Open Journal of Ecology, 2023, 13, 199-228
https://www.scirp.org/journal/oje
ISSN Online: 2162-1993
ISSN Print: 2162-1985

Economic Valuation of Auctioned Tourist Hunting Blocks in Tanzania

Reