Scenario-Based Approaches to Change Management in Fisheries Can Address Challenges With Scale and Support the Implementation of an Ecosystem Approach to Fisheries Management

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The Ecosystem Approach to Fisheries (EAF) management, recognising complexity, aims for the holistic, sustainable management of fisheries to promote healthy marine ecosystems and sustainable livelihoods. Effective implementation of the EAF has been problematic as we continue to grapple with issues of scale, knowledge integration and meaningful stakeholder engagement. Scenario-planning approaches in marine social ecological systems (SES) can address some of these challenges. Using systems-thinking, scenario-planning presents the opportunity to address challenges simultaneously at different scales of interaction by addressing the needs at smaller and larger decision-making scales. We here present a prototype scenario-based approach in which we used structured decision-making tools (SDMTs) in an iterative and interactive research process with marginalised stakeholders in a small-scale fishery in South Africa's southern Cape. Using this approach presented an opportunity for fishers to consider pathways for future responses to change while enhancing personal and local adaptive capacity. At the same time, these marginalised fishers were provided with an important opportunity to freely air their views while engaging with tools new to them. The process did not only benefit fishers, but also provided valuable insights into how they view and experience their marine SES. The use of these tools has provided a means to integrate different knowledge streams, identifying ways in which challenges presented by scale in SES is better addressed. As a next step in the prototype development, expansion to more diverse stakeholders in the biogeographical region relevant for this fishery is recommended. We highlight how this approach can contribute to multi-level governance. When considering EAF implementation, we highlight how engaging marginalised stakeholders need not mean losing the reproducible, transparent processes required for modern management. Lastly, we discuss how multi-scalar flow of information could improve the implementation of an EAF in a developing society, such as that of South Africa.

Keywords: ecosystem approach to fisheries management, scenario-planning, fishing communities, scale, marine social-ecological systems

INTRODUCTION

Fisheries, complex adaptive marine social-ecological systems (SESs), already beset by inherent complexity, are becoming increasingly uncertain due to escalating anthropogenic pressures on a global scale (e.g., Tegner and Dayton, 2000; Jackson et al., 2001; Scheffer et al., 2005; Halpern et al., 2008; Hoegh-Guldberg and Bruno, 2010; Poloczanska et al., 2013). This makes it more difficult for those who depend on fisheries for livelihoods and manage fishing activities to make proactive, informed decisions at various temporal scales (e.g., Berkes, 2003; Garcia and Cochrane, 2005; Jentoft and Chuenpagdee, 2013; Link et al., 2017; Jarre et al., 2018).

Recognising the complexity of marine SESs has given rise to research that seeks to incorporate approaches to management which take wider, system-based views (e.g., Garcia et al., 2003; Garcia and Charles, 2007; Ommer and Team, 2007; Haapasaari et al., 2012). Such approaches seek to cross disciplinary lines, perceptions, forms of knowledge and scales (Degnbol and McCay, 2007; Garcia and Charles, 2007, 2008; Ommer and Team, 2007). The ecosystem approach to fisheries management (EAF) - a widely adopted, inclusive management approach - strives to promote long-term sustainability in fisheries through management interventions that are bottom-up, systematic and participatory (FAO, 2003; Garcia et al., 2003). The question that arises is: are there inclusive methods that can be applied at the smallest scales of operation of a fishery, which can at the same time also inform large-scale decision-making to promote management approaches such as an EAF?

To address this central question, we should consider reframing approaches used in fisheries management and research to explore new (or different) methods and approaches. To this end, several authors advocate for the use of scenario-planning in marine SES to address challenges with the effects of long-term system change, uncertainty and complexity (e.g., Jarre et al., 2013; Daw et al., 2015; Maury et al., 2017). Scenario planning commonly takes place in global assessments such as the IPCC assessments of climate changes and the IPBES ecosystem assessments (e.g., IPCC, 2014; IPBES, 2016). Scenario-based approaches provide us with an opportunity not only to reframe some of the challenges (problems) encountered in marine SES but also offer an alternative to forecasting dynamically to consider future impacts and consequence of change. In South Africa, large scale scenario planning exercises, based on transformative scenario planning (TSP), include the Mont Fleur scenarios (charting the course or post-Apartheid development – see Kahane, 1992) and the Vumalena land reform scenarios[1], although these are all largely terrestrial.

Scenarios are an appropriate method for dealing with uncertainty within the entire SES. Uncertainties in SESs are generally difficult to quantify as some key drivers are unpredictable and change typically is non-linear and complex; human response actions to forecasts tend to be reflexive, and the system may change faster than the forecasting models can be recalibrated particularly in turbulent periods of transition (e.g.,

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Walker et al., 2002). At smaller scales - of the individual, group of fishers or town – it is a useful tool for capacity building and social learning (Quay, 2010). As such, these approaches present the opportunity to address challenges simultaneously at different scales of interaction (e.g., Berkes, 2006; Cash et al., 2006) by addressing the need of the individual and/or household while informing larger scale policy processes such as the EAF. While scenarios based on forecasts for South African fisheries have been conducted (e.g., long-term adaptation scenarios for South Africa (DEA, 2013), participatory scenario planning approaches together with fishers have not been introduced or initiated as a decision-making or change-management tool, nor has participatory scenario planning been employed to inform governance or the implementation of an EAF at the national scale. We therefore embarked on a case study to assess the feasibility.

This paper focuses on the overarching scenario-based[2] approach used in the case study. We draw on results published independently (Gammage, 2019; Gammage et al., 2019; Gammage and Jarre, 2020; Gammage et al., in review[3]) to outline the philosophical approach taken in developing this interdisciplinary approach, operationalised in a developing context in support of improving the human dimension of EAF implementation in South Africa's southern Cape linefishery. We proceed with a brief overview of some concepts that are pertinent to the approach. We describe the over-arching methodology and results of the underlying case study (as published) before presenting a reflection on the process in relation to challenges with scale in managing human activities in the southern Cape linefisheries. We discuss the contribution made toward promoting the EAF implementation in South Africa, together with recommendations for future research.

THE NEED OF COHESIVE APPROACHES TO ADDRESS MULTIPLE OBJECTIVES IN MARINE SES

Global Policy Frameworks for Sustainable Fisheries Management in Small-Scale Fisheries

Adopting SES perspectives is integral to ecosystem-based management approaches, offering the opportunity to better integrate natural and human-social system components in pursuit of sustainability. Globally, the need for sustainable

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[1] https://www.landreformfutures.org/

[2] The scenario-based approach outlined here, follows the principles of a transformative scenario planning (TSP) approach (see Kahane, 2012a,b; Kahane and Van Der Heijden, 2012). A participatory scenario planning approach, backcasting techniques are used to create normative scenarios which explore possible futures. These scenarios are exploratory and speculative (Wiebe et al., 2018) and are designed for all participants (or actors in the system) to work cooperatively and creatively to get a complex problem untangled and moved forward (Kahane, 2012a,b).

[3] Gammage, L. C., Jarre, A., and Mather, C. (in review). Failing to plan is planning to fail – lessons learnt from embarking on a scenario-based approach to change in a small-scale fishery. Submitt. Ecol. Soc.

futures and oceans are highlighted by the adoption of multi-national policy frameworks such as Agenda 2030[4] for sustainable development which recognises the need for systems thinking to address modern societal problems (UN, 2015). The importance of fisheries is highlighted by 'SDG 14 – Life below water' although fisheries make important contributions to the attainment of other SDGs. By implication, achieving the main goals of Agenda 2030 for all fishers and communities is a requirement (FAO, 2018).

The Food and Agriculture Organisation of the United Nations (FAO) provides the 'umbrella' policy goals that can facilitate integrative and innovative approaches for global fisheries management. The Code of Conduct for Responsible Fisheries (CCRF)[5] (FAO, 1995), is becoming increasingly relevant as global fish consumption increases (FAO, 2018). Developed as a compliment to the CCRF, the small-scale fishery (SSF) guidelines (FAO, 2015) provide a policy framework for the attainment of sustainability of SSFs. Not legally binding, instruments such as the SSF guidelines provide context and frameworks for achieving the SDGs. With greater emphasis on the role that fisheries play as sources of livelihoods, places where cultural values are expressed and as a buffer for shocks for poor communities; further development of the understanding of SSFs is required to support the commitments to SSF development and SDGs (FAO, 2015, 2018).

