



Assessing South Africa's Potential to Address Climate Change Impacts and Adaptation in the Fisheries Sector

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Specialty section:

This article was submitted to
Marine Conservation
and Sustainability,
a section of the journal
Frontiers in Marine Science

Received: 13 January 2021

Accepted: 10 May 2021

Published: 10 June 2021

Citation:

Ortega-Cisneros K, Cochrane KL,
Rivers N and Sauer WHH (2021)
Assessing South Africa's Potential
to Address Climate Change Impacts
and Adaptation in the Fisheries
Sector. *Front. Mar. Sci.* 8:652955.
doi: 10.3389/fmars.2021.652955

The marine fisheries sector is one of the most important income sectors in South Africa and plays an important role in food security for small-scale and subsistence fishers. Climate-driven impacts have resulted in distribution shifts and declines in abundance of important fisheries targets, with negative consequences to the users dependent on these resources. The sustainability of the sector depends on its readiness to adapt to climate change. The inclusion of climate change impacts and adaptation in fisheries management documents in South Africa is essential to ensure adequate climate adaptation responses are implemented at the short- and long-term. This study aims to 1) determine if the relevant fisheries national management documents address climate change and adaptation, 2) determine if the relevant national climate change documents address climate change and adaptation in the fisheries sector and 3) evaluate the extent to which fisheries management documents address climate change and adaptation. A content analysis of fisheries management and climate change documents was carried out to determine if they incorporated information on climate change impacts and adaptation and marine fisheries respectively. Fisheries management documents were then screened against nine pre-determined criteria (or themes) based on climate change adaptation to determine the level of inclusion of best practice for climate change adaptation. Results indicate that climate change impacts and adaptation are rarely incorporated in the main fisheries management documents, except for the Climate Change Adaptation and Mitigation Plan for the agriculture, fisheries and forestry sectors. However, this document is still waiting to be adopted. The only direct reference identified in all the fisheries documents that supports climate change adaptation was 'conservation and sustainable management of biodiversity'. With regards to indirect references to climate change adaptation, 'equity,' 'participatory management,' and 'capacity building' were most frequently incorporated in fisheries management documents. There is a need to explicitly incorporate information on climate change impacts and adaptation in South African fisheries management documents and increase the human and financial capacity at national institutions to ensure that the fisheries sector can adequately adapt to climate change.

Keywords: fisheries, climate change, adaptation, aquaculture, management instruments

INTRODUCTION

Climate change is impacting marine ecosystems around the world, with effects that include changes in species abundance and distribution, reductions in catch potential and changes in other ecosystem services provided by oceans (Doney et al., 2012; Cheung et al., 2018). This is especially evident in fast warming areas, or hotspots, and will likely have even stronger impacts on areas with high numbers of people dependent on these services (Hobday and Pecl, 2014). South Africa, a fast warming area, has experienced changes in sea surface temperature, sea level rise, rainfall and primary production among others over the past decades (Jarre et al., 2015; van der Lingen and Hampton, 2018). Warming rates vary spatially and seasonally in South Africa, but some areas such as the Agulhas Current have consistently warmed over the last decades (Rouault et al., 2009; Sweijid and Smit, 2020). Climate-driven biological changes, including distribution shifts of species of commercial importance such as west coast rock lobster *Jasus lalandii*, sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus* (Cockcroft et al., 2008; Coetzee et al., 2008; Crawford et al., 2008), have resulted in severe economic impacts for the users dependent on these resources highlighting the need for dynamic and adaptive approaches to respond to the impacts of climate change (Cochrane et al., 2020a).

The fishing sector is one of the most important income sectors in South Africa, contributing less than 1% of the total Gross Domestic Product (Brick and Hasson, 2016). It is valued at R 8 billion per year and generates over R 3.4 billion (~ 254 million USD, 1 USD = 13.38 ZAR) in total foreign exchange from sales (Brick and Hasson, 2016). The South African fishing sector has two components: wild capture fisheries and aquaculture sectors. The former comprises the commercial, small-scale¹, subsistence² and recreational sub-sectors. The commercial sector provides direct employment to 28 000 people, and indirect employment to 100 000 -130 000 people (Brick and Hasson, 2016). There are 22 commercial sub-sectors in South Africa with the demersal hake trawl and the small pelagics fisheries being the most important in economic terms. Estimates indicate that there are approximately 30 000 subsistence fishers in South Africa (Clark et al., 2002). Small-scale and subsistence fishers heavily rely on fishing since it represents a source of employment and food security in coastal communities with limited opportunities (Isaacs and Hara, 2015). The aquaculture sector in South Africa is relatively small and contributes approximately 6,400 tons annually (Britz et al., 2019). The aquaculture sector generates approximately US\$77 million

and provides direct employment for 2 300 people (Aquaculture SA, 2017 values).

Several initiatives have been conducted to incorporate the effects of climate change into South African fisheries and identify possible adaptation options for the sectors (e.g., Hampton et al., 2017a,b,c). A vulnerability assessment of South African marine fisheries to climate change indicated that the small pelagics and linefish (commercial small boat, small-scale and net fisheries) fisheries were the most vulnerable to climate change, while the aquaculture sector was identified as moderately vulnerable (Hampton et al., 2017b). This led to the establishment of the Benguela Current Convention (BCC) and the FAO project 'Enhancing Climate Change Resilience in the small and large scale fisheries of the Benguela Current Large Marine Ecosystem,' which assessed the vulnerability and possible adaptation options of the stakeholders of the small pelagics fishery and small-scale fishing communities in the three BCC countries: Angola, Namibia and South Africa (Cochrane et al., 2020b,a; Sowman, 2020).

Most climate governance studies in South Africa have focused on sectors such as energy, transport and agriculture with no inclusion of the fisheries and aquaculture sectors (e.g., DEA, 2011a; Averchenkova et al., 2019). Some of the main challenges identified by these studies were the lack of alignment and policy coherence, limited implementation, lack of coordination and clarity on how policies will be jointly implemented as well as limited capacity in the public sector and available funding (Averchenkova et al., 2019). A recent ocean governance baseline assessment for the Benguela Current Large Marine Ecosystem (BCLME) evaluated the environment, fisheries, mining and transport sectors of three BCC countries. This assessment recognizes that climate change is an important threat and factor to be considered in all three countries but it did not address it specifically (Cochrane et al., 2019a).

Despite widespread awareness and considerable exposure to the impacts of climate change on fisheries, there are few examples of approaches taken to address them (Ogier et al., 2016; Lindegren and Brander, 2018). This is, perhaps, not surprising because climate change is usually one more stressor that fisheries management agencies have to take into account in addition to, for example, preventing overfishing, conflicts over space and resources, impacts of pollution and habitat loss, and others (Barange and Cochrane, 2018). Nevertheless, in an increasing number of cases the additional impacts of climate change cannot be ignored. Changes in distribution of species can affect the effectiveness of spatial management measures and lead to conflicts between users, including international conflict when stocks are shared or straddle international boundaries (Lindegren and Brander, 2018; Pinsky et al., 2021). Climate change also frequently adds to the uncertainty in stock trends and status and can result in changes in composition of catches and fishing dynamics (Pinsky et al., 2021). The responses in fisheries management that are required and feasible vary according to the specifics of each case but common themes emerge. Adaptive management is critical, which requires the availability and monitoring of robust indicators and appropriate flexibility in management frameworks and measures, and should

¹Small-scale fisheries refers to 'persons that fish to meet food and basic livelihood needs, or are directly involved in harvesting/processing or marketing of fish, traditionally operate on or near shore fishing grounds, predominantly employ traditional low technology or passive fishing gear, usually undertake single day fishing trips, and are engaged in the sale or barter or are involved in commercial activity' (Policy for the Small Scale Fisheries Sector in South Africa, pp. 6–7). The definition of small-scale fishers varies considerably between countries, changes according to context and also depends on who is defining themselves as a small-scale fisher.

²Subsistence fishers refers to 'a natural person who regularly catches fish for personal consumption or for the consumption of his or her dependants, including one who engages from time to time in the local sale or barter of excess catch, but does not include a person who engages on a substantial scale in the sale of fish on a commercial basis (Marine Living Resources Act 1998, pp. 12).

be embedded in an ecosystem approach that strives to maintain or increase the adaptability and resilience of the fished resources and ecosystems and of the stakeholders engaged in the fishery. Co-management is also recognized to be fundamental to effective management within this adaptive framework (Ogier et al., 2016; Barange and Cochrane, 2018; Lindegren and Brander, 2018).

Management of South African fisheries is undertaken by the Department of Forestry, Fisheries and the Environment (DFFE, previously Department of Agriculture, Forestry and Fisheries). The current effectiveness of marine fisheries management differs between the inshore and offshore fisheries of the country. In general, management of the offshore fisheries, which are easier to monitor and control than inshore fisheries, is effective in ensuring productive and sustainable fisheries, while management of inshore fisheries has been less effective, in large part as a result of the difficulties in controlling illegal and unreported fishing (Cochrane et al., 2020a). Management of the commercial fisheries in South Africa is conducted through Operational Management Procedures (OMP) (Plagányi et al., 2007), an adaptive process which allows for adjustment of management measures in response to changes in resource abundance and productivity, including any caused by climate change. However, the long-term risks and possible impacts of climate change on resources or stakeholders in the country's fisheries are currently not considered in strategic planning.

