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DISCUSSION FORUM

CRITERIA AND INDICATORS OF SUSTAINABLE HUNTING – THE AUSTRIAN ASSESSMENT APPROACH

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Abstract
Concepts and assessment tools for sustainable natural resource management have been developed in, amongst others, forestry, agriculture, fishery and tourism, but not for hunting or wildlife management. We applied a broad participatory stakeholder approach for the development of criteria and indicators of sustainable hunting in Austria. Based on international and national obligations and provisions, the concept is operational by defining ecological, economic and socio-cultural principles, criteria and sub-criteria with indicators and performance scales. The assessment set enables hunters to assess the degree of sustainability of their own individual practice of hunting in a self-reliant way. Its main function is to serve as a decision-supporting and awareness-raising instrument on hunting to identify deficiencies in sustainability, provide guidance for more sustainable future hunting practices and monitor effectiveness of management actions. The concept allows adaptation to specific regional conditions and different national hunting systems and application on regional and supra-regional scales.

Introduction

The concept of sustainable use is the leading paradigm of natural resource policy of the twenty first century. Following the emergence of the model of sustainable development at the Earth Summit in Rio in 1992 [1,2], generic principles of sustainable natural resource management have been codified and further elaborated for sectoral implementations. With regard to biological resources, in particular the Ecosystem Approach [3,4] under the Convention on Biological Diversity (CBD), and the recently adopted Addis Ababa Principles and Guidelines for the Sustainable Use of Biodiversity [5], are powerful concepts that provide major guidance. Developing operational concepts of sustainable use, however, requires adequate tools for assessment, monitoring, and adaptive management. For this purpose, the application of criteria and indicators (C&I) has become a widely recognized methodical approach. In the course of follow-up processes to Rio and the adoption of the CBD [6], in many countries and by different international institutions criteria and indicators for sustainable resource management have been developed for

specific applications in various sectors of landuse (e.g., forest management, agriculture, fishery, tourism). In hunting and wildlife management, however, a lack of coherent approaches to define and assess sustainable use has existed.
The need for sustainable hunting is reinforced by a number of reasons. Hunting is a consumptive use of biological resources that is highly environmentally effective and actively interferes with many ecosystem processes [7]. By preserving and taking huntable wild living animals, hunting influences genetic diversity and composition of game species, game populations in terms of size, density, distribution, structure, dynamics and behaviour, and condition of game habitats. Indirectly, hunting management also exerts impacts on non-huntable animal species, plant species and ecosystems in general. In particular in European multiple-use cultural landscapes these impacts often cause conflicts with the interests of other forms of landuse, such as forestry, agriculture, transport, and tourism [8]. Moreover, public acceptance of hunting as a legitimate form of landuse is decreasing [9,10]. In this context, the issue of the sustainability of hunting should be addressed. While sustainable hunting may be an almost universally accepted goal, there is, however, no clear understanding of what “sustainable hunting” exactly means and how it is to be achieved and measured. Therefore, in the course of a participatory, multi-sectoral stakeholder process for the first time a comprehensive assessment framework for sustainable hunting has been developed in Austria [11,12].

Methods

Objectives

The main objective of the project was to create a consistent, coherent and transparent set of principles, criteria, sub-criteria and indicators that would enable hunters and game managers to assess the degree of sustainability of their own individual practice of hunting in a self-dependent and user-friendly way. Conceptual design and indicator set-up have been fitted to the intended key functions of the assessment set. These main tasks are to function as a decision-supporting, awareness-raising and educational instrument for hunters to (1) facilitate analysis and diagnosis of individual strengths and weaknesses in sustainable hunting, (2) identify sustainability gaps and prior needs for action, (3) provide guidance in deducing measures for more sustainable future hunting practices, (4) assess effectiveness of management actions and monitor progress in the implementation of hunting sustainability, (5) measure changes in levels of hunting sustainability on the time-scale, and (6) facilitate comparisons of sustainability performances between different spatial hunting units (benchmarking). By defining measurable criteria and indicators, the concept of sustainable hunting shall be made operational. Apart from serving as a tool for adaptive management, the assessment set shall contribute to the understanding of "sustainable hunting" by using practice-relevant contents. Creating a common understanding of "sustainable hunting" shall foster communication with non-hunters, facilitate reconciliation of conflicts with involved groups of landusers and create more objective and solution-oriented discussions on hunting-related issues.

External basic conditions

Particular attention has been given to coherence with obligations resulting from international binding legal sources (conventions, agreements), and "soft law" regulations, national implementation strategies and relevant political initiatives and processes. Sustainable hunting is expected to be part of a comprehensive sustainable development, as stated at the Earth Summit in Rio [1,2] and in the preceding Brundtland-Report [13], and as further particularised in the course of subsequent sectoral processes, such as the Ministerial Conference on the Protection of Forests in Europe (MCPFE), whose Pan-European Criteria, Indicators and Guidelines for Sustainable Forest Management offer many interfaces with game management [14-16]. Our approach is explicitly committed to the objectives of the CBD [6]. In Article 2 of the CBD, "sustainable use" is defined as the "... *use of components of biological diversity in a way and a rate that does not lead to the long-term decline of biodiversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations*." The Ecosystem Approach, as the primary frame of action under the CBD, provides operational principles of integrated ecosystem management that have thoroughly been considered [3,4]. Recommendations in terms of hunting and wildlife management contained in the Austrian Biodiversity Strategy [17] have been taken into account. Our assessment approach is also based on the "Resolution of the IUCN on the sustainable use of wild living resources" (Amman, 2000), which appreciates that the consumptive use of wild animals, if it is sustainable, can be an important conservation tool [18]. However, to determine if a use is sustainable or not, appropriate assessment criteria are needed.
Within natural resource management a use may be termed sustainable in general terms if it (1) achieves a proper balance between conservation and sustainable use of biological resources, (2) obeys the limits of ecological carrying capacity and ecological functioning of ecosystems, (3) does not exceed the regeneration capacity of renewable resources, (4) is socially fair and equitable, and (5) preserves an equivalent resource basis for the needs of future generations [19-21].