Ecosystem Approach to Fisheries Management (EAF)

The recognition and emphasis placed on the social (human) dimension in marine SESs are reflected in an ecosystem approach to fisheries management (EAF). The EAF[6], built on the principles of Sustainable Development, is a broader framework which aims for inclusive and sustainable management, accounting for the impacts that other sectors have on fisheries and *vice versa* (FAO, 2003). EAF was formally recognised as a fisheries management goal by the Reykjavik Conference on Responsible Fisheries Management in the Marine Ecosystem in 2001. The commitment to the EAF was restated at the 2002 World Summit on Sustainable Development (WSSD) by signatories, which included South Africa, to the Johannesburg declaration (WSSD, 2002). Despite the publication of the 'Guidelines for the implementation of the EAF' and the FAO recommending steps for the implementation and development of an EAF management plan (FAO, 2003; Garcia and Cochrane, 2005), the

successful implementation of EAF has been challenging (also see Cochrane et al., 2015).

Moving toward more inclusive approaches such as the EAF requires multiple stakeholders, disciplines and objectives that see fisheries as SESs (Cochrane and Garcia, 2009; Berkes, 2012; Ommer et al., 2012) along with management structures that match scales, complexity, and interdependencies of SESs (Ommer et al., 2012). However, current approaches for implementing an EAF tend to be used in a way that expands traditional management paradigms rather than changing them. This evolutionary approach to implementing EAF is inadequate in dealing effectively with fisheries' multiplicity of issues and complexities, suggesting a more revolutionary approach is required (Berkes, 2012).

EAF Implementation in the Southern Benguela

In South Africa, the Marine Living Resources Act (No. 18 of 1998, MLRA) espouses the concept of an EAF, although significant gaps and weaknesses exist. Although progress has been made in understanding the ecological context, it has proven to be more difficult and complex to integrate social components (Shannon et al., 2010; Sowman et al., 2011). While some progress has been made toward the implementation of an EAF, especially in the country's larger industrialised fisheries, more sound and comprehensive policy and legal frameworks continue to be required for long-term fisheries governance in South Africa's fishing sectors (Cochrane et al., 2015).

Noteworthy progress toward implementing an EAF in South Africa include the agreement on sets of comprehensive management objectives through ecological risk assessments (ERAs) (Shannon et al., 2006; Nel et al., 2007; Petersen et al., 2010), further development of the ERA methodology to measure progress toward achieving the objectives (Paterson and Petersen, 2010), spatial approaches (Sink et al., 2011) and methodology to evaluate effects of different management strategies in system contexts (Shannon et al., 2010, 2020; Watermeyer et al., 2016; Weller et al., 2016; Cooper and Jarre, 2017a,b; Ortega-Cisneros et al., 2018).

Some progress has been made in the human dimensions of an EAF, with South Africa's southern Benguela ranking in the middle globally (Bundy et al., 2016). Research into the human dimension of the marine SES often places the focus on fishing communities, focussing (amongst others) on research into the human and political-economic dimensions of sustainable fishing, specifically in SSFs (e.g., Isaacs, 2012, 2013), assessments on the socio-ecological vulnerability and development of adaptation strategies to climate change in the Benguela Current Large Marine Ecosystem (BCLME) (e.g., Sowman and Cardoso, 2010; Sowman and Raemaekers, 2018; Sowman, 2020), social-ecological indicators for SSFs and drivers of poverty in fishing communities (e.g., Hara, 2014) and governance approaches in relation to high-value species such as abalone and lobster (e.g., Raemaekers, 2009). The impact of marine protected areas on some coastal communities is

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[4]Agenda 2030 pursues the goal of achieving a just and sustainable world where the fulfilment of human potential contributes to shared prosperity (UN, 2015; CEB, 2017). The Sustainable Development Goals (SDGs) affirm the commitment of placing equality and non-discrimination at the centre of Agenda 2030.

[5]The Code of Conduct for Responsible Fisheries (CCRF) is a framework for the implementation of the principles of sustainable development in fisheries (FAO, 1995).

[6]Built on the principles of Sustainable Development, the EAF "strives to balance diverse societal objectives, by taking into account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and other interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries" (Garcia et al., 2003) and specifically emphasises stakeholder engagement in management (FAO, 2003; Garcia et al., 2003; Wilson, 2006).

being researched (e.g., Sunde and Isaacs, 2008; Sowman et al., 2011; Muhl, 2019), and various newer studies enhance our understanding of the history of, and social dynamics in western Cape fishing communities under global change (e.g., Isaacs, 2013; Norton, 2013; Visser, 2015; Duggan, 2018; Duggan et al., 2020). The working conditions of compliance inspectors in SSF were researched by Norton (2014) and findings were synthesised in an assessment tool for the governance dimension of the EAF in South Africa (Norton and Jarre, 2019).

RAPID PROTOTYPING OF THE SCENARIO-BASED APPROACH USING A CASE-STUDY

The Southern Cape Linefishery System

The southern Cape line fishery operates in the coastal waters in the inshore area of the central Agulhas bank (**Figure 1**). Part of the southern Benguela, one of four sub-(eco)systems of the Benguela Current Large Marine Ecosystem (BCLME) (Hutchings et al., 2009; BCC, 2013), the Agulhas Bank subsystem overlaps with one of the climate change hotspots identified by Hobday and Pecl (2014). Various natural and anthropogenic drivers result in various multi-scalar spatial and temporal changes (Jarre et al., 2013, 2015; Blamey et al., 2015), making it challenging to establish the exact nature of the drivers of change and their interactions (Moloney et al., 2013). Long-term effects of anthropogenic climate change are inevitable and will add to inherent complexity, challenging both fishery resources and resource users (Jarre et al., 2013; Gammage et al., 2017a,b).

The South African (hand-)linefishery is a boat-based, multi-user, multi-area and multi-species fishery that conducts mostly day trips ranging from six to eight hours. The primary target species of the fishery is silver kob (*Argyrosomus inodorus*) (Blamey et al., 2015; Griffiths, 2000), other species targeted in the absence of kob include silvers/carpenter (*Argyrozona argyrozona*), redfish (like red roman, *Chrysoblephus laticeps*) and various species of shark. In recent years, increasing resource scarcity, variability in physical systems and policy uncertainty has plagued this fishery (Gammage, 2015; Gammage et al., 2017a). The crew component – small-scale fishers who act as crew in the commercial linefishery – are the focus of this study. This group of fishers, marginalised under South African Apartheid laws, remain designated as 'previously disadvantaged'. Generally, these fishers are poor, not well (formally) educated and highly vulnerable to change (Gammage et al., 2017a, 2019; Martins et al., 2019). Due to their perceived inability to participate meaningfully in formal decision-making processes, they often remain excluded (also see Isaacs, 2006; Sowman, 2006; Sowman et al., 2014). They live in rural, semi-rural and peri-urban areas (**Figure 1**) with direct and indirect access to the ocean (Gammage et al., 2017a).

In South Africa small-scale fisheries are managed through the Small-Scale Fisheries Policy (Act No. 474 of 2012) (DAFF, 2012). Adopting a people-centred approach to management, and recognising the important role played in poverty alleviation, the

SSFP seeks to address sustainable development, empowerment, and inequality for small-scale fishers (Sowman et al., 2014). The implementation of this policy (alongside the commercial handline fishing rights) has, however, been plagued with delays, with government being unable to successfully implement across South Africa since promulgation in 2012. Hamstrung by the non-allocation of long-term fishing-rights, challenges associated to policy and regulation remain 'top of mind' (Gammage et al., 2017a, 2019; Gammage and Jarre, 2020).