The marked changes in the abundance, distribution, productivity and availability of marine resources observed in South Africa (reviewed in van der Lingen and Hampton, 2018) has prompted responses by private actors (i.e., commercial sector) from the fisheries sector. These responses have been driven by the necessity to maintain the viability of the fisheries and have been possible due to the resources available to the commercial fishing sector (Cochrane et al., 2020b,a; van der Lingen, 2021). Government has a central role to play in aiding the response of the economic sectors and society to the impacts of climate change. For the fisheries sector, good practice adaptation measures include enhancing monitoring programs through community-based approaches, incorporating environmental variables in fisheries assessments, development of early warning systems among others (Bahri et al., 2021). Reviewing legislation to ensure it guides adaptation responses and explicitly addresses climate change is necessary to ensure effective adaptation (Bahri et al., 2021).

The level of inclusion of climate change in the management documents for the marine fisheries and aquaculture sectors (hereafter the fisheries sector) in South Africa has not been assessed, although, the main legal framework has been evaluated to determine its adequacy to support the implementation of an ecosystem approach to fisheries in South Africa (Cochrane et al., 2015). This study aims to address that gap by (1) determining if the relevant fisheries national management documents address climate change and adaptation, (2) determining if the relevant national climate change documents address climate change and adaptation in the fisheries sector, and (3) evaluating the extent to which fisheries management documents address climate change and adaptation.

BACKGROUND

Climate Change Impacts in South Africa

The observed and predicted impacts of climate change in South African marine resources and systems have been reviewed in van der Lingen and Hampton (2018) and Cochrane et al. (2020b; 2020a). A summary of climate change impacts based on the information from these reviews can be found in **Table 1**. Several environmental, biological and social changes have already taken place in South Africa, however, direct attribution to climate change has been established only for sea surface temperature (Hampton et al., 2017b). The link between the observed changes in other environmental variables and climate change is likely. Some predicted impacts of climate change include increase in sea temperature, frequency and intensity of extreme events (e.g., marine heatwaves and harmful algal blooms), sea level rise, ocean acidification and changes in rainfall (**Table 1**). Sea temperature changes have been associated with a number of biological impacts in South African marine systems including eastward shifts in the distribution of several species (Roy et al., 2007; Bolton et al., 2012). Climate-driven distribution shifts have in turn caused changes in community structure, competition for resources and interactions (e.g., abalone and urchins) (Blamey et al., 2010) and ultimately severe economic impacts. Increases in fishing and steaming costs, decreases in the availability of fish to fisheries, changes in landing sites and processing facilities are some of the observed economic impacts in South Africa, and have affected the livelihoods of people dependent on these fisheries (van der Lingen and Hampton, 2018; Cochrane et al., 2020b,a).

Institutional Arrangements in South Africa

The arrangements for coordination, stakeholder engagement, policy development, implementation and research on climate change in South Africa are quite broad and include several national, provincial and local institutions. An overview of these arrangements is presented below to provide context on the institutions responsible for policy development and other initiatives (**Figure 1**).

National Institutions

The Department of Forestry, Fisheries and the Environment (DFFE, former Department of Environmental Affairs and Tourism and subsequently Department of Environmental Affairs), specifically the Deputy Director General of the Climate Change and Air Quality branch, is mandated with climate change functions in South Africa (e.g., coordination and integration, policy development, mitigation and adaptation responses). The Department of Environmental Affairs and Tourism (DEAT) was created in 1994 and mandated with environmental management, including fisheries and aquaculture, and tourism development. In 2009, the government departments were reconfigured and staff and functions related to fisheries and aquaculture were divided between an Oceans and Coasts Branch in the newly configured Department of Environmental Affairs (DEA) and a Fisheries Management Branch in the reconfigured Department

TABLE 1 | Observed and predicted climate change impacts in South Africa associated to the nine pre-determined climate adaptation themes.

Category	Impacts	Observed/Predicted	Climate adaptation themes
Environmental	Ocean acidification	O, P	1
	Changes in rainfall, river inflow and run-off	O, P	1, 3, 5
	Circulation patterns	O, P	1
	Extreme events (Marine Heatwaves)	O, P	1, 3, 5, 6
	Frequency and severity of storms	P	1, 3, 5, 6
	Incidence of Harmful Algal Blooms	O, P	1, 3, 5, 6,
	Intensification of mesoscale variability	O, P	1
	Poleward shift of the St Helena Anticyclone	O, P	1
	Sea Level Rise	O, P	1, 3, 5, 6
	Temperature changes	O, P	1, 3, 5, 6
Ecological	Wind strength, speed and direction	O, P	1, 3, 5, 6
	Decreases in invertebrate and fish abundance and catch	O, P	1, 3, 4
	Changes in size structure, reproductive scope, community composition, growth rates, recruitment and spawning behavior and success	O, P	1, 3, 4
	Loss or reduction of breeding and nursery areas	P	1, 3, 4
	Changes in production and food availability in estuarine and nearshore areas	O, P	1, 3, 4
	Phenology changes (spawning, breeding, availability to fisheries)	O, P	1, 3, 4
	Distribution shifts of species	O, P	1, 3, 4
Social	Increase in fishing/steaming costs	O, P	2, 3, 5, 7
	Changes in landing points and processing plants	O, P	2, 3, 5, 7
	Mismatch of Territorial Use Rights for Fishing and species distribution	P	2, 3, 5, 7
	Increase in unemployment	P	2, 3, 5, 7
	Increase in compliance issues (poaching)	P	2, 3, 5, 7
	Damage to coastal infrastructure	P	2, 3, 5, 6, 7
	Changes in Food security/nutritional content of species	P	2, 3, 5, 7
	Poverty levels	P	2, 3, 5, 7
	Safety at sea	O, P	2, 3, 5, 6, 7
	Changes in Food supply/higher variability of product availability	P	2, 3, 5, 7

See **Table 2** for the theme numbers. Source: van der Lingen and Hampton (2018) and Cochrane et al. (2020b; 2020a).

of Agriculture, Forestry and Fisheries (DAFF). In 2019³, the Fisheries Management Branch was brought into the newly created DFFE, alongside Oceans and Coasts.

Climate change functions are shared by the environment, risk management and planning directorates in other sector departments with environmental functions (DEA, 2018b). DFFE coordinates with other government departments at different levels to integrate and align climate change strategies under the National Climate Change Response White Paper (NCCRWP). There is no climate change unit in the Fisheries Management or Oceans and Coast branches of the DFFE but the Climate Change Task Team (CCTT, formed by volunteer scientists in 2011) from the Fisheries Management Branch has recently been appointed as a DFFE Scientific Working Group.

Inter-departmental Arrangements

There are several structures and mechanisms responsible for the inter-sectoral coordination of climate change issues in South Africa including the Inter-Ministerial Committee

on Climate Change (IMCCC), the Forum of South African Directors General (FOSAD), the Intergovernmental Committee on Climate Change (ICCCG) (DEA, 2011a) and the recently formed Presidential Climate Change Coordinating Commission (PCCCC). The IMCCC is a coordination committee at the Executive (Cabinet) level, chaired by the Minister of Environment and composed of ministers with a mandate in climate change policy. The IMCCC sets out the coordination and alignment of actions with national policies and legislation. The FOSAD is formed by directors from the main departments and is grouped in the Economic Sectors and Employment, Infrastructure and International Cooperation clusters (DEA, 2011b). FOSAD coordinates policy development, cross departmental alignment of policies, monitors implementation of programs and provides technical support to ministerial departments. The PCCCC (approved by Cabinet in September 2020) will coordinate South Africa's transition to a low-carbon and climate-resilient economy and society by 2050. The Commission will be formed by government, civil society, representatives from academia and research institutions. Finally, the ICCCG is the mechanism through which DFFE

³<https://www.gov.za/speeches/president-cyril-ramaphosa-announces-reconfigured-departments-14-jun-2019-0000> Accessed 01/12/2020.

