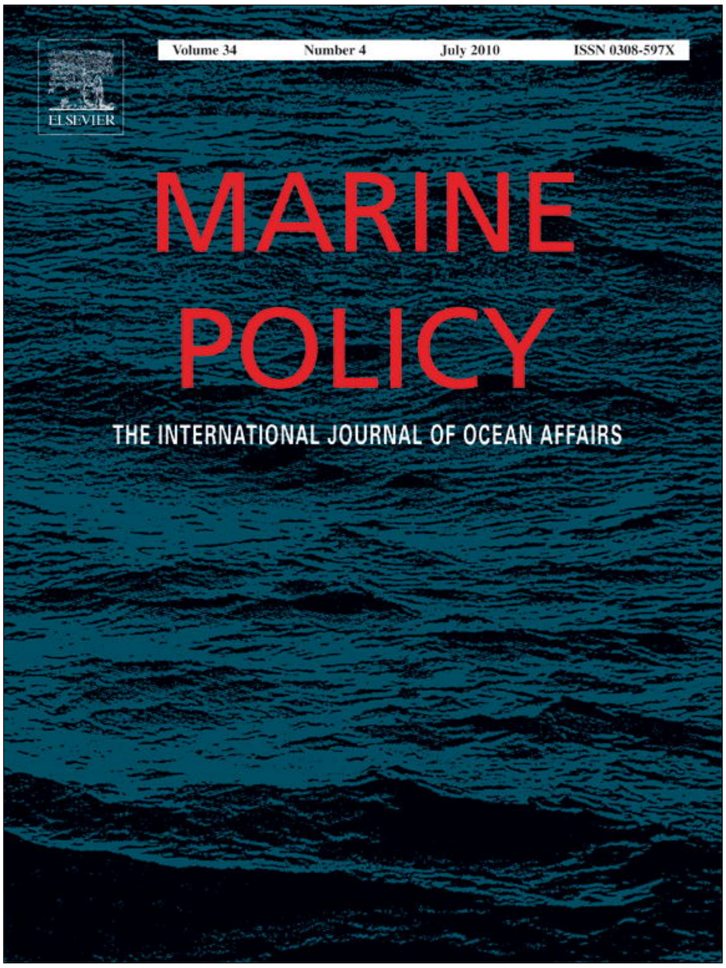
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Transdisciplinary co-operation for an ecosystem approach to fisheries: A case study from the South African sardine fishery

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ABSTRACT

Integrative approaches that involve natural and social scientists are needed to manage fisheries, but these are difficult to achieve. The process of developing a prototype, knowledge-based, electronic decision support tool for the South African sardine *Sardinops sagax* fishery provided a platform for fostering collaboration and achieving active participation of many stakeholders. The aim of the decision support tool is to assist managers in evaluating how effectively an ecosystem approach to fisheries (EAF) has been implemented for this fishery. The collaborative process involved a series of meetings during which knowledge was elicited from fisheries scientists, social scientists, resource managers and fishing industry representatives. Conceptualisations of the different stakeholder perspectives were developed in terms of objectives and indicators following the hierarchical tree approach recommended by FAO. This paper describes the collaborative process. Hierarchies of objectives, indicators and data sets for the human dimension of an EAF in the South African sardine fishery are introduced. The value of a transdisciplinary approach towards an EAF in South Africa is discussed.

1. Introduction

An ecosystem approach to fisheries (EAF) aims at achieving sustainable development in the context of fisheries [1,2]. The term EAF denotes a management concept that combines ecosystem concerns, i.e. approaches aimed at conserving biophysical components of ecosystems, with fisheries management, i.e. management that focuses on fishing activities and target resources in order to satisfy societal and human needs. Dealing with human interaction with the environment, sustainable development is a field where social, technical and economic developments interact and create increasingly complex, multi-dimensional and interrelated problems. Past disciplinary approaches no longer suffice to address these complex challenges [3]. Typically, resource management is linked to fields within the natural sciences, with some economics at best. Consequently, the preferred scientific approach for managing industrialised fisheries is based on single species stock assessment methods within the old paradigm of comprehensive rational planning [4]. However, management of industrialised fisheries is not about managing the resource but about managing fishing fleets and processing industry [5], i.e. managing people. Thus fisheries management is faced with problems outside the purely scientific domain and there is a need to involve not only natural scientists but also social scientists and stakeholders. Moreover, fisheries management problems may reflect deeper sociopolitical and institutional problems within society [6], e.g. issues such as equity, poverty alleviation and redistribution of fishing rights [7]. The natural sciences are not equipped to address these issues and consequently human issues have been misidentified as subjective and political by the natural science dominated discourse [6]. Thus, the analytical strength of the natural sciences has to be combined with the social science study of social transformations [8].

1.1. Transdisciplinarity for an EAF

There is a need for a new approach to fisheries science, one which transcends disciplinary boundaries by changing fisheries management to include a social perspective [e.g. 5,6,9–12]. Integrative and transdisciplinary approaches are required to develop new attitudes, methods and solutions. Although the terms "multidisciplinary", "interdisciplinary" and "transdisciplinary" denote distinct concepts, the words are often used interchangeably. Multi-disciplinarity is a non-integrative mixture of disciplines in the sense that a subject is studied simultaneously in different disciplines. A multidisciplinary research approach aims to deepen the understanding of a topic within each discipline

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through the results obtained in another discipline. For example, the results of historic or religious research inform and deepen the understanding of a particular piece of art studied in art history. Thus multidisciplinary approaches maintain and assert disciplinary boundaries [13,14], whereas interdisciplinarity and transdisciplinarity draw from different disciplines in order to work towards a common goal.

Although there is a substantial body of literature on transdisciplinarity, for an overview see [14,15], it is not easy to make a clear distinction between inter- and transdisciplinarity. In fact, German philosopher of science, Juergen Mittelstrass, suggests that true interdisciplinarity causes changes in the disciplinary order itself, so "transdisciplinarity" is no different from interdisciplinarity [14]. A more radical view of transdisciplinarity is informed by a new worldview of complexity [17], the concept of postnormal science [18] and the theory of Mode 2 knowledge production, i.e. the contextualisation of research around the interests of stakeholders [19–21]. Here the goal of transdisciplinarity is the understanding of the present world through contextualisation of knowledge. This understanding of transdisciplinarity rejects reductionist and mechanistic assumptions, and a belief in the certainty of scientific findings. Instead, the definition of a problem is considered to be a social process and a product of multiple stakeholder involvement, which contributes heterogeneous skills and expertise [3]. This notion is reflected in the rhetoric of "co-management and decentralisation" in managing natural resources [3]. For the purpose of this paper transdisciplinarity is understood as research that starts from real-world problems to develop solutions in partnership with multiple stakeholders [22].

The single most important requirement for developing sustainable transdisciplinary research partnerships is a common vision [12,23], which is exemplified here by developing an ecosystem approach to fisheries management. A second requirement is a means of facilitating useful interactions among people, which is exemplified here by a knowledge-based decision-support tool (DST). DSTs can help guide managers in situations characterised by complexity and uncertainty [24] and the process of developing them for EAF is a way to foster a common focus for transdisciplinary research. The value of such tools (also called expert systems) to foster discussion and enhance communication between scientists and managers has long been stressed [25,26]. Knowledge-based systems provide a way to integrate knowledge from different disciplines into a unified framework and encourage focused and disciplined thinking about this knowledge [23,24]. Different approaches to knowledge-based systems in a marine context are discussed in Jarre et al. [27].