In addition to the regulatory challenges, the southern Cape linefishery is experiencing challenges with resources scarcity, increasing variability in physical systems and policy uncertainty (Gammage et al., 2017b, 2019; Martins et al., 2019). For fishers to secure sustainable livelihoods in future, these communities will need to respond to change more proactively, engaging in activities that are based on informed decisions (Gammage, 2015; Gammage et al., 2017b).
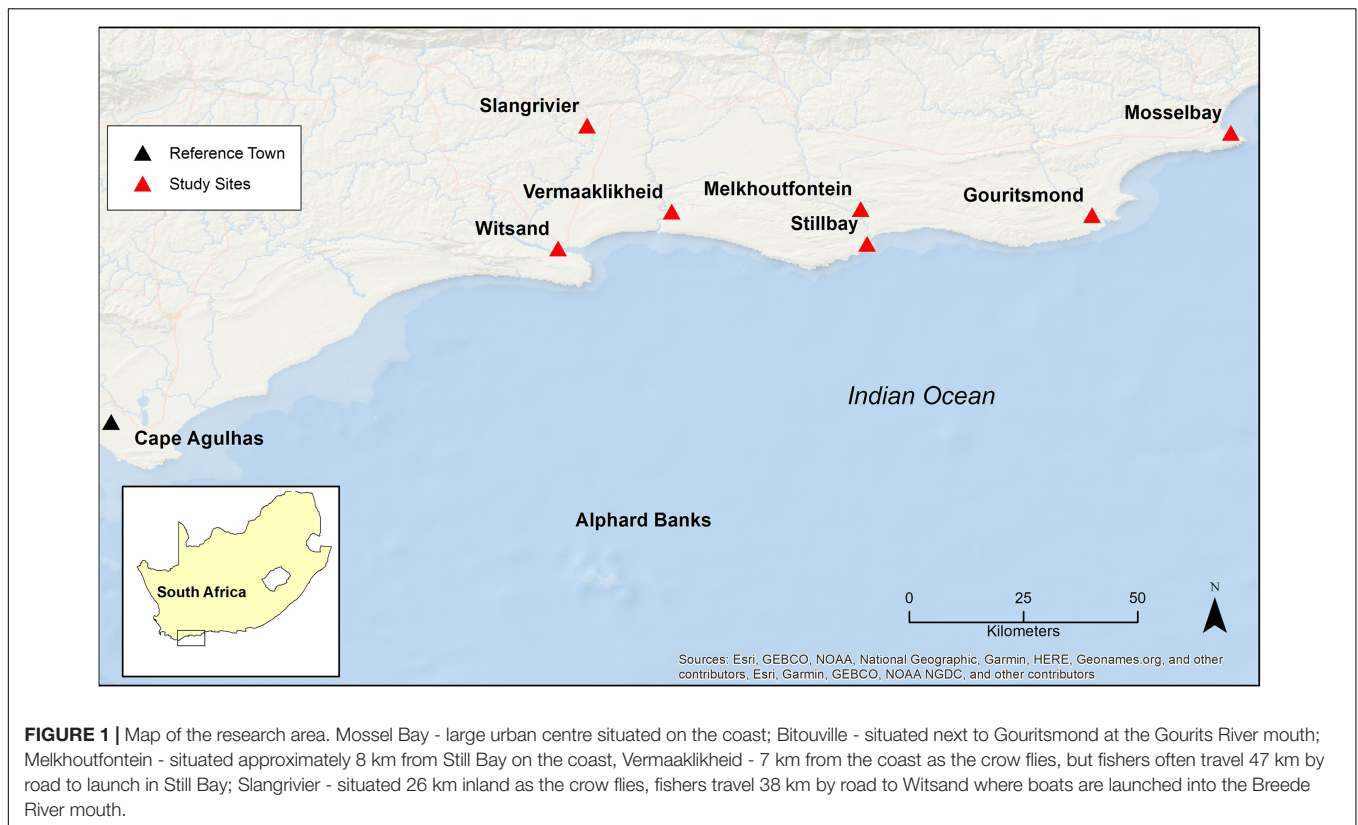
Using Structured Decision-Making Tools (SDMTs) to Include Marginalized Fishers Into Management Discourses

We used systems-thinking[7] to implement a prototype scenario planning approach developed with small-scale fishers who operate in South Africa's southern Cape linefishery. After establishing the drivers[8] of change from the fishers' perspectives using qualitative (see Gammage, 2015; Gammage et al., 2017a) and quantitative (see Gammage et al., 2019) survey methods, we used structured decision-making tools (SDMTs, specifically causal mapping and Bayesian belief networks for problem structuring) to contribute to a more complete system description, thereby adding to the knowledge base on drivers of change (Gammage and Jarre, 2020). As the next step, scenario stories were generated in an interactive and iterative process (Gammage, 2019; Gammage et al., in review). The overall approach provides a prototype which can be expanded to include more diverse stakeholders from various decision-making scales (**Figure 2**).

Firstly, we describe the broad findings of each component of the overarching approach (**Figure 2**) as they relate to the SDMTs outcomes (product). Detailed methods and results for each component have been published elsewhere (Gammage et al., 2019; Gammage, 2019; Gammage and Jarre, 2020; Gammage et al., in review). The process-related results are provided in section "Addressing Challenges Associated With Scale" as a reflection on challenges associated with scale as they relate to this case study. Details of the overarching methodology

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[7]Arnold and Wade (2015: 675) define systems thinking as "a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects. These skills work together as a system."

[8]The terms 'stressor' and 'driver of change' were often used synonymously throughout this research. The term 'stressor' was specifically used in the interactions with the fishers as the meaning was universally understood. For the purposes of this research the terms stressors and drivers of change are "broadly defined to include a wide range of factors, including micro-and macro level social and environmental changes. . .of which impacts can manifest at individual household and community level as gradual or sudden shocks. . ." (Bunce et al., 2010, 409).

FIGURE 1 | Map of the research area. Mossel Bay - large urban centre situated on the coast; Bitouville - situated next to Gouritsmond at the Gourits River mouth; Melkhoutfontein - situated approximately 8 km from Still Bay on the coast, Vermaaklikheid - 7 km from the coast as the crow flies, but fishers often travel 47 km by road to launch in Still Bay; Slangrivier - situated 26 km inland as the crow flies, fishers travel 38 km by road to Witsand where boats are launched into the Breede River mouth.

of the approach and the data sources used are provided in **Supplementary Appendix A**.

Component 1: Stressors That Lead to Change

This component, which forms the basis for scenario-based approach is based on previous research in the southern Cape linefishery (Gammage et al., 2017a, 2019; Martins et al., 2019). Based on this independently published research, we outline salient findings to provide context. These authors describe stressors (drivers of change) in the linefishery system. Gammage et al. (2017a) identified a thematic framework of these drivers (**Figure 3**), dividing them into major stressors (mentioned by 80% and above of participants), mid-range stressors (50% and above, but less than 80%) and minor stressors, (mentioned by less than 50% of participants). Major stressors comprised policy and regulation, climate variation and other fishing sectors; mid-range stressors comprise policy enforcement, economics (capital), "political" issues and socio-economic issues, and minor stressors comprise the geography of the area, infrastructure, social factors, and lack of knowledge. This research has shown that although these stressors are consistent throughout the research area, the poorer fishing communities tend to cope and react rather than proactively adapt, impacting adaptive capacity (Gammage et al., 2017b).

Gammage et al. (2019) argued that the lack of internal variation in responses makes a case for area-specific management in this fishery, echoing findings by Blamey et al. (2015) who argue that spatialised management approaches of the linefish stock at the scale of the southern Cape biogeographic region would be more appropriate than the current practice. At the same time, taking a more inclusive view of the linefishery system also highlighted the complexity and associated uncertainty of the interactions of, and between, these stressors. The same complexity and uncertainty made it difficult for fishers to apply risk-adverse decision-making strategies. In this case, determining principal drivers of change was a first crucial step in this scenario-based approach.

Component 2: Causal Mapping to Structure Complexity

A set of causal maps, implemented across the research area, built on the thematic framework and was further refined by an iterative participatory process with fishers (Gammage and Jarre, 2020). Here we present a broad overview of the findings. The resulting, final causal map, constructed from inputs from all towns in the research area, are shown in **Figure 4** (also refer to Gammage and Jarre (2020) for more detail on the map). These maps highlight feedback loops and indirect interactions not immediately apparent from the previous, qualitative research (Gammage et al., 2017a). These causal maps helped fishers form a more complete picture of their fishery, including direct and indirect relationships between stressors and highlighting system complexity.