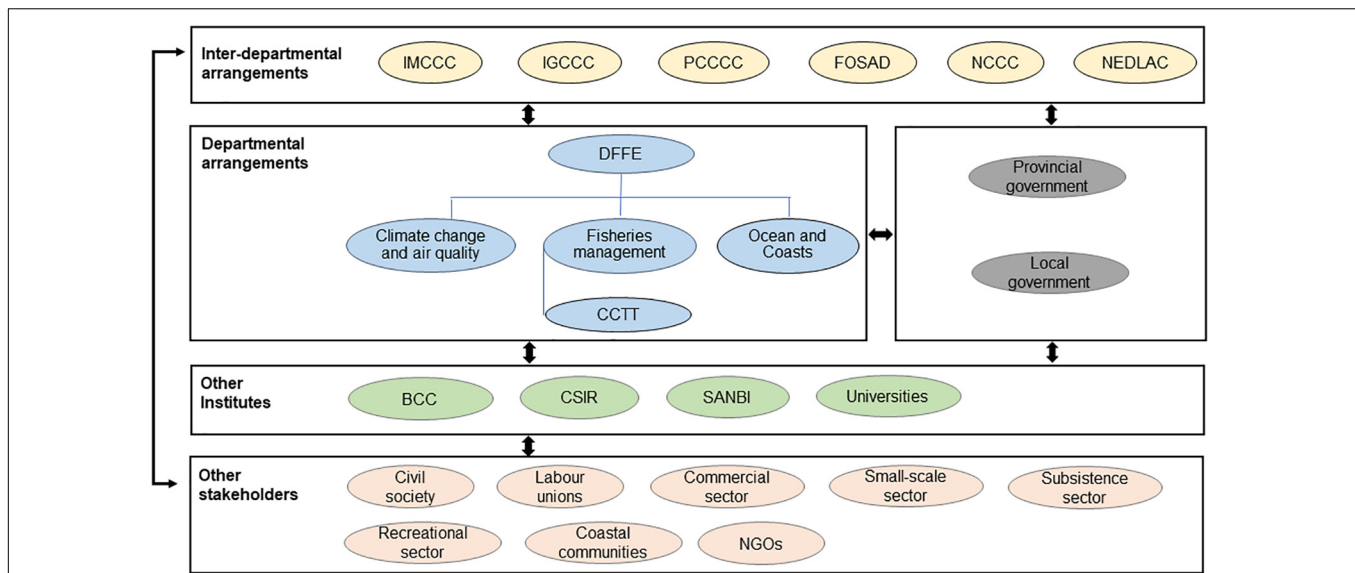


FIGURE 1 | Schematic representation of the institutional arrangements for climate change and fisheries in South Africa. The figure shows a clear delineation between stakeholders, however in reality, there is an overlap between different institutions, mandates and roles which the figure does not show. See section “Background” for abbreviations.

encourages cooperative governance in the area of climate change (DEA, 2016). It is formed by key national agencies, representatives from the provincial departments responsible for environmental management, science councils, and conservations bodies amongst others.

Stakeholder engagement and consultation takes place through the National Committee on Climate Change (NCCC) and the National Economic Development and Labour Council (NEDLAC). The NCCC is also responsible for overseeing the coordination of climate change activities, and was established to ensure that appropriate adaptation responses are mainstreamed into development plans and implemented. Through NEDLAC, government, organized business, labor and community groupings ensure that climate change policy implementation is balanced and meet the needs of all sectors of the economy. The outcome of the discussions is reported to the ministries for consideration in policy design and have been taken into account in policies such as the NCCRWP, Carbon Tax Bill and the Integrated Resource Plan 2019 (Averchenkova et al., 2019).

Provincial and Local Institutions

Provincial and local governments are required to integrate climate change into their planning, and each province is required to develop a climate response strategy and to coordinate adaptation responses across their departments and between municipalities within the province (DEA, 2011b). The provincial government departments relevant to the marine fisheries sector are the Department of Environmental Affairs and Nature Conservation -Northern Cape, Department of Environmental Affairs and Development Planning – Western Cape, Department of Economic Development and Environmental Affairs - Eastern Cape and the Department of Agriculture, Environmental Affairs and Rural Development – KwaZulu-Natal (Figure 2).

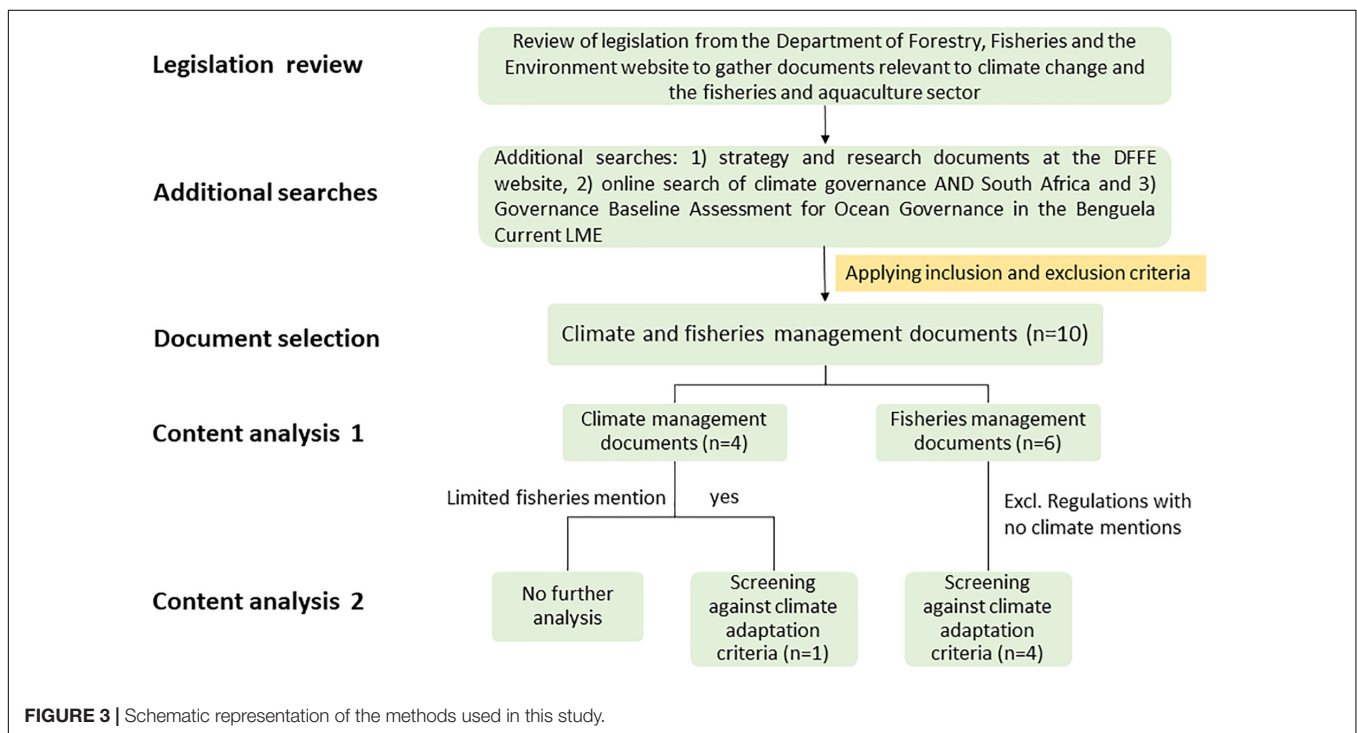
The South African Local Government Association (SALGA) supports, represents and advises local government action, participates in the intergovernmental system, ensures climate adaptation and mitigation actions are integrated into development plans, and plays an important role in public education, awareness and communication of information on climate change.

Other Institutions

A number of international and national institutions are involved in climate change initiatives and research in South Africa and a list of national stakeholders conducting climate change research relevant to the fisheries sector can be found in Hampton et al. (2017c). In addition to DFFE and other government departments, institutions implementing projects relevant to climate change impacts, vulnerability and adaptation include the Council for Scientific and Industrial Research (CSIR), the South African National Biodiversity Institute (SANBI) and the Benguela Current Commission (BCC).

MATERIALS AND METHODS

This study aims to determine if the South African fisheries management documents address climate change and adaptation and the extent to which climate change and adaptation has been accounted for in these documents (see Figure 3 for a summary of the methodology). This study conducted a review of South African legislation relevant to climate change and the fisheries sector. Our approach involved the use of content analysis, a research method that ‘systematically categorizes and records features of text (e.g., aural, textual, visual material) for analysis’ (Krippendorff, 2004; Coe and Scacco, 2017).



Content analysis on two set of documents (i.e., climate and fisheries) was conducted to determine the level of inclusion of specific climate and fisheries search words (see section “Content Analysis”). This was followed by a second content analysis of fisheries management documents to determine the level to which climate adaptation has been included in fisheries management documents (Tables 2, 3).

Review of Climate Change and Fisheries Management Documents

A review of climate and fisheries management documents (gray literature) was conducted using the website of the Department of Forestry, Fisheries and the Environment (DFFE)⁴ to gather relevant documents for this study (accessed on June 2020 and revised March 2021), spanning year 1997 to 2020. Relevant documents were identified on this website under the legislation section. The Legislation section has eight subsections including Green papers, White papers, Bills, Acts and regulations, Guidelines and policies, International agreements and obligations, Gazetted notices and Public notices. Green papers were not included in the analysis because they are still in a formative stage. The documents in the International agreements and obligations section were also excluded because this study is focused on national documents on the intersection of climate change and the fisheries sector. Gazetted and public notices were similarly excluded from the study as they do not represent the final version of a policy and have several purposes such as call for nominations or invitations to apply for committees or rights. The titles of the documents in the five remaining sections (White papers, Bills, Acts and regulations, Guidelines and policies) were screened and only those documents referring to aquaculture, climate, marine (systems or resources), mitigation, fisheries, ocean or vulnerability were considered for the purpose of this study ($n = 98$). The next step was to check the documents to look for duplicates or different versions of the same document ($n = 16$). Only the adopted policy or latest draft version of a document was included in the analysis. 82 records were assessed for eligibility and the exclusion criteria in Table 4 were applied. The aim and purpose of the document was verified to ensure the exclusion criteria was correctly applied. After this selection process, a total of nine documents were included in this study.