The objectives of this study were threefold. First, a focus group approach was tested as a means of involving multiple stakeholders in the DST development. Second, the study investigated whether the process of developing a DST is useful as a framework for structuring and focussing discussions with different stakeholder groups. In the case that this second point was found to be true, the study intended to make progress with respect to integrating the human dimensions of an EAF into a DST for fisheries management.

2. Challenges to transdisciplinary collaboration in South African EAF research

South Africa looks back on a track record of internationally renowned marine science. The first scientific assessment of fish stocks for industrial exploitation was undertaken by Gilchrist in 1896 [28]. Since then there has been close cooperation between assessment scientists and industry [29]. During the Apartheid era, the South African fishing industry comprised few big companies, which made communication easy and allowed functional co-management while the majority of South Africans were excluded from access to fisheries resources. Thus besides the barriers that hinder transdisciplinary research in general, EAF research in South Africa faces additional challenges in the legacy of Apartheid. With the achievement of democracy in 1994 and the need to reform the sector to address inequities and correct the imbalances of the past, fisheries scientists saw themselves facing a unique challenge: the transformation of the fishing sector [7,30].

During Apartheid the Sea Fisheries Research Institute was responsible for conducting scientific assessments to support the optimal utilisation of South Africa's living marine resources and the conservation of the country's marine ecosystems. It was recognised that fisheries management institutions needed to change in order "to maintain (or develop) legitimacy, efficiency and efficacy" [31]. Consequently the Sea Fisheries Research Institute was renamed "Marine and Coastal Management". This name change notwithstanding the inclusion of complex social objectives (such as equity and poverty alleviation) into fisheries management, while at the same time retaining a highly scientific form of management based on stock assessment, created conflict.

Although there have been some successful collaborations between natural and social scientists in South Africa addressing industrialised fisheries, notably the Knowfish Project [29], the predominant experience is that it is difficult to bring both natural and social scientists to the table. In 2004 an EAF project was launched in South Africa [32], which included a series of stakeholder workshops at which few, if any, social scientists participated [33]. These workshops had been designed and convened by natural scientists who considered the socio-economic dimension of EAF important and invited social scientists to participate in the workshops. From the perspective of the natural scientist, who associates knowledge creation with data and solutions, this is an adequate way of involving stakeholders. From the perspective of the social scientist, however, knowledge creation is context dependent and begins with the conceptualisation of the problem. Thus by not being involved in the design phase, the social scientists feel their knowledge is reduced to technical expertise, which is called in during the final stages of a process to sketch out the relevant social issues or provide hard facts about living communities. Such an extractive practice focuses on the technical expertise of the experts instead of involving them, and reduces the person to a research object rather than an active participant. Similar experiences have been made in transdisciplinary research projects elsewhere [34].

Challenges to transdisciplinarity experienced by natural and social scientists are grounded in the different world views in which the disciplines are embedded. On the one hand there is the realist (positivist) belief that science is a process of discovering the truth about an existing objective reality. As a consequence science is expected to provide answers to all humanity's questions [35]. At the other end of the worldview continuum there is the constructivist belief that scientific findings depend on the kind of questions that are asked and that all knowledge is socially constructed and context dependent [36]. Between these opposite ends there is the pragmatist's view that perceptions, scientific ideas and theories do not necessarily reflect the real world accurately, but are useful instruments to explain, predict and control our experiences [36]. Social science tends to contextualise, whereas natural science focuses on analysis and data processing [37]. This is not to say that all scientists believe in an objective reality not that all social scientists are constructivists. However, many natural scientists observing the impacts of human behaviour on the environment tend to draw conclusions regarding what constitutes good environmental conduct. Such normative conclusions assume that what is natural is good and that knowledge of environmental degradation should prescribe action for conservation [38]. However, empirical knowledge can never prescribe but only inform decisions [39], and what is good remains an open question [40]. Moreover, the underlying value dichotomy of nature versus culture places resource users on the side of the morally wrong [41] and is thus unhelpful to fisheries management and collaborations between social and natural scientists.

In our experience, many natural scientists feel that although they invite social scientists, these either do not attend or do not contribute, but instead question the research approach on so fundamental a level, that it is not considered constructive. Social scientists on the other hand feel that the meetings are designed in a way that does not constitute a forum to which they feel they can make a constructive contribution. In any forum, if one group outnumbers the other there is a danger that the larger group may highjack the discussion. Extended technical discussions between experts of one group give other participants the feeling that they are wasting their time in this forum. At the junctures between fields and disciplines problems arise when the content belonging to one discipline is compressed in favour of another [38]. This can lead to rejection by scientists from other fields, because views differ as to what constitutes the critical dimension of the problem. This tendency represents both a challenge and an important motivation for transdisciplinary research [38]. Such sidelining is often unintentional due to fundamental differences in research approaches. In South Africa it has also been perceived as grounded in the firm disbelief by some assessment scientists that social science can make a meaningful contribution.

Another challenge to successful transdisciplinary discourse are differing constitutive metaphors [38]. Terms are often borrowed from and used across different fields or disciplines with distinct connotations. For instance, the term "regime shift" in its original context refers to a change in prevailing social pattern or a form of government. Marine scientists have borrowed the term to denote the rapid change in the natural drivers that lead to reorganisation of natural systems. The term "environment" used by a marine ecologist refers to the conditions, resources, stimuli, etc. with which an organism interacts, and which may include other organisms. In oceanography the term is used in a stricter sense referring to physical phenomena, such as air, water, climate, etc. Thus, although different fields and disciplines may tap into a common pool of language, the deeper meanings of technical terms are often only clear to the practitioner of the respective discipline. The result is a confusing situation that impedes understanding across different fields and disciplines [38]. The lack of a common universe of discourse can create disappointment when expectations are not met, and spoil the success of interdisciplinary collaboration.

Notwithstanding these challenges, successful transdisciplinary programmes have proved that social and natural science are not incommensurable [e.g. 12]. However overcoming disciplinary boundaries is only possible if awareness of the differences exists [e.g. 6, 38] and effort is made to make connotations and assumptions explicit in order to avoid misunderstandings and disappointments. In South Africa, the desire for inter- or transdisciplinary collaboration is felt by both natural and social scientists alike and has been expressed not only at meetings convened by natural scientists but also at social science meetings. But, although in the context of EAF in the Benguela the need for collaboration has been frequently stressed, it has been difficult to get both natural and social scientists around one table to address the problem together. In the northern hemisphere context, similar experiences were made trying to form an ICES working group to address human (socio-economic) aspects of fisheries management. This working group underwent a pendulum development from first being a predominantly social science forum, then being a mainly natural science forum to a somewhat stable mix at present [42–44].

The transdisciplinary challenges of EAF management require both social and natural science but also benefit from the humanities [45,46]. Unlike natural and social sciences, the humanities are not committed to a particular method. Humanists are used to a multiplicity of seemingly contradictory methods and research objects, from formal logic, linguistics and philosophy to art history and creative writing. This "lack of disciplinary purity" [47], coupled with interpretative methodologies as a means of producing knowledge [47,48], makes humanities practitioners well suited to facilitate transdisciplinary research.

