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Safe, sustainable, legal use and trade in wild species: testing a new five-dimensional sustainability assessment☆

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ABSTRACT

The Kunming Montreal Global Biodiversity Framework, adopted by the UN Convention on Biological Diversity in 2022, sets ambitious targets to ensure that the use, harvesting and trade of wild species is sustainable, safe and legal. While the definition of 'sustainable' is traditionally inclusive of ecological, social, and economic dimensions, many practically applied standards and regulations often exclude non-ecological perspectives such as human health and animal welfare. Recognising the challenge of assessing sustainability in a comprehensive, but accessible, way, a five-dimensional sustainability assessment framework (5DSAF) was developed, explicitly focusing on social, ecological, economic, animal welfare, and human health dimensions of sustainability. This paper documents the experiences of applying and testing the 5DSAF in multiple species use examples: geographically, by different sectors, and socio-economically. Its application in the United Republic of Tanzania (game meat industry), in South Africa (game meat sector), in Indonesia (reticulated python skins), and in Zimbabwe (Nile crocodile) is discussed. It proposes the steps for the future adaptations, and application of 5DSAF beyond the initial case studies aiming to assist conservation practitioners, policymakers, as well as indigenous peoples and local communities and private sector actors to demonstrate that the use of wild animal species and products is safe, legal and sustainable and, meeting the objectives of One Health approach, and where it is not, to identify the necessary improvements that need to be made.

1. Introduction

In 2022, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services published an assessment report on the sustainable use of wild species. The report highlighted that 50,000 wild species are used globally, with one in five people relying on them for income and food. This reliance is particularly true of the world's poorest people - 70 % of whom are directly dependent on wild species [6]. Wild species use is also an important part of global legal trade [2]. Simultaneously, overexploitation of species is one of the key drivers of biodiversity loss [5]. The use of wild species can also have negative implications for human health and the welfare of wild animals.

The Kunming-Montreal Global Biodiversity Framework includes Target 5 to ensure that the use of wild species is not only sustainable and legal, but also "safe". The dimension of safety is defined as undertaking harvesting, use and trade in a way that is safe for people, other species and ecosystems, including in the context of the reduction of risks of the spread of disease and pathogen spillover. Thus 'safe' can be interpreted within the basic tenets of the One Health approach [9] in the context of use of wild species, while also echoing One Health's call to mobilize multiple sectors, disciplines and communities approaches to achieve sustainability.

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Sustainability is a complex concept and one that is technically challenging to assess. Nevertheless, an approach is needed that cuts through the complexity, is accessible to policymakers and practitioners, and supports a process of continuous improvement among wild species enterprises, initiatives, and value chains. The authors of the present paper developed a five-dimensional sustainability assessment framework (5DSAF). In addition to capturing the more typical social, ecological and economic dimensions of sustainability, the framework adds the dimensions of animal welfare and human health ([11], in prep).

This paper documents the experiences of applying and testing the 5DSAF in multiple wild animal species use examples and proposes the steps for the further adaptation and application of 5DSAF.

2. Methodology

An international consortium IIED, TRAFFIC, IUCN SULi, Endangered Wildlife Trust and EPIC Biodiversity – under the guidance of a multidisciplinary expert advisory group – developed a 5DSAF ([11], in prep). For each of the five dimensions, the framework articulates seven key principles in addition to seven cross-cutting principles that are relevant to all dimensions. These principles were derived from a wealth of existing international standards, frameworks, and guidelines that address one or more dimension of sustainability (see [11] in prep, [12]).

Each principle is underpinned by four scoring criteria that identify how closely the use of wild species is aligned with the principle. Each principle has a score from 0 to 3. The scores indicate the following; 0 = no alignment with the principle (bad practice); 1 = emerging good practice with evidence for some but insufficient alignment with the principle; 2 = good practice with evidence for good overall alignment albeit with some weaknesses; and 3 = exemplary or best practice with evidence that the provisions of the principle are met or even exceeded (Fig. 1).