Participatory project design and work process

The set-up of the C&I set involved a broad participatory approach that was gradually extended. It was a multi-sectoral, interdisciplinary, "bottom-up" process that involved a wide range of stakeholders, experts and practitioners, particularly representing hunters, science (wildlife ecology, hunting science), forest management, agriculture, nature conservation, and landowners. In terms of institutional membership, participants came from organised pressure groups, NGOs, small and large-scale operations, scientific institutions, authorities, and state agencies [22]. As a result, the assessment set is based on scientific knowledge and practice-related expert knowledge, but also reflects the consensus-building process. In typological terms, the basic conception of our assessment tool may be characterised as a dynamic, collaborative expert system that is open to updating and future improvements.

In detail, procedural organisation of the workflow comprised the following sequential stages (Fig. 1): International and national agreements and initiatives on the sustainable use of biological resources [e.g.: 3,6,14,15,17,18,23-28], international standards for designing environmental criteria and indicators sets [29-45], and principles in terms of hunting ethics, as expressed in the Austrian hunting laws, were used as a reference frame. Based on preparatory works of the Umweltbundesamt [7,46], in particular the results of a workshop on "Hunting and Sustainability" [47], the architectural structure of the assessment set was conceived by the core project team. Candidate C&I were collected and reviewed, examined as to their relevance and completeness, supplemented, newly defined and adapted to the requirements of the large-scale Austrian game habitats. This lead to a first draft concept version with a preliminary set of C&I, which then was intensely discussed within expert groups of limited size. Comments and suggestions were harmonised and worked into a revised concept version. Subsequently, field testings were

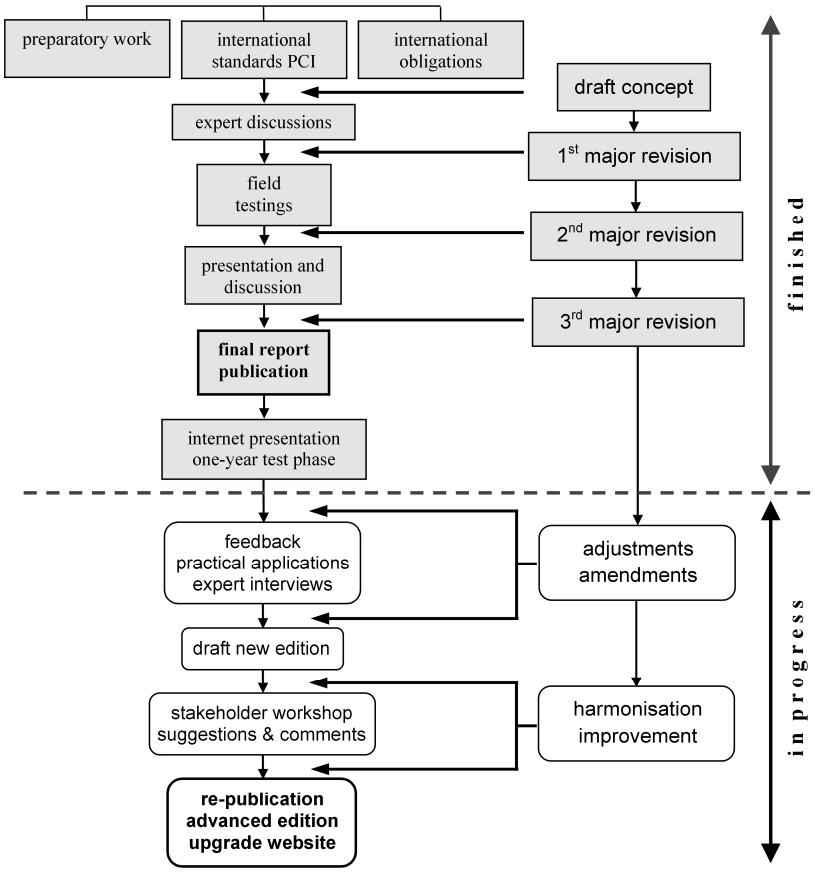


Fig. 1. Sequential stages of the participatory work process.
Grey boxes: elaboration of present C&I set (finished); white boxes: intended further development (in progress).

conducted by applying the assessment set practically in hunting units of varying size - hunting grounds, “hunting rings” (loose associations of hunting grounds), small and large-scale operations. The set proved to be suitable for practical application; some requests for modifications, however, were integrated into the concept. In parallel, indicator scalings and evaluation schemes were adjusted by carrying out scenario analyses. At a workshop, an improved draft final report was then presented to an extended expert audience and discussed in depth within a large panel. Comments, amendments, and requests for changes were to a great extent integrated into the report. Written statements, which were considered at least partially in the final report, are documented in full text in the annex of the published study. Therewith, each work phase was accompanied by improvements of the concept. The full final report "Criteria and Indicators of Sustainable Hunting" [11,12] has in the meantime also been made available to a broader audience through an interactive platform in the World Wide Web (http://www.biodiv.at/chm/jagd). The website also offers a guided electronic self-assessment by means of an online-questionnaire. Voluntary feedback of the users is collected and evaluated and will be used as input for further development [48].