Finally, the Draft Climate Change Adaptation and Mitigation Plan (CCAMP) for South African Agriculture, Forestry and Fisheries sectors was also included in our analysis due to its importance informing adaptation for the fisheries sector. CCAMP is the only instrument that integrates the fisheries and aquaculture sectors and climate change. The last version of CCAMP (including the fisheries sector) was not available on the government website, but was provided to the authors by the CCAMP developers.

The Documents section of the website of the DFFE (accessed on June 2020 and revised March 2021) was then searched. The Documents section has five subsections: Annual reports and strategic plans, Strategy and framework, Research, Forms

and Other documents. The documents on the Strategy and framework and Research subsections (specifically “Sustainable development” and “Oceans and coasts”) were scanned to determine if there were other relevant documents to this study and complement our findings. The titles of all the documents ($n = 42$) in these two subsections were screened using the criteria listed above (Table 4 and Supplementary Table 1) to determine their relevance to this study. One document from these sections were considered relevant to the study (policy-informing study). The second step of identifying relevant documents included an online search for publications and gray literature (i.e., reports, policy brief) on climate governance for South Africa. Google search engine was used (March 2020) with the search terms ‘climate governance’ OR ‘climate change governance’ AND ‘South Africa’. The search was considered to be complete after scanning the first ten pages of results since no new information appeared on the search. The exclusion and inclusion criteria referred above was applied and documents limited to a single sector (i.e., energy, agriculture) were not further scanned. Recent reviews on climate governance in South Africa (e.g., Averchenkova et al., 2019; CAT, 2019) and the third National Communications submitted to the United Nations Framework Convention on Climate Change (UNFCCC) were, identified through the online search, reviewed to evaluate the totality of information on climate documents. Similarly, the Governance Baseline Assessment (GBA) and Strategy for Strengthening Ocean Governance in the Benguela Current Large Marine Ecosystem Region (Cochrane et al., 2019a) was reviewed to ensure information completeness for the fisheries sector.

Content Analysis

When all documents were identified ($n = 10$), they included acts, laws, strategies, bills and white papers. Some of which have already been formally adopted while others have not. These ten documents were split into fisheries and climate documents based on the aim or focus of the document, and a content analysis was conducted using Nvivo12 Pro for (1) fisheries management documents ($n = 6$) (hereafter fisheries documents) to determine if they included information on climate change and (2) climate change documents ($n = 4$) to determine if they included information on climate change relevant to the fisheries sector. For the climate documents, the following search terms were coded for: ‘fish’ (including fishing, fisheries, fisher, shellfish), ‘aquaculture,’ ‘marine,’ and ‘ocean.’ For the fisheries documents, the following seven search terms were used: ‘climat’ (for climatic, climate), “change,” “impact,” “vulnerab” (for vulnerable, vulnerability), “adapt” (for adaptive, adaptation), “resilien” (resilient or resilience), and “risk.” The occurrence of these search words was recorded to provide an overview of the inclusion of the given topics (either climate change or fisheries) in the fisheries and climate change documents. For words such as change or impact that can be used in a context outside climate change, the identified reference was checked to make sure it was relevant to the aim of the study.

The fisheries documents were then analyzed to identify the prevalence of nine pre-determined climate adaptation criteria (deductive codes) (see Table 2). Relevant references (i.e., text

⁴Department of Forestry, Fisheries and the Environment (<https://www.environment.gov.za/>).

TABLE 2 | Themes, description and sub-themes used to determine the adequacy of fisheries documents to incorporate climate change.

Themes	Description	Sub-themes	Typology of climate adaptation action (following Biagini et al., 2014)
(1) Develops and applies data and knowledge for impact assessment and adaptation	Based on the assessment of climate change impacts on marine systems and the sector, and the role and implications of vulnerability. Determine knowledge gaps and research priorities	1.1 Climate change as a challenge to the sector 1.2 Climate change impacts and sector vulnerability 1.3 Climate-related research as priority 1.4 Uncertainty in climate predictions	Management and planning Policy Capacity building Practice and Behavior Management and planning
(2) Supports governance for climate change adaptation	Promotes political commitment, effective coordination, infrastructure and capacity. Foster stakeholder engagement and transparency	2.1 Development of policies, organizational infrastructure and institutional capacity in support of climate adaptation 2.2 Participatory stakeholder engagement central to climate governance 2.3 Institutional coordination and collaboration key to climate adaptation 2.4 Communication, awareness, knowledge dissemination 2.5 Barriers to adaptation	Information Warning or observing systems Technology Physical infrastructure Green infrastructure Warning or observing systems Management and planning Policy
(3) Focus on building of livelihood resilience to climate change	Provide clear considerations on the importance of building resilience on the fisheries and aquaculture sector by identifying and implementing effective adaptation responses	3.1 Strategies to improve the resilience and adaptive capacity of the sector	Capacity building Practice and Behavior
(4) Targets approaches for conservation and sustainable management of biodiversity	Accounts for the ecosystem impacts of the fishery (e.g., habitat, other species) and the precautionary approach. Includes approaches such as spatial and temporal management, input and output control	4.1 Effective management to improve resilience to climate change 4.2 Principles to achieve effective management	Management and planning Information Warning or observing systems Technology
(5) Identifies, supports and applies innovative technologies	Promote and applies technological innovations to minimize the impacts of climate change on the sector and increase resilience	5.1 Development of innovative technologies to minimize climate change impacts 5.2 Increase access to information and technological developments	Physical infrastructure Green infrastructure Warning or observing systems
(6) Improves disaster risk management (DRM)	Provide clear disaster risk reduction strategies (e.g., how to prevent new risks, reduce existing risks)	6.1 Climate change poses the risk of increased climate variability and frequency of extreme events 6.2 Development of strategies that directly reduce disaster risk (i.e., warning systems, climate resilient infrastructure)	Management and planning Policy
(7) Identify resources to support prioritized actions at all levels.	Provide a detailed and comprehensive budget, and identifies source of finance to support climate change adaptation	7.1 Access to finance critical to climate change adaptation 7.2 Funding sources	Capacity building Practice and Behavior
(8) Includes implementation framework	Provide information on sequencing and prioritization of actions, responsible implementing actors etc.	8.1 Implementation plan in place to respond to climate impacts and address adaptation	
(9) Includes detailed monitoring and evaluation (M & E) framework	Provide specific targets and responsible actors for monitoring	9.1 Development of M & E plan as a key priority	

in the document) were categorized to one of these nine pre-determined criteria (hereafter referred as themes). Both direct and indirect references to climate change were considered relevant. Indirect references refer to those initiatives that contribute to climate change adaptation but do not directly refer to it. For instance, increasing resilience of the fisheries

sector or dependent communities was considered a relevant, indirect reference since it requires the response of the sector or community to the impacts of climate change. A number of sub-themes emerged while reviewing the documents (under the nine pre-determined themes), these were revised to combine similar ones, reduce overlap and develop the subject of the

TABLE 3 | List of climate and fisheries documents included in the analysis.

Document	Year	Type	Content analysis 1	Content analysis 2
National Climate Change Response White Paper (NCCRWP)	2011	Climate	✓	
Climate Change Bill (CCB)	2018	Climate		
National Climate Change Adaptation Strategy (NCCAS)	2020	Climate	✓	
Draft Climate Change Adaptation and Mitigation Plan (CCAMP) for South African Agriculture, Forestry and Fisheries sectors	2018	Climate and Fisheries	✓	✓
White Paper on Fisheries Policy (WPPF)	1997	Fisheries	✓	✓
Marine Living Resources Act (MLRA), Act No. 18 of 1998 (RSA, 1998) and Amendment Act, 2014 (Act no5 of 2014)	1998, amended in 2014	Fisheries	✓	✓
Regulations in terms of the Marine Living Resources Act, 1998	1998	Fisheries		
MLRA (18/1998): Policy for the Development of a Sustainable Marine Aquaculture Sector in South Africa (PDSMAS)	2007	Fisheries	✓	✓
Policy for the Small-Scale Fisheries Sector in South Africa (SSFP)	2012	Fisheries	✓	✓
Marine Living Resources Act (Act 18 of 1998): Regulations relating to small-scale fishing	2016	Fisheries	✓	

TABLE 4 | Inclusion and exclusion criteria used to select document for analysis.