The successful implementation of the tool demonstrated the usefulness in showing complexity, together with the ability to easily integrate perspectives and knowledge from various sources
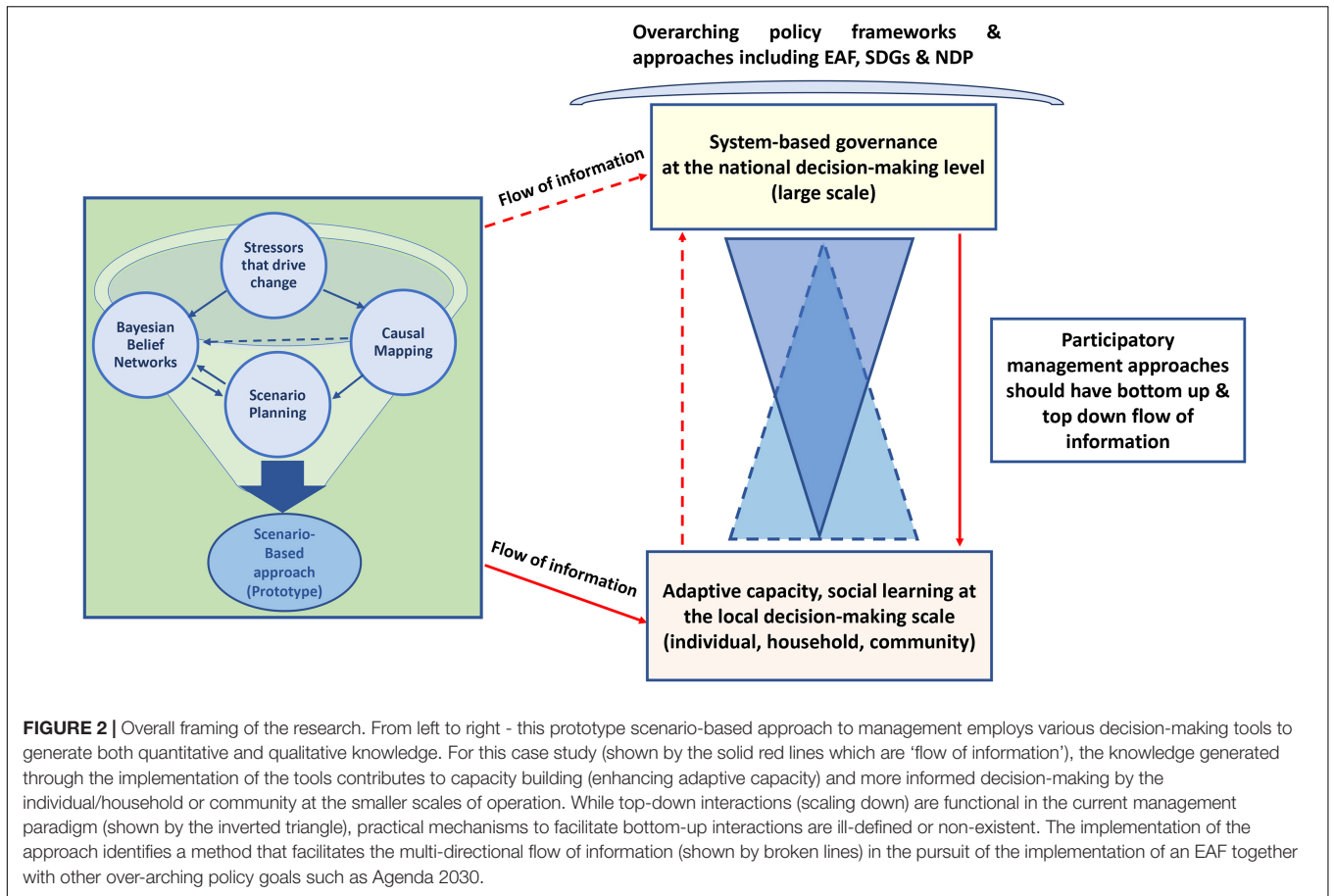
FIGURE 2 | Overall framing of the research. From left to right - this prototype scenario-based approach to management employs various decision-making tools to generate both quantitative and qualitative knowledge. For this case study (shown by the solid red lines which are 'flow of information'), the knowledge generated through the implementation of the tools contributes to capacity building (enhancing adaptive capacity) and more informed decision-making by the individual/household or community at the smaller scales of operation. While top-down interactions (scaling down) are functional in the current management paradigm (shown by the inverted triangle), practical mechanisms to facilitate bottom-up interactions are ill-defined or non-existent. The implementation of the approach identifies a method that facilitates the multi-directional flow of information (shown by broken lines) in the pursuit of the implementation of an EAF together with other over-arching policy goals such as Agenda 2030.
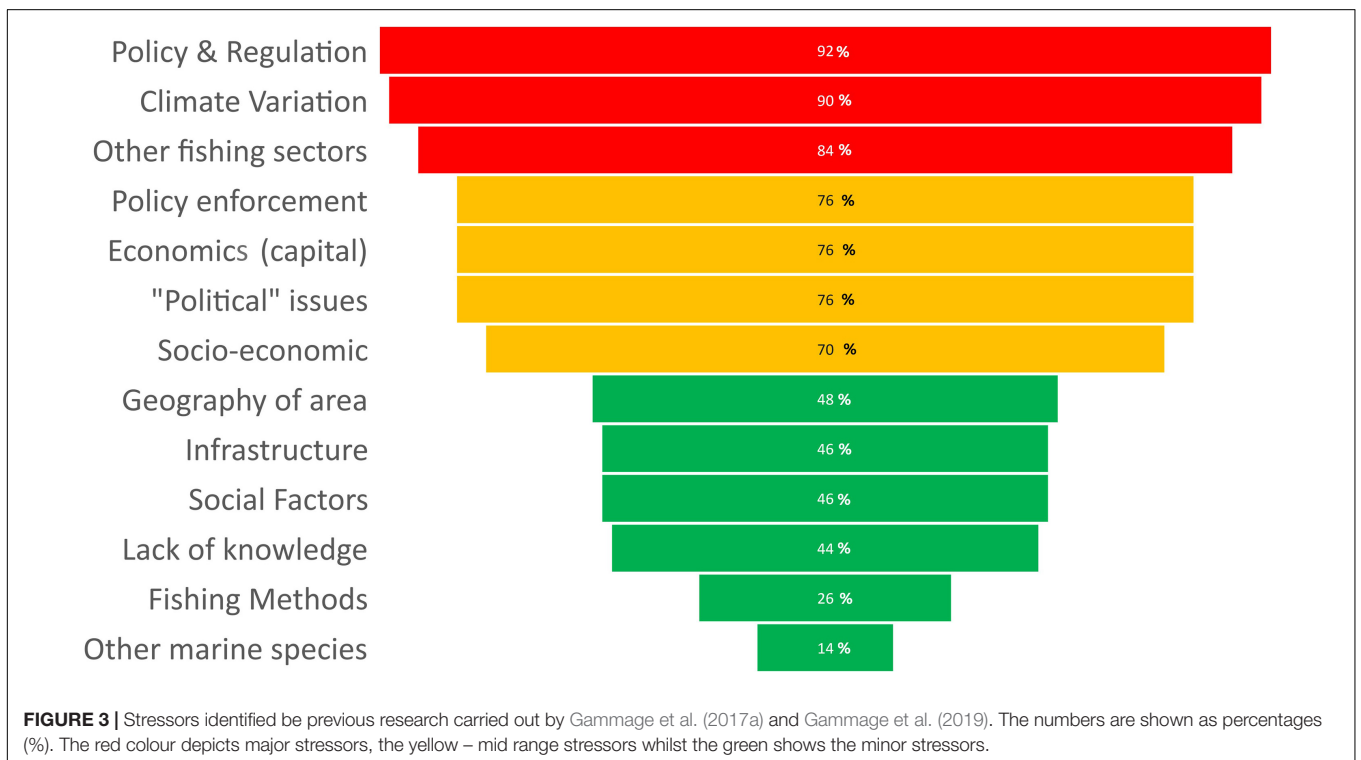

FIGURE 3 | Stressors identified be previous research carried out by Gammage et al. (2017a) and Gammage et al. (2019). The numbers are shown as percentages (%). The red colour depicts major stressors, the yellow – mid range stressors whilst the green shows the minor stressors.

(Gammage and Jarre, 2020). When considering challenges with scale, the parity in results depicting stressors with results from previous research suggested that geographic scale should not be considered above contextual (or conceptual) scale (also see Gibson et al., 2000) in management and decision-making contexts. For the southern Cape linefishery, this implies that management decisions should rather be made at an appropriate ecosystem scale (biogeographic region) (also see Blamey et al., 2015) as opposed to the currently defined linefish management zones.

Component 3: Bayesian Belief Networks to Capture Different Views on Relative Impact of Main Drivers

A prototype Bayesian Belief network[9] (BBN) (**Figure 5**) was constructed through a workshopping process that took place in the town of Melkhoutfontein (see Gammage and Jarre, 2020).

Insights into the drivers resulting from the construction process are consistent with those from previous research and the causal mapping. Sensitivity analyses of the BBN confirmed the high uncertainty in the system, across the various stressors relating to principal drivers (see Gammage and Jarre, 2020). Importantly, the BBNs presented the opportunity to combine different knowledge streams and data, whilst capturing the uncertainties that have arisen from discrepancies in individual views. Furthermore, through the iterative construction process, important space for dialogue was created where 'top of mind' concerns which often dominated the discourse, were addressed in a constructive forward-thinking setting. The importance of the findings in this context is that the tool, though abstract, was implementable with a group of disenfranchised fishers who would not normally be involved in such a development process. This prototype BBN is not yet suitable to inform decision-making, its value lies in the process around its construction. It created an important space for participants to engage with each other on difficult topics through mutual learning. The process demonstrates the value of continued engagement with fishers and other stakeholders to create enabling conditions such as spaces for active dialogue and learning (Gammage and Jarre, 2020) – a requirement for active participation of all stakeholders in a decision-making context.

The implementation of both the causal maps and the BBN have provided insights into how human dimensions of marine SES can be better integrated into an EAF in South Africa, by offering a possible methodological blueprint for future multi-stakeholder processes at larger scales of operation, while at the same time promoting mutual learning and capacity building at the local scale. The use of these tools allowed for the reframing of questions on familiar topics, thereby moving conversations beyond the superficial, standard responses toward a more positive forward-thinking and solution-driven space (Gammage and Jarre, 2020).