Assessment methodology

The assessment set is structured along two major axis: on the horizontal axis, the model of "sustainable hunting" is divided into ecological, economic, and socio-cultural areas of concern, following the common discrimination of "three pillars" of sustainability [49]. On the vertical axis, within each area the assessment system is organised as a hierarchical framework that is composed of principles, criteria, sub-criteria and indicators with performance scales. The set has a tree-like architecture which - starting from the level of principles at the top and proceeding on down to the level of sub-criteria - shows a gradually increasing degree of ramification (Fig. 2). Each principle is specified by a set of criteria, which are again specified by a set of sub-criteria. Thus, the degree of practical relevancy increases level by level from top down, while simultaneously the degree of closeness to the model decreases to the same extent.

Principles describe fundamental objectives derived from the paradigm of sustainable hunting. They are based on axiomatic value judgements and characterise a desired ideal state of conditions. Criteria designate certain attributes of sustainable hunting that are appropriate to define the principles more precisely. Sub-criteria particularise further selected observable or measurable attributes of the criteria. Indication and assessment are carried out on the level of the sub-criteria. Thus, they are required to be particularly practically relevant and meaningful to the issue of sustainable hunting, representative to the aspect under consideration and easily verifiable.

Attaching performance scales to each sub-criterion makes them operational and capable of functioning as indicators (i.e. as measuring parameters which provide relevant information about the state of the entity that is the object of assessment [19]). In general terms, the function of indicators is to reduce the complexity of the real world and improve interpretation by aggregating and simplifying the available information [50,51]. In a more specific sense used here, the purpose of the

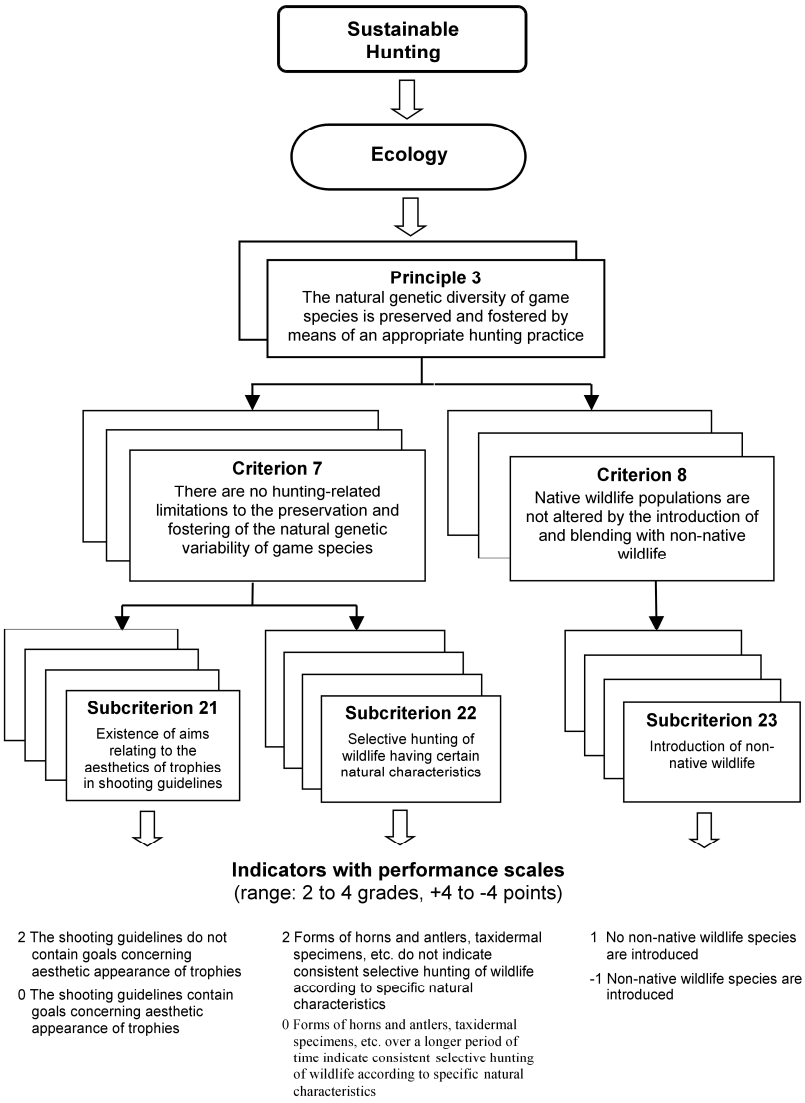


Fig. 2. Exemplification of the hierarchical structure of the assessment framework (detail). Within each area of sustainability (ecological, economic, socio-cultural aspects), each principle is specified by a number of criteria, of which each is again particularized by a set of sub-criteria. Setting ordinal performance scales with a band width of 2 to 4 grades makes sub-criteria suitable for operational indication. Grades are defined verbally and describe degrees of fulfilment of a sub-criterion in practice. By assigning points to each grade they are transformed to numerical scores. Scaling, benchmarking, and implicit weighting of indicators was done through participatory decision-making.

