frontiers | Frontiers in Climate

TYPE Original Research
PUBLISHED 23 October 2023
DOI 10.3389/fclim.2023.1197167

OPEN ACCESS

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RECEIVED 30 March 2023
ACCEPTED 13 September 2023
PUBLISHED 23 October 2023

CITATION
Ziervogel G and Taylor A (2023) A co-produced national climate change risk and vulnerability assessment framework for South Africa. *Front. Clim.* 5:1197167. doi: 10.3389/fclim.2023.1197167

A co-produced national climate change risk and vulnerability assessment framework for South Africa

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Introduction: There are mounting demands to undertake climate risk and vulnerability (CRV) assessments for policy, planning, funding, insurance, and compliance reasons. In Africa, given the adaptation imperative, this is particularly important. Increasingly, it has become clear that sub-national assessments are needed to inform adaptation practice. However, there has been relatively little guidance on how to undertake these more local assessments and aggregate them making it difficult for national governments to know the extent and variability of climate vulnerability and risk across the country.

Methods: In South Africa, the national government, led by the Department of Forestry, Fisheries and the Environment (DFFE), undertook to establish a common framework to guide the development and review of CRV assessments. This paper presents the framework that was co-developed through a series of engagements with stakeholders active in implementing and supporting CRV assessments.

Results: The framework is intended to provide guidance on what to consider when undertaking CRV assessments within diverse South African contexts in order to enable alignment, comparison, and aggregation between them and work towards an effective climate adaptation response across scales. Rather than standardizing a methodology, the framework promotes the use of a standard set of concepts as the basis for each assessment and profiles a diversity of methods, tools and data sources for applying the concepts in a contextually sensitive way. This provides a flexible yet structured sequence of three interlinked steps in a risk and vulnerability assessment process, namely: (1) Planning, (2) Scoping and (3) Assessing. The framework guides users through the choice and application of three assessment depths, depending on decision-context, resourcing and extent of pre-existing data and information. It encourages the integration of participatory and indicator-based methods through an impact chain approach, profiling more than 30 freely available tools and resources. This process builds a strong evidence base and a deepening set of engagements and shared understanding between relevant stakeholders, upon which to act.

Discussion: This South African process can provide insight and support for actors driving the climate agenda in other countries looking to develop comparable assessments as the basis to drive equitable and transformative climate action and learning.

KEYWORDS

climate risk and vulnerability assessments, South Africa, vulnerability assessment framework, climate change adaptation, co-production, integrated risk and vulnerability assessments

1. Introduction

Adapting effectively to variable and changing climate conditions requires building up a nuanced picture of risk and vulnerability dynamics. A solid understanding of vulnerability can help to inform where, to what extent, and by whom climate impacts are being felt and how this might change into the future (Bruno Soares et al., 2012). Across Africa many households and sectors are significantly exposed to climate risk, yet often capacity and resources are limited, making a nuanced understanding of vulnerability particularly important as a basis for supporting adaptation (Wood et al., 2017). To date, there has been relatively little synthesis of risk and vulnerability assessments across sectors and scales within African countries. In addition, guidance on how to undertake these assessments has been limited, particularly at the sub-national level. This has made it hard for government entities and non-state actors alike to assess the extent of climate vulnerability and risk locally and provide an aggregated bottom-up national picture.

Although numerous climate vulnerability and/or climate risk assessments have been done over the last two decades, these have been patchy in their coverage and have used a variety of different approaches, methods and data. This has proved problematic for planning, decision making and evaluation. Consequently, South Africa's national government, like others such as the German and Indian governments (Satapathy et al., 2014; Buth et al., 2017), undertook to establish a common framework to guide the development and review of such assessments to enable a more integrated approach to climate adaptation. The need for this framework stems from the mounting set of demands for various public, private and non-governmental organizations to undertake climate risk and vulnerability (CRV) assessments for policy, planning, funding, insurance and compliance reasons.

A framework to streamline assessments is timely given the increasing proliferation of policies and plans calling for climate action and climate risk and vulnerability assessments, specifically in South Africa. The 2011 National Climate Change Response Policy called on each province to "develop a climate response strategy, which evaluates provincial climate risks and impacts and seeks to give effect to the National Climate Change Response Policy at provincial level" [Republic of South Africa (RSA), 2011, p. 38]. It further notes the need to "perform climate risk analysis on all sectoral plans" [Republic of South Africa (RSA), 2011, p.16), and for relevant sectors to develop and implement climate change response strategies and action plans. Municipal development planning tools, such as the Integrated Development Plans (IDP) and municipal service delivery programmes, are also called on to integrate climate change considerations and constraints. The 2022 Climate Change Bill and the 2020 National Climate Change Adaptation Strategy (NCCAS) further cement the call of the Climate Change Policy for provinces and municipalities to develop and implement climate change response and implementation plans that take climate change risk and vulnerabilities into account [Republic of South Africa (RSA), 2020, 2022]. They require sector departments to identify and map climate change risks and vulnerabilities. In addition, the Spatial Planning and Land Use Management Act No. 16 of 2013 (SPLUMA) broadly provides for the inclusion of climate adaptation measures in municipal land use systems [Republic of South Africa (RSA), 2013]. The 2015 Disaster Management (DM) Amendment Act explicitly requires each national, provincial and municipal organ of state, as well as provinces and municipalities, to prepare disaster management plans that set out "the way in which the concept and principles of disaster management are to be applied in its functional area, including expected climate change impacts and risks" [Republic of South Africa (RSA), 2015]. And then, growing requirements need to be fulfilled for international funding processes and reporting under the United Nations Framework Convention on Climate Change (UNFCCC). Given all these demands, a framework for risk and vulnerability to climate change is timely and strategic.

A framework consists of a set of organizing principles that helps identify the elements in a system under assessment and the relations between the elements. This can help assessors to target their engagements, data collection, analysis, and outputs to improve clarity, consistency, replicability and legibility. In South Africa, the need for a Climate Risk and Vulnerability (CRV) Framework was identified to provide guidance on how the many assessments being undertaken by various local, regional, national and international actors might align to better enable comparison and aggregation. The custodian of the CRV Framework is the Department of Forestry, Fisheries and the Environment (DFFE), the national government entity responsible for guiding and coordinating the implementation of activities to ensure that South Africa (our society, economy and ecosystems) becomes progressively more climate resilient and less carbon intensive. The Framework is aimed at any actor in South Africa setting out to assess climate risk and vulnerability. It provides a flexible yet structured sequence of steps and set of options that ensures that, whichever CRV assessment context, scale or focus, a standard set of concepts and questions have been taken into consideration.

The paper starts by providing a short overview of international climate risk and vulnerability assessments, as well as a review of the nature of past South African vulnerability assessments. It is followed by an overview of how the South African climate risk and vulnerability assessment (CRAVA) framework was developed, and describes the three interlinked steps the framework proposes. The paper ends with a discussion on the challenges emerging around vulnerability assessments and the implications of trying to create a more standardized approach to them.

