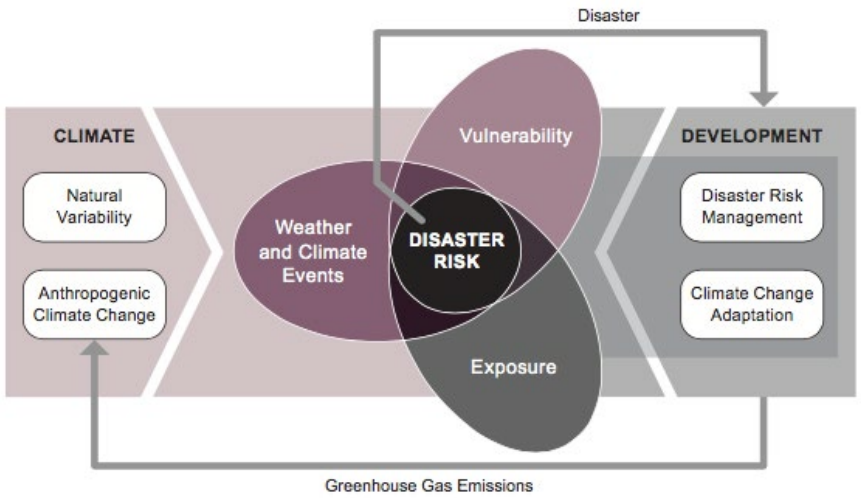

Figure 1.2 A framework for understanding vulnerability, exposure and risk in the context of climate change and disaster risk reduction (We-Adapt 2015).

Vulnerability is, therefore, determined as a function of the character, magnitude and rate of climate variation and change to which a system is exposed, together with its sensitivity and adaptive capacity (Climate-ADAPT n.d; UNISDR 2011). Regardless of the context in which vulnerability is viewed, both vulnerability and exposure vary across temporal and spatial scales and are dependent on economic, social; geographic, demographic, cultural, institutional, governance and environmental factors (IPCC 2012). Vulnerability is thus not static and different individuals, institutions, communities and even economic sectors are affected differently based on the above factors. Vulnerability is, therefore, both content- and location-specific and needs to be assessed with consideration of the socio-economic and natural factors of that location (Vogel and O'Brien 2004; Field et al. 2014). In particular, changes in settlement patterns, such as urbanisation and changes in socio-economic conditions will directly influence exposure and vulnerability to extreme events (IPCC 2012). Fast-paced urbanisation has increased the vulnerability of poor populations, particularly through the growth of informal settlements. This has increased the prevalence of social vulnerability (IPCC 2012).

Social vulnerability is one dimension of vulnerability to multiple stressors and shocks, including natural disasters. Social vulnerability to disasters refers to the inability of people, societies, and organisations to withstand adverse impacts from multiple stressors to which they are exposed, due in part to characteristics inherent in social interactions, institutions, and systems of cultural values (Warner 2006). Social vulnerability is, therefore, a pre-existing condition that affects people's ability to prepare, respond or and recover from a disruptive event. The pre-existing condition will be based on the aspects that limit the ability of communities to withstand or respond to adverse climate change impacts. These aspects include poverty, inequality, marginalisation and lack of access to basic services (Davis et al. 2017).

In summary, social vulnerability can be understood as a dynamic state experienced by an individual or group, who through various and interacting socio-economic characteristics, are susceptible to stresses that may leave them negatively affected when compared to someone in the same setting who does not experience these same socio-economic characteristics (Rance & Fünfgeld 2014).

Vulnerability assessment

There are many definitions of vulnerability and exposure, however, the key concepts of risk and vulnerability and the frameworks used to assess these are often similar in that they are identify potential areas of loss and impact as well as the source of the threat, thus answering the questions of who is vulnerable, to what, how and why? (SARVA n.d.).

Vulnerability assessment is the analysis of the expected impacts, risks and the adaptive capacity of a region or sector to the effects of climate change. Vulnerability assessment includes more than simple measurement of the potential harm caused by events resulting from climate change; it also includes an assessment of the region's or sector's ability to adapt in the face of these events (We-Adapt 2015). Vulnerability assessment is extensively used in many disciplines such as disaster risk reduction, food security, and recently, climate change (O'Brien et al. 2009).