indicators is to characterise the extent to which a sub-criterion is met by the given hunting practice. For scaling the indicators, an ordinal performance scale with a band providing a number of two to four grades per indicator is used. The grades represent verbal descriptions of degrees of fulfilment of a sub-criterion (i.e. they describe qualitative states of the indicandum). The grades may also be viewed as a set of verbalised assessment options from which the user shall choose the one most fitting. Wherever possible, quantitative parameters are applied to verify fulfilment of sub-criteria. In case a scale features only two grades, simple yes/no-decisions are required. Sometimes, however, only assessments based on qualitative information are possible, depending on the aspect of hunting being assessed.
Numerical transformation of indicators from grades to scores is done by points which are assigned to each grade on the performance scale [29]. The maximum range is between + 4 to – 4 points per indicator, scores below zero meaning "unsustainable". As the indicator scalings in terms of points are not equal for each indicator, this implies that an implicit weighting is being applied. However, no further weighting of indicators is done.
Principles, criteria, and sub-criteria are provided with detailed explanations to give guidance on their interpretation, to facilitate understanding of their underlying rationales and to foster critical reflection of the users´ hunting practice.
The application of certain criteria and sub-criteria is dependent on the specific regional situation or on the spatial scale being assessed and might not be feasible in any case. Assessing these optional aspects may be omitted, if the reasons are pointed out adequately. This is taken into account when evaluating the assessment results (variable maximum/minimum number of points).
Particularly with regard to intolerable forest damage caused by game species the use of "knock-out" (KO) or "killer criteria", whose non-compliance would justify the overall qualification of the practice of hunting as non-sustainable (and whose compensation in terms of scored points through good results from the assessment of other criteria would not be possible), is feasible. As the sustainability of hunting is determined by influences other than hunting (e.g. game damage by silviculture-related susceptibility of forests to game damage), it was decided to abstain from mandatory KO criteria for the time being. However, some of those candidate KO criteria have been weighted heavier than the others by assigning more points to them. Under special local or regional conditions, nevertheless the definition of KO-criteria can be useful, provided that adequate justifications are provided.

Scope of application

The targeted user groups are hunters, hunting managers, and owners of a proprietor's hunt and tenants of a proprietor's hunt or a co-operative hunt. The assessment refers to the present state of conditions or - where required - to the preceding calendar year. For some sub-criteria, the required temporal reference frame may as well extend longer into the past. The intended spatial reference unit is the hunting ground, hunting operation or a "hunting ring". Moreover, application to larger assessment units - across hunting grounds - is possible (e.g., by means of synoptical or comparative evaluation of hunting ground-based assessment results

within a region, an administrative province or a natural landscape unit that is homogenous in terms of wildlife-ecological conditions). Considering the often large-scale mobility of many large game species (e.g., red deer [*Cervus elaphus*], wild boars [*Sus scrofa*], brown bears [*Ursus arctos*]) and migratory birds, this can be very useful.

The assessment methodology and the set of principles are designed in such a way as to allow general applicability and spatial transferability. Based on the broad spectrum of Austrian game habitats, ranging from river floodplains to high alpine regions, the criteria and sub-criteria are particularly attuned to the conditions of Central European countries with hunting systems based on hunting grounds. However, by modifying single sub-criteria in an appropriate way, the set can be adjusted to specific regional conditions and different national hunting systems.

Our mostly qualitative, user-oriented assessment approach is suitable to be fed back with quantitative results of complementary objective, large-scale monitoring systems for wildlife species, game populations and game habitats (e.g., network of representative monitoring areas) [52,53].

The assessment system shall be used voluntarily as a means to support self-estimation. It was not designed for use as an instrument of governance, legislation or administration, although the expertise contained therein can be adapted for such purposes if demanded by future social and political developments [22]. However, introduction of major contents to teaching aids and education and training programmes for hunters is a desired application.

Evaluation scheme

Evaluation operates with the number of points scored for each sub-criterion. To gain clear information on the sustainability of hunting, two types of evaluation are provided. In a synoptical type of evaluation, the scored points of each individual sub-criterion/indicator are represented separately and visualised in juxtaposition using a coloured "sustainability performance scale" (Fig. 3). As no aggregation of the primary indicators is applied, specific strengths and weaknesses become visible at a glance on the level closest to practical hunting. A second type of evaluation uses a simple numerical-additive technique of aggregation up to the hierarchical level of the three major groups of sustainability aspects (i.e., ecology, economy, socio-cultural aspects). Scores in points within each group are added up, calculated in percentage of the respective maximum number of points and then allocated to one of five evaluation classes, which are assigned value rates ranging from "very good (1)" to "very bad (5)" (Fig. 4). The qualification “very bad” is given to sums below zero. Thereby, a condensed representation of assessment results within each major group of sustainability aspects is accomplished, and both deficiencies and balance with regard to major aspects of sustainable hunting become evident. The same evaluation procedure may also be applied to individual principles or criteria. The concept basically also allows the establishment of point limits (minimum requirements) for individual principles or criteria if a justification is given.

Both types of evaluation are intended to be used complementary to provide a maximum amount of information on sustainable hunting practice.