2. Climate risk and vulnerability assessments internationally and in South Africa

Climate risk and vulnerability is assessed to get a better handle on the problem (i.e., exploratory in nature) or to support decisions on targeting interventions to reduce vulnerability (i.e., prescriptive in nature) (Dilling et al., 2015; Jurgilevich et al., 2017). The reasons for undertaking an assessment are likely to inform the boundaries of the assessment, the design of the process, the selection of methods for collecting and analyzing relevant data, and the type of information generated from the assessment that underpins any resulting recommendations (Næss et al., 2006). Three broad approaches are used to undertake assessments:

1. Indicator-based approaches (to develop comparative scores);
2. System models (to evaluate determinants and feedbacks);

3. Participatory approaches gathering first-hand accounts (to aggregate experiential knowledge).

Preston (2012), who reviewed 81 published vulnerability assessments, found that one of the main benefits of undertaking such assessments were the opportunities they provided to bring stakeholders together around climate issues to share information and perspectives and form a more integrated understanding of how changes in the climate and the environment more broadly were linked to changing socio-economic conditions. However, the review found that too few stakeholders benefited from the opportunity to deeply engage in the deliberations involved in such assessments, resulting in much of the potential value being lost and not translating into different decisions or widespread action being taken to reduce climate vulnerability. It found that one of the main reasons for this disconnect between assessments and action is the lack of specificity regarding where to target interventions. Although this review was done a decade ago, there seems to have been insufficient progress on ensuring that the benefits of vulnerability assessments and resulting adaptation efforts actually reach the most vulnerable groups.

A review of 42 sub-national climate risk and vulnerability assessments, undertaken by Jurgilevich et al. (2017), found that assessments more often focus on biophysical changes over time and take a more static and simplistic view of the socio-economic aspects of vulnerability, partly because of the poor availability of methods and data. Like Preston (2012) and Jurgilevich et al. (2017) recommend that assessments include more stakeholder involvement, more deliberation over the purpose of the assessment, and the use of multiple methods (including sensitivity analyses). Jurgilevich et al. (2017) suggest that assessments should be positioned within an adaptation pathways approach, which aims to chart a variety of courses of action that account for a range of plausible climate scenarios, emphasizing flexibility and the need for continuous monitoring to adjust adaptation actions as circumstances change (Haasnoot et al., 2013; Wise et al., 2014).

More recently, increased emphasis has been placed on positioning vulnerability within a risk framework, as established in IPCC Special Report Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation and in the Fifth Assessment Report, with continued emphasis in the Sixth Assessment Report (Cardona et al., 2012; Oppenheimer, 2014; Jurgilevich et al., 2017; Lee et al., 2023). In the IPCC Sixth Assessment Report Guidance for authors on the concept of risk, Reisinger et al. (2020) state that "risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards." This was a shift from the IPCC Fourth Assessment report, where exposure was included as part of the vulnerability definition. In summary, earlier vulnerability assessments included exposure whereas now vulnerability and exposure are assessed separately within a risk framing. Previous risk assessment approaches tended to not adequately consider interactions between multiple systems and across time scales, which has been accounted for in the risk framing now used in climate assessments (Adger et al., 2018). Linked to this is the growing complexity of methods, particularly those that are integrated and take an interdisciplinary approach, linking dynamic biophysical and socio-economic components of risk exposure and vulnerability (Adger et al., 2018).

The calls for more integrated approaches to assessing risk and the goal of reducing climate risks are complex to operationalise. Now, more than ever, it is crucial to enroll diverse actors in a learning process, carefully define the purpose, target and boundaries of risk assessments, and use methods that match the context and allow for adjusting the course of action over time, as conditions change [increasingly referred to as a climate resilient development pathways approach, see Taylor et al., 2023].

To inform the development of the South African framework, we reviewed other CRV assessment guidance frameworks to draw out lessons (notably GIZ and EURAC, 2017; Sharma et al., 2018; CARE., 2019; Indian Institute of Technology (IIT), 2019; Sharma and Ravindranath, 2019). The review highlighted that an ongoing tension exists between being prescriptive with regards steps to follow and methods to use, so as to increase standardization, and offering a variety of approaches and methods to accommodate different contexts, resources and needs. This can result in producing long dense guidance documents that are comprehensive but not user friendly. Possibly more important than methodological standardization is conceptual clarity and consistency, which is key to interpreting and applying assessment findings. While recognizing that there are many interconnected systems, it is critical to establish clear boundaries of an assessment, especially relating to what hazards and which exposure units will be assessed, over what time frames, for what range of scenarios.

Methodologically, there is a push globally for the use of quantitative indicators of risk and vulnerability, but huge diversity in terms of what indicators are proposed, depending on context, priorities and data availability (or in many cases data scarcity). Developing impact chains, as a basis for identifying indicators, is emerging as a potentially useful method (GIZ and EURAC, 2017; Zebisch et al., 2021). A mix of qualitative and quantitative methods can help to enable meaningful participation across a range of stakeholders and are suited to assessing different components of risk and vulnerability. The difficulty is ensuring a team with these diverse skills and integrating between the results. Positioning an assessment within a broader view of the climate adaptation process of learning and adjusting over time is necessary to increase relevance of assessment findings and resulting action. As such, implementing the recommendation by Jurgilevich et al. (2017) to position it within the adaptation pathways approach would be innovative.

2.1. Reviewing assessments in the South African context

Since the development of South Africa's National Climate Change Response Policy in 2011, there has been a proliferation of provincial, sectoral and local government (district and local municipalities) climate change strategies and climate mainstreaming processes into policies and plans (Pieterse et al., 2021). These generally incorporate a climate impacts, risk and vulnerability assessment specific to the sector, province or municipality. Each takes a different assessment approach.

To understand how CRV assessments have been conceptualized and undertaken in South Africa, it is useful to look at different examples. A review was undertaken of published and unpublished climate risk and/or vulnerability assessments conducted in South Africa between 2011 and 2019. A total of 28 assessments were reviewed, of which 2 assessed national sectors, 11 focused on the provincial scale, 6 assessed climate risks and vulnerabilities at the district municipality scale, 4 at the city scale, and 5 at the local scale.

For each of the 28 assessments the following questions were asked:

- Who is assessing climate risk and vulnerability?
- What was the purpose of the assessment?
- How were risk and/or vulnerability conceptualized?
- What methods and tools were used in the assessment?
- What challenges were encountered?

From the review, captured in Table 1, we found that those that have been active in undertaking climate risk and/or vulnerability assessments in South Africa to date include non-governmental and civic organizations (e.g., Environmental Monitoring Group and Conservation South Africa), academic units and research organizations (e.g., University of Fort Hare, Gauteng City Region Observatory and University of Cape Town) and private consultancies (e.g., Umvoto, Urban Earth and One World), sometimes in partnership with or commissioned by departments within local, provincial or national government. In the private sector, a number of companies, for example insurance companies such as Santam, have begun incorporating climate risk and/or vulnerability assessments into their existing risk management framework, sometimes in partnership with research institutions and government or with the support of external consultants and experts [National Business Initiative (NBI), 2017].