The framework is implemented with a simple spreadsheet-based scoring tool, allowing users to score performance against each of the 42 principles and identify areas where improvements are needed. For each principle, it first asks if the principle is relevant to the wild species use under consideration (for example the animal welfare principles will not be relevant to plant and fungi uses). A reason why a particular principle may not be relevant must be provided. It then asks the user to assign a score of 0–3 to the relevant principles and to provide evidence to justify the score. The tool sums the scores under each of the sustainability dimensions and presents the results in the form of a radar chart which shows how the enterprise/initiative is performing based on a maximum possible score which is automatically worked out by the tool based on the number of principles that are relevant. One of the case studies below presents the outcomes of evaluation in tabular format and others in a radar chart form, to demonstrate the diversity of application of the framework.

The framework was applied and tested in four wild animal use case studies. The intended outcome is a preliminary working tool that can be used to assess the sustainability of a wildlife-based commercial enterprise, sector or trade chain objectively and transparently. Potential future options for applying the framework are depicted in Fig. 2. The case studies presented were not set-out to follow any specific assessment approaches, but their approach they fit best in 'Expert analyst appraisal' and 'SU Score Card/Dashboard'. It is envisioned that further developments of the framework will take systematic approach to implementing the various assessment approaches. There are certain inherent biases in each of the approached. For example, single person review may potentially mean lesser familiarity with supply chain, and hence the application and scoring against the criteria. Conversely, a group of stakeholders or larger survey team may have greater overall understanding.

This paper summarises the feedback obtained from piloting the 5DSAF in four case studies – in the United Republic of Tanzania (game meat industry), in South Africa (game meat sector), in Indonesia (reticulated python skins), and in Zimbabwe (Nile crocodile), including the framework itself, the methodology used to collect evidence, lessons learned and recommendations for the effective utilization of the 5DSAF framework.

3. Case studies – how the framework was used and feedback from the evaluation

3.1. Tanzanian game meat industry

3.1.1. Background

In 2020, the government of the United Republic of Tanzania established regulations that allowed the selling of wild meat (also legally referred to as Game Meat) through licensed outlets known as Game Meat Selling Facilities (GMSFs) as provided in the Wildlife Conservation (Game Meat Selling) Regulations, announced in Government Gazette no. 84 on 07 February 2020. These regulations frame the governance of legal hunting, trading, and sale of game meat, allowing any Tanzanian business that meets all the specified requirements to open a GMSF and sell game meat to the public.

The legal framework in place is complex and the industry has developed rapidly since 2020. There are various classifications for sourcing of a wide list of wild animals (mammals) for hunting and onward sale via registered GMSFs within Tanzania. These include resident and tourist hunting, wildlife farming and ranching, and problem animal control. These variations in sourcing create supply chains with different

The species use does not adversely affect the conservation or restoration of non-target elements of biodiversity (eg non-target species, ecosystems, ecological processes, natural habitats, soil and water condition and quality)	0: The species use has a demonstrated negative ecological effect on non-target species or on the wider habitat with no plans for mitigation OR there is no information about presence of non-targeted elements of biodiversity that are likely to be affected by target species us 1: The species use has some negative effects, these are recognised but mitigation plans are not yet in place or implemented 2: The species use is not a threat to survival of non-target species or the wider ecosystem but there may be some localised or timebound negative effects that require mitigation (and can be mitigated with adaptive management) 3: The species use has a documented positive or neutral effect on biodiversity, including non-target species, ecosystems, ecological processes, etc
The species use does not facilitate the introduction or spread of invasive species or non-native species that have a detrimental conservation impact.	0: The species use is associated with the introduction or spread of invasive species or non-native species and these are having a detrimental conservation impact 1: The species use is associated with the introduction or spread of invasive species or non-native species but the conservation impact of these has not been determined 2: The target species use does not facilitate the introduction or spread of invasive species, or where such risk is established, adaptive management plan is in place 3: The species use is not associated with the introduction or spread of any invasive species or non-native species

Fig. 1. Examples of the criteria underpinning each of the 5D SAF principles. The next iteration of the 5D SAF will include the explicit use of terms 'alien species' and 'invasive alien species', replacing 'non-native species' and 'invasive species'.