Inclusion	Exclusion
Climate- climate change is addressed as a cross-sectoral issue and document provides guidelines, regulations for climate change in South Africa	Climate: Climate change specifically addressed only other key economic sectors (i.e., agriculture, energy) ($n = 1$)
Climate: Climate change specifically addressed the aquaculture and fisheries sector by itself or in combination with other key economic sectors	
Fisheries: Setting guidelines, regulations and management actions for marine fisheries in South Africa	Fisheries: Sector specific permit conditions and allocation of fishing rights, including subsequent amendments ($n = 24$) Fisheries: Regulations for the management of Marine Protected Areas ($n = 24$) or other sectors (i.e., tourism) ($n = 5$) Fisheries: General aquaculture guidelines (including authorization requirements, funding organizations, water guidelines, application process) ($n = 19$)

specific sub-themes ($n = 20$). All identified codes were double-checked to ensure they were allocated to the correct sub-themes. The pre-determined themes were based on the Food and Agriculture Organization (FAO) priority action areas for climate change adaptation in agriculture, forestry and fisheries (FAO, 2009) and additional themes: identifying financial sources (Theme 7), implementation (Theme 8) and monitoring and evaluation plans (Theme 9) (Gogoi and Harshita, 2018; CAT, 2019). These additional themes were included because of the central role of implementation effectiveness on adaptation success (e.g., Villamizar et al., 2017; Leal Filho et al., 2018). While developing implementation plans does not directly result in

effective implementation, these plans represent important steps to implement climate adaptation.

The themes (adaptation criteria) were also linked to the observed and predicted impacts of climate change in South African marine environments (Table 1) to ensure they reflect the specific adaptation responses that will be needed by the South African fisheries sector. Adaptation responses for the fisheries sector with regards to observed and predicted impacts of climate change have been identified in previous studies, and include increasing awareness on the potential impacts of climate change (Theme 2), technological developments (i.e., early warning systems for storms, Theme 5), and increasing access to finance (Theme 7), among others (see Hampton et al., 2017a; van der Lingen and Hampton, 2018; Cochrane et al., 2020b,a; Sowman, 2020 for a list of adaptation options). The themes were also reviewed against the adaptation typology developed by Biagini et al. (2014), based on an analysis of 92 projects financed by the Global Environment Facility adaptation funding portfolio (Table 2).

For each document, a score was assigned of either (1) the number of direct (from 0 to 9, based on the nine pre-determined themes) and indirect (from 0 to 3, emergent themes) themes, (2) the number of direct and indirect sub-themes referred to (0 to 20 and 0 to 15 respectively), and (3) the number of direct and indirect references to provide a more detailed view of the extent of inclusion of climate change for the sector.

RESULTS

Limited Reference to Climate Change in Fisheries Management Documents

We reviewed six fisheries documents including three acts, one White Paper and two policies (Table 3). Fisheries documents reviewed contained no or very limited reference of the impacts of 'climate,' 'change,' 'impact,' 'resilience,' 'risk,' 'vulnerability,' or 'adaptation.' Two of the six fisheries documents analyzed included climate change search words, i.e., The Marine Living

Resources Act (18/1998): Policy for the development of a sustainable marine aquaculture sector in South Africa (PDSMAS) and the Small-Scale Fisheries Policy (SSFP) (see **Supplementary Table 2**). The SSFP, adopted in 2012, aims to recognize the rights of the small-scale fisher communities in South Africa (RSA, 2012). The SSFP contained the highest number of climate change references ($n = 9$) and search words ($n = 4$). ‘Climate,’ ‘change,’ ‘impact,’ and ‘vulnerability’ were referenced in the SSFP, while ‘risk’ was only referred in the PDSMAS (**Supplementary Table 3**). Risk management is referred to under section 4 (Policy considerations, p. 8) of the PDSMAS, as one of the proposed policy measures aimed at creating an enabling environment for the development of marine aquaculture.

Limited Reference to Fisheries in Climate Change Documents

Four climate change instruments were reviewed, including a strategy, white paper, bill and a plan. The Climate Change Bill and the Climate Change Adaptation and Mitigation Plan for South African Agriculture, Forestry and fisheries sectors (CCAMP) are awaiting approval. The Climate Change Bill (CCB), developed by the DEA and gazetted in 2018, aims to guide South Africa’s climate change response and the transition to a climate resilient and low carbon economy and society (DEA, 2018a, p. 6). The CCB made no reference to ‘marine’ or ‘ocean’ or ‘aquaculture’ or ‘fish’.

Fisheries search words were referred to in the National Climate Change Response White Paper (NCCRWP) and the National Climate Change Adaptation Strategy (NCCAS). ‘Marine’ and ‘ocean’ were more frequently referred to in the NCCRWP, and ‘fish’ in the NCCAS, while no reference was made to ‘aquaculture’ in these documents (**Supplementary Table 3**). The NCCRWP, released in 2011 by the former Department of Environmental Affairs (DEA), is a comprehensive framework outlining potential responses to climate change, an approach to mitigation and adaptation in South Africa, and includes eight near-term priority flagship programs including adaptation research. The NCCRWP refers to ‘marine’ ($n = 10$) and ‘ocean’ ($n = 3$), specifically in terms of the impacts of climate change on South African marine ecosystems and users on the ‘Biodiversity and Ecosystems’ section (section 5.5, p. 20). ‘Fish’ ($n = 3$) were referred to in relation to the need to improve research to determine the impacts of climate change on coastal fishing communities (p. 24) and impacts on marine systems (p. 20). The NCCAS, developed by the DEA, was released in 2017 and approved by Cabinet in August 2020. The NCCAS consists of four objectives, nine strategic interventions and 12 strategic outcomes covering the water, oceans and coast, biodiversity and ecosystems sectors among others. There were seven relevant references to ‘fish’ (including fishers, fishing and fisheries) on the NCCAS. The search words ‘marine’ ($n = 2$) and ‘ocean’ ($n = 4$) were also referred in the NCCAS.

CCAMP had references for all the fisheries related search words (**Supplementary Table 3**). An important document identified on the DFFE website is the Long-Term Adaptation Scenarios (LTAS) released in 2013 and developed by DEA

in collaboration with SANBI. The LTAS was not included in the analysis as it is a policy informing study and not legislation. The LTAS informs the policy planning process across different sectors, such as agriculture and forestry, human health, marine fisheries and biodiversity. The LTAS for marine fisheries provides information on climate change impacts, adaptation response options and research requirements (DEA, 2013). Some of the proposed adaptation options for the fisheries sector include effective spatial management, adaptive and dynamic management and enhanced social resilience in the face of uncertainty and variability among others (DEA, 2013, pp. 34–35).

Climate Change Adaptation in Fisheries Documents

The first content analysis indicated that three of the four climate documents included fisheries search words. A closer inspection of these documents revealed that the ‘fish’ references in the NCCRWP were very limited ($n = 3$), and rather identified climate change as a threat to marine ecosystems with less focus on the fisheries sector. This was noted on section 5.5 ‘Biodiversity and Ecosystems’ (p. 20), referring to impacts of climate change on the main South African ecosystems (including marine and oceans). Adaptation for the water, agriculture and commercial forestry, health and other sectors are included in the NCCRWP but not for fisheries. The fisheries references in the NCCAS ($n = 7$) are higher than in the NCCRWP (see section “Limited Reference to Fisheries in Climate Change Documents” and **Supplementary Table 3**), however, these are general with limited specific adaptation strategies or actions identified to improve its resilience. The fisheries sector is not recognized as a key socio-economic sector in the strategy, therefore its sensitivity, exposure, vulnerability and adaptive capacity are not addressed as there are for other sectors such as agriculture and forestry. While the coastal zone is evaluated as a sector, it does not fully represent the sensitivity and exposure of the marine environment and economic activities such as fisheries. It is still advised by the authors of this paper to recognize the fisheries sector explicitly in the NCCAS so adaptation options for the sector can be prioritized. It is important to note that the NCCAS was reviewed in relation to the fisheries sector in the context of climate change. The applicability of this strategy to the agricultural sector would most likely render a different outcome. Since the fisheries sector was not considered a priority in these two documents as reflected by the first content analysis, they were not included in the second content analysis addressing climate adaptation for the fisheries sector.

Only two of the six fisheries documents included climate change references, and therefore it was anticipated that climate adaptation would have very limited direct references in these documents. Five documents (four fisheries documents plus CCAMP, **Table 3**) were included in the second content analysis using pre-determined themes for climate change adaptation (**Table 2**). The fisheries documents excluded at this stage were the Regulations in terms of the Marine Living Resources Act, 1998 and Marine Living Resources Act (Act 18 of 1998): Regulations relating to small-scale fishing. These documents list

specific regulations for the right of access, permit conditions, use of gear for the different commercial sectors, offenses and penalties, and are of a technical measure. It was thus deemed that these documents would not indirectly refer to climate change adaptation to warrant further analysis.

All remaining documents included references to at least one of the nine themes and 20 sub-themes. CCAMP had references for all 20 sub-themes and nine themes, while the SSFP and PSDMAS referred to two sub-themes and two themes each. Considering the specific sub-themes and themes, all documents referred to sub-theme 4.2 'Principles to achieve effective management' within theme 4 'Targets approaches for conservation and sustainable management of biodiversity'. The precautionary approach, marine spatial planning, adaptive management and the ecosystem approach were some of the principles referred to in order to achieve effective management in the fisheries documents. These references were not specific to climate change but statements supporting conservation and sustainable management that nevertheless will contribute to climate change adaptation. The sub-themes 1.2 'Climate change impacts and sector vulnerability' and 6.2 'Development of strategies that directly reduce disaster risk' were referred to in CCAMP and PSDMAS respectively.