The conceptualisations of risk and/or vulnerability varied considerably between assessments. Some took a quantitative, hazard-oriented focus on risk as a function of exposure, likelihood of occurrence and possible damages (e.g., spatial mapping of risk to coastal flooding in the Overberg District), others took a more socio-economic perspective on vulnerability assessing climate impacts on livelihoods viability, household income and social capital (e.g., vulnerability narratives of small scale rooibos tea farmers in the Northern Cape, Oettle 2012), while others did not provide a clear indication of how they were defining and operationalizing the concepts. At the time of conducting the review, there were very few assessments strictly applying the IPCC AR5 framework to assess vulnerability and exposure as components of climate risk.

Those that reported challenges in undertaking the assessment noted: difficulty obtaining data and information at a relevant scale, especially within the constraints of short duration projects and in data-scarce parts of the country; having the facilitation skills needed to engage in the local language of the community and translate their experiences into the elements of the assessment structure; lack of time needed to build trust with stakeholders and build their confidence to contribute knowledge to the assessment process; not identifying all relevant stressors because certain knowledge holders are missing from the participatory process; census data not covering all factors shaping social vulnerability (e.g., social support networks and influence in public decision-making); and lack of capacity and resourcing to undertake additional investigations to fill key gaps.

Reflecting on the recommendations made by Preston (2012) and Jurgilevich et al. (2017), it is interesting that none of the South African assessments reviewed have been formally evaluated as part of a learning process (at least not publicly). In addition, none of the assessments are positioned within an adaptation pathways approach. This means that few of the assessments account for the dynamic nature of the biophysical and socio-economic changes occurring over time which makes it hard to prepare for a range of possible interventions to be triggered as particular circumstances emerge or thresholds are reached (Taylor et al., 2023).

Some of the South African assessments mentioned the challenge of achieving sufficient stakeholder engagement, in line with the findings of the Preston (2012) and Jurgilevich et al. (2017) reviews. This raises questions about what additional capacities and methodological design features are needed to enable broader and deeper engagement for ensuring societal relevance and resulting action around climate change adaptation (Ziervogel et al., 2022).

3. Process of co-developing a CRV framework

Commissioned by national government (specifically DFFE), in collaboration with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, a team from the Climate Systems Analysis Group (CSAG) at the University of Cape Town led the development of the framework between May 2019 and April 2020. To develop a framework that is grounded in diverse South African contexts and reflects the experiences and needs of practitioners, stakeholder engagement was prioritized in scoping and designing the framework. This approach ensured multiple perspectives were harnessed, both around previous experience in assessing vulnerability and risk, as well as ideas for what might be most useful and needed from a framework going forward. Two stakeholder workshops were designed and facilitated by applied researchers with experience in social learning processes, and post-workshop opportunities were created for feedback on draft documents. The two workshops were both well attended, with over 50 participants at each, representing a broad range of expertise, sectors, spheres and interests. Across the two workshops 36% of participants were government officials (a mix of national, provincial, and local government representatives), 26% were non-governmental practitioners, and 38% were academics involved in climate risk and vulnerability research. Participants were invited based on their involvement in climate risk, vulnerability and adaptation-related projects and programs across the country. Travel grants were used as a means of supporting less resourced stakeholders to participate in the workshops by covering their transport and subsistence costs, especially for those working outside of the large cities.

To create a sense of openness and build a basis for honest sharing of experiences and lessons, including unsuccessful efforts, time was dedicated to introductions by all participants and exercises to position everyone in the room relative to various characteristics of their work and background. For example,

TABLE 1 Summary table of South African CRV assessments reviewed.

#	Title of assessment	Who is assessing	Purpose of assessment	Methods used
1	A status quo vulnerability and adaptation assessment of the physical and socio-economic effects of climate change in the Western Cape (Midgley et al., 2005)	Provincial govt with consortium of research entities	Identify key adaptation strategies for physical and socio-economic sectors	Time series analysis of historical climate trends; downscaling climate projections; desktop review, expert elicitation and stakeholder workshop to identify physical and socio-economic impacts, qualitatively assess relative vulnerability, and identify potential adaptation strategies
2	Western Cape Sea level rise risk assessment: Eden District (Umvoto Africa, 2010)	Consultancy for Provincial govt	Identify high risk areas to 3 coastal hazard types (sea level rise induced coastal erosion and inundation, groundwater contamination from saltwater intrusion and extreme coastal events—storm surges, estuarine flooding, and tsunamis) to inform adaptation planning	Coastline subdivided based on biophysical features into sections called Coastal Zone Management Units (CZMUs) and risk of each CZMU to 3 coastal hazards qualitatively assessed using rapid risk assessment methodology based on 1 to 5 scoring of hazard probability and severity, 3 types of vulnerability (social, environmental and economic) and coping capacity (based on level of implementation of Hyogo Framework for Action priorities)
3	Western Cape sea level rise risk assessment: West Coast District (Umvoto Africa, 2010)	Consultancy for Provincial govt		
4	Western Cape sea level rise risk assessment: overberg District (Umvoto Africa, 2010)	Consultancy for Provincial govt		
5	Climate change strategy Gauteng (2011)	Provincial govt	Develop action plan	Methods unclear
6	Climate change strategy Eastern Cape (2011)	Provincial govt	Provide information on risk and vulnerabilities for the province and which sectors will be impacted	Climate Change risk assessment matrix
7	Adaptation with a human face (Oettlé, 2012)	NGO	Identify vulnerabilities, informing adaptation strategies at community level, building community awareness and learning	Participatory methods
8	Climate change risk and vulnerability assessment for rural human settlements (2013)	Consultancy for National govt	Identify factors that increase climate change risks for rural human settlements to inform planning and relevant adaptation strategies at a regional and local level; establish a conceptual framework for spatially evaluating climate change risk and vulnerability	Draws on existing local spatial modeling of key indicators in relation to the environmental risks and social vulnerabilities using census data and data from SARVA
9	Capacity building for climate change adaptation and disaster risk reduction in rural communities: Tsengiwe, Eastern Cape (Hay and Hay, 2014)	Consultancy	Understand rural challenges in adapting to climate change and the role of community-based organizations and community-level coping strategies to link these with local and district municipal resources plans	Participatory Mapping, Participatory Rural Appraisal, and Constructive Dialogue
10	Climate change vulnerability assessment for the Namakwa District (Bourne et al., 2015)	NGO	Complement the existing bioregional plan by providing a tool for the rapid assessment of district scale social and ecological vulnerability, as well as identify priority areas for planning and implementing Ecosystem-based adaptation	Indicator-based approach to produce an ecological vulnerability index, a socio-economic vulnerability index, and an overall integrated climate change vulnerability index
11	Community-level socio-ecological vulnerability assessment in the benguela current large marine ecosystem (FAO, 2015)	University	To understand existing perceptions and adaptation strategies and to review and inform alternative strategies	Rapid Vulnerability Assessment involving village mapping, identification and ranking of key threats/stressors

(Continued)

TABLE 1 (Continued)