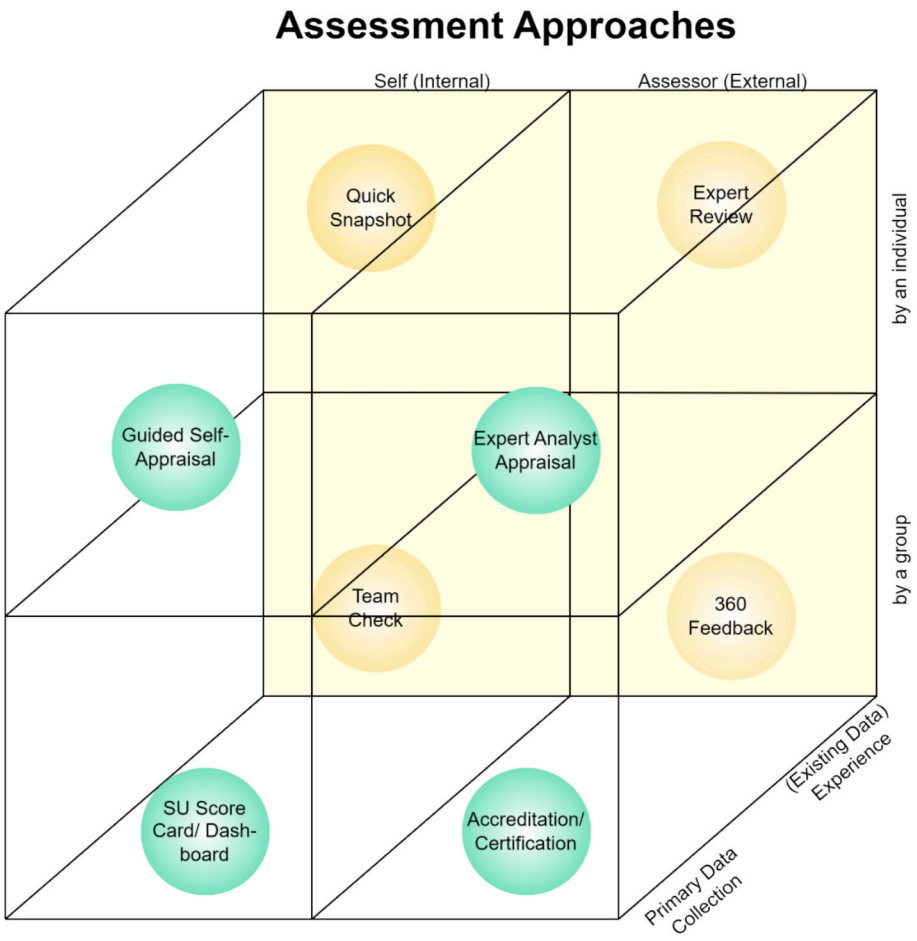


Fig. 2. Application scenarios for the 5D SAF framework considered by the international consortium along three dimensions

characteristics and multiple stages that require multi-sectoral oversight, including monitoring wildlife harvests and sales, undertaking research into wildlife populations and trade dynamics, control of food safety and meat quality, and disease surveillance [7]. The new game meat industry provided a suitable context for piloting the 5DSAF.

3.1.2. Methods

The application of the 5DSAF in Tanzania involved an internal evaluation by TRAFFIC's East Africa staff followed by external consultation with a suitably diverse group of expert stakeholders to evaluate the utility of the 5DSAF. This group consisted of a range of government officials and private sector actors involved at various stages and jurisdictional responsibilities along supply chains, who make up the national Game Meat Selling Advisory Committee (GMSAC) including government officials working in the jurisdictions of wildlife management, veterinary health, public health, livestock and wildlife farmers and game meat selling facility operators, legal experts, and local hunters.

The GMSAC team spent approximately two hours discussing this topic and undertaking a quick test. Participants then ranked the five dimensions relative to the game meat-selling industry. Participants formed three groups based on their roles or expertise with reference to what were determined to be the three most relevant dimensions (Health, Economy and Ecology). Each participant was required to fill in the scores for the dimension in which they are experienced or if their roles within the game meat value chain are relevant.

3.1.3. Results

The majority of the participants agreed that the framework could be a helpful checklist in assessing the overall sustainability of the Tanzania game meat industry. The health, ecological, and economic dimensions scored the highest in terms of relevance to the game meat industry, whereas welfare and social scored the lowest (Table 1). Participants highlighted that because no established farms and ranches have started supplying game meat/animals, it is difficult to assess the welfare principles as they are more related to wildlife farming and ranching. For the social dimension, traditionally, wildlife legislation recognizes social rights over wildlife for only a few tribes, making sector-wide assessment

Table 1
Scores for each dimension, indicating relevance to Tanzania's game meat industry.