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[9]"Bayesian Belief Networks (BBNs) are models that provide graphic and probabilistic representations of the relationships that exist amongst the variables within a parameterized system (Smith et al., 2018). The term BBN refers to an acyclic directed graph of probability distributions (Nicholson and Flores, 2011; Johnson and Mengersen, 2012)" – Gammage and Jarre, 2020:5

Component 4: Developing Stories of Multiple Future Scenarios
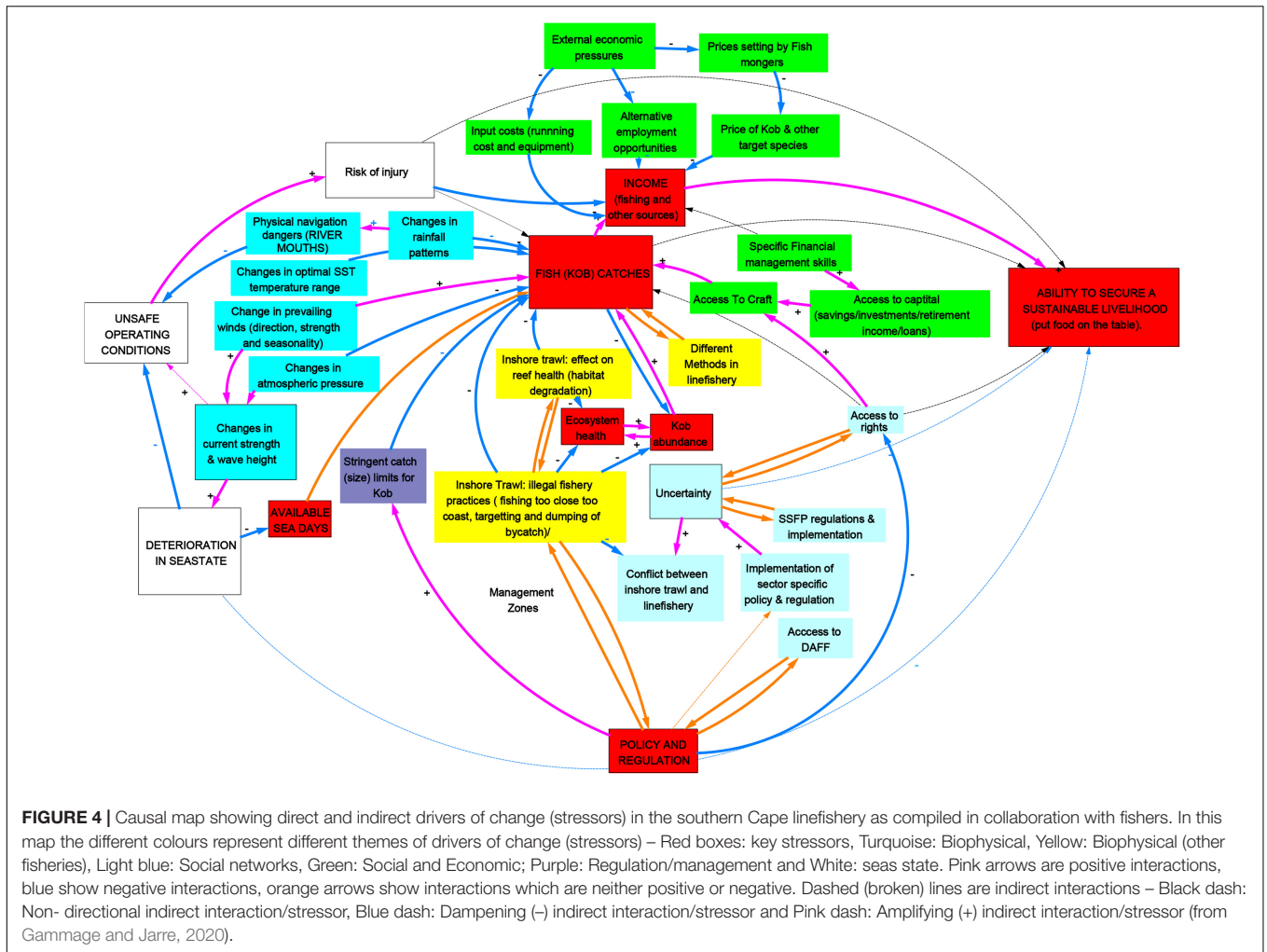
Scenario stories, using information gained from the same workshopping process used to derive the BBNs, were constructed for the town of Melkhoutfontein. The details of this component are being published independently (see Gammage, 2019 and Gammage et al., in review). Here we present a brief overview of the research and findings.

Centred on two key driving forces (KDFs) identified by participants – 'Access to capital' and 'Access to Marine resources (Rights)', the final stories were complemented by two more KDFs identified through the BBN sensitivity analysis – 'Climate change' and 'Fish availability,' which were subsequently used as a basis to build four scenarios for the town in 30 years' time. **Figure 6** presents an artistic depiction of these stories. The first story, 'Nothing much has changed,' closely follows the present conditions in the town. The second story, 'We will get there eventually,' is based on a possible future where fishers do have access to marine resources, but they lack access to funds, curtailing their options and resulting in quite subtle differences between this and the first story. The last two – more positive - stories, 'The going is good' and 'The future is bright,' result from more positive politico-economic scenarios. Interestingly and significantly, the participants did not imagine futures where the individual's riches were foregrounded, but rather built futures where the increased money in the town is used to improve the town for everyone in the community, e.g., through increased employment opportunities in small businesses, through the development of a business district, improvement of public amenities and infrastructure and the development of tourism (Gammage, 2019; Gammage et al., in review).

In their current form these scenario stories - developed at a small scale and with a homogenous group of stakeholders - are most valuable to the fishers of Melkhoutfontein. This is due to the mutual learning that took place, the knowledge co-creation and the development of a systems view. As with the SDMTs, the process created the space to reflect on interactions in the marine SES and the implications of changes on the possibilities of the future under certain conditions, sometimes forcing fishers to contrast and consider more diverse issues at scale. From our results, there is no doubt that scenario planning can provide opportunities to address some of the challenges associated with multi-scalar governance in marine SESs. The promotion of learning and capacity building is not only valuable at the level of the individual or community, but also an important step in eventually building the capacity for disenfranchised stakeholders to meaningfully engage in larger scale scenario-planning processes (Gammage, 2019; Gammage et al., in review).

Addressing Challenges Associated With Scale

In implementing the overall approach, important insights have been gained related to the process and how this can be improved upon, specifically on the role of scale in the management of this fishery. As a start, it is important to define the flow of information between the various decision-making scales in the linefishery

FIGURE 4 | Causal map showing direct and indirect drivers of change (stressors) in the southern Cape linefishery as compiled in collaboration with fishers. In this map the different colours represent different themes of drivers of change (stressors) – Red boxes: key stressors, Turquoise: Biophysical, Yellow: Biophysical (other fisheries), Light blue: Social networks, Green: Social and Economic; Purple: Regulation/management and White: seas state. Pink arrows are positive interactions, blue show negative interactions, orange arrows show interactions which are neither positive or negative. Dashed (broken) lines are indirect interactions – Black dash: Non- directional indirect interaction/stressor, Blue dash: Dampening (–) indirect interaction/stressor and Pink dash: Amplifying (+) indirect interaction/stressor (from Gammage and Jarre, 2020).

governance structure. To successfully implement collaborative system-based approaches such as EAF, multi-level and cross-scale governance require information and knowledge that is not only 'top-down' but also 'bottom-up'. **Figure 7A** shows the current management paradigm in the South African context. Although bottom-up management practices may be espoused in legislation such as the MLRA, the mechanism to affect practices from the bottom up is not defined nor effective (shown by the broken line); management remains top-down with local scale interaction not being considered at the policy decision-making scale (Sowman, 2011). Importantly, the SSFP makes explicit provision for the co-management of small-scale fisheries, although the same is not true for other fishing sectors. When considering the interaction between national and multinational (**Figure 7B**), the bottom-up interaction is more effective as South Africa is afforded the opportunity to give input as participant in and signatory of multi-national/international fora and agreements, such as the EAF.

For the southern Cape, a bottom-up management approach would imply an uptake of fishers' knowledge at the policy-making scale together with more meaningful sharing of information and interactions between the small-scale, commercial handline and inshore trawl fisheries, which operate in the same area (Gammage, 2019). Competing interests at various levels of

decision-making exist - for example, local perspectives on biodiversity tend to focus on livelihoods (Gammage et al., 2019; Gammage and Jarre, 2020), the national level may focus on tourism development and the international level on global biodiversity conservation. Importantly, these competing interests also exist between different fishery sectors. All these perspectives are unique and valid and need to be incorporated into overarching governance and decision-making structures.