#	Title of assessment	Who is assessing	Purpose of assessment	Methods used
12	Durban preliminary resilience assessment (2015)	Municipal government	Assess shocks and stressors facing city, including climate change impacts; underpin development of city resilience strategy	City Resilience Framework used with stakeholders to assess four dimensions of resilience, 12 drivers and 50 sub-drivers
13	The city risk and vulnerability assessment (CRVA) for Tshwane (2015)	Municipal government	To develop adaptation options and actions	Social vulnerability index with spatial representation
14	Adaptation strategies for North West (2015)	Consultancy with Provincial govt	To provide a sound understanding of current and future climate change risks in key sectors, create a shared knowledge base for key stakeholders, and inform provincial adaptation strategies	Assessment done with data from the Long Term Adaptation Scenarios (LTAS) and SARVA and assessment template from Lets Respond Toolkit
15	Adaptation strategies for Mpumalanga (2015)	Consultancy with Provincial govt		
16	Adaptation strategies for Limpopo (2015)	Consultancy with Provincial govt		
17	Current climate change status quo for the Northern Cape Province (2015)	Consultancy for National govt	Take stock of existing information on climate change in the Northern Cape to inform a climate change strategy	The assessment included information from key sectoral stakeholders and review of relevant documents
18	Current climate change status quo for the free state (2015)	Consultancy for National govt	Develop a comprehensive climate change adaptation strategy for the Free State	The assessment included information from key sectoral stakeholders and review of relevant documents
19	Vulnerability to climate change related disasters in the Eastern Cape Province: an application of the household Vulnerability Index (Zhou et al., 2016)	University	Establish the costs and benefits of different rural adaptation strategies; recommend fiscal-policy measures and instruments to improve household resilience	Household Vulnerability Index (HVI)
20	Climate change, household vulnerability and smart agriculture: The case of two South African provinces (Ncube et al., 2016)	University	Assess micro-level impacts of climate change, evaluate household vulnerability and assess alternative adaptation strategies in rural areas	HVI index, interviews and structured questionnaire, climate projections and impact modeling
21	The SmartAgri status quo review (Midgley et al., 2016)	Provincial govt with university	Provide information on climate risks and impacts for the agriculture sector, outlining climate trends for specific commodities and 23 agro-climatic zones	In-depth desktop study, two stakeholder workshops, and interviews with experts
22	A framework to assess the vulnerability of protected areas to climate change, and application to South African National Parks (2016)	Universities	Inform adaptation strategies for parks	Index-based approach assessing 6 environmental drivers of climate change
23	Status quo analysis on the impacts of climate change in KwaZulu-Natal (2009, updated 2017)	Consultancy and university for Provincial govt	Assess and prioritize climate impacts as basis doe developing adaptation response strategies and implementation plan for adaptation options	Desktop research, stakeholder workshop, analysis of climate tends and downscaled projections, assess impacts, prioritized 20 impacts
24	Cape Town preliminary resilience assessment (2017)	Municipal government	Assess shocks and stressors facing city, including climate change impacts; underpin development of city resilience strategy	City Resilience Framework used with stakeholders to assess four dimensions of resilience, 12 drivers and 50 sub-drivers
25	Turkey (limpopo) vulnerability assessment (Kruger et al., 2019)	NGO	Develop an understanding of climate change for the village and the small-scale farmers to inform adaptation strategies for small scale farmers	Baseline individual interviews, homestead visit, resilience and impact indicators, participatory impact assessment through focus groups
26	Let's respond toolkit: vulnerability assessments carried out with all district municipalities (various)	Consultancy for National govt	To form part of Municipal CC Response Plan	Standardized vulnerability assessment scoresheet to assess if an impact will take place (exposure); assess sensitivity; assess ability to respond (adaptive capacity)

(Continued)

TABLE 1 (Continued)

#	Title of assessment	Who is assessing	Purpose of assessment	Methods used
27	Mapping relative social vulnerability in six mostly urban municipalities in South Africa (Apotsos, 2019)	University	Understand and visualize spatial patterns of social vulnerability	Social vulnerability index based on census data
28	Mapping household vulnerability to disasters in Gauteng (2019)	Provincial govt with think tank	Explore how climate change is likely to affect households across the Gauteng City-Region (GCR)	Survey used to construct a Vulnerability Index incorporating 35 variables relating to poverty, health, dependency, access to housing and services, communication, mobility, and coping capacity

participants were asked to move around the room and physically position themselves on a spectrum in response to questions like "Are you more likely to conduct an assessment yourself or commission someone else to do an assessment?," "How many years have you been working on issues of climate risk and vulnerability?," and "Do you work more with quantitative or qualitative data and information?." The first workshop was held in Gauteng in August 2019. It started by presenting the review findings and a few presentations from participants on the methods they used and their experiences of assessing risk and vulnerability. The workshop also included exercises that were designed to gather experiences of doing assessments and reflecting on what worked well, what proved challenging, and how a framework could support assessments and alignment between assessments and progress reporting in future. The second workshop (held in Cape Town in February 2020) presented a draft framework and provided a structured means of suggesting improvements. Each workshop was designed to intersperse information sharing with interactive reflection and feedback, in pairs and in break-out groups. For example, after hearing feedback from the first workshop, the objectives of the second workshop, and an overview of the framework, participants were asked to reflect in small groups to complete the following statements: we wonder... (i.e., a question that has emerged for you); we worry... (i.e., a concern that you have about the direction this work is taking); we wish... (i.e., a suggestion or aspiration you have for this work). After the draft framework was presented, participants were divided into five groups, each focusing on one aspect of the framework (i.e., scoping step, planning step, screening assessment, mid-range assessment and in-depth assessment). Groups were asked to flag concerns and suggest enhancements.

Through this process a lot of useful feedback was gathered to strengthen the framework and to help think about what would be needed going forward. Participants emphasized the importance of finding a variety of ways to share and trial the framework. They noted that it would need to be adapted for different types of assessments and sectors, and that perhaps in trying to standardize approaches we might lose out on some specific contributions. There was concern expressed over making the framework accessible at grassroots level, which would require increased funding and capacity in many instances. Many stakeholders also drew attention to the need to dramatically increase the availability and accessibility of data that is collected, especially by government entities. Similarly, many cautioned of the growing frustration that comes from ongoing investment in undertaking assessments without commensurate investments in implementing adaptation actions needed to address the findings of the assessments. This feedback was written into a revised version of the framework document, as well as a summary version, and used as a basis to recommend next steps for operationalising and enhancing the framework, including through developing training and a support function for those applying the framework. The two workshops provided a foundation for co-producing a workable framework. Supporting the practical application of the framework and feeding lessons into updating and refining the framework is essential for further co-development.

4. Resulting framework

Emerging from the literature review, workshops and deliberation, a final CRV Assessment Framework was developed. The framework takes as a point of departure a definition of climate risk based on hazards, exposure, vulnerability and impacts. It recognizes the need to assess the current risk profile accounting for differential social vulnerability and include a long-term climatological perspective of at least the preceding 30 years, before considering a range of possible future scenarios that account for changing biophysical and socio-economic conditions, as depicted in Figure 1.

The framework is structured around three separate yet interlinked steps, moving from (1) Scoping: *Unpacking the purpose and context*, into (2) Planning: *Deciding on the depth of assessment*, into (3) Assessing: *The components of conducting an assessment,* each step of which is unpacked in more detail below.