	Department	Dimension score (0–5): 0 not relevant - 5 very relevant				
		Welfare	Health	Ecological	Social	Economic
1	Wildlife management (1)	4	5	5	5	5
2	Wildlife commerce (1)	5	3	5	1	5
3	Wildlife veterinary (1)	4	4	5	1	5
4	Veterinary and Inspection (1)	0	5	5	0	3
5	Public health (1)	0	5	5	0	3
6	Meat safety and quality (1)	0	5	5	0	1
7	Food and Drugs Control (2)	2	5	5	2	1
8	Local hunters (2)	5	5	5	0	5
9	Game meat traders (2)	5	5	5	2	5
	Average score	3	5	5	1	4

difficult. Overall, the majority of the participants in the trial acknowledged that navigating through the scoring tool was smooth, but that the end result (assessment outcome) chart presentation was challenging to interpret.

3.2. The use of Nile crocodiles in Zimbabwe

3.2.1. Background

Wild populations of Nile crocodiles (*Crocodylus niloticus*) are sustainably harvested in Zimbabwe for the purpose of sport hunting and for the captive production of skins, meat, and medicinal products [10]. The population was originally listed in CITES Appendix I in 1975 due to historic overexploitation but was down-listed to CITES Appendix II in 1983 following the successful demonstration of a market-based approach to conservation [4], and *C. niloticus* is now assessed as Least Concern against the IUCN Red List criteria. The Nile crocodile is regarded as one of the most dangerous of all crocodilians. Key threats include reprisal killings for attacks on humans and livestock and the loss of freshwater habitats [17].

3.2.2. Methods

Primary data were collected from the Crocodile Producers Association of Zimbabwe and via semi-structured interviews with three crocodile ranch owners, one crocodile farmer, and 11 professional hunters. Questions centred on the 5DSAF principles, in relation to respective operational/management approaches. Numerous site visits by the assessor over the last two years enabled direct observations and the validation of responses for the appraisal of the country-wide use of Nile crocodiles.

3.2.3. Results

Crocodile farming and ranching. Nile Crocodile farming (closed-cycle captive breeding) and ranching (harvest of eggs from the wild for captive hatching and rearing) in Zimbabwe was considered sustainable for all dimensions (Fig. 3). The rationale for a high animal welfare score included an industry-wide certification system which actively promotes optimal health and wellbeing. In crocodile production systems, poor welfare standards readily translate into poor skin pricing. The assessor concluded that there is a high degree of compliance with science-based standards and international expectations. The most important threat to viability comes from external economic pressures, driven mostly by changing perceptions and declining demand for exotic leather products.

Trophy hunting. The trophy hunting of Nile crocodiles in Zimbabwe was considered sustainable in all dimensions except human health (Fig. 4). This is explained by a severe lack of oversight of the key principles governing the handling of crocodile carcasses and associated products. A potential mitigating factor that was poorly captured by the 5DSAF was the fact that the trophy hunting of crocodiles typically occurs in remote locations on a seasonal basis and thus involves low rates of carcass throughput, thereby dampening some of the risks to human health. The most important threat to viability comes from declining social license for trophy hunting, increasing human crocodile conflict, and diminishing freshwater habitat.

Acceptable industry standards are evident in the crocodile farming, ranching and trophy hunting industries in Zimbabwe, although implementation and enforcement can be improved. Better stakeholder understanding of the threats facing the industry, and proactive communication of the broader benefits of the industry within the context of sustainability is recommended. There is a need to address the potential threat of zoonotic diseases associated with handling animal carcasses in the trophy hunting industry.