3. Methods

3.1. Decision support for evaluating the effectiveness of EAF

A prototype DST has been developed to monitor the implementation of EAF in the southern Benguela, using the South African sardine fishery as an example [49]. This first prototype used information gathered in an Ecological Risk Assessment (ERA) workshop for the South African Small Pelagic Fishery [33,50], which formed part of the South African EAF project. The tool follows the hierarchical tree approach recommended in the FAO guidelines for responsible fisheries, which organises issues under three categories: human well-being, ecological well-being and ability to achieve EAF [1].

A value tree was developed by breaking the three general top level objectives into increasingly specific operational objectives (Fig. 1). The prototype DST was built by structuring these issues as NetWeaver [51] dependency networks and modelling the indicators for each operational objective as fuzzy input variables [49]. These variables transform input data into truth values which are then propagated bottom-up throughout the hierarchy (Fig. 2). For instance, the fuzzy variable "TB (tuberculosis) incidence rate" (Fig. 2a) returns positive truth values when input values for TB incidence in the Western Cape are below 250 cases per 100,000 inhabitants per year, with 100 or less (TB incidence rate) returning 100% true. When input values for TB incidence rate are above 250 the proposition returns negative truth values, with inputs greater than or equal to 500 (TB incidence rate) returning 100% false. When the TB incidence rate is 250 the proposition is neither true nor false. In line with the first prototype [49], the truth values of the various indicators were aggregated by fuzzy AND nodes.

The prototype tool was evaluated as overall useful [49]. However, because it was developed based on the ERA results, the tool reflected the same low level of disaggregation and detail for the category human wellbeing as the ERA, which suffered from lack of social science input [33]. A different approach was needed to ensure that all stakeholder groups, i.e. natural scientists, resource managers, social scientists and industry, participated equally in the development of the tool.

3.2. Decision support tool development as a mechanism for transdisciplinary EAF research in South Africa

One goal of the DST development was to bring all participants together to work towards an integrative conceptualisation of the fishery. However, at the start not all potential participants were equally prepared to contribute. However, participation is a major

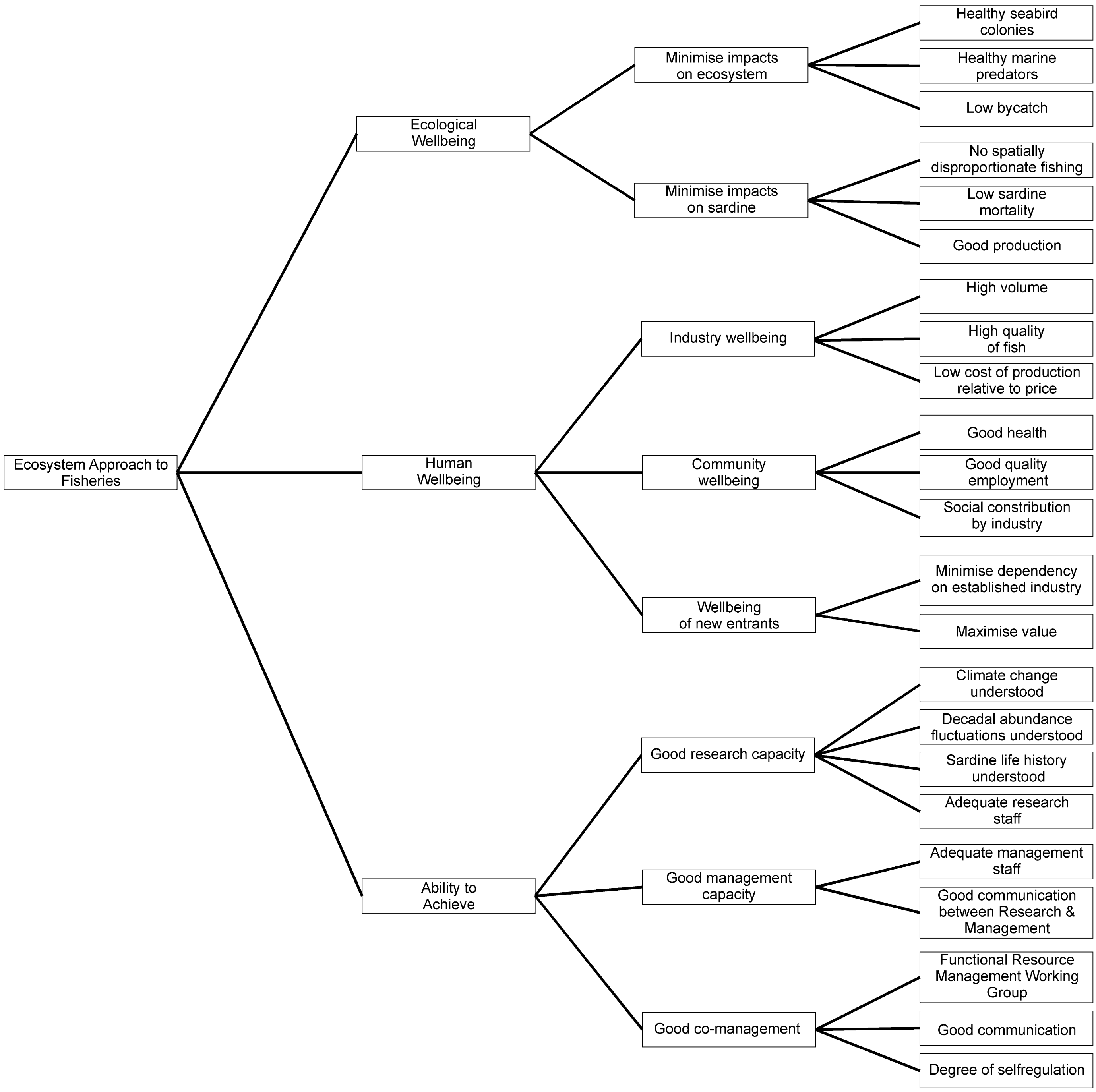

Fig. 1. The decision support tool conceptualises EAF for the South African sardine fishery as a hierarchy of objectives.

determinant of the representivity of the outcomes. The results would be weakened if important stakeholder groups choose not to participate. Thus there was a need to overcome negative past experiences and misunderstandings before all stakeholders could work together constructively. To foster support from all stakeholder groups the different perspectives were initially developed in separate focus group meetings (Fig. 3).

3.3. *The focus group approach*

A total of four small focus groups were formed, each comprising 3–5 participants: a natural science focus group consisting of natural scientists from MCM and the University of Cape Town addressed the biological and ecological issues of the fishery; a group of fisheries managers and scientists from MCM addressed institutional issues under the dimension ability to achieve; the industry focus group included representatives from the major companies and addressed the issue of human wellbeing from the perspective of the larger rights holders. The social science focus group consisted of social scientists from the University of the Western Cape, who addressed the issue of what constitutes human wellbeing from the perspective of the coastal communities that depend on the small pelagic fishery and from the perspective of new entrants into the sector.