Several methods of measuring or observing vulnerability have been applied, ranging from indicator or proxy-based methods to geographic information systems (GIS) and multiple-stressor-based methods. The intended purpose of a vulnerability assessment, the scale and the available resources usually determine the type of method used for the vulnerability assessment. In some instances, a combination of methods is used to better understand vulnerability (Davis et al. 2017).

Contextual (bottom-up) methods of vulnerability assessment often take into account that climate variability and change interact with socio-economic, political and institutional issues/factors in a dynamic way (Füssel 2009). Other assessment methods adopt a more linear approach, focusing on impacts of projected changes in climate on the different social, economic and natural systems. In these assessments, the impacts are counter-balanced with the adaptive capacity. Some of the common approaches to vulnerability assessment are discussed below.

Indicator-based methods

Indicator-based methods employ the use of indicators to measure vulnerability; thus, requiring measurable indicators. These methods can be used to assess different levels of vulnerability within one community or system (Davis et al. 2016). This approach is also appropriate for decision making and for monitoring changes in vulnerability. The key challenges associated with this approach include the lack of data at appropriate scales, which captures the spatial and temporal heterogeneity of vulnerability, and its uncertainty (Vincent 2007; Davis et al. 2017). Some elements of adaptive capacity are difficult to measure quantitatively (Vincent 2007).

GIS-based methods

GIS-based methods involve the visualisation of vulnerability through the mapping of trends and patterns through spatial analysis. As modelling is used for this type of spatial analysis, vulnerability is portrayed as being geographically-based and represented by both place and people. This approach often highlights the drivers of vulnerability per sector (Davis et al. 2017). Some challenges associated with these methods include the representation of vulnerability as a snapshot in time and of a place. This approach is, therefore, not appropriate/useful for decision making or policy development (Hinkel 2011; Davis et al. 2017). For the mapping of vulnerability to be effective (to incorporate information for decision making), stakeholder involvement in the process is essential (Preston et al. 2011).

Multi-stressor approach

The multi-stressor approach uses a combination of biophysical and social factors to determine the tendency of a system to be affected by change, especially when analysing local vulnerability. This approach acknowledges that vulnerability is a result of multiple stressors occurring concurrently (Ziervogel & Calder 2003). Various frameworks of vulnerability use the multiple-stressor approach to understand both vulnerability and its drivers, as well as resilience (Leichenko & O'Brien 2008).

Participatory methods

Affected communities or population groups help in the identification of their own vulnerability using tools such as participatory or cognitive mapping, stakeholder engagement workshops and interviews, surveys and expert-based inputs (Davis et al. 2017). This participatory approach acknowledges the interaction of exposure, sensitivity and adaptive capacity over time. Overall vulnerability changes over time and that this happens at different scales. This type of assessment is usually used to identify community-based vulnerability (Davis et al. 2017).

It is, however, acknowledged that there is no one-size-fits-all solution to vulnerability assessment, given its multi-faceted nature (Davis et al. 2016) and that there can therefore also not be one strict or enforced definition of vulnerability either (We-adapt 2015). To date, methodologies for conducting vulnerability assessment have been fragmented and various approaches have been used. In this edition of the second edition hardcopy Atlas, the sector vulnerability is assessed in terms of the natural resources and ecological systems upon which key economic activities depend. The economic activities such as agriculture, forestry, water and biodiversity are crucial in the economic development of the country. The ecosystems such as air quality and water are crucial for human health, and a negative impact on any of these resources will have negative effects on the economy. Social vulnerability is assessed in the 'Socio-economic and Settlement Vulnerability' chapter.