4.1. Scoping—Unpacking purpose and context

The aim of the first step is to think deeply about and develop clarity on why there is a need to assess climate risk and vulnerability, and to unpack the context in which an assessment is being conducted. This will help to guide the choices around the depth of assessment and the methodology to use. Eight questions are presented that are central to understanding the assessment purpose and context. These are presented in Figure 2. Working through these questions informs the writing of a brief (which may

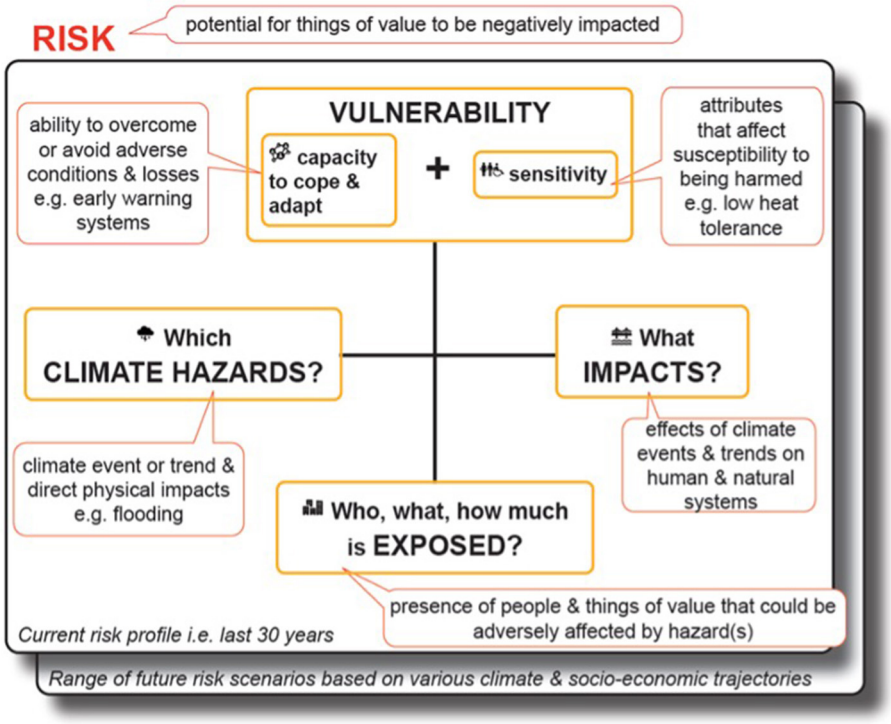

FIGURE 1
Key components of climate risk, adapted from GIZ and EURAC (2017).

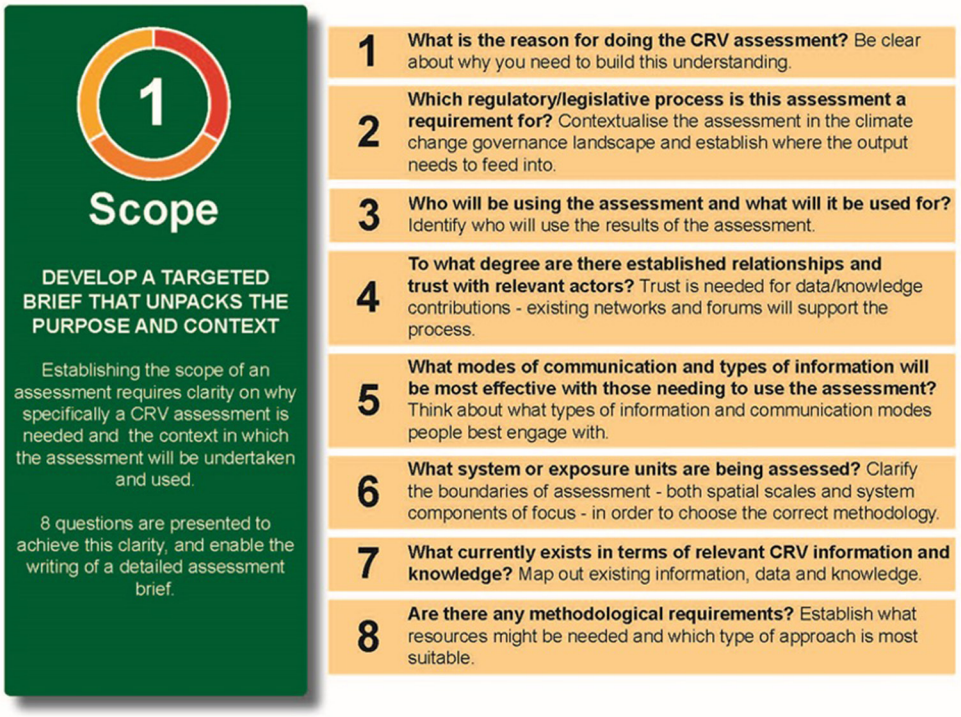

FIGURE 2
Scoping questions to inform a climate risk and vulnerability assessment.

become the basis for a terms of reference and/or the introduction of the assessment report) outlining what the assessment sets out to do and the context in which it operates. The framework presents a set of possible answers to each of these questions that can be used as a basis for scoping the assessment. All questions will not apply in all contexts. Every assessment and context is different. By answering these questions, and documenting the answers clearly, those not directly involved in the assessment will be able to better understand and utilize the findings. Getting to grips with *the why, the who* and *the what* is key for designing and undertaking a relevant and useful assessment. A study looking to advance the academic literature related to the climate risk of certain bird species will have a very different process and output from an assessment aiming to put climate change on the map amongst high level provincial government officials, or an assessment aimed at enabling the incorporation of climate risk into a manufacturing company's safety practices.

4.2. Planning—Deciding on the depth of assessment

The second step provides another set of questions, this time to guide the choice of assessment depth. The framework suggests three possible depths of assessment: an initial CRV screening; a mid-range CRV assessment; and an in-depth CRV assessment, as shown in Figure 3.

The differentiation between various depths of assessment is based on the principle that climate risk and vulnerability assessments need to be an iterative process, starting with broad assessments based on existing available information to raise awareness and identify areas of concern for further investigation. Having engaged with relevant stakeholders and scoped a wide range of possible climate concerns, vulnerable groups, places, species, processes or assets can be identified that warrant further investigation. Only when and where there are particular climate-sensitive decisions to be made, such as revising set-back lines along rivers and coastlines or designing new water treatment works, does it make sense to invest in highly detailed assessments. However, as further discussed below, the three depths of assessment are not mutually exclusive. They are presented as distinct for the purposes of structuring a set of guidelines, but in real terms there is a continuum of assessment depth and any assessment undertaken may apply different depths to different elements to meet the specific needs of the context. The set of questions presented in Table 2 help to select a suitable depth of assessment.

It is not advisable to jump straight into an in-depth assessment without some form of scoping or mid-range assessment, as this may lead to wasteful expenditure if an in-depth assessment is poorly targeted because it does not build on initial stakeholder engagement and risk screening. It may however be the case that elements of a screening assessment are included as a first component of a mid-range assessment, or aspects of a mid-range assessment are undertaken as the scoping component to target an in-depth assessment. In effect, fine-scale, focused assessments that are needed for concrete planning should build upon more broad, sectoral, scoping assessments that establish strategic priorities based on widespread engagement.