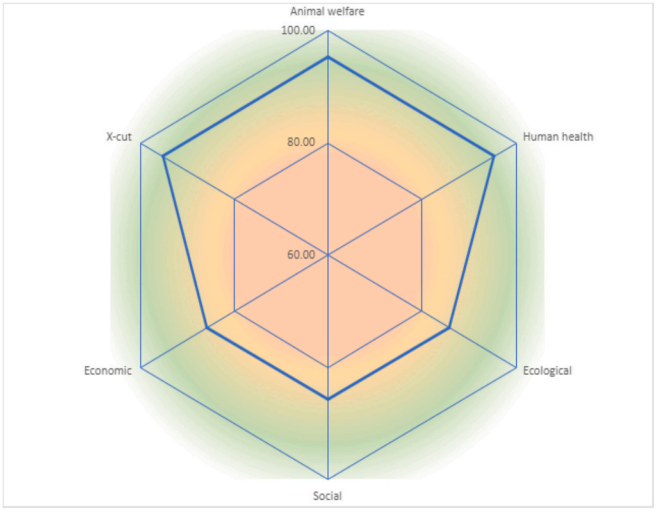


Fig. 3. Results of the assessment on Nile crocodile farming and ranching in Zimbabwe.

3.3. South African game meat

3.3.1. Background

South Africa has a large and vibrant wildlife economy [1,14–16]. Many individual wildlife economy enterprises can be classified as wildlife ranches, which are private land enterprises that use wildlife-based land uses to generate profits. The scale of the wildlife ranching sector in South Africa is not known precisely but is thought to encompass an area of more than 17 million hectares [16], or about 15 % of the country.

Wildlife ranches may be strictly wildlife-based or may keep both wildlife and domestic livestock (either in separate or overlapping areas), with the latter referred to as mixed farming. Many wildlife ranches offer wild meat hunting ('biltong hunting'), where local hunters pay to hunt wildlife and take the carcass for their own use. In contrast, far fewer wildlife ranches practice commercial wild meat production, generally referred to as 'game meat' in South Africa. In the latter case, wildlife ranchers can develop a professional game meat production enterprise that culls, processes and sells the meat as part of various supply chains. Among other factors, one reason for commercial game meat production being uncommon is a lack of suitable legislation to incentivise and control the practice among wildlife ranchers [3]. This, along with the complex requirements for establishing a legal commercial game meat-producing enterprise make it an unattractive proposition to most wildlife ranchers.

Game meat hunting and production on wildlife ranches in South

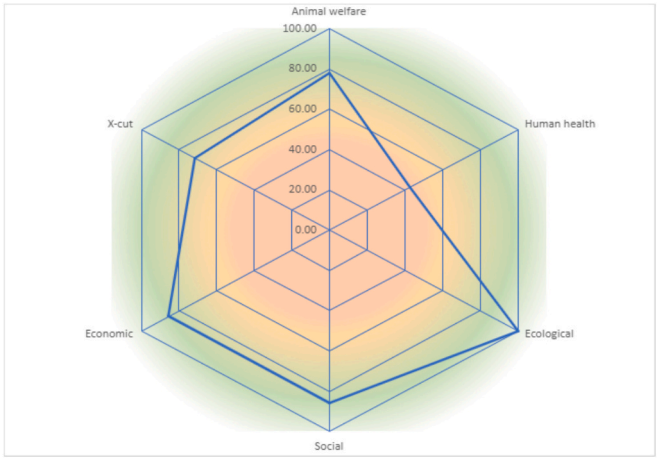


Fig. 4. Results of the assessment on Nile Crocodile trophy hunting in Zimbabwe

Africa constitute an interesting case for testing the 5DSAF, as the hunting sector is well-established with sufficient data and experiences to conduct the appraisal. Furthermore, the newer developments towards more commercial production of game meat for the wider retail market in South Africa or overseas provide an interesting scenario for applying the framework in a forward-looking, prospective manner.

3.3.2. Methods

To reflect the wide spectrum of different ranching models, the 5DSAF was applied to three purposefully selected wildlife ranches, two in the Eastern Cape and one in the Limpopo Province of South Africa. The application was conducted by an external assessor who collected primary data from individual wildlife ranches. A purposefully developed questionnaire served as the primary data source asking evidence-based questions about the ranchers' properties and management approaches. The questionnaire contained 83 questions, intending to cover all principles with relevant data to evaluate them according to the scoring items. In addition, game ranch management plans and business plans were obtained where available. On-site meetings also enabled the assessor to make direct observations of the wildlife ranch enterprise to validate questionnaire responses. The same expert analysed this data (questionnaire, shared game ranch management plans) subsequently to score the principles of the 5DSAF.