A total of 210 direct references to the nine themes and 20 sub-themes were identified in five documents. CCAMP had the highest number of references ($n = 154$), while PSDMAS had the lowest ($n = 7$) (Table 5). CCAMP contains 73.1% of all the direct references. Theme 4 'Targets approaches for conservation and sustainable management of biodiversity' and sub-theme 4.2 'Principles to achieve effective management' had the highest number of references ($n = 61$ and 59 respectively) from the five documents analyzed. Sub-theme 4.2 alone represents approximately a third of all the direct references. Theme 1 'Develops and applies data and knowledge for impact assessment and adaptation' and 2 'Supports governance for climate change adaptation' followed in terms of number of references, with 52 and 45 references each from two and one documents respectively. Similarly, sub-themes 1.2 'Climate change impacts and sector vulnerability' and 3.1 'Strategies to improve the resilience and adaptive capacity of the sector' had the highest number of individual references from two and one documents.

The content analysis identified a total of 167 indirect references from all documents, grouped into three themes and 15 sub-themes (Table 6). CCAMP had the lowest number of indirect references ($n = 7$), covering one theme and 2 sub-themes. While the SSFP had the highest number of references ($n = 79$) from 3 themes and 13 sub-themes. SSFP contains 47% of the total indirect references identified in the content analysis. Theme 1 'livelihood' had the highest number of indirect references, while sub-themes 2.3 'participatory management', 2.1 'equity', 2.3 management, and 3.2 'capacity building' were the sub-themes with the highest number of references. These three sub-themes represented 45% of all indirect references. The sub-theme 1.1 'environmental variability' was found only in CCAMP, recognizing the high natural variability that characterizes South African marine systems.

The MLRA does not refer to 'climate,' 'change,' or 'variability' and thus climate change is not recognized as a significant challenge to the sector. However, the act does recognize the importance of building livelihood resilience and the need to use approaches to fisheries management that contribute to food security, socio-economic development and the alleviation of poverty. The MLRA does not directly refer to funding instruments to support prioritized actions related to climate change but does state that the Marine Living Resources Fund will provide for the administration of the provisions of the Act to achieve its objectives, which include sustainable management, a precautionary approach, MPAs, and pollution prevention among others. The policy acknowledges the need for conservation and the sustainable management of biodiversity and has a chapter on Marine Protected Areas, prohibited fishing methods and emergency measures (sub-theme 4.2, $n = 17$).

The SSFP recognizes the impacts of climate change on coastal communities including changes in biodiversity distribution, potential loss of species and ecosystem services such as food provision on the policy problem statements. Poverty alleviation, ensuring food security and sustainable livelihoods are some of the policy principles, and thus the SSFP indirectly addresses the need to improve the resilience of the sector to adapt to the potential impacts of climate change but their direct relationship to climate change is not stated. This is a critical point since evidence indicates that small-scale fishers are among the most vulnerable groups to climate change impacts (Hampton et al., 2017b; Martins et al., 2019).

The sustainable management of biodiversity and the need for an ecosystem approach to fisheries is another strategic objective in the SSFP and substantial attention is given to this in the document (sub-theme 4.2, $n = 20$, Table 5), specifically in section 5 (Mechanisms and instruments for the management of small-scale fisheries). The policy briefly identifies the use of innovative technologies in Section 4.4.4 (Research for technology), where it states the need to promote and develop technologies for sustainable harvesting as well as the importance of technical and advisory support centers to provide information to fishers on research findings, weather forecasts, fish movements and other information (sub-theme 3.8, $n = 3$, Table 6). Small-scale fishers are at high risk to extreme events such as storms and increased wind speed among others, however, the SSFP includes only one reference to disaster management. While the policy does not include an implementation framework, a draft implementation framework for the small-scale fisheries policy was released for consultation in 2013 and finalized in 2019.

The PSDMAS in South Africa had the lowest number of direct and limited indirect references (Tables 5, 6). Most of the indirect references belong to theme 3 'livelihood,' specifically the sub-theme 3.7 'financial assistance'. The policy highlights the need for financial support to ensure the viability of the sector. The sub-theme 3.2 'capacity building' was mentioned three times, however, information from consultations suggests that an understanding of potential climate change impacts on the aquaculture sector is lacking (Britz et al., 2019). Implementation is dealt with separately on the Marine Aquaculture Policy Implementation Plan 2009–2014, which

TABLE 5 | Number of direct climate references identified in the fisheries documents.

Themes	Sub-themes	WPFP	MLRA	PSDMAS	SSFP	CCAMP	No. of documents	No. of References
(1) Develops and applies data and knowledge for impact assessment and adaptation	1.1 Climate change as a challenge to the sector	–	–	–	–	2	1	2
	1.2 Climate change impacts and sector vulnerability	–	–	–	1	34	2	35
	1.3 Climate-related research as priority	–	–	–	–	12	1	12
	1.4 Uncertainty in climate predictions	–	–	–	–	3	1	3
(2) Supports governance for climate change adaptation	2.1 Development of policies, organizational infrastructure and institutional capacity in support of climate adaptation	–	–	–	–	10	1	10
	2.2 Participatory stakeholder engagement central to climate governance	–	–	–	–	6	1	6
	2.3 Institutional coordination and collaboration key to climate adaptation	–	–	–	–	6	1	6
	2.4 Communication, awareness, knowledge dissemination	–	–	–	–	11	1	11
	2.5 Barriers to adaptation	–	–	–	–	12	1	12
(3) Focus on building of livelihood resilience to climate change	3.1 Strategies to improve the resilience and adaptive capacity of the sector	–	–	–	–	21	1	21
(4) Targets approaches for conservation and sustainable management of biodiversity	4.1 Effective management to improve resilience to climate change	–	–	–	–	2	1	2
	4.2 Principles to achieve effective management	11	17	6	20	5	5	59
(5) Identifies, supports and applies innovative technologies	5.1 Development of innovative technologies to minimize climate change impacts	–	–	–	–	6	1	6
	5.2 Increase access to information and technological developments	–	–	–	–	3	1	3
(6) Improves disaster risk management (DRM)	6.1 Climate change poses the risk of increased climate variability and frequency of extreme events	–	–	–	–	3	1	3
	6.2 Development of strategies that directly reduce disaster risk (i.e., warning systems, climate resilient infrastructure)	–	–	1	–	5	2	6
(7) Identify resources to support prioritized actions at all levels.	7.1 Access to finance critical to climate change adaptation	–	–	–	–	7	1	8
	7.2 Funding sources	–	–	–	–	3	1	3
(8) Includes implementation framework	8.1 Implementation plan in place to respond to climate impacts and address adaptation	–	–	–	–	1	1	1
(9) Includes detailed monitoring and evaluation (M & E) framework	9.1 Development of M & E plan as a key priority	–	–	–	–	2	1	2
Number of themes		1	1	2	2	9	5 (Total)	210 (Total)
Number of sub-themes		1	1	2	2	20		
Number of references		11	17	7	21	154		

WPFP: White Paper on Marine Fisheries Policy, MLRA: MLRA 1998. Act No. 18 of 1998, incl. amendment in 2014, SSFP: Policy for the Small-Scale Fisheries Sector in South Africa., PSDMAS: the MLRA (18/1998): Policy for the Development of a Sustainable Marine Aquaculture Sector in South Africa and CCAMP: Climate Change Adaptation and Mitigation Plan for marine fisheries and aquaculture.

TABLE 6 | Number of indirect climate references identified in the content analysis of fisheries documents.

Themes	Sub-themes	WPFP	MLRA	PSDMAS	SSFP	CCAMP	No. of documents	No. of References
Environmental impacts and research	1.1 Environmental variability	–	–	–	–	6	1	6
	1.2 Research needs	6	–	6	1	1	4	14
Governance	2.1 Equity	7	4	–	16	–	3	27
	2.2 Need for legislation development and amendments	2	–	1	1	–	3	4
	2.3 Participatory management	8	1	3	15	–	4	27
	2.4 Transformation	3	–	3	1	–	3	7
	2.5 Transparency and accountability	4	–	–	2	–	2	6
Livelihood resilience	3.1 Activity as an opportunity to improve livelihoods (i.e., through poverty alleviation and food security)	1	1	2	15	–	4	19
	3.2 Capacity building	7	1	3	10	–	4	21
	3.3 Infrastructure development	1	–	–	3	–	2	4
	3.4 Processing and value adding	–	–	–	7	–	1	7
	3.5 Safety	1	1	–	–	–	2	2
	3.6 Disaster management	–	–	1	1	–	2	2
	3.7 Financial assistance	4	1	5	4	–	4	14
	3.8 Development of technical support services	2	–	2	3	–	3	7
Number of themes		3	2	3	3	1	5 (Total)	167 (Total)
Number of sub-themes		12	6	9	13	2		
Number of references		46	9	26	79	7		

See **Table 5** for abbreviations.

includes a comprehensive budget. Since climate change is not included in the PDSMAS, the implementation plan does not include specific actions related to climate change adaptation nor does the budget identify sources of finance to support adaptation.