Invitation to participate in the focus groups was informal and experimental. There were no explicit criteria for participant selection. Informal connections and existing work relationships

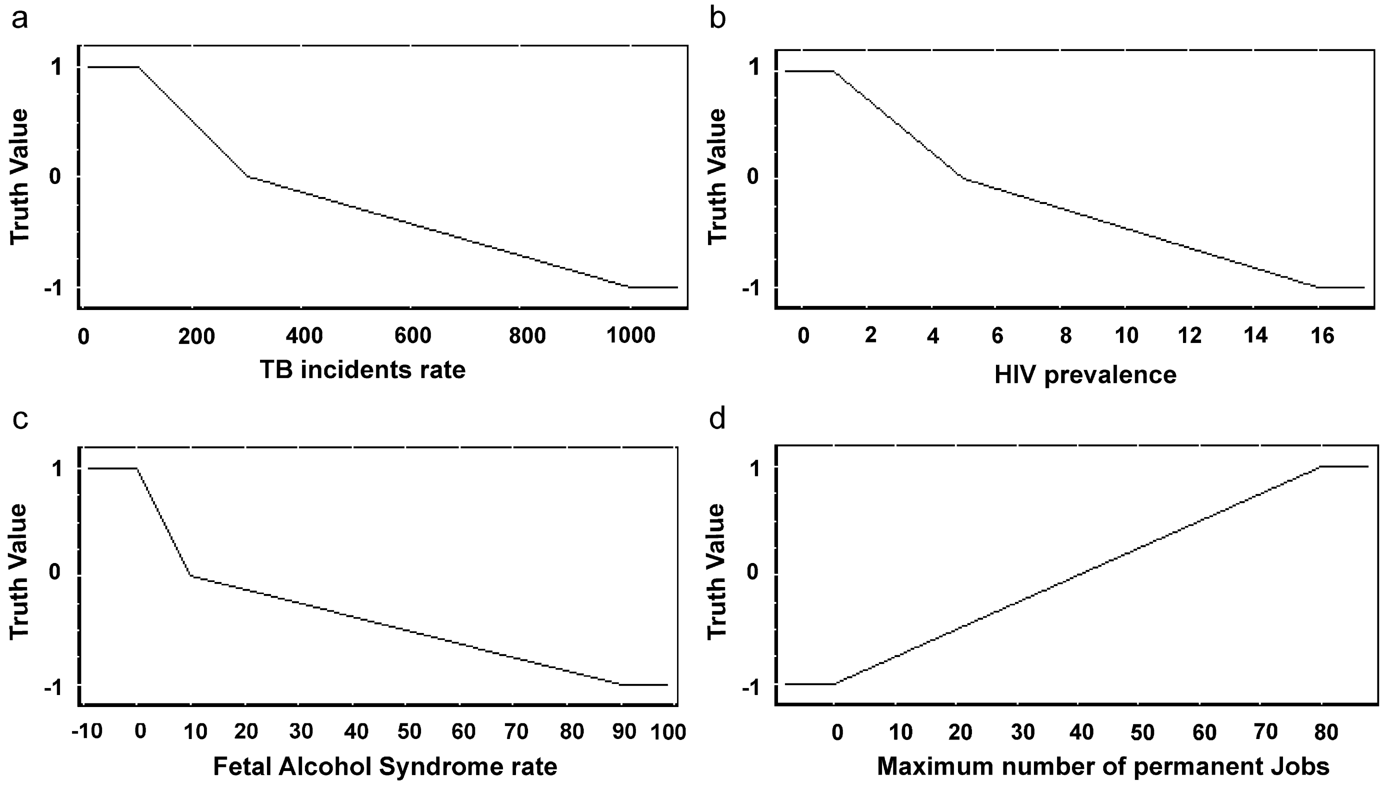

Fig. 2. Fuzzy arguments defining the qualitative truth values of some of the social variables: (a) the number of cases of tuberculosis (all types) per 100 000 population; (b) fraction (%) of women with HIV; (c) number of children with fetal alcohol syndrome; and (d) fraction (%) of permanent jobs in the fishery.

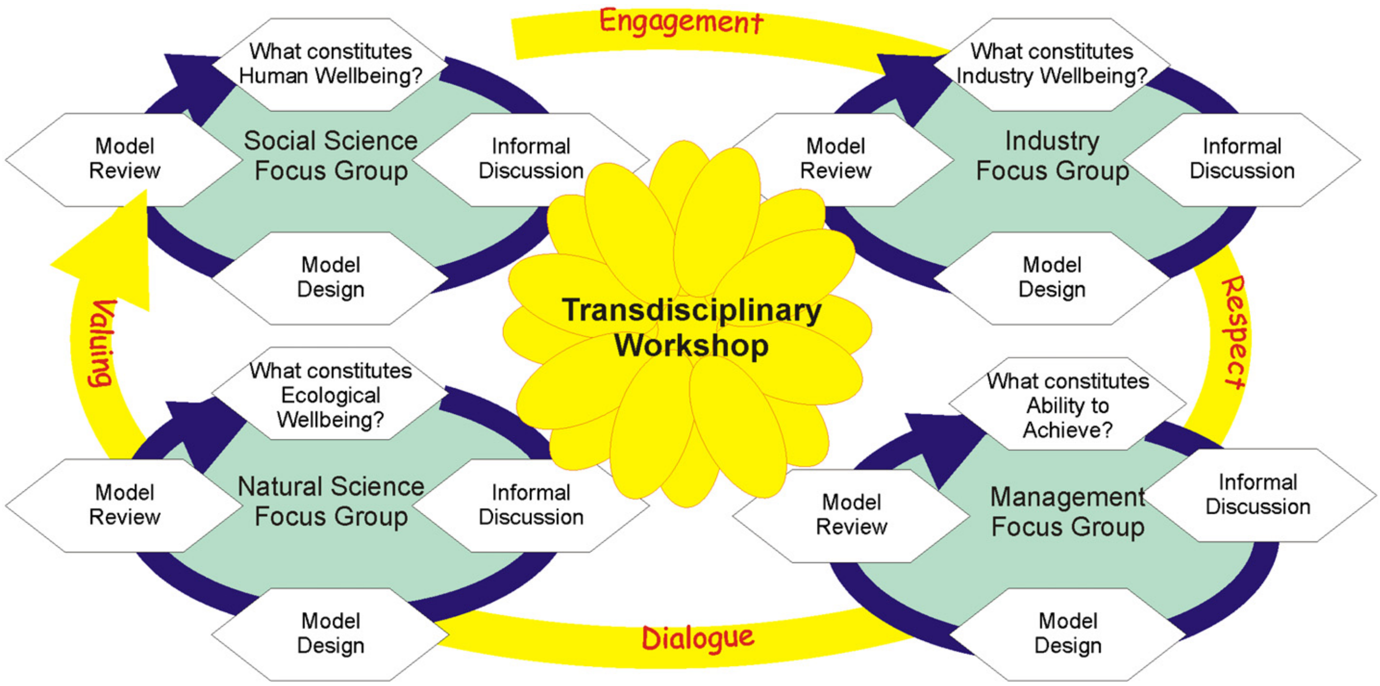

Fig. 3. The focus group approach as a dialectical cycle of engagement and conceptualisation emphasised the fostering of relationships through dialogue, respect and equal valuing.

between individual participants were used to form the focus groups. It has to be noted, however, that there is only a small pool of social scientists and industry experts in South Africa that is able to provide specific knowledge regarding the small pelagic fishery.