3.3.3. Results

Facility 1 (Fig. 5) scored very highly on the ecological and animal welfare principles. This outcome aligns with the management approach of the property, which is to be a sustainable wildlife reserve. It scored well on the human health and economic principles, attaining 70 % for each, but less well relative to Facility 2. This makes sense because Facility 1 is not a commercial game meat producer and does not need to comply with the highest national standards. The low score for the social principle reflects the fact that the facility is privately owned with no land claims or community requirements that necessitate the inclusion of communities (other than employees) in management processes.

Facility 2 (Fig. 6) scored highly on all principles, especially human health, which received a perfect score. This outcome aligns with the management approach of the property, which is to be both a sustainable wildlife ranch, but also a commercial producer of game meat. The owner went to considerable lengths to meet national standards for meat production, and this was apparent during the site visit. The property also aspires to have sound ecological management, which shows in the high ecological score.

Facility 3 (Fig. 7) scored highly on the animal welfare and economic principles. This outcome aligns with the management approach of the property, which does not interfere with the wildlife but ensures that animal numbers are suitable for the habitat. It also reflects the economic focus of the property. It scored reasonably well on the other principles as well. Like Facility 1, the lower human health score relative to Facility 2 reflects the fact that Facility 3 is not a commercial game meat producer and does not need to comply with the highest national standards.

In addition to applying the framework described, in this case, the 5D SAF principles and their rating scales were evaluated according to the applicability to game meat production in South Africa (Fig. 8 below). The principle and its rating scale proved fully applicable for green cells ('Y' for yes), while principles in red ('N' for no) were deemed as not relevant. Yellow cells ('R' for review) indicate a proposed need for customising the principle's rating scale. Cells in light green ('D' for discuss) should be discussed to review the scoring that results from the way the rating scales are worded.

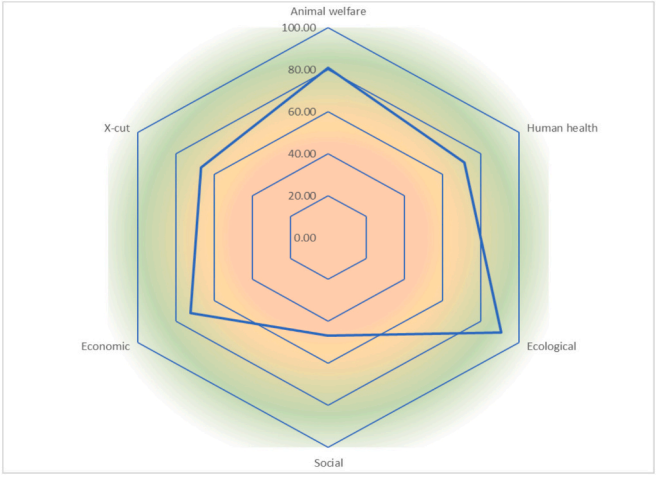


Fig. 5. Result of assessment of South African Game Meat for Facility 1: Limpopo property.

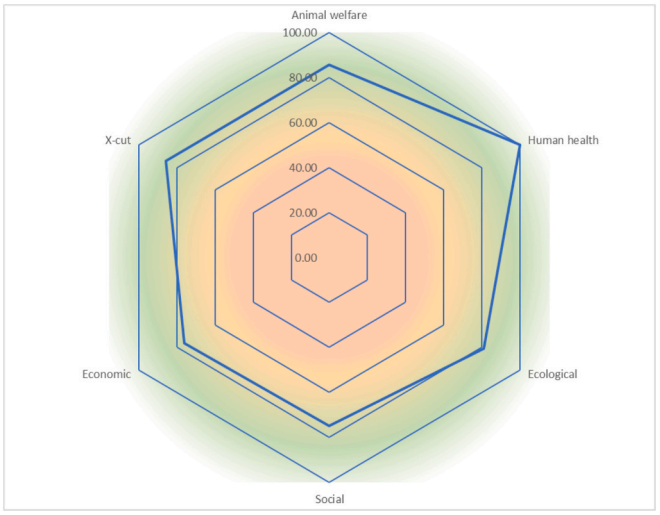


Fig. 6. Result of assessment of South African Game Meat for Facility 2: Eastern Cape property 1.