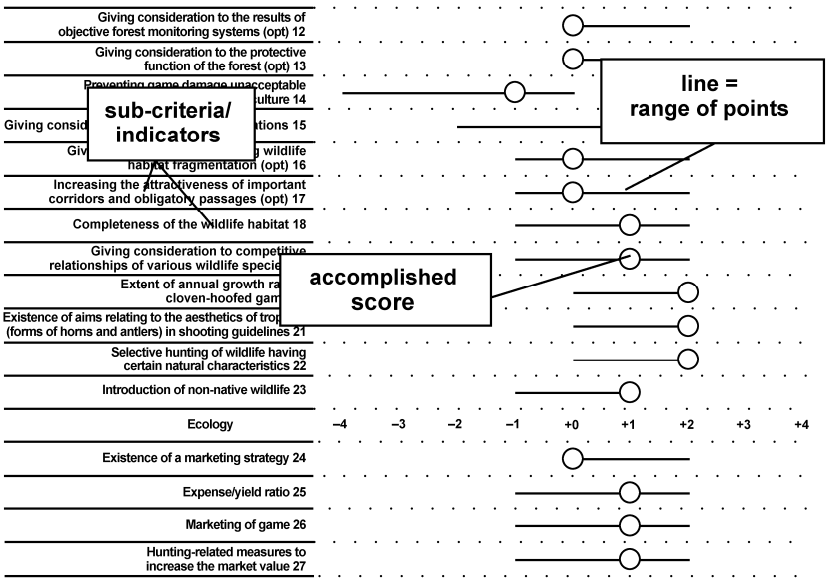
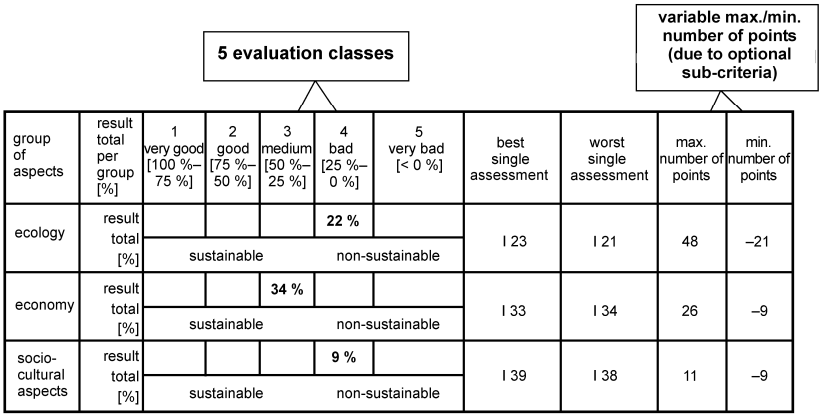


Fig. 3. Evaluation scheme type 1: Assessment profile of one assessment unit (fictitious evaluation example, detail; for full coloured figure refer to [11,12,48]).
Assessment results for individual indicators are visualized and represented synoptically. Column on the left: sub-criteria/indicators; horizontal lines on the right: band width of scales per indicator; white dots: scored no. of pts. per indicator; figures: scores in pts. per grade; interpretation: high positive scores (right end of band) indicate good sustainability performance, low negative scores (left end of band) indicate unsustainable hunting practices.



group of aspects	result total per group [%]	1 very good [100 %– 75 %]	2 good [75 %– 50 %]	3 medium [50 %– 25 %]	4 bad [25 %– 0 %]	5 very bad [< 0 %]	best single assessment	worst single assessment	max. number of points	min. number of points
ecology	result				**22 %**		I 23	I 21	48	–21
	total [%]	sustainable			non-sustainable					
economy	result			**34 %**			I 33	I 34	26	–9
	total [%]	sustainable			non-sustainable					
socio-cultural aspects	result				**9 %**		I 39	I 38	11	–9
	total [%]	sustainable			non-sustainable					

Fig. 4. Evaluation scheme type 2: Aggregation of assessment results within each major group of sustainability aspects (fictitious evaluation example; for coloured figure refer to [11,12,48]). Additive aggregation of scored points, calculation in percentage of maximum number of points per group, allocation to one of 5 evaluation classes, verbal rating of intervals, coloured sustainability performance scale with continous transition between sustainable (green) and unsustainable (red). “Best” and “worst” results for individual indicators are displayed separately. Maximum and minimum numbers of points are variable to allow for consideration of omitting of optional indicators.

Results

Assessment Set: Technical contents

We defined 11 principles, 20 criteria, and 39 sub-criteria with indicators (Table 1). In the following section, major contents of the assessment set are briefly outlined. For complete information, refer to [11,12,49].

Table 1. Synopsis of the principles, criteria and sub-criteria of sustainable hunting [11,12]. Cell margins of columns and rows indicate the hierarchical structure of the assessment set. Positive and negative figures give the possible maximum and minimum number of points per group of sustainability aspects, per principle, and per criterion, and the band width of indicator scalings respectively. Column "No" … sequential numbers of sub-criteria; **X** … optional sub-criteria (assessment may be omitted, if justification is given).

PRINCIPLE (Pts. max./min.)	CRITERION (Pts. max./min.)	No	SUB-CRITERION	optional	Range of points max.	min.
Ecology					48	-21
The practice of hunting shall within its range ensure the conservation and improvement of the diversity of game species through protection and use (15/-6)	Potential natural wildlife species inventory taking into account the current habitat situation (applies only to larger territorial units, e.g. a wildlife-ecologically homogeneous area or a Province) (6/-3)	1	Current and potential list of wildlife species		2	0
		2	Dealing with newly appearing species (in accordance with the potential wildlife species inventory)	X	2	-1
		3	Dealing with wildlife species not contained in the potential wildlife species inventory	X	2	-2
	Hunting is oriented according to the behaviour of wildlife species (9/-3)	4	Giving consideration to the undisturbed life cycle of wildlife species		2	-1
		5	Considering the reproductive periods of the individual game species		3	0
		6	Existence of hunting guidelines across hunting grounds		4	-2
The conservation and improvement of wildlife habitats is an objective of the practice of hunting (28/-14)	Hunting and its interrelationship with other forms of land use (10/-4)	7	Existence of a strategy to coordinate hunting with other forms of land use		2	0
		8	Considering seasonal bottleneck situations in food supplies		2	-2
		9	Existence of a shooting plan and a shooting list		3	-1
		10	Structure of shooting plan and shooting list		3	-1
	Giving consideration to the impact of game on vegetation (8/-6)	11	Existence of control fences to monitor browsing	X	2	0
		12	Giving consideration to the results of objective forest monitoring systems	X	2	0
		13	Giving consideration to the protective function of the forest	X	2	0
		14	Preventing game damage that is unacceptable particularly in terms of public interest		0	-4
		15	Giving consideration to population fluctuations		2	-2
	Conservation and promotion of biotope connectivity (4/-2)	16	Giving consideration to existing wildlife habitat fragmentation	X	2	-1
		17	Increasing the attractiveness of important wildlife corridors and obligatory wildlife passages	X	2	-1
	Giving consideration to habitat capacity (6/-2)	18	Completeness of the wildlife habitat		2	-1
		19	Giving consideration to competitive relationships of various wildlife species		2	-1
		20	Extent of annual growth rate in ungulates		2	0