CCAMP had the highest number of direct references ($n = 154$) to both the themes and sub-themes (Table 5). CCAMP outlines the projected impacts of climate change on marine fisheries and aquaculture in South Africa (section 3.5, pp. 37–42), adaptation options based on the available knowledge of climate impacts for the fisheries and mariculture sectors and on consultations with different stakeholders. Information on specific vulnerabilities is presented for smaller-scale fishers and industrial fisheries. Importantly, the policy recognizes the vulnerabilities and challenges faced by fishers (and also farmers) due to the limited access to information and technologies and the need to address these issues (theme 5, Table 5). CCAMP notes the relevance of using innovative technologies in the fisheries and aquaculture sector and their importance to improving the resilience and adaptive capacity of the sector, especially for small-scale fishers (see sub-theme 5.2, Table 5). Adaptation options are presented for large-scale industrial fisheries, small-boat commercial fisheries, small-scale fishers, recreational fishers and marine aquaculture.

CCAMP recognizes the need to obtain and provide funding to facilitate adaptation identifies possible sources of international funding, and the need to develop partnerships between the private sector, government and civil society to successfully implement climate change policies (Theme 7). Financial constraints are listed as a limitation to achieve adaptation: section 7.5 states ‘Insufficient funding, lack of accessibility to funding resources for climate change research projects both nationally and internationally, is a long-standing challenge’ (p. 84). CCAMP identifies the Marine Living Resources Fund, the BCC and the Water Research Commission as possible sources of local funding. Despite the extensive reference to funding sources, CCAMP does not include a detailed budget.

CCAMP also provides a comprehensive list of general recommendations to achieve successful implementation of the plan (p. 90). Some of the recommendations applicable to the fisheries sector include effective coordination among government departments, policy alignment with national plans, government/industry partnerships, incisive enforcement and implementation of current strategies, more effective science communication and further development of CCAMP into a more comprehensive plan for the marine fisheries and aquaculture, among others. In terms of monitoring and evaluation (M&E), CCAMP covers several aspects of monitoring in different sections but in section 11 specifies that a climate change monitoring system for the agriculture, forestry and fisheries sectors in South Africa, preferably placed under the DFFE, must be implemented.

DISCUSSION

Our review indicates that there are a number of climate change and fisheries documents in South Africa that mandate

and encourage efforts to address climate change impacts and adaptation, and that progress has been made toward these goals. Our analysis suggests, however, that more attention has been paid to other sectors (i.e., energy) while the fisheries sector has not been fully accounted for in national climate change documents. As a result, the inclusion of climate change impacts in the main fisheries documents are mostly limited even though efforts have been made in recent years to address these gaps.

An important factor contributing to the somewhat limited attention being given directly to climate change is that while it is well recognized as a threat to the fisheries sector, at present any actual impacts are very difficult to differentiate from impacts of longer-term but potentially reversible variability. As reported in section “Climate Change Impacts in South Africa,” direct attribution to climate change has only been established for sea surface temperature (Hampton et al., 2017b) and while a link between climate change and environmental changes and changes in species’ distributions observed in recent decades is considered likely, there is still uncertainty. This uncertainty probably explains not only the limited attention so far given to climate change in fisheries policies and practices but also that most of the actions identified here as directly or indirectly addressing climate change are of a generic nature and applicable to efforts to ensure adaptability and environmental and social resilience in highly variable environments in general, rather than any additional threats brought about by climate change. This is also apparent amongst stakeholders. For example, in the South African fishery for small pelagics, there have been far-reaching actions to adapt to distributional shifts in the target species and the current low biomass of sardine, including substantial actual and planned investments in new vessels and processing facilities that reflect at least a medium-term perspective but without necessarily attributing the changes to climate change (Cochrane et al., 2020b,a; van der Lingen, 2021). It is likely to require wider, robust attribution and greater confidence in long-term forecasts of change for stronger and more urgent attention to be given specifically to the additional threats brought about by climate change. However, we hope this is not the case, since climate change will likely 1) make the existing limitations in South African fisheries management more serious and urgent to address and 2) bring new challenges to the sector or worsen conditions. In this sense, South Africa should prepare to the anticipated climate change impacts because the cost of inaction will certainly be very high.

Ogier et al. (2016) identified a number of ‘critical capacities’ required for fisheries management, and governance, in order to enable adaptation and develop resilience to climate change. While that study addressed different fisheries management approaches in Australia, the capacities required are globally relevant and include learning orientation, the capacity to deal with complexity and uncertainty, a focus on the long term and at ecosystem level, integration of the different sectors and scales involved, the ability to monitor and review developments, and effective stakeholder engagement and empowerment. The management agency in South Africa, the Fisheries Management Branch within the DFFE, has these capacities, to varying degrees (Cochrane et al., 2020a),

but the extent to which they are being applied to address the impacts of climate change is largely limited.

The MLRA (1998) did not include direct reference to climate change and the 2014 amendments were limited and aimed specifically at enabling implementation of the 2012 SSFP. While the MLRA does not directly address climate change, it includes management actions that can be used to reduce and mitigate the impacts of climate change. For example, measures aimed at the conservation of marine living resources and protection of the ecosystem as a whole help to maintain resilience of ecosystem to climate impacts, and allowance for emergency measures enables the authorities to take action if climate impacts are considered likely to endanger fish stocks or other components of the ecosystem. Management of the commercial fisheries in South Africa is adaptive, usually through application of operational management procedures (Plagányi et al., 2007), which allows for adjustment of management measures, such as total allowable catches, in response to changes in resource abundance and productivity, including any caused by climate change. At present there is no formal longer-term strategic planning that considers the longer-term risks and possible impacts of climate change on resources or stakeholders in the country's fisheries. Failing to consider the longer term can not only exacerbate the longer-term risks to the sustainability of resources but also to the fishing sector, which needs to plan in the long term in, for example, making decisions on investments (Pinsky et al., 2021). It would therefore be valuable to amend the MLRA to include direct reference to climate change and its implications for short term tactical management as well as the need for longer term strategic management, and to explicitly support 'indirect' climate change-related actions. A revision of the MLRA will take place in line with the Fishing Rights Allocation Process to account for the new allocation rights. This represents an opportunity to revise several aspects of the MLRA and explicitly include climate change impacts and adaptation.

CCAMP, the first adaptation plan for the South African fisheries sector, had the highest number of references to climate change adaptation. The main limitations of CCAMP were the lack of references to disaster risk management, implementation, and monitoring and evaluation plans. Disaster risk management strategies are however currently being drafted (Jean Githaiga-Mwicigi, DFFE pers. com), and this should increase the usefulness of CCAMP to guide climate adaptation for the sector. Using monitoring, evaluation, reflection and learning (MERL) tools is also advised, since MERL departs from the deterministic approaches of mainstream monitoring and evaluation (M&E) which focus on input/output over process and instead emphasizes adaptive learning to respond to dynamic problems such as climate change (Bours et al., 2013; Rosenberg and Kotschy, 2020). It is highly advisable that clear guidelines are developed to ensure successful implementation and monitoring of CCAMP at all levels (national, provincial and local). Information on prioritization of actions, responsible implementing actors and an implementation budget plan should also be included. Implementation of CCAMP should be included in fisheries management plans but at present, there are no formal management plans in place for any of the South African

fisheries. Formulation and implementation of management plans encourages comprehensive planning, transparency and accountability and should include short and long-term objectives (Cochrane et al., 2015, 2020a). Plans should also include the likely impacts of climate change in both the short and longer-terms. Cochrane et al. (2015) proposed a revision of the MLRA to include, amongst other aspects, a requirement for formal fisheries management plans. This assessment reinforces the value of a revision of the MLRA, which should also facilitate the implementation of CCAMP when finalized. The technique of management strategy evaluation (Punt et al., 2016) uses simulations to test the effectiveness of alternative management options and different scenarios, which could be particularly useful in consideration of measures and adaptations to address climate change when developing plans (Lindgren and Brander, 2018). The development of management plans would also provide an opportunity to consider and incorporate those aspects of fisheries management that are generally neglected in the current management strategies, particularly the rigorous consideration of social and economic implications when deciding on specific management measures, policy choices and adaptation options.

The SSFP had the highest number of indirect references to climate change highlighting that this policy includes several actions that will indirectly improve the resilience of small-scale fishers to climate change. Participation, equity and a recognition of the key role of fishing to improve the livelihood of coastal communities are themes that emerged from the content analysis and had the highest number of references in the SSFP. While the incorporation of these actions in the policy will certainly improve the resilience of small-scale fishers to climate change, a concerted effort is required on the part of decision-makers based on the high vulnerability and low adaptive capacity of the small-scale sector (Hampton et al., 2017a,b). In this sense, we again suggest a revision of the SSFP to explicitly address climate adaptation actions following best practices in adaptive management of fisheries (Bahri et al., 2021) but to also account for specific contextual livelihood realities of small-scale fishers in South Africa (Sunde and Erwin, 2020). Sowman (2020), in consultation with small-scale fishing communities in the BCC countries, identified a lack of communication with and support from government, limited participation in decision-making, conflict with other fishing sectors and unclear administrative processes as the most 'common management/governance stressors'. Moreover, some of these stressors speak directly to the emergent themes identified in the SSFP, and it is expected that the implementation of the SSFP, which has so far been problematic (e.g., Cochrane et al., 2020a; Sunde and Erwin, 2020), will help to address these pressing issues. It is clear that government support is needed to build the resilience of this sector and to ensure that climate change does not become a major threat to the sustainability of this already vulnerable sector.