Fig. 7. Result of assessment of South African Game Meat for Facility 3: Eastern Cape property 2.

3.4. Reticulated Python harvest and trade in Indonesia

3.4.1. Background

Wild populations of reticulated pythons (*Malayopython reticulatus*)

Principle	Framework Dimension					
	Animal Welfare	Human Health	Ecological	Social	Economic	Cross-Cutting
1	D	D	R	D	Y	R
2	D	D	R	R	D	D
3	D	Y	Y	N	D	D
4	D	Y	D	N	D	D
5	Y	R	Y	D	R	Y
6	D	Y	Y	R	N	D
7	D	Y	D	R	Y	D

Fig. 8. Applicability of the respective principle's scoring/rating scale to the test case of game meat production on South African wildlife ranches.

are legally harvested in Indonesia for skins, food, medicines, and pets [8]. The species is widespread across Southeast Asia and occurs commonly in anthropogenic habitats [13]. Exports have exceeded 100,000 individuals per annum since at least 1984 and the vast majority of these were for the luxury skin trade (CITES trade database, 2023). An estimated 190,000 Indonesians are involved in the trade with substantial benefits accruing in impoverished rural areas. Trade is regulated at the national and international levels using a management system that includes ongoing monitoring, annual quotas and export permits.

3.4.2. Methods

A survey team travelled to major reptile trade hubs across Indonesia to conduct site inspections and social surveys with exporters, tanneries, hunters, processing facility personnel, and other stakeholders. Both structured and semi-structured questionnaire techniques were employed with a subset of questions tailored to each of the main livelihood types and each of the main principles outlined within the 5D SAF. Conversations were held prior to the surveys to explain survey aims, objectives and protocols, and to obtain consent. In total we carried out 120 interviews across three islands and eight provinces.

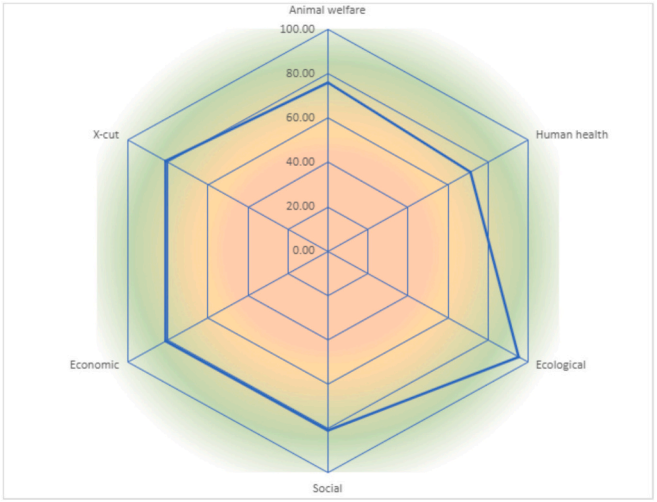


Fig. 9. Results of the assessment on Reticulated Python skin in Indonesia.

3.4.3. Results

The trade in Reticulated Python *Malayopython reticulatus* skins in Indonesia was considered sustainable in all dimensions (Fig. 9). Overall, there is a high degree of compliance with science-based standards and international expectations. Ongoing improvements/development within the industry are evident through a recent series of welfare training and traceability workshops. Compliance failures appear to be mostly related to cultural nuances and a lack of formal standards prior to 2021.

Ongoing training of key stakeholders (i.e., processing facility staff, transporters, hunters) is recommended to improve the level of knowledge and uptake. For instance, harvest methods can probably be further refined to reduce bycatch (e.g., encourage capture by hand and ban the use of nets). This may be best achieved through a series of online training videos as staff turnover rates appear to be high and many stakeholders live in remote and inaccessible areas, making centralised workshops of limited value.

4. Discussion and recommendations

Sustainable use of wild species is one of the pillars of the Convention on Biological Diversity, but there are no regulatory frameworks governing sustainable use of wild species that measure ecological, social, economic, animal welfare and human health outcomes together. To address this shortcoming, a 5-dimensional sustainability assessment framework (5DSAF) was developed.