It is likely that the mandate of the assessment, or the areas of primary concern and intervention, will shape the depth to which the various elements are assessed. For example, an organization that is largely concerned with social justice is likely to focus more on unpacking the social and economic aspects of the sensitivity and adaptive capacity elements of risk and vulnerability. Whereas, those concerned with disaster management are likely to place a stronger

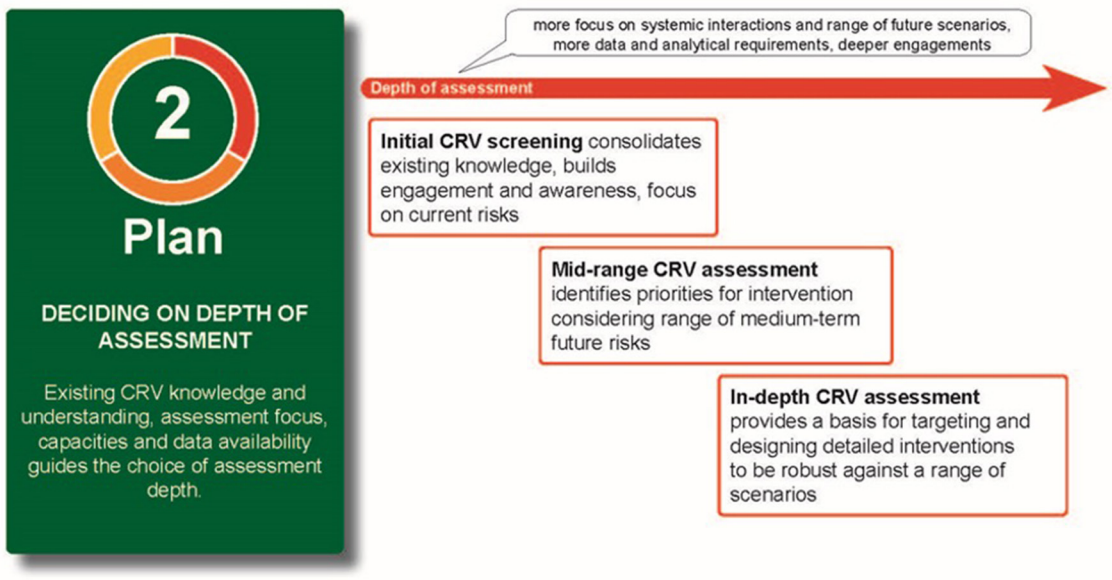

FIGURE 3
Deciding on the depth of assessment required to fit the need.

TABLE 2 Questions and possible answers to guide selecting the appropriate depth of assessment.

	Initial CRV screening	Mid-range CRV assessment	In-depth CRV assessment
Is this	A starting point, to raise awareness and highlight priority risks	The basis for strategy development and high-level planning, through the identification of priorities for intervention	For targeting and designing complex and costly interventions
Is the focus	Highlighting risks and vulnerabilities	Identifying or comparing levels of risk and vulnerabilities for some form of prioritization	Detailed unpacking of the context and drivers, and quantification of risk and vulnerability
Are human and financial capacities	Limited; 3–6 months	Modest; 6 months–1 year	Substantial; 1–2+ years
Will the assessment rely on	Easily available, existing data and information; workshops and surveys	Getting some new data and information; workshops and expert inputs	Extensive new data collection and analysis

focus on understanding the nature and frequency of hazards, levels of exposure and related impacts. Whether these assessments were considered to be screening, mid-range or in-depth, the assessment's mandate or primary areas of concern and intervention would thus likely lead to looking at some elements more thoroughly than others.

Once there is clarity and consensus on what depth(s) of assessment make sense and can feasibly be undertaken, the next step provides more detailed guidance on each of the elements of the assessment.

4.3. Assessing—The components of conducting an assessment

In line with the new standard on assessing climate change vulnerability, impacts and risk developed by the International Organization for Standardization, ISO 14091, the CRV framework guides the user through unpacking the main components of climate vulnerability and risk. These are:

- the climate hazards or stimuli;
- the exposure of the system to climate hazards/stimuli;
- the sensitivity of the exposed elements of the system to climate hazards/stimuli;
- the subsequent (potential) direct and secondary climate impacts;
- and the capacity (or lack thereof) of those/that which are exposed to the climate hazards/stimuli within the system, to prepare for, cope with and adapt to the (potential) climate impacts.

Based on these components, it is important to first consider the current and historical impacts and levels of risk associated with climate conditions and events, including if and how these have changed over the last 30 years. The next step is to engage with scenario-based information about possible future states to evaluate anticipated changes in climate risks and vulnerabilities. This serves as a basis for prioritizing interventions as part of a long-term, iterative climate adaptation process. It is important to recognize that there will be trade-offs when deciding on which adaptation responses to implement. A thorough assessment of climate risk and vulnerability can help to ensure that these trade-offs are carefully considered and investments/budget allocations are well justified.

As the depth of the assessment increases so the focus narrows to target particular decision needs, as unpacked in Table 3. The type of decision depends on who the assessment is for and will vary greatly if it is for a national government department, a community-based organization, a conservation agency, a manufacturer or local retailer, an industry body or someone else. The focus on decision needs is based on a recognition that the complexity and costs of doing highly detailed assessments across broad areas or sectors is often not warranted. The main challenge this framework grapples with is how to integrate information on the magnitude and frequency of climate hazards and the damages from or costs associated with impacts, with information on social dimensions of sensitivity and capacity to prepare for and respond to climate hazards and associated impacts, all within a context of severe data scarcity and limited analytical capacities.

These three depths of assessment get progressively more targeted in focus (i.e., prioritizing risks to concentrate on) and more detailed in terms of gathering both quantitative and qualitative data and engaging more deeply with stakeholders in creating composite scores to enable comparison between places and over time (i.e., how has the risk rating for a given place changed over a period of five or ten years). The idea is that, through steps 1 and 2, the user can determine where to enter and exit the assessment process for the current iteration of the assessment, which may involve combining elements from different depths of assessment. This decision should be based on how much has already been done, how much existing information is readily available for the various components, what capacity and resources are available for undertaking the assessment, and what level of assessment will suffice for the planning and decision needs driving the assessment.

The third step of the framework is designed to:

- provide guidance on how to design an assessment, including filling gaps in previous assessments;
- guide assessors to make use of qualitative and quantitative data and information to develop a rich understanding of what drives climate risk and vulnerability;
- progress from risk awareness and sensitization of relevant stakeholders to generate detailed information needed to target interventions as part of a climate adaptation programme of work (as the depth of the assessment undertaken increases);
- identify where there is a need to expand the climate risk and vulnerability monitoring system and;

TABLE 3 Overview of similarities and differences between the three assessment depths.