Through the implementation of the SDMTs within the context of our approach, it became clear that the approach presented an opportunity for more direct engagement with problems of scale, due to the potential it holds for the facilitation of dialogue at various levels of the decision-making structure. Applied in the approach pursued here, the tools present a means to engage more directly with problems of scale by facilitating dialogue at and between various levels of the decision-making structure. Even when carried out at this small scale, it was not only useful for capacity building but also provided valuable insights that would be valuable at larger scales. **Figure 8** shows how such a multi-scalar decision-making process using scenario approaches could work in the South African context. Here we suggest how approaches such as this one (the tools or methods), can facilitate both 'top-down' and 'bottom-up' flow of information within
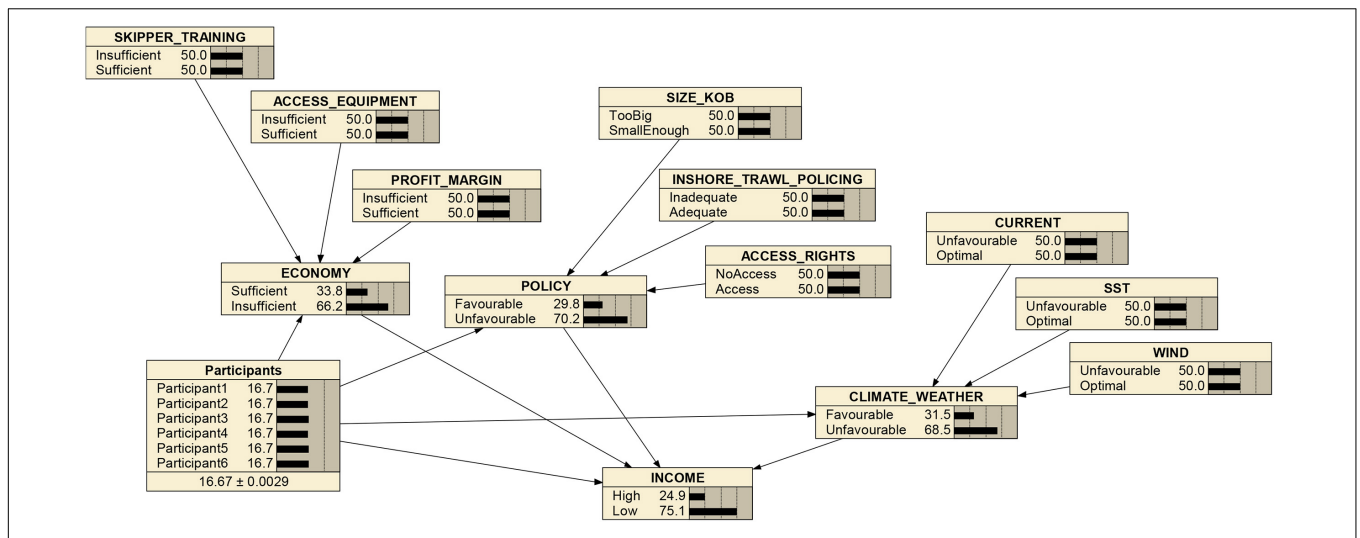
FIGURE 5 | This prototype Bayesian Belief network (BBN) represents six individual networks combined into one through the addition of the auxiliary node "participants" (each with a weighting of 16,7%). The outcome node for this network is "Income" and refers to the 'Ability to earn a sustainable fishery-derived' income. At the next level of the network are the "Climate-Weather," "Economy" and "Policy" nodes. Each of these nodes have three contributing factors which have no inputs in this particular model, and the states are thus set as being 50/50. Each node in the network has a dichotomous state indicating a favourable/unfavourable outcome expressed as a percentage (%) (from Gammage and Jarre, 2020).
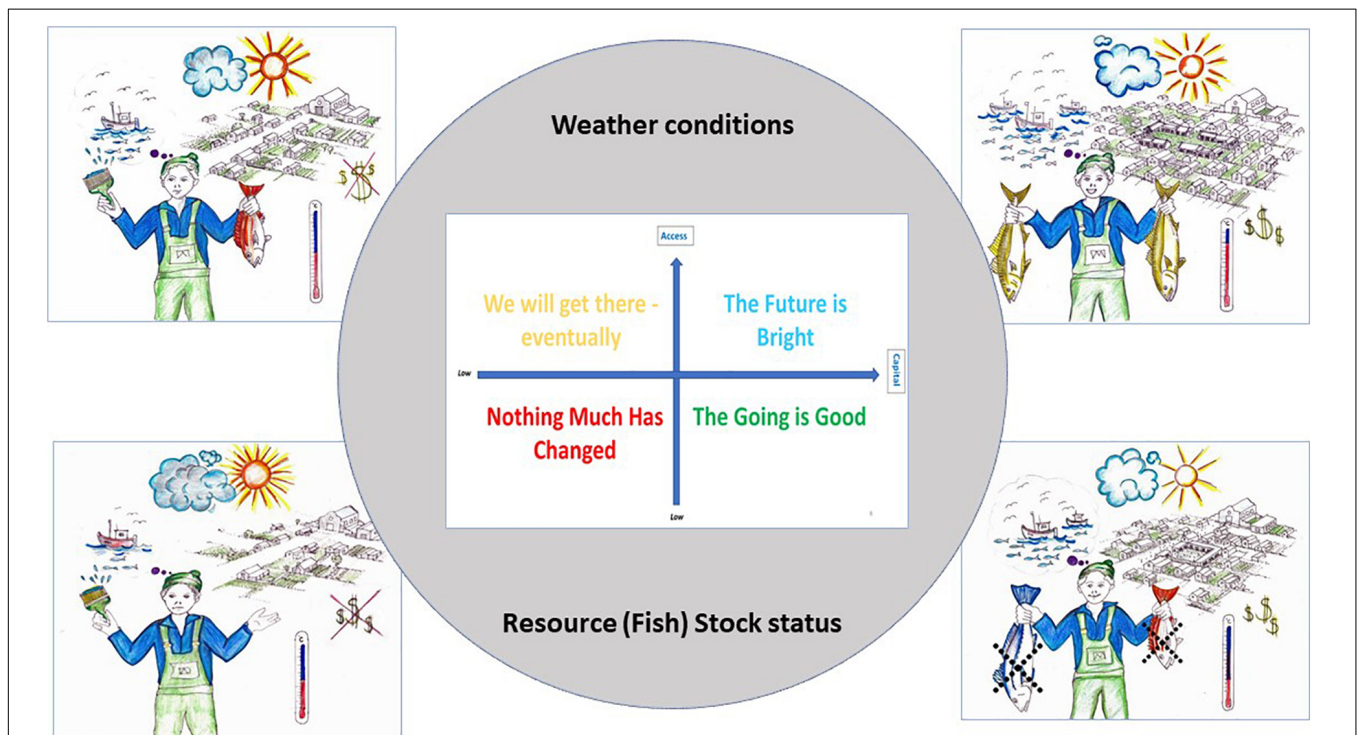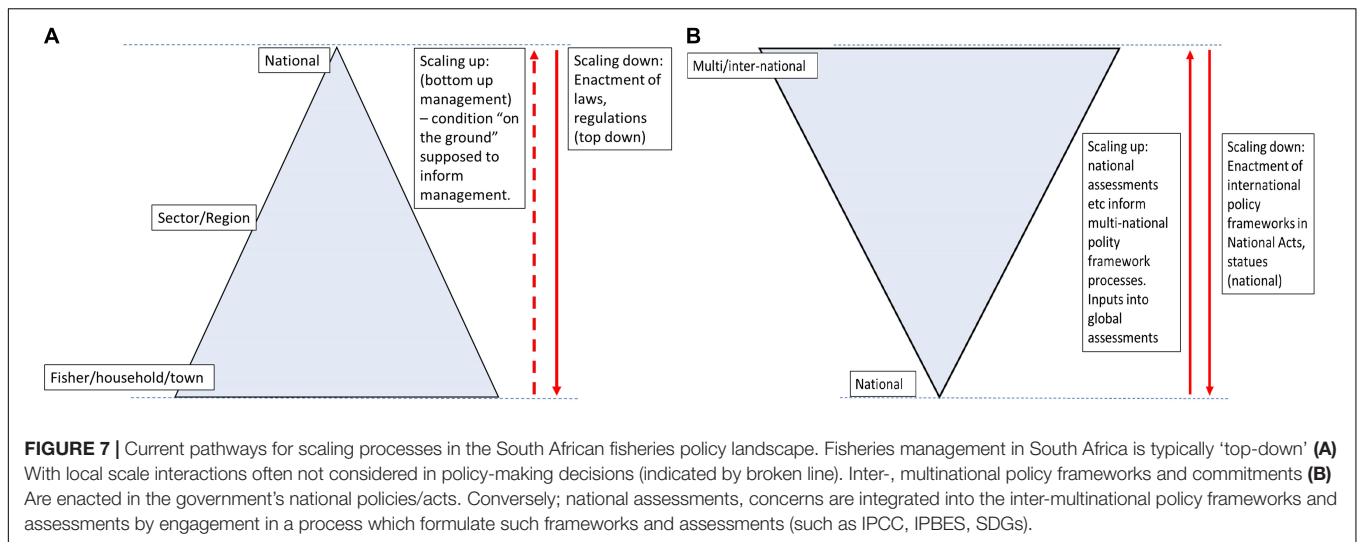

FIGURE 6 | Representation of the four scenario stories were designed around two Key driving forces (KDFs) defined by participants – access to (fishing) resources and access to (financial) capital. The context of two additional KDFs – resources (fish) availability and climate variation, were integrated with the fishers' stories into four distinct stories – "Nothing much has changed," "We well get there, eventually," "The future is bright" and "The going is good" (adapted from Gammage, 2019).

and between various decision-making (or governance) scales, where policy processes are not linear, but iterative. By facilitating bottom-up flow of information, the small-scale 'situation on the ground' can inform policy decisions to ensure best-fit policies at the national level that take all stakeholders and their needs into account. National assessments and policies would in turn inform the country's inputs to international fora and policy frameworks. These multi-and international policy frameworks must at the

FIGURE 7 | Current pathways for scaling processes in the South African fisheries policy landscape. Fisheries management in South Africa is typically 'top-down' **(A)** With local scale interactions often not considered in policy-making decisions (indicated by broken line). Inter-, multinational policy frameworks and commitments **(B)** Are enacted in the government's national policies/acts. Conversely; national assessments, concerns are integrated into the inter-multinational policy frameworks and assessments by engagement in a process which formulate such frameworks and assessments (such as IPCC, IPBES, SDGs).

same time be enacted in the country's national legislation, which in turn must be enacted regionally and locally through the implementation of appropriate regulations and incentives. This two-way flow is essential for the needs and goals at the smallest scale of operation to be represented adequately.

By using SDMTs in these approaches, it not only becomes possible to integrate diverse knowledge streams from stakeholders across the SES, but also to facilitate communication and flow of information between various management scales. For multi-scalar processes, this is demonstrated by the ability to build local adaptive capacity, through learning, at the scale of the individual or town while at the same time engaging in processes that can inform larger-scale decision making (see Gammage, 2019; Gammage and Jarre, 2020; Gammage et al., in review).

DISCUSSION

This scenario-based approach is an example of how existing methods can be used in novel ways to address some of the challenges raised by changing marine SESs. Viewed holistically, the implementation of this approach highlights issues of complexity and scale of decision-making in the southern Cape linefishery, specifically within the context of the promotion implementation of an EAF in South Africa.
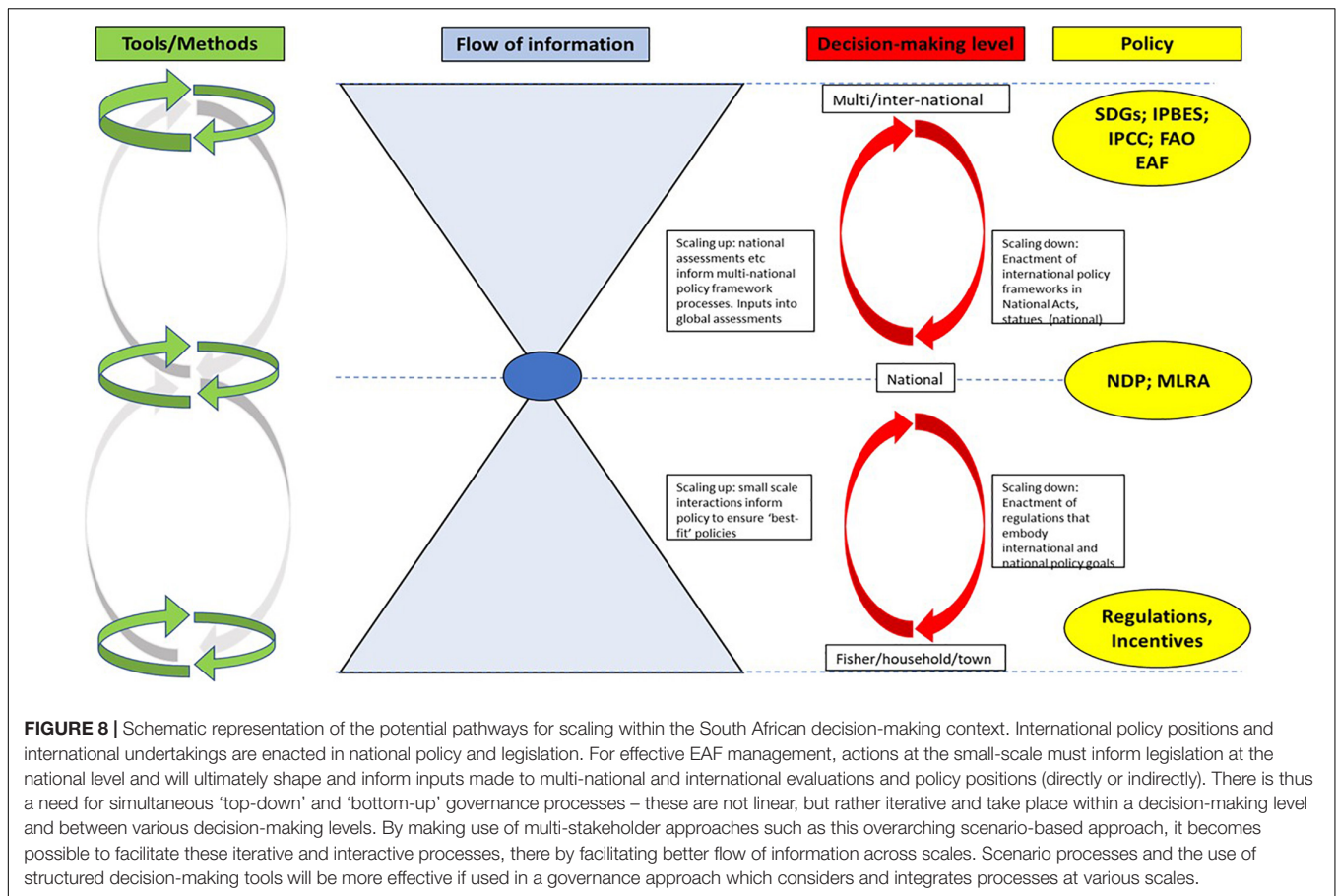
Complexity, Uncertainty and Managing Human Activities in the Southern Cape Linefishery

For the fishers of the southern Cape, it could be argued that what matters is not how fishers respond (adapt, react, cope), but instead how they are capacitated to respond to changes and drivers of change in proactive ways that are appropriate (in time and scale) for the situation. The scenario stories underscore the realistic (and attainable) ambitions participants hold for developments over the next generation. Notably, one of the highlights was that they do not limit their focus on

the individual/household response but consider the community (town) as a whole – which is in keeping with the findings of previous research where change response strategies were identified per town (Gammage et al., 2017b). The Coasts Under Stress project (Ommer and Team, 2007) had similar findings in Canada. The importance of the community and its well-being recognised by fishers in this study for the ability to achieve sustainable livelihoods and well-being has important implications for management objectives, which should target at the level of the community.

The challenge presented by issues of scale is a key characteristic of the complexity of the human-environmental system, especially where multi-level decision-making is required. Governance issues in the Anthropocene are often multilevel and cut across jurisdictional scales while linking decision-makers both horizontally and vertically (Berkes, 2017). A governance approach will be more effective when the scale of ecological processes is well matched within the human social institutions that are charged with managing in the human-environmental interactions (Leslie et al., 2015).

In the case of South African fisheries, sectoral management enforces a mismatch between the scales of the ecosystem and that of the management structures. This is demonstrated by the delineation of management zones in the South African linefishery (DAFF, 2013) and the linefish stock composition on the western Agulhas bank (Blamey et al., 2015). To ensure better alignment between management and ecological scales, Blamey et al. (2015) show how management zone delineation could be adjusted to better suit the fish assemblages (ecological) units of scale. For the southern Cape line fishers, a better alignment between ecological and management scales would benefit both the natural subsystem of the SES and the fishers operating in the revised regions because it would provide a (1) meaningful boundary on the set of stakeholders to be included in management decisions and (2) provide them with an appropriate space in the decision space. Such a shift in approach could

FIGURE 8 | Schematic representation of the potential pathways for scaling within the South African decision-making context. International policy positions and international undertakings are enacted in national policy and legislation. For effective EAF management, actions at the small-scale must inform legislation at the national level and will ultimately shape and inform inputs made to multi-national and international evaluations and policy positions (directly or indirectly). There is thus a need for simultaneous 'top-down' and 'bottom-up' governance processes – these are not linear, but rather iterative and take place within a decision-making level and between various decision-making levels. By making use of multi-stakeholder approaches such as this overarching scenario-based approach, it becomes possible to facilitate these iterative and interactive processes, there by facilitating better flow of information across scales. Scenario processes and the use of structured decision-making tools will be more effective if used in a governance approach which considers and integrates processes at various scales.

result in the reduction of friction within the fishery, by allowing for trust to be built between various stakeholders (Duggan, 2018).