The focus group discussions were loosely structured around the following open ended questions:

1. How would you describe your interest in the sardine fishery?
2. What (other) interests should be taken into account when decisions are taken about the sardine fishery?
3. What are the main problems related to the sardine fishery and what kind of (cooperative) solutions to these problems would you like to propose?

4. What indicators could be used to measure whether these issues are being resolved?

These questions were put to the experts in an informal, relaxed manner in 2–3 h long meetings. All focus group meetings were facilitated by the same person. The aim of this process was to develop a conceptualisation in terms of objectives and indicators for each dimension of the fishery. However, the process of eliciting this knowledge from the group members underwent various phases and differed from group to group. The natural science and management focus groups used the objectives hierarchy that was developed for the first prototype as a starting point. The discussion focused on improving and refining this conceptualisation and clarifying assumptions. The social science and industry focus groups started with very open and general discussions which allowed the experts to explore the nature of the problem from various angles. As the discussion became more specific the main issues emerged and objectives were formulated. The outcome of the discussion was then conceptualised as value trees (Fig. 4). These diagrams were sent back to the focus group participants for verification. Follow up discussions were then based on the value trees which thus evolved over a series of meetings. This dialectical cycle of engagement and conceptualisation continued over a one-year period, facilitated by a humanist and emphasising the fostering of relationships through dialogue, respect and equal valuing (Fig. 3).

3.4. Transdisciplinary workshop

After a series of meetings the focus group participants were reasonably satisfied with the conceptualisation of the dimension they addressed. A workshop was held to bring all focus groups together and to start transdisciplinary discussions (Fig. 3). Unfortunately no member of the industry focus group could participate.

During the focus group discussions the facilitator had established rapport with all participants. The aim was now to start building transdisciplinary relationships between members from different focus groups. Some participants having been involved in research pertaining to the sector were known to each other, others had not previously met.

The workshop was structured to bring all focus group members together to meet and engage in dialogue with one another, but also to provide an opportunity for creating informal interpersonal relationships. The first session included a plenary presentation of the whole model by the focus group facilitator showing all dimensions. For most participants this presentation was the first time they saw the outcome of the other focus group discussions. Participants then split into small groups to discuss the different dimensions based on set questions. Care was taken to ensure that each group included participants from each stakeholder group. The groups were facilitated by the project core group members. This session aimed to encourage engagement between different disciplines and to encourage participants to follow the line of thinking that underpins the "other" dimensions. The prototype DST assumes equal weights for all antecedents. During the next workshop session discussions continued in disciplinary groups with a focus on assigning weights to the various components of the model. Participants found that it was not easy to agree on the weightings, but this process forced them to delve even deeper into the assumptions and concepts underlying the model. As a result some parts of the model were changed and the need for further revision of some model inputs was noted. As one step to address this need, a series of qualitative interviews with industry stakeholders was conducted.

4. Results

4.1. Value trees

The focus group work and the transdisciplinary workshop resulted in an updated prototype DST, in particular a more detailed objectives hierarchy for the human wellbeing component of the model (Fig. 4). The human dimension of the South African sardine fishery has been unpacked into three top level objectives: industry wellbeing, community wellbeing and the wellbeing of new entrants into the sector. Industry here refers to the processes of catching, landing and processing fish by the established companies and larger rights holders. Profitability is the main concern for the industry and consequently industry wellbeing is represented as depending on an adequate quota, a good quality product and low production costs. The wellbeing of new entrants is assumed to be determined by the degree of independence from the established industry and value adding of the product. For the communities it is assumed that wellbeing depends on health, the quality of employment and poverty alleviation. Because the main concern of the established industry is the contribution of fish resources to economic growth, social issues are of secondary concern to the industry. It follows that steps have to be taken to ensure that economic growth also benefits the poor [52]. The model therefore assumes that, with the right to utilise a common natural resource, a duty is associated to contribute towards national social objectives.

4.2. Input data and model outputs

For each of these three perspectives indicators and threshold values were identified to measure performance (Table 1).

4.2.1. Industry wellbeing

Profitability for the industry is determined by cost of production, which is measured as a fraction of the selling prize. Because the fishery is geared towards high volume, profitability is associated with the size of the landings; high volume of landings is assumed to be beneficial to industry. All landings are utilised for canning, freezing or fishmeal; dumping is known to occur, but is not thought to be a major problem. Profitability is further influenced by the quality of the product. Canning is the dominant method of value adding and the preferred form of processing. The selling prize for canned products is higher than the price for fishmeal; assuming that all fishers want to achieve a higher price for their landings and further assuming that it is unlikely that all vessels simultaneously lose their cooling system, it is likely that the canning requirement will always be filled. High mean length of catch and a high proportion of canned catch are understood to be indicative of high quality.

4.2.2. Community wellbeing

Three indicators for community health are used: TB incidence rate, HIV prevalence and Fetal Alcohol Syndrome (FAS). FAS is associated with poverty in rural communities and has direct implications for poverty alleviation. Four employment indicators are used: the unemployment rate, the proportion of permanent jobs in the industry, the proportion of jobs with benefits and the proportion of jobs that are held by women. The latter is based on the assumption that money earned by women is more likely to be used in ways that benefit the family and the community, e.g.