Elements	Initial CRV screening	Mid-range CRV assessment	In-depth CRV assessment
Aim	Begin engagement, raise awareness, minimal capacity and time and data requirements	Build climate risk management agenda, identify priorities for intervention	Target key risks, design complex interventions, requires considerable capacity and data
Specify system of concern	Likely to be broad e.g., whole organization/jurisdiction area/sector	Priority sub-systems of concern	Focus on fine scale (e.g., piece of infrastructure, specific species, livelihood strategy or business operation) long-lived (10+ years) high impact decisions
Identify past (last 30 years) hazards and impacts	Desktop review of existing knowledge and information; participatory brainstorming with key stakeholders	Estimate impact of previous hazards (qualitative or quantitative scale)	Quantify hazard-related damages and losses
Establish baseline risk and vulnerability	Cluster and set-aside risks & impacts primarily influenced by non-climatic factors; gather available information on who/what was impacted how, and how often the hazards have occurred, and any indications of frequency or severity having changed over the last 30 years	Identify causal relationships, develop impacts chains including sensitivity factors and capacities to cope and adapt; investigate co-occurrence of climate hazards and how climate hazards exacerbate non-climatic hazards (e.g., insect infestations or viral epidemics)	Select indicators and quantify exposure, sensitivity and adaptive capacity to establish a formal vulnerability and risk rating for three suitable time-slices
Decide on future time periods and scenarios	None (i.e., focus only on current and historical climate risk and vulnerability); OR mid-century, high emissions scenario (i.e., business-as-usual with minimal mitigation)	Mid century, high and low end scenarios to consider range over 30–40 years; for near future (5–10 years) assume current climate range (i.e., observed averages and extremes) but consider how trends in sensitivity and capacity factors change risk profile	Mid century and end century, extreme high end and low end scenarios (RCP 8.5 and 4.5) to establish possible range over 80–100 years using outputs from multiple models to account adequately for uncertainties; socio-economic scenarios should also be considered
Assess future climate risks and vulnerabilities	Stakeholder engagement and review published sources to establish high, increasing and new climate risks due to changing hazards, exposure and/or vulnerability factors to prioritize no-regrets risk reduction measures and further investigations	Estimate range of future climate risk in light of scenarios; establish risk evaluation criteria/benchmarks to identify unacceptable levels to target interventions and/or further investigation	Normalize, weight and aggregate indicators to calculate vulnerability and risk ratings, factoring in secondary impacts and inter-dependencies; undertake model-based stress testing evaluating exceedance and co-exceedance of specified thresholds; convene experts and stakeholders to assess risk acceptability/tolerance
Output	Report drawing together existing information and key stakeholder views to describe the extent of and trends in current climate risks and highlight priority concerns	Set of impact chains showing causal linkages between hazards and differential impacts and description of future, medium-term risk trajectory under business-as-usual emission scenario	Narrative description of key risks. Database of indicators; set of risk ratings under high and low emissions scenarios for medium- and long-term future; impact model; monitoring system to track changes and identify when tolerable limits are exceeded

- ensure that relevant stakeholders and decision makers are involved at critical steps throughout the assessment process, to ensure that the results adequately reflect the experiences of affected parties, and to streamline implementation.

4.3.1. Selecting data and methods

The intention is to provide some flexibility to meet different user needs, while also creating enough standardization to enable the evaluation and aggregation of assessments at the national scale. Instead of insisting on a common set of methods and data, the framework provides a common set of concepts and elements to structure the assessment. Suggestions for specific methods, tools and data sources that can be used to undertake various elements of the assessment are provided in the full framework document, that is available on the DFFE website [Department of Forestry, Fisheries and the Environment (DFFE), 2020].

There are a whole variety of data and information portals, guidelines, methods and tools that are used in assessing climate risk and vulnerability to gather and analyse data and information and to visualize and communicate the results. Examples of these have been captured in Appendix One of the Framework (link above): Resources for Assessments where they are linked directly to the assessment elements. Some are more quantitative in nature, others are more qualitative; some are designed to be participatory and include social processes, while others are more technical and expert oriented. Each comes with different strengths and weaknesses or blind spots. For that reason, combining different data and information portals, guidelines, methods and tools gives a richer picture and understanding of climate risk and vulnerability from which to make decisions about what to prioritize. Although collecting data is important and necessary, it is important to remember that the analysis of the data is critical as it is needed to identify the nature of risk and vulnerability and identify potential ways to reduce risk and adapt to climate change.

4.3.2. Integrating qualitative and quantitative information

There is no neat way to package the variety of methods and tools used for risk and vulnerability assessments. One can broadly distinguish those methods and tools focused on enabling broad participation and those aimed at creating climate risk and vulnerability indices. However, there are many other approaches and methods that also provide useful inputs. These include methods such as systems mapping and governance assessments as examples. Integrated assessment modeling is one approach used to pull together models that cover the biophysical and social system and capture both mitigation and adaptation aspects of the climate change problem. This approach requires significant resources and capacity and is not widely used in South Africa (Ziervogel et al., 2014).

An area of methodological innovation is emerging around integrating participatory approaches and more quantitative approaches. Participatory approaches tend to gather primary data directly from those impacted or affected by climate hazards, whereas indicator-based approaches rely more on secondary data but can use participatory processes to evaluate the indicators. Integrating the two approaches is hard because they often rely on different worldviews and frameworks. The impact chain methodology (GIZ and EURAC, 2017) is increasingly being used for climate risk and vulnerability assessments. It provides a means to think through, discuss and communicate the linkages between climate hazards, direct and secondary impacts, and the social, economic and biophysical factors that play a role in generating or reducing these impacts. Developing impact chains requires the integration of inputs from scientists, professionals, government officials, and representatives from affected sectors and communities. This mixed methods approach and participative development of impact chains helps to support commitment to adaptation responses (Zebisch et al., 2021).

When undertaking an assessment, a first step is always to clearly specify the system of concern that is being assessed for climate related risks and vulnerabilities. In a CRV screening assessment a simple set of impacts chains can be developed by reviewing existing information sources and facilitating a multi-stakeholder workshop to identify historical climate-related impacts, who, what, where was impacted, how severe the impacts were, how often they were experienced, what were the hazards triggering the impacts, and what measures were used to reduce or deal with the impacts. Again, reviewing existing information sources and asking relevant experts (including indigenous knowledge holders and scientific knowledge holders), is there evidence of changes in the patterns of hazard occurrence and impacts experienced? Using a voting or ranking exercise, priorities for interventions can be explored, not focussing on the type of action but on which aspects of risk to tackle.

A mid-range assessment narrows the focus within the system of concern and adds specificity to the causal factors in the impact chains based on historical records. More emphasis is placed on the range of modeled future scenarios to assess how risks might change from the historical baseline, and on multi-stakeholder processes for determining thresholds of unacceptably high risk (including). The in-depth assessment focuses on the selection of suitable indicators and collection of relevant qualitative and quantitative data to evaluate when and where these thresholds have already been exceeded or might foreseeably be exceeded based on plausible scenarios. For further details see the tables provided in the Supplementary material. Each assessment depth has a table describing what each element of the assessment involves. Various methods and tools can be used, depending on the context and expertise of those coordinating the assessment, so these are not specified.

4.3.3. Repeating assessments for monitoring and evaluation

Repeated CRV assessments are one way to monitor how risks and vulnerabilities change through time and whether adaptation interventions are having the desired outcomes. Evaluation, however, entails understanding *why* CRV is changing (or not). Monitoring through CRVs can act as a *trigger* for evaluations, showing where or what is changing or not changing, so that targeted evaluations can be conducted. For example, say there is a CRV assessment that looks at the spatial hazard risk of an urban municipality, and it is repeated every three years. If after three iterations it shows that a certain section of the city is at increasing risk to impacts of extreme rainfall, this may trigger an evaluation into understanding the underlying drivers of this change. However, if a CRV assessment informs the development and implementation of adaptation action, then repeat CRV assessments can be used for monitoring and evaluating these actions. Such monitoring and evaluation assumes that adaptation efforts are intended to decrease risk and vulnerabilities, and will shine light on the relevance, efficacy and efficiency of the actions. If the assessment is used for monitoring and evaluating adaptation action, careful thought needs to be given as to how one deals with a shifting baseline. Various elements that inform assessed risk and vulnerability, e.g., adaptive capacity and climate trends, are also shifting through time independent of the adaptation action.