Table 1. (cont.)

PRINCIPLE (Pts. max./min.)	CRITERION (Pts. max./min.)	No	SUB-CRITERION	optional	Range of points max	Range of points min.
The natural genetic diversity of game species is conserved and fostered by means of an appropriate hunting practice (5/-1)	There are no hunting-related limitations to the conservation and fostering of the natural genetic variability of game species (4/0)	21	Existence of aims relating to the aesthetics of trophies (forms of horns and antlers) in shooting guidelines		2	0
		22	Selective hunting of wildlife according to certain natural characteristics of individuals		2	0
	Native wildlife populations are not altered by the introduction of and blending with exotic (not native, alien) wildlife (1/-1)	23	Introduction of exotic (not native, alien) wildlife		1	-1
Economy					26	-9
Securing and/or improving the economic profitability of hunting is an objective of hunting (8/-3)	The profitability of hunting is secured over a medium term (6/-2)	24	Existence of a marketing strategy		2	0
		25	Expense/yield ratio		2	-1
		26	Marketing of game	X	2	-1
	The value of hunting is maintained and/or fostered by the practice of hunting (2/-1)	27	Hunting-related measures to increase the market value	X	2	-1
Preserving and fostering the condition of the game is an objective of hunting (8/-1)	Average game weight (5/-1)	28	Continuous, long-term comparison of game weights		3	0
		29	How high is the game weight?		2	-1
	Existence of a time- and area-specific hunting strategy (3/0)	30	Existence of an economically sound hunting strategy for the temporal and spatial implementation of hunting, documentation of the planning, practice and evaluation of hunting		3	0
Preventing damage to agriculture and forestry is an objective of hunting (4/-2)	Hunting is oriented according to the susceptibility of agricultural land and managed forests to game damage (4/-2)	31	Giving consideration to game damage susceptibility		4	-2
Making use of synergies with other economic branches is an objective of hunting (6/-3)	Hunting forms an economic unit with other foreseeable anthropogenic forms of land use (2/-1)	32	Confirming a common policy		2	-1
	Optimising planned changes in wildlife habitats by way of interdisciplinary spatial planning (4/-2)	33	Interdisciplinary wildlife-ecological spatial planning (WESP)		4	-2
Socio-cultural aspects					11	-9
The use interests of the local population in hunting are taken into account (3/0)	Hunting establishes balanced relationships to the local population through an appropriate involvement of local hunters (3/0)	34	Reconciling the interests of local hunters permitted to hunt locally and local hunters not permitted to hunt locally		3	0
Securing local jobs in the field of hunting is to be an objective (2/-1)	Hunting contributes to securing employment by providing job opportunities (2/-1)	35	Providing jobs in the field of hunting		2	-1
Hunting should find broad acceptance among the local population (2/-2)	Giving consideration to the interests of the local population (2/-2)	36	Documentation of disagreements at the local authority		2	-2
Hunting is oriented according to the well-being of the game (4/-6)	Hunting is practised with as little adverse effects on the natural behaviour of wildlife as possible (2/-2)	37	The behaviour of wildlife shows that it feels safe and undisturbed by hunting activities		2	-2
	Hunting causes as little pain for animals as possible (2/-4)	38	Violations of legal regulations regarding animal protection		0	-4
		39	Training in shooting		2	0

Ecology

As far as ecological aspects are concerned, the P, C and I are oriented on the conservation and improvement of game species diversity, genetic diversity of game species and diversity of game habitats. Particular importance is attached to the handling of potentially natural game species (present, returning, extinct species) and non-autochthonous species. The amount of consideration that is given to the undisturbed life cycle of wildlife species, to critical factors of the reproductive biology of sensitive species and to the large-scale mobility of game species across hunting grounds indicates whether hunting is oriented according to the behaviour of wildlife species.
Other indicators deal with interactions of hunting with other forms of land use (e.g., agriculture, forestry), which requires an adequate strategy that should be established in a hunting concept. Hunting strategies should consider the seasonal fluctuations in food supplies of wildlife. Shooting plans and shooting lists are an absolute requirement for planning and documenting hunting activities because they are crucial instruments for the regulation of game stocks.
Considering the impact of game on vegetation is highly important [54]. Browsing control fences and forest monitoring systems are considered to be useful instruments to control game impacts by browsing. When assessing ecological sustainability, preventing unacceptable game damage is of particular significance, especially with regard to the protective function of forests. Tolerating temporary natural population fluctuations of abundant ungulate game species below average levels is another indicator related to this issue.
The last few decades have seen an increase in habitat alteration and fragmentation, which was caused mainly by agricultural landscapes poor in structural diversity and by high-ranking transportation infrastructure. It is therefore assessed whether the possibilities for linking biotopes are exhausted and whether migration zones and wildlife corridors are taken into account by hunting. Furthermore, the varying habitat capacity for game populations has to be considered [7]. By considering habitat improvement measures, hunting is able to contribute to meeting the habitat requirements of wildlife. Competitive relationships of various species should be given consideration to by hunting (e.g., by regulating increasing populations of game species that are threatening the viability of other wildlife species directly or indirectly). The extent of annual growth rate in ungulates may indicate whether the density of game populations is adapted to habitat capacity.
The impact of hunting on the genetic diversity of game species is indicated by assessing whether shooting guidelines are oriented on aims relating to the aesthetics of trophies (i.e., forms of horns and antlers), and whether shooting is carried out in a selective way (e.g., according to idealised (unrealistic) images of trophies, preferred shooting of male individuals or of individuals with certain natural behaviour patterns). Moreover, the introduction of exotic game species contributes to alteration of the natural gene pool.