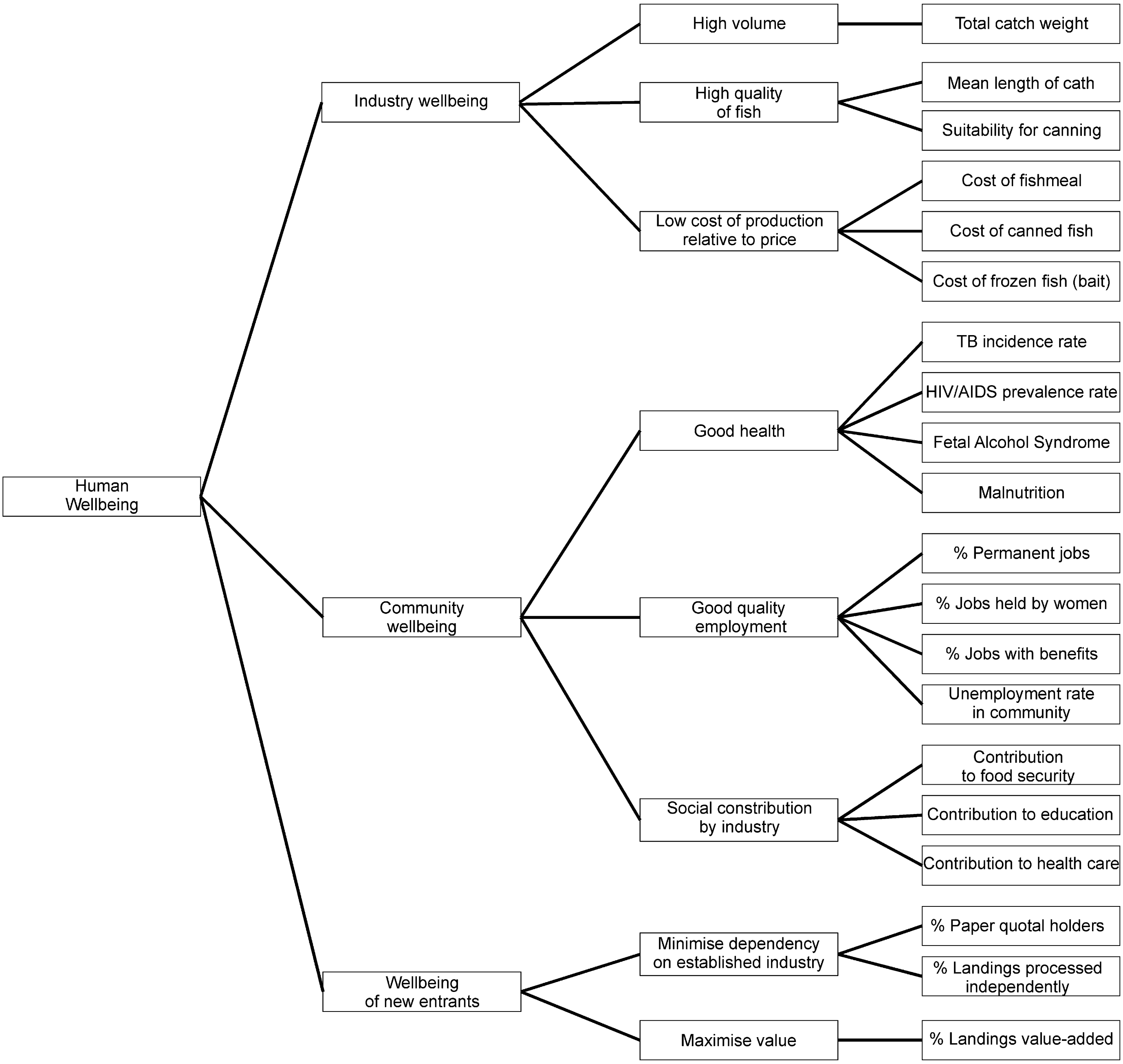

Fig. 4. Conceptualisation of the human dimension of EAF as implemented in the second prototype decision support tool. Human wellbeing is disaggregated into three perspectives: industry, coastal communities and new entrants into the sector.

through child health care, food, rent, and school fees. Direct contributions by the industry towards alleviating poverty in the communities are an additional indicator, to measure how effective the fishery is in achieving community wellbeing.

4.2.3. *New entrants*

Three indicators are used to measure the well being of new entrants: the fraction of landings that are value added as opposed to reduced to fishmeal, the fraction of paper quota holders and the proportion of the landings that are processed independently from the established industry infrastructure. The established industry is characterised by high volume and low value products. New entrants into the sector have a better chance of profitability with higher value products.

4.3. *Model outputs*

Data series were developed to populate the DST (Table 1). Data for the industry wellbeing indicators were obtained from Government scientists and from one of the major companies. Although not all data reflect values for the entire industry the data are of good quality. Indicator data for community wellbeing were taken from government data, literature and stakeholder interviews. The data regarding fetal alcohol syndrome (FAS) refer to one specific farming community in the Western Cape. There are no data on FAS available for any of the coastal communities. However, observations made in at least one fishing community in the Western Cape suggest that the cited data are representative (M. Isaacs, University of the Western Cape, Cape Town pers. comm.). The data on the contribution by industry towards social

Table 1
Description of indicators for the human dimension of the South African sardine fishery as used in the prototype decision support tool.

Indicator	Characteristic	Description	Thresholds	Properties
Cost of production of fishmeal	"Industry wellbeing" Low cost of production	The cost of fishmeal production as a fraction (%) of the selling price	−1: 100 0: 90 1: 85 Source: industry focus group	Years available: 1996–2005 Source: data provided by one of he major companies Quality: very good Time scale for management: 1–3 years
Cost of production of canned fish	"Industry wellbeing" Low cost of production	The cost of canning sardines as a fraction (%) of the selling price	−1: 100 0: 90 1: 80 Source: industry focus group	Years available: 1997–2008 Source: data provided by one of he major companies Quality: very good Time scale for management: 1–3 years
Cost of production of frozen fish	"Industry wellbeing" Low cost of production	The cost of producing frozen sardines as a fraction (%) of the selling price	−1: 100 0: 90 1: 80 Source: industry focus group	Years available: 1993–2007 Source: data provided by one of he major companies Quality: very good Time scale for management: 1–3 years
Volume (catch weight)	"Industry wellbeing" Size of landings	Sardine landings (1000 tons) directed & by-catch;	−1: 40 0: 100 1: 200 Source: industry focus group	Years available: 1990–2007 (SAPFIA); 1987–2005 (MCM) Source: SAPFIA data base; MCM data [55] Quality: good; comparison of both data sets shows max 5% difference Time scale for management: 1–3 years
MLOC	"Industry wellbeing" Quality	Mean length of catch (cm)	−1: 9 0: 17 1: 20 S. Source: industry focus group	Years available: 1987–2005 Source: MCM data [55] Quality: good Time scale for management:1–3 years
Quantity canned	"Industry wellbeing" Quality	Sardine landings (1000 tons) that are canned	−1: 85 0: 140 1: 150 Source: industry focus group	Years available: Source: SAPFIA landings data Quality: sample based estimate Time scale for management: 3–5 years
TB incidence rate	"Community wellbeing" Health	Number of cases of tuberculosis (all types) reported to the Department of Health per 100 000 population	−1: 1000 0: 300 1: 100 Source: WHO, Global Tuberculosis Control 2008 (www.who.int/tb/publications/global_report/en/index.html)	Years available: 2001–2007 Source: Provincial Government of the Western Cape, South Africa Electronic TB recording system Quality: good Time scale for management: 3–5 years
HIV prevalence	"Community wellbeing" Health	Fraction (%) of women with HIV among antenatal clinic attendees in the Western Cape	−1: 10 0: 5 1: 1 Source: WHO regional statistics	Years available: 2001–2006 Source: [56,57] Quality: good Time scale for management: 1 generation
Fetal alcohol syndrome	"Community wellbeing" Health	Number of children with FAS per 1000 births	−1: 90 0: 10 1: 0 Source: [58]	Years available: 2000, 2002, 2005–2007 Source[a]: [59–63] Quality: good Time scale for management: 3–4 Years
Permanent jobs	"Community wellbeing"	Fraction of total employment (%) which is permanent	−1: 0 0: 40	Years available: 1994–2006

Table 1 (*continued*)