5. Considerations when implementing climate risk and vulnerability assessments

The steps of the framework are a guideline. In practice numerous issues emerge when undertaking assessment. Input from discussions with stakeholders at the workshop and from reflecting on the process, bring up a number of lessons and insights that should be considered when supporting the implementation of climate risk and vulnerability assessments and the framework more broadly.

5.1. Diversity of terms and methods and flexibility in approach

Firstly, there is a general lack of conceptual clarity and confusion over terms relating to risk and vulnerability, particularly

emerging from the changing definition of vulnerability in the IPCC 5th Assessment report (Ishtiaque et al., 2022). This makes it hard for those thinking about vulnerability assessments to know what terms and methodology to use and subsequently undermines comparability between studies. This framework has sought to clarify how these terms are used to increase conceptual alignment but still enable methodological diversity.

Secondly, the diversity of conceptualization of vulnerability has resulted in many frameworks, methods and tools to undertake vulnerability assessments (Gumel, 2022). However, careful consideration needs to be given to the criteria used to determine their usefulness, especially in light of the conceptual shift presented in the IPCC AR5 report. Knowing when to undertake participatory processes or climate modeling can be a challenge. When working through participatory processes, a team can collectively identify when and where modeling is needed. But then access to modeling is required and careful consideration needed in terms of how to integrate it into the assessments.

It is clear that assessments need to be tailored to the local context and to the expertise and data available. Given this conceptual, methodological and capacity variation in approaches to assessing climate risk and/or vulnerability, comparison and aggregation of findings is often difficult. Flexibility and adaptability is needed both when choosing methods and tools and deciding on the depth of analysis. The CRAVA framework is innovative in the way it suggests the tiered approach, encouraging depth when the decision context and resources support it.

5.2. Limited understanding of what approaches others have used

Methodologies are in flux, and many are not keen to share their methodology. Many assessments are often not well documented or made publicly available. This means there is limited information to inform future assessments related to the details of the assessment approach and the challenges encountered. This makes it hard for new and experienced practitioners to learn from each other and see what works and what does not work in different contexts. It also makes it hard to interpret the findings, if the methodology is not well documented.

5.3. Availability of data differs and is generally limited

Availability and access to climate change and socio-economic data for vulnerability assessments is a challenge internationally (Cavan and Kingston, 2012; Zebisch et al., 2021). In the South Africa context, there are challenges accessing data (e.g., slope risk or flood risk data), getting people to hand over data and the price of data (e.g., South African Weather Service data). This often makes it difficult for NGOs and consultants to get access to all relevant information they would like to undertake a risk and vulnerability assessment. In particular, workshop participants mentioned challenges in getting budget information, and noted that there is a scarcity of data for the social dimensions of vulnerability (especially for future projections). In addition, different assessments work off different baseline information, for example different climate scenarios developed by CSAG or Center for Scientific and Industrial Research (CSIR), or different water availability projections developed by AURECON (now Zutari) or University of KwaZulu Natal (UKZN). It can be hard to know when there is enough information to conclude an assessment and base recommendations on.

6. Conclusion

Assessing risk and vulnerability to climate variability and change is not an easy task, but it is important for understanding who and what is exposed to climate hazards, how sensitive they are, their capacity to adapt and how vulnerability might evolve under changing conditions into the future. Bringing together different climate risk and vulnerability assessments undertaken at different scales, using different approaches and methods and in different sectors across a country is important for getting a handle on how to prioritize adaptation interventions. Yet due to limited common assessment frameworks, many countries battle to have a comprehensive view of sub-national vulnerability and the implications nationally.

The South African Climate Risk and Vulnerability (CRV) Assessment Framework presented here aims to guide a broad range of users through a structured yet flexible sequence of steps, namely: (1) Planning, (2) Scoping and (3) Assessing. The framework guidance acknowledges that diverse needs and capacity exist which means that assessment depths are likely to differ, as are the types of methods used. Methodologically, the framework encourages the integration of participatory and indicator-based methods. The intention is to help standardize assessment components and outputs where possible, enabling results to be compiled and aggregated at the national level to assess climate risk and vulnerability across the country and track how it is evolving in light of changing conditions and interventions. This is also important in relation to the international climate regime, that is increasingly requesting reporting through the UNFCCC mechanisms.

In terms of limitations, it is important to note that this was a first step toward streamlining risk and vulnerability assessments in South Africa. There is still work to be done translating the guidance into practical applications that can provide worked examples for others to draw on when designing their assessments to fit the contexts in which they work. The existence of a framework does not necessarily mean it will be used. However, if increasing sub-national assessments draw on a common framework, it would hopefully develop more national capacity and understanding of vulnerability assessments, along with increased conceptual and methodological alignment. If is it used, it is also likely to develop over time, refining questions as well as being able to provide more targeted guidance on when and how different methods might be most suited to different contexts, especially for addressing issues of equity and justice from an intersectional perspective that sit at the heart of differential vulnerability.

If these CRV assessments, based on the framework, were able to feed into the work of different government departments and long-term planning, that would be a sign of success. Given

that one of the main aims of undertaking climate risk and vulnerability assessments is to inform adaptation interventions, the implementation of adaptation based on CRV assessments would be another sign of success. However, this will require concerted effort, capacity building, improved data and finance for implementation. This South African process can hopefully provide support for actors driving the climate agenda in other African countries looking to develop comparable assessments as the basis to drive equitable and transformative climate action and learning.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval were not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the workshop participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Both authors contributed equally to the conceptualization and writing of this paper.

Funding

The project that this paper refers to was commissioned by the South African National Department of Forestry, Fisheries and the Environment (DFFE), in collaboration with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), and funded by the International Climate Initiative (IKI). The project was undertaken by a team from the Climate Systems Analysis Group (CSAG) at University of Cape Town. Two of the team have written this paper.

Acknowledgments

The content of this manuscript has been presented in part in the National Climate Risk and Vulnerability (CRV) Assessment Framework that is available online at the Department of Environment, Forestry and Fisheries, Republic of South Africa [Department of Forestry, Fisheries and the Environment (DFFE), 2020]. The development of the framework was commissioned by the National Department of Environment, Forestry and Fisheries (DEFF) and guided by a team at the University of Cape Town. The framework was developed in consultation with, and benefited from the inputs of, various national and local stakeholders. The authors especially wish to acknowledge and thank the following individuals for their contribution to the work that went into developing the framework: Katinka Waagsaether; Faith Nkohla; Keobakile Lenyibi; Tsepang Makholela; Lindelani Mudau; Tlou Ramaru; Rebecca Cullis for the graphics; and Candice-Lee Arendse for research assistance.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2023.1197167/full#supplementary-material

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