Economy

Securing the capability of yielding returns and the profitability of hunting is a major objective of economically sustainable hunting [55]. Accomplishment of this objective is, for instance, indicated by the existence of a marketing strategy for game, bags,

shootings, and trophies, by the monetary expense-yield ratio of a hunting operation, and by the amount of proceeds from game. Also, for tenants and owners of proprietor's hunts, hunting-related measures to increase the market value of a hunt are evaluated, such as investments in installations and equipment on the hunting ground. Long-term documentation of game weights is used as an indicator for the yield and economic value of hunting; it can also provide some evidence on the condition of the game, which in turn can to some extent be influenced by hunting strategies [56]. An economically sound, spatial and temporal hunting strategy is crucial for the efficiency of hunting and therefore should be continuously documented in a written hunting concept.
Orientation of the practice of hunting on the susceptibility of agricultural crops and forest stands to damage by game is an important attribute of economically sustainable hunting. This requires organizing hunting activities with other land use sectors and their representatives on a regular and mutual basis. Hunters are able to optimise both synergies with other economic branches and interferences in wildlife habitats by actively supporting wildlife ecological spatial planning (legally binding or applied voluntarily on a regional scale) [57]. Such commitment is therefore considered as a contribution to the sustainability of hunting.

Socio-cultural aspects

Indicators of socio-cultural aspects refer to the relationships among hunters and between hunters and non-hunters, and to ethical issues.
Reconciliation of interests between local hunters permitted to hunt locally and those who are not indicates the extent to which the hunting interests of the local population are considered. Disagreements documented at the local authority provide clues as to whether the interests of the non-hunting local population, particularly those of land owners, land users and their representatives, are taken account of, which is seen as a valuable contribution to safeguarding sustained social acceptance of hunting. Contributions of hunting to securing local jobs are used as another indicator.
Sustainable hunting must comply with the requirements of modern animal protection. Hunting must be carried out in such a way as to ensure that the pain caused to the hunted game is as little as possible. Here, appropriate and regular training in shooting and compliance with animal welfare laws are demanded. If the behaviour of game shows that it feels safe and undisturbed by hunting activities, this is regarded as an important indicator of its well-being.

Discussion

Participatory process

For the process set-up, no particular socio-scientific model, but a flexible, case-based approach was applied. While various forms of participation may not be new to conflict management in environmental planning and natural resource affairs, no similar nation-wide multi-stakeholder process in relation to hunting issues is known in Europe. Responding to increasing international demands for participatory indicator development [2,3,4], our basic idea was to establish an organisational framework that fosters collaborative learning and acceptance of the project outcome by the targeted

users. We assumed that acceptance is facilitated by active personal involvement in the decision-making process and is, in turn, the pre-condition for commitment to implementation of jointly elaborated results [58]. Involving the accountable social actors directly from the beginning was also based on the conviction that hunting and wildlife management in the end is to a greater extent a human problem than a biological one, and that managing people is much more effective than managing the animals [59,60,61].
All stages of the participation process brought about modifications and improvements of the study without, however, fundamentally altering the substance of the draft version agreed upon in the first expert group discussion. Also, the basic structure of the assessment set and the assessment methodology remained virtually unchanged. When bargaining trade-offs, the core project team was flexible about the wordings, while remaining firm about substantial contents. Further changes focused on scalings, scores and weighting of indicators.

Assessment Methodology

Among the C&I sets studied, the conceptual framework of CIFOR for sustainable forest management [29,31] and two topical workshops held by the Umweltbundesamt [32,47] provided guidance for our project. The development of indicators usually faces the so-called “pyramid dilemma”. Top-down approaches that attempt to infer indicators from the generic model often lack problem-adequacy, whereas problem-oriented bottom-up approaches that try to condensate indicators by aggregating available data may lack coherency with the questions being asked [50,62]. To bypass this dilemma, we chose a more flexible, dual approach by practising a mix of both techniques. The construction of the assessment framework was based on a scoping of existent practical problems, while simultaneously orienting on superior principles of sustainable hunting [19,50]. No particular theoretical model was used to derive our indicator set.
"*Basically, everything is an indicator of something but nothing is an indicator of everything*" [63]. This statement shows that the selection of indicators and the identification of attributes suitable for verification is a difficult and critical step. Indicators are tools that determine the image we construct about our environment. The choice of indicators determines what is being assessed and affects the quality of assessment results [64].
Apart from standard methodical criteria [62,65], indicator selection is heavily dependent on the intended purpose of assessment and the targeted user group [62]. Our assessment set directly appeals to hunters and is aimed at influencing practical hunting behaviour. Thus, indicators were required to be representative and relevant to hunting-related problems and meaningful in terms of sustainable hunting [19]. Moreover, in particular pragmatic, user-oriented selection criteria were essential to meet the specific practice-related requirements: simplicity, practicability, easy applicability and user-friendliness, clearness and time-efficient verification.
This has implications for data requirements: indicators must be applicable without a large amount of quantitative data, additional data collections, or in-depth investigations. Instead, data input for assessment must largely rely on the information that can be expected to be readily available within the individual hunting ground, and on instant "soft" expert knowledge based on experience.