Conclusion

In conclusion, vulnerability, as a concept, is a powerful analytical tool that can be used to define the exposure to damage, powerlessness and marginality of physical and social systems. The multifaceted nature of risk and vulnerability, and how it is influenced by physical, social, economic and political frameworks makes it dynamic and ever-changing. This means that vulnerability, as well as the ways in which it is assessed, will continue to evolve. This is crucial in the face of projected changes and variability in climate as well as in global change and the projected impacts of these changes on socio-economic sectors. The identification and mapping of the aspects of vulnerability are, therefore, a criterion for identifying vulnerable economic sectors, populations and spatial locations, the nature of their vulnerability, and the likely future impacts, before interventions are planned. Such information is needed in order to develop strategies and plans that:

- will introduce appropriate measures to reduce the current harmful impacts of change, and
- will further ensure that those societies are resilient to extreme future events.

Information on identified vulnerability may thus be utilised for multiple climate-related purposes, including informing policy, climate change adaptation as well as the prioritisation of response actions for climate change.

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Davis, C.L., Waagsaether, K. and Methner, N. 2017. Development of a risk assessment methodology and vulnerability indices. In Climate change over South Africa: From trends and projected changes to vulnerability assessments and the status quo of national adaptation strategies. Chapter 3 in the DEA, South Africa's 3rd National Communication to UNFCCC. Pretoria: Department of Environmental Affairs.

References

Adger, N.W. 2006. Vulnerability. *Global Environmental Change*, 16: 268-281.

Brunckhorst, D., Reeve, I., Morley, P., Coleman, M., Barclay, E., McNeill, J. et al. 2011. *Hunter & Central Coasts, New South Wales – Vulnerability to climate change impacts*. Report to the Department of Climate Change and Energy Efficiency, Australia.

Climate-ADAPT. n.d. Vulnerabilities and risks. [Online] Available at http://climate-adapt.eea.europa.eu/knowledge/adaptation-information/vulnerabilities-and-risks [Accessed 10 May 2017].

Davis, C.L., Waagsaether, K. and Methner, N. 2017. *Development of a risk assessment methodology and vulnerability indices.* In Climate change over South Africa: From trends and projected changes to vulnerability assessments and the status quo of national adaptation strategies. Chapter 3 in the DEA, South Africa's 3rd National Communication to UNFCCC. Pretoria: Department of Environmental Affairs.

Field, C. B., Barros, V.R., Mach, K.J., Mastrandrea, M.D., van Aaist, M., Adger, W.N. et al. 2014, Technical summary. In *Climate change 2014: Impacts, adaptation, and vulnerability. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change* [C.B. Field, V. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir et al. (eds)]. Cambridge, UK and New York, NY: Cambridge University Press.

Füssel, H-M. 2009. *Development and climate change: Review and quantitative analysis of indices of climate change exposure, adaptive capacity, sensitivity, and impacts*. World Development Report. [Online] Available at http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1255547194560/WDR2010_BG_Note_Fussel.pdf [Accessed 24 May 2017].

Hinkel, J. 2011. 'Indicators of vulnerability and adaptive capacity': Towards a clarification of the science–policy interface. *Global Environmental Change* 21(1): 198-208.

IPCC (Intergovernmental Panel on Climate Change). 2007a. *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* [M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden &

C.E. Hanson (eds)]. Cambridge, UK: Cambridge University Press.

IPCC (Intergovernmental Panel on Climate Change). 2007b. *Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change* [S.D Solomon, D. Qin, Z. Manning, Z. Chen, M. Marquis, K. Averyt et al. (eds)]. Cambridge, UK and New York, NY: Cambridge University Press.

IPCC (Intergovernmental Panel on Climate Change). 2012. *Managing the risks of extreme events and disasters to advance climate change adaptation.* A special report of working groups I and II of the Intergovernmental Panel on Climate Change [C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi et al. (eds)]. Cambridge, UK and New York: Cambridge University Press.

Lavell, A., Oppenheimer, M., Diop, C., Hess, J., Lempert, R., Li, J. et al. 2012. Climate change: New dimensions in disaster risk, exposure, vulnerability, and resilience. In: C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi et al. (eds). *Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the Intergovernmental Panel on Climate Change.* Cambridge, UK and New York, NY: Cambridge University Press.