Implications for the Implementation of an Ecosystem Approach to Fisheries Management in South Africa and Scope for Future Work

While rooted in the human dimensions of SES and keeping a focus on stakeholder engagement, this case study has explored tools which can be practically implemented to achieve a balance between social, economic and ecological objectives, as needed for a successful EAF. The research, which is reproducible, transparent and adhering to principles of democracy and ecosystem justice[10] (Brunk and Dunham, 2000) opens a new view on the human dimensions of the southern Cape linefishery (Gammage and Jarre, 2020) and describes a methodology which can be applied in ecologically meaningful regions and across fishery sectors in South Africa.

For any EAF implementation to succeed, various perspectives need to be integrated into the decision-making process at various scales. Paterson et al. (2010) highlight the need for a

transdisciplinary approach where real-world problems are used to develop solutions in partnerships with multiple stakeholders. They identify a common vision, exemplified by the development of an EAF and the means to facilitate useful interactions using SDMTs, as the two most important requirements for the development of sustainable research partnerships. SDMTs do not only help stakeholders make sense of their SES, but also guide managers in uncertain and complex systems. Through participating in processes where such tools are developed in support of an EAF, a common focus for all stakeholders can be fostered. Additionally, through the implementation of such approaches, it is also possible to address barriers to the successful implementation of an EAF. Importantly, through the development and implementation of scenario-based approaches, we are also able to address different system needs at various scale simultaneously which may be a crucial step forward in appropriately addressing the challenges associated to practically dealing with challenges presented by scale mismatches in SES.

Considering these requirements, the scenario-based approach presented here provides a means to conduct the type of transdisciplinary research required in the development and implementation of an EAF in South Africa. This research has shown that SDMTs can work in communities where participants/fishers have little formal education. Here we show that to engage stakeholders there is no need to lose structure altogether. With structure crucial to the practical aspects of

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[10]Ecosystem justice is "the ethically acceptable relationship among all competing and complementary interests of an ecosystem 'community'" (Brunk and Dunham, 2000:294).

fisheries management to ensure repeatability and transparency, this finding shows that by using SDMTs in processes where the required groundwork, capacity building and resourcing take place, it is possible to integrate vulnerable, marginalised stakeholders into formal decision-making processes directly and effectively, as required by the EAF (Garcia et al., 2003).

This paper presents an approach which will need to be developed more widely and comprehensively to make a meaningful decision-making contribution. As a start, this would entail scaling up to cover a larger geographical scale. For the southern Cape linefishery this would entail engaging with all fishery sectors who target linefish in the area between Cape Infanta and Cape St Francis. Crucial to the success of such a process is the painstaking work of laying the appropriate basis to ensure that all stakeholders are engaged in a co-initiating (or convening phase). Kahane (2012a,b) describes the requirements of this first phase of the process in detail while also highlighting the importance of the phase for the overall success of the process.

Initiating the scenario-planning process will be challenging given the South African fisheries management context. Although the State is central to management, it is considered weak (Norton, 2014; Jarre et al., 2018). To convene a process that can have meaningful inputs at various decision-making scales, it will be important to at least have a champion within the State who would be willing to participate in such a process. Institutions such as NGOs who have close links to the target communities will also be crucial to the co-initiating phase, as discussed above. Importantly, much time and effort will have to be spent by the research and facilitation team to identify and approach key individuals from the State and other institutions who will be willing to learn from each other, remain engaged in a long-term project and who can facilitate collaboration with various communities of fishers. It does not mean it cannot be done.

Given the inductive nature of the research, it remains important that some flexibility is built into the research design. Although the prototype process has been based on the principles of a TSP, there is space to integrate other types of scenarios into the process. There is also a need to ensure that the tools used for structured decision-support are appropriate, bearing in mind that there are more tools that can be developed. While the tools were mostly used successfully in this research, these tools may not be suitable for all contexts and would require testing (prototyping) in different contexts to ensure wide applicability. As the robustness of the process depends on diverse stakeholders giving diverse opinions on often sensitive matters, an experienced facilitator (or facilitation team) remains key to the eventual success of the planning process. Importantly, the need to implement the process in a slow-and-careful manner which ensures that all participants are prepared to actively engage with the process, together with the time and resources to ensure a properly facilitated process with diverse stakeholders, remains key to the successful implementation of the approach. These findings underline the simultaneous focus on product and process highlighted by McGregor (2015) in her research with stakeholders in the large, highly capitalised SA small pelagic fishery (also see McGregor et al., 2016).

For linefishers, the creation of enabling conditions, where policy and decision-makers (which include fishers as direct resource users) at various levels actively engage on issues affecting the marine SES, is key to effectively implementing an EAF, moving fisheries and dependent coastal communities closer to attaining sustainable futures. Specifically, this research shows that by engaging in capacity building on the ground, disadvantaged communities can actively be empowered to participate in more complex, multi-stakeholder planning processes. Their inputs could thus inform policy processes in a bottom-up approach, as opposed to the current top-down approach. While bottom-up management mechanisms do not currently function well in South Africa, the approach demonstrates the potential to facilitate a two-directional flow of information between scales.

CONCLUSION

Complexity and uncertainty in marine SESs hamper effective decision-making at all scales. Traditional forecasting approaches will likely not overcome the limitations posed by various uncertainties in models, thereby hampering decisions toward mitigation and adaptation (Quay, 2010). This contribution argues that scenario-based approaches present a practical, scalable methodology that can facilitate learning, capacity building and decision-making with the ultimate aim of improving the implementation of an EAF. Importantly, through the use of SDMTs, crucial local system insights have been documented, enhancing our understanding of local system interactions.

The benefit of oceans to people is undeniable and well described. Complexity and uncertainty in marine SES require a change in thinking in how we perceive, study, manage and govern. Considering that the earth system seems to be nearing critical tipping points faster than previously expected, it becomes evident that this paradigm shift cannot take the traditional 'slow and steady' trajectory generally favoured by researchers and decision-makers alike. Importantly, this change in thinking calls for research that moves beyond the traditional framings and discourses that place the focus on what we know, toward approaches where there is a focus on increasing the capacity of stakeholders to make sustainable decisions within rapidly changing complex adaptive systems with an eye on actively planning for the future.

The research presented in this paper has shown that modelling approaches such as SDMTs can be carried out with disenfranchised stakeholders, even if they have not previously been exposed to such methods. Through the implementation of an interactive and iterative process, the process has resulted in the promotion of capacity building at the scale of the individual, household and community of fishers. Importantly, meaningful scenarios have been developed with the small-scale fishers in Melkhoutfontein. Reflecting on the development and implementation process has allowed for the discussion of multiple stakeholder settings and the value of the approach in addressing issues across multiple scales in SESs.

By building on this essential knowledge of the local SES, the next implementation step will be to scale up the scenario-planning process to an appropriate ecological scale. To facilitate the necessary learning and capacity building required for valuable interactions, the research shows that it is crucial to lay the appropriate basis for multiple stakeholder meetings, with all the effort that needs to go into it. Only then is it meaningful to embark on a full-blown, multiple stakeholder planning process.

Through the implementation of tools and approaches that aim to promote the holistic implementation of an EAF (such as this one used here), it may become possible to improve decision-making at all scales, by promoting adaptive capacity of the person, household and community while enabling improved governance at the larger scale. Ultimately, better decision-making does not only promote social justice for fishers, but also ecosystem justice, both of which are crucial not only for the implementation of an EAF, but more generally, for long-term system sustainability.

DATA AVAILABILITY STATEMENT

The datasets generated for this study cannot be made publicly available due to restrictions from ethics requirements and agreements with research participants. Requests to access the datasets should be directed to LG, louise.gammage@uct.ac.za.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Cape Town – Faculty of Science Research Ethics Committee (FSREC 03 – 2016). The participants provided informed consent to participate in this study, in writing.

AUTHOR CONTRIBUTIONS

LG conceptualised the research, carried out the fieldwork, and authored the manuscript which formed part of her Ph.D. research. AJ was the primary supervisor of the research. All authors contributed to the article and approved the submission.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2021.600150/full#supplementary-material

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