Indicator	Characteristic	Description	Thresholds	Properties
	Quality of employment		1: 80 Source: social science focus group	Source: interviews with industry representatives Quality: sample based estimate Time scale for management: 3–5 years
Jobs with benefits	"Community wellbeing" Quality of employment	Fraction (%) of total employment which includes benefits	−1: 0 0: 50 1: 100 Source: social science focus group	Years available: 1994–2006 Source: interviews with industry representatives Quality: sample based estimate Time scale for management: 3–5 years
Jobs held by women	"Community wellbeing" Benefit to families and future generations	Fraction (%) of total employment	−1: 0 0: 25 1: 50 Source: social science focus group	Years available: 1994–2006 Source: interviews with industry representatives Quality: sample based estimate Time scale for management: 3–5 years
Unemployment rate	"Community wellbeing" Unemployment	Fraction (%) of people without employment in the Western Cape Province	−1: 50 0: 25 1: 0 Source: statistics South Africa	Years available: 2001–2007 Source: Statistics South Africa (www.statssa.gov.na) Quality: National surveys Time scale for management: 5–10 years
Contribution towards poverty alleviation	"Community wellbeing" Poverty alleviation	Fraction (%) of profit contributed directly by industry towards poverty alleviation	−1: 0 0: 0.5 1: 1 Source: resource management focus group	Years available: 2000–2002, 2006 Source[b]: MCM Quality: internal reports Time scale for management: 1–3 years
% of landings value added	"New entrants' wellbeing" Maximise value	Fraction (%) of catch that is not reduced	−1: 0 0: 14.5 1: 25	Years available: 1990–2007 Source: SAPFIA data base Quality: sample based estimate Time scale for management: 3–5 years
Paper quota holders	"New entrants' wellbeing" Dependency on established industry	(%) Fraction of quota holders who sell quota without investing into the sector	−1: 75 0: 35 1: 0 Source: [29,30]	Years available: 1994–2002 Source[c]: stakeholder interviews Quality: sample based estimate Time scale for management: 10 years
% catch processed independently	"New entrants' wellbeing" Dependency on established industry	Fraction (%) of landings which are neither canned nor reduced	−1: 0 0: 45 1: 90	Years available: 1994–2002 Source: SAPFIA data base Quality: sample based estimate Time scale for management: 3–5 years

[a] Data sample refers to one specific farming community in the Western Cape. There are no data available for coastal communities. However, observations made in at least one fishing community in the Western Cape suggest that the cited data are representative (M. Isaacs pers. com.).

[b] In the absence of data on industry profits, we assume these to be 10% of the wholesale value of the production. We further assume that 1% of the profit should go towards social objectives.

[c] The introduction of medium term rights in 2002 was aimed at eliminating paper quotas, however, 25% of rights holders are assumed to be paper quota holders (Denagie pers. Com). Assuming that this fraction was higher before the introduction of mid-term rights the percentage of paper quota holders is set to 50% for 1994–2001 and 25% 2002–2006.

welfare were obtained from the government economists and reflect the total contribution by the industry as a whole. These data currently do not distinguish between contributions made towards health, education or food security. In order to populate the DST with realistic data the three indicators were temporarily lumped into one indicator "poverty alleviation" (Table 1). Indicator data reflecting the wellbeing of new entrants was partially derived from stakeholder interviews and partially provided by the South African Pelagic Fishing Industry Association (SAPFIA).

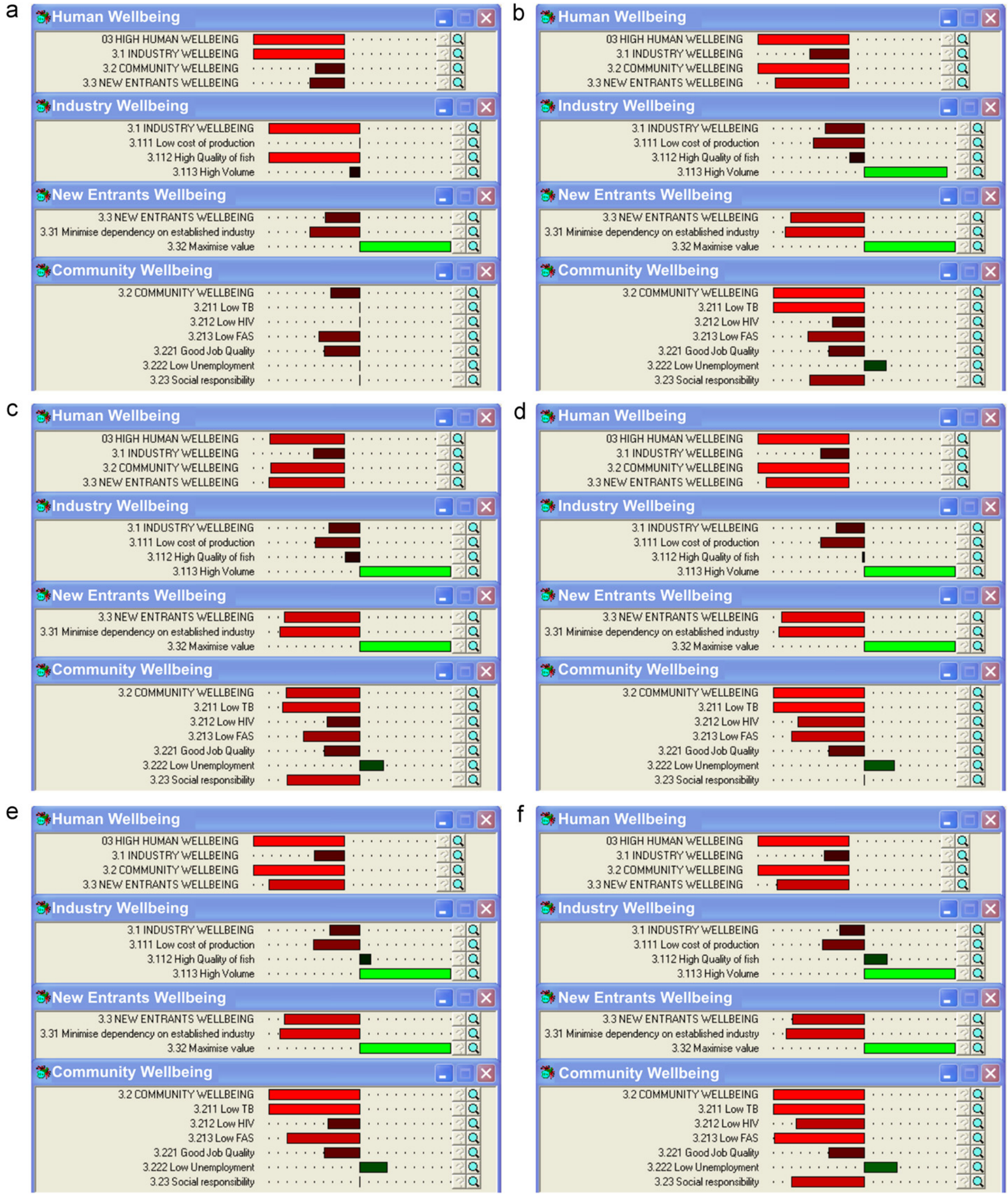

Fig. 5. Model results for the human dimension of the South African sardine fishery based on indicator data for the years: (a) 1994, (b) 2001, (c) 2002, (d) 2004, (e) 2005 and (f) 2006. Note the lack of data for many community wellbeing indicators in 1994.

Based on the value trees and the indicator values, the DST generates outputs represented in the form of bar charts (Fig. 5). Results were generated for 1994 and 2001–2006. The first year of democracy of post-Apartheid South Africa was in 1994. In 2001 small pelagic fish stocks were at maximum abundance. The most recent data available at the time of the study were for 2006.