Leichenko, R. & O'Brien K. 2008. *Environmental change and globalisation: Double* exposure. Nrew York, NY: Oxford University Press.

NPS (National Parks Service). 2017. Climate change vulnerability and adaptation: Coastal hazards and climate change asset vulnerability assessment tool. [Online] Available at https://www.nps.gov/subjects/climatechange/vulnerabilityandadaptation.htm [Accessed 24 May 2017]

O'Brien, K., Quinland, T. & Ziervogel, G. 2009. Vulnerability interventions in the context of multiple stressors. Lessons from the Southern Africa Vulnerability Initiative (SAVI). *Environmental Science and Policy,* 12(1): 23-32.

Preston, B. L., Yuen, E.J. & Westaway, R.M. 2011. Putting vulnerability to climate change on the map: A review of approaches, benefits, and risks. *Sustainability Science,* 6(2): 177-202.

Rance, A. &Fünfgeld, H. (2014): *Rural people: Resilient futures – Social vulnerability to climate change in rural contexts*. Melbourne: Centre for Urban Research, RMIT University.

SARVA. n.d. Understanding risk and vulnerability. *SARVA online spatial database 2.0* [Online] Available at http://sarva2.dirisa.org/resources/reading-risk [Accessed 10 May 2017].

Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, C.H.D., Oppenheimer, M. et al. 2007. Assessing key vulnerabilities and the risk from climate change. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (eds), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change.* Cambridge, UK: Cambridge University Press.

SEI (Stockholm Environment Institute). 2004. *Vulnerability, global environmental change and food systems.* Poverty and Vulnerability Programme. GECAFS Project, Stockholm Environment Institute. [Online] Available at http://www.sei.se/ [Accessed 26 June 2006].

UNDP (United Nations Development Programme). 2007. *Human development report 2007/2008: Fighting climate change: Human solidarity in a divided world*. New York, NY: UNDP. [Online] Available at http://hdr.undp.org/sites/default/files/brown_oli.pdf [Accessed 24 May 2017]

UNDP (United Nations Development Programme). 2010. *Mapping climate change vulnerability and impact scenarios: A guidebook for sub-national planners*. New York, NY: Environment and Energy Group, Bureau for Development Policy, UNDP. [Online] Available at http://www.adaptationcommunity.net/?wpfb_dl=58 [Accessed 5 September 2013].

UNSIDR (United Nations Office for Disaster Risk Reduction). 2009. *Briefing Note 02: Adaptation to climate change by reducing disaster risks*. Geneva: ISDR.

UNISDR (United Nations Office for Disaster Risk Reduction). 2011. *2011 Global assessment report on disaster risk reduction: Revealing risk, redefining development.* Geneva: ISDR.

Vincent, K. 2007. Uncertainty in adaptive capacity and the importance of scale, *Global Environmental Change,* 17(1):12-24.

Vincent, K. & Cull, T. 2010. A household social vulnerability Index (HSVI) for evaluating adaptation projects in developing countries. Paper presented at the PEGNet Conference 2010: Policies to foster and sustain equitable development in times of crises, Midrand (2-3 September 2010).

Vogel, C. & O'Brien, K. 2004. Vulnerability and global environmental change: Rhetoric and reality. *Aviso*, 13:1-8.

Warner, K. (ed.). 2006. *Perspectives on social vulnerability. Selected papers from the First Summer Academy on Social Vulnerability 22-28 July 2006, Hohenkammer, Germany*. [Online] Available at https://www2.gwu.edu/~icdrm/publications/PDF/SOURCE%206_Inhalt.pdfhttps://www2.gwu.edu/~icdrm/publications/PDF/SOURCE%206_Inhalt.pdf [Accessed 24 May 2017]

Wisner, B., Blaikie, P., Cannon, T. & Davis, I. 2004. *At risk: Natural hazards, people's vulnerability, and disasters* (2nd edition). London: Routledge.

Ziervogel, G. & Calder R. 2003. Climate variability and rural livelihoods: Assessing the impact of seasonal climate forecasts in Lesotho. *Area* 35(4):403–417.