In the application of 5DSAF to Tanzania's Game Meat sector, the overall feedback suggested that the framework can be a valuable tool for assessing whether the use of wild animals for food is well managed in the context of trade, food security, conservation, and the interrelationships between animal health and public health. The assessment, however, can be conducted more effectively when the scope is narrowed down to individual supply chains. A diverse selection of stakeholders should participate in the application of the framework, and when applied in the context of a multi-stakeholder process, the evaluation should include a group discussion. Stakeholders involved should also represent a mix of frontline law enforcement officers and high-level decision-makers to enable a full analysis of the actual situation on the ground versus the policy and legal framework in place. There has also been an observation that the interpretation of the radar chart has presented some challenges, and the 5DSAF results presentation could be improved in future.

In the case of Indonesia Reticulated Python skins off-take, it was observed that not all questions are perfectly relevant or sensible for some trade/harvest situations. However, it was considered not possible to avoid this given the breadth and diversity of systems that the assessment can be applied to.

In the application of the framework to three individual facilities of South Africa's game meat sector, the dimensions were found valid and relevant. The findings were helpful for discussing improvement areas for each facility. All except three principles of the framework applied to the game meat sector. However, the scoring system for some principles was found debatable. The test results suggest that it might be useful to review the rating scales of some principles highlighted in Fig. 8 from the perspective of assessing: an entire sector vs. an individual facility; a large organisation/institution vs. a sole proprietor (family business) vs. an informal/customary use case; a commercial vs. a non-commercial/subsistence scenario; an intensive vs an extensive wildlife utilization system. Further guidance material may be useful for external evaluation scenarios allowing external experts to align efforts and share practices.

The insights gained from these 5DSAF self-assessments undertaken by individual wildlife use enterprises/initiatives (e.g. a game meat ranch, crocodile farm etc) are intended to meaningfully inform future adaptations and application of 5DSAF, including the applicability at a sectoral/programmatic level. 5DSAF is intended to be used for all wild terrestrial species of fauna, flora, and fungi, with certain principles relevant to only sub-sets of these species. In the immediate term, and in terms of self-assessment, there is no specific guidance as to how the

process should be conducted, although the need to assist with the results interpretation has been noted. Much depends on the context in which the wild species use takes place and the characteristics of the wild species use initiative that is being explored. For example, an individual owner/manager of an enterprise may decide to simply run through the tool in a desk-based exercise as a check-list to inform management practices. In other cases, it may be useful to bring a group of stakeholders together in a workshop to collectively go through the process. In a workshop scenario it may be useful for one person to conduct the assessment ahead of the workshop and then share the results, discuss and amend where needed in a multi-stakeholder meeting, or it may be useful to complete the assessment collectively through the workshop process.

The inclusion of animal health and welfare, together with public health considerations, as criteria for sustainability ensures that the 5DSAF engages sufficient multi-disciplinary expertise in line with a One Health approach, which is particularly relevant for the use, harvest and trade of certain terrestrial fauna taxa, while also contributing to ecological sustainability parameters and overall ecosystem health.

The application of the tool to date suggested its usefulness in a range of scenarios, and further adaptations, refinement and further testing is recommended, including considering how such assessment could assist in standardizing the nation-level wild species use assessments (providing input into the methods of measuring against national or global commitments, such as GBF, One Health national strategies, and CBD Biodiversity and Health Action Plan), and – in parallel - gradually progress 5DSAF application from a self-assessment tool to an independently audited standard.

CRediT authorship contribution statement

A. Timoshyna: Writing – original draft, Methodology, Investigation, Conceptualization. **D. Roe:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **P. Aust:** Writing – review & editing, Methodology, Investigation, Conceptualization. **J. Compton:** Writing – review & editing, Investigation, Funding acquisition. **C. Hiller:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Q. Kagembe:** Methodology, Investigation. **N. Long:** Project administration. **D. Natusch:** Writing – review & editing, Methodology, Investigation, Conceptualization. **W.A. Taylor:** Writing – review & editing, Methodology, Investigation, Conceptualization. **K. Rock:** Writing – review & editing.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Co-author serves in an editorial capacity for the Special Issue of One Health journal - J.C. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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