The following results assume equal weights for all indicator values. According to model outputs human wellbeing is low in all sample years. The results for industry wellbeing are lowest in 1994 (100% false). Results are higher in the following years and in 2006 industry wellbeing is 20% true. Community wellbeing is least low in 1994 (30% false), however, four out of six indicators lack data for this year and were therefore evaluated as neutral. In all other sample years community wellbeing is evaluated as negative. The results for the wellbeing of new entrants are least low in 1994 (30% false) and 80% false in all other sample years.

5. Discussion

5.1. Process

The focus group approach and the use of open ended questions in only loosely structured interviews worked well to make participants feel that their contribution was desired and valued.

To overcome previous negative experiences, the focus group approach not only aimed at eliciting information but also was a process of making people relax and develop trust. This approach provided the necessary space for participants to contribute what they feel is important rather than answering a prepared set of questions, which prescribes what is important. Judging the importance of issues is part of the expert's knowledge.

During each focus group meeting the facilitator integrated the elicited information into the decision support tool. It is important to note that the conceptualisations captured in the value trees were a result of the discussions rather than preceding them. Thus instead of an extractive information gathering there was an iterative process of research and action. The value trees provided both a visualisation of the results of the previous discussion and structure for the next. The DST development thus facilitates the knowledge structuring process, which is central to multi-criteria problem analysis [53]. Problem structuring helps experts to clarify their thinking and improves understanding of the issues and their context. The knowledge analysis consolidates the components and integrates them into the tool as equal modules. It is important that the knowledge analyst, who interacts with different disciplinary scientists in order to gather information and perspectives, is not biased towards any of the groups whose perspectives are to be integrated. The analysts must be neutral and must be perceived as neutral. In our case the knowledge analyst, who also facilitated the focus group process, is trained as both a humanist and a computer scientist, thus bringing skills from both disciplines to the task.

Through the active involvement in the process and the relationship with the facilitator, who acted as common denominator, trust and belief in the project were developed. The focus group meetings thus paved the way for the transdisciplinary workshop aiming to achieve active engagement by all participants. Conducting parallel meetings with all focus groups and having regular follow-up meetings ensured that all participants perceived that their contributions were valued equally. All participants now shared a common goal, i.e. to improve their own conceptualisation and to understand the issues raised and conceptualisations developed in the other focus groups.

5.2. Conceptualisation and the value trees

The focus group approach succeeded in achieving a more detailed conceptualisation of the human dimension. It has become clear that the first round of ERA analysis was too simplistic to adequately represent the human dimension of this fishery. This first conceptualisation was based on the assumption that high profitability for the industry translates into benefits for the coastal communities, e.g. through employment. The revised value tree reflects what, according to social scientists, are the fundamental concerns of the people living in those communities. These concerns are not only good quality employment for some but also issues of poverty alleviation, such as food security, basic health care and education for the youth (Fig. 4). It is beyond the scope of this contribution to suggest ways in which these concerns can be addressed through the fishing industry, recognising that not all structural problems are rooted in the fishery. There is clearly a need for further collaborative research with social scientists to address the linkages between pelagic fisheries and community wellbeing.

The first prototype did not differentiate between the established industry and new entrants into the sector. The perspective of new entrants, however, highlights a lack of necessary skills and financial resources. New entrants cannot compete with the established companies who still control the sector through ownership of processing and packaging infrastructure. As a consequence, many sell their quota to bigger companies, without creating additional employment to benefit the community [7,30].

5.3. Model results

Judging from the present model results, the industry wellbeing would only partially be dependent on high volume. In our present model the low cost of production and the generally low quality of fish counterbalance the positive effect of large catches, leading to a negative evaluation of industry wellbeing. Further discussion with the industry focus group should consider variations of model structure, e.g. unequal weighting or the use of weighted averages instead of fuzzy ANDs to aggregate the indicator information.

The results for community wellbeing suggest a trickle down effect from the sub-optimal industry wellbeing. On the other hand it cannot be expected that high industry wellbeing and associated higher employment would directly solve the catastrophic health situation. The direct social contributions by the industry to the community wellbeing could be improved (see indicator: contribution towards poverty wellbeing). On a national scale it would need to be considered how fishing communities could benefit from the fishery in times of sardine resource abundance.

The new entrants' wellbeing is determined by value adding and dependency. The added value is high throughout the time series. However, this indicator reflects the status in the general pelagic fishery rather than that for new entrants specifically. The general industry approach to value adding is canning, which is restricted by market opportunities. The positive effect of this general indicator is counterbalanced by the continuing strong dependency of new entrants on the established industry for catching and canning. Among the solutions discussed in the transdisciplinary workshop were new market opportunities, such as fresh sardines for human consumption. Such initiatives would require outside interventions by government or other established initiatives to develop viable opportunities for new entrants specifically. The Southern African Sustainable Seafood Initiative (SASSI, www.wwfsassi.co.za) could be an avenue for promoting the sale of fresh sardines in southern African supermarkets.

5.4. Transdisciplinarity

Theory warns that transdisciplinarity is a very difficult process requiring investment in terms of commitment, time, openmindedness and a readiness to question held beliefs and values [3,11,17,54]. Such a process cannot be forced but depends on good inter-personal relationships to overcome the inevitable challenges. It has to be remembered that the actors first and foremost are people who need to develop respect and trust for one another. Transdisciplinary methodologies therefore must be non-hierarchical; no one discipline or field should dominate the process. Only through equal participation can a climate arise in which "people who have different ways of regarding the world can learn to learn from each other" [34]. As such transdisciplinarity is about building bridges, which is best initiated on a personal basis between individuals before it can be expected to work in a formal institutionalised structure. The concept of "bridge building", as used originally in engineering, refers to the connection of static disjointed geographical points. In the natural sciences "bridge building" is used to connect different evolving fields, e.g. marine ecology and stock assessment; the transdisciplinary field of EAF requires the building of bridges between flexible individuals. Although time consuming, the process of establishing trust and belief in the project through a series of focus group meetings was essential for the success of the transdisciplinary workshop. As a transdisciplinary concept, EAF has to be inclusive. EAF cannot be addressed from just one perspective and one methodological approach. It is hoped that from this process a core group of researchers will emerge who form a transdisciplinary working group which would not be restricted to participants of the initial focus group meetings. The work presented here marks only a small beginning of a transdisciplinary research approach to EAF in South Africa.

6. Conclusion

Transdisciplinarity can only work if participants are committed and prepared to suffer difficulties and set backs. The role of the facilitator to drive the transdisciplinary process is vital to maintain cohesiveness and continuity. A meeting aiming towards active participation by a broad spectrum of participants requires that all understand their role within the process and feel their contributions are equally valued.

The common goal of developing a DST proved to be a useful structuring framework for transdisciplinary interactions. These interactions fostered the development of indicators for the human dimension of an EAF in the South African small pelagic fishery. These indicators present an important step forward, even if the database behind them needs to be consolidated and revised.

The South African context requires the building of bridges not only between different disciplines and research fields, but also between different personalities and different cultures. It is easy to regard the South African EAF context as fraught with too many additional political and cultural difficulties. However, this context can also be seen as an opportunity to overcome these challenges through transdisciplinarity. Because of its hybrid character, transdisciplinarity as an overarching concept offers an opportunity for fisheries management in post-Apartheid South Africa to overcome the seemingly overwhelming social and political challenges. Transdisciplinarity, if undertaken with the necessary commitment, provides a framework to develop trust, common vision, and common values.

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