Effective implementation of policies remains a challenge in South Africa, as is the case in many areas of the world (e.g., Lombard et al., 2019; Taljaard et al., 2019; Alves et al., 2020; Reed et al., 2020). Some of the common challenges faced to achieve effective implementation are related to limitations in

climate change knowledge, institutional capacity, funding and awareness mechanisms, and coordination among and within government institutions (Spires et al., 2014; Totin et al., 2015; Ampaire et al., 2016; Taljaard et al., 2019). While there have been few assessments of the implementation of climate change actions, it is clear that there are a number of strategies available to guide climate change adaptation but very few examples of actual implementation (e.g., Ziervogel et al., 2014; Ogier et al., 2016; Alves et al., 2020; Bell et al., 2020; Fogarty et al., 2020). Bell et al. (2020) summarizes examples of climate-ready fisheries moving from policy to action with a focus on the Northern Hemisphere. These authors concluded that despite a substantial increase in the body of work on climate change impacts and vulnerability in recent years, integration of climate change impacts into fisheries management is still not adequate for the complexity of the issue (Bell et al., 2020).

Limited climate change knowledge is perceived as one barrier to achieve effective implementation of climate adaptation. The importance of integrating science into decision-making for natural resource governance has been extensively recognized, but an implementation gap between science and management persists (Knight et al., 2008; Kirchhoff, 2013; Cvitanovic et al., 2015; Fogarty et al., 2019). A study on coral dominated Marine Protected Areas (MPAs) in Australia, Belize and Kenya indicated that only 14% of information cited in management plans corresponds to primary scientific literature (Cvitanovic et al., 2014), with technical reports and local government documents being the most used information sources. Possible reasons include long publication times for articles, limited accessibility to articles (journal subscriptions needed) and articles not providing outcomes relevant to management. A number of efforts have been conducted to summarize the projected impacts of climate change on South African marine environments and fisheries (Jarre et al., 2015; Potts et al., 2015; van der Lingen and Hampton, 2018) and vulnerability assessments have been conducted for a number of South African marine species (Ortega-Cisneros et al., 2018) and fisheries (Hampton et al., 2017b; Cochrane et al., 2020b,a; Sowman, 2020). While some of this work has informed the development of CCAMP and a few local adaptation plans (St. Helena Bay fishing community, Sowman, 2020), there is still a need to improve uptake of research to explicitly address short- and long-term climate change impacts on natural resources as well as the socio-economic and cultural impacts on fishing communities in South Africa (Sunde and Erwin, 2020). Even with a reasonable evidence base, limited understanding by stakeholders of how this information is used or disseminated combined with limited access, adoption and integration of climate information by policy makers and government leads to stakeholders not knowing (1) how to interpret complicated and inaccessible legislative language, (2) who to contact and approach with regard to climate challenges and knowledge, and (3) who to hold accountable for implementation. These findings are supported by the most recent World Meteorological Organization (WMO) report stating that the capacity in disaster risk knowledge and forecasting in Africa is well advanced, but the information is not yet actionable and accessible highlighting the need to improve the transition from knowledge into action

(WMO, 2020). A response to this challenge could be: (1) conduct a knowledge availability and needs assessment for the South African context across governance levels and sectors and (2) ensure that capacity (time, knowledge, skills, and funding) exists to translate climate change knowledge and science into meaningful action.

Co-production of knowledge, knowledge brokers and institutional reforms to support knowledge exchange have been suggested as possible responses to reduce the science implementation gap (Cvitanovic et al., 2015; Fogarty et al., 2019). A knowledge and information audit should be conducted for the South African fisheries sectors in order to understand why climate information is not reaching the people who need it (from policy-makers at national level through to fishers at a local level) and why it is not being integrated more effectively into policy and implementation. For example, is the information inappropriately technical and therefore inaccessible, is the problem a lack of time and capacity, and are there other barriers? Existing knowledge gaps also need to be identified such as the need for research on the socio-economic linkages of climate change impacts on the fisheries sector to other sectors (DEA, 2013). The knowledge audit should be considered a priority since previous studies have identified a lack of awareness of climate change information as a barrier to achieve climate adaptation in the Benguela region (Cochrane et al., 2020b,a). Lessons from the integrated water management and agricultural sectors in South Africa indicate that contextual factors must be understood in order for the development of relevant research and research dissemination to take place, not only in these sectors but across other sectors, including in fisheries and aquaculture (Lotz-Sisitka and Burt, 2006; Jiggins et al., 2007; Burt and Berold, 2012). Understanding contextual factors implies also understanding and integrating other forms of knowledge such as indigenous, local and experiential knowledge and how these knowledge systems can, and should, be integrated into policy recommendations (Klein, 2000; Smith, 2012; Reed et al., 2014; Gee et al., 2017).

Contextual factors need to be better understood in South Africa so knowledge and learning of climate change challenges can be better supported (Sunde, 2014; Rivers, 2015; Sowman, 2020; Sunde and Erwin, 2020). For this to happen, information needs to be packaged in a relevant manner (contextualized) and then presented in a way that best suits the needs of the users (i.e., DFFE managers, small-scale fishers, etc.). For research findings to be better taken up into policy and management. Fisheries scientists and managers need to communicate more effectively in order to interpret climate science information and what research results means in practice. Both parties need to take ownership of this knowledge exchange process with scientists understanding what research is needed to respond to climate issues holistically and managers understanding the science so they can implement it more effectively (Moser and Dilling, 2012; Cochrane et al., 2019b).

In order to ensure effective and sustainable climate change resilience and adaptation implementation, stakeholders impacted by climate change need to be engaged with. The overall design of stakeholder engagement processes around policy formulation needs to be truly inclusive and democratic. This

requires careful planning, early inclusion, transparency and trust building, capacity building of all stakeholders from decision-makers to local community stakeholders, acknowledging power imbalances and real decision-making power for marginalized communities and groups. Acknowledging the need for more democratic government stakeholder participation processes (Sunde and Erwin, 2020) call for an official review into the public participation processes comprising the implementation of the SSFP. Commenting on participation with small-scale fisheries in South Africa, Sunde (2014: 106) argues for best practice guidelines for participation that “include representatives of rights holders and stakeholders from the beginning of the planning process and to define the roles, powers and authority of these parties at different stages in the planning and management process.”

Limited capacity and skills in the climate change field are identified as key challenges faced by government officials in responding to climate change in South Africa (DEA, 2016). This is not only a local problem, and the 2020 State of Climate Services report noted that Sub-Saharan Africa faces persistent technical and financial capacity constraints (WMO, 2020). As suggested above, synergies and knowledge exchange between managers and scientists can help address this issue. Resources in the form of funding, time and skills training need to be invested over a sustained period in order to build human and institutional capacity. Improved collaboration and coordination among and within government departments can also help to address capacity issues. The recent merger between the former DEA and the Fisheries Management Branch of DAFF into DFFE, bringing fisheries management and environmental expertise together in the same department, has been problematic with many challenges presently being addressed, but provides an opportunity to improve coordination of climate change aspects for the fisheries sector.

This study aimed to evaluate the extent to which climate change impacts and adaptation are incorporated into the fisheries sector in South Africa, and contributes to the attempts to effectively integrate climate adaptation with the fisheries sector by assessing to what extent climate change adaptation principles are currently incorporated. The general recommendations that emerged from this study were: (1) revise the primary fisheries management instruments to explicitly include climate change mentions or to strengthen them, for example in the case of the SSFP; (2) compile fishery management plans for all sectors, thus allowing climate change to be included in a comprehensive and logical framework; (3) improve communication, information and knowledge exchange among stakeholders, including between scientists and managers in DFFE; (4) develop implementation budgets with specific targets

and responsible actors for monitoring and implementation of the climate change policy; and (5) allocate and prioritize funding to increase capacity building (institutional and human capacity) and effective stakeholder engagement in the DFFE. Overall, the fisheries sector does not yet appear to be given high priority for climate change adaptation measures in South Africa. As suggested for other sectors (Ramanathan and Haines, 2016; Chersich and Wright, 2019), explicit framing of climate change adaptation for the fisheries sector as critical for the nation (i.e., food security) may secure more dynamic actions by government, and strengthen the engagement of civil society and local communities most vulnerable to climate change impacts.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

KO-C conducted the data collection and analysis. All the authors provided comments on and inputs to the manuscript.

FUNDING

This study was funded by the Global Environment Facility through the project ‘Enhancing Climate Change Resilience in the Benguela Current Fisheries System,’ implemented by FAO and the Benguela Current Convention, and the United Kingdom Research and Innovation (UKRI) Global Challenges Research Fund (GCRF) One Ocean Hub (Grant Ref: NE/S008950/1).

ACKNOWLEDGMENTS

Carl van der Lingen and Jean Githaiga-Mwiciigi are thanked for sharing a draft version of the CCAMP with us. The authors are indebted to the two reviewers for providing very useful comments, which improved this manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2021.652955/full#supplementary-material>

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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.

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