Basically, each indicator approach represents a trade-off between scientific accuracy and both practicability and usefulness [65]. Not everything that can be observed can easily be measured [39]. Moreover, observable attributes often do not have to be measured to provide useful information. For us, it was essential to include qualitative, behaviour-related attributes of hunting in the C&I-set. Focussing exclusively on information that can easily be quantified would have unnecessarily narrowed our perception of reality and reduced the set's force of expression [65]. This implies that verification of some sub-criteria may demand a certain amount of discretionary decision on the part of the users. However, one must remember that this is a self-reliant approach meant to support self-assessment, whose emphasis is on changing cognitive and behavioural patterns related to hunting, rather than on accurate "measuring" of hunting sustainability in quantitative terms.
Since participatory indicator development grants legitimization by stakeholders, scaling and benchmarking of indicators could be done in a collaborative manner, which warrants inter-subjectivity. To some extent, the implicit weighting of the indicators (i.e., range of points, no. of points per grade) is therefore connected to value-based decisions of the participants that, however, reflect the consensus-building process. Still, as the scores in points are laid open via the performance scales, the accomplishment of the assessment results is transparent and reproducible [66].

Evaluation scheme

Aggregation of indicator performances by means of simple mathematical summation of scored points, as applied in evaluation type 2 (Fig. 4), is an often used technique to condense information [29,31,34]. This may lead to the concealing of interdependencies and of overlaps between individual indicators [67]. But for the pragmatic purpose of supporting a quick and rough assessment of the extent to which the three major areas of sustainability are affected by strengths and weaknesses, this objection is negligible (e.g. hunters might want to know if they are "better" in the ecological or economic area). However, no further aggregation beyond the level of ecological, economic, socio-cultural groups of aspects is performed, because producing one single "sustainability value" would only reduce the value of information. Also, except adding up scores in points and relating them to the maximum number of points of each group, no other calculations and no mathematical algorithms are applied, since this would reduce transparency of the evaluation scheme and might be questionable in methodological terms due to the use of ordinal indicator scalings [57]. Possible loss of information in consequence of aggregation is avoided by providing the evaluation type 1 (Fig. 3), which presents the scores of all individual analytical indicators in overview. It provides a complete assessment profile of the assessment unit under investigation. In a similar way, for comparative assessment of different hunting grounds, indicator profiles displaying all results of one indicator for each assessment unit can be produced. Complementary use of both evaluation schemes allows swift identification of strengths and weaknesses regarding sustainability performance and facilitates interpretation. Using coloured graphical "sustainability performance scales" increases the clearness of representation.

The issue of feeding is not dealt with directly in the assessment system because it can have very diverse impacts on the indicators and thus is difficult to assess as to its effects in terms of sustainable hunting. Depending on how and on which location it is carried out, feeding may reduce game damage (e.g. of forests), but it may also cause such damage. Where natural winter habitats, e.g. for red deer, are not available anymore (due to anthropogenic influences), feeding may represent a technical "remedy" for the lost habitat, which allows a sustainable use of the respective animal species [68]. If feeding contributes in a positive sense to a better fulfilment of the sustainability criteria, it is automatically positively entered into the assessment. Negative impacts of feeding on sustainability are sufficiently reflected in the existing sustainability criteria.

Interpretation of assessment results

The concept is deliberately weighted towards ecological sustainability, because the integrity and functional capability of the ecological system determines the potential for sustainable development of the social and economic human sub-systems [20,69]. This is reflected by the higher number of sub-criteria and the higher number of maximum and lower number of minimum scores in the ecological area. This implies that the class widths of the evaluation classes (evaluation scheme 2; Fig. 4) are larger in the ecological area compared to the economic and socio-cultural areas, which particularly applies to the class "very bad". Thus, good evaluation results in terms of ecologic sustainability may be more difficult to achieve.
Certain indicators from different areas of sustainability may be controversial to each other. Also, the same sub-criterion may be assessed differently from the perspective of different areas. During the assessment process, it therefore is important to always be aware of the area a certain sub-criterion belongs to, to avoid, for instance, an intuitive incline towards economic judgement when assessing an ecological sub-criterion (and reciprocally).

Limitations

This is a hunting-specific C&I-set. The influences of hunting on animal species that are not hunted are not explicitly covered by our approach. Also, the manifold impacts from other land uses on wildlife, wildlife habitats and hunting management which often superimpose influences exerted by hunting itself and restrict its scope for action [8] are not subject of our assessment system. Only actions of hunting itself that may contribute to optimising interrelations with other economic sectors are assessed. Nevertheless, it intendedly offers interfaces towards other forms of land use; it therefore can be integrated into future cross-sectoral sustainability concepts.
As is inherent in any self-assessment, a source of constraint lies in a certain scope of subjective interpretation some sub-criteria leave to the user. A certain amount of honesty and ability for self-criticism is required and must be expected from the users.
Due to difficulties in defining verifiable sub-criteria, the present version of the assessment set may lack socio-cultural indicators dealing with aspects of hunting tradition and hunting culture in the narrower sense. This gap shall be closed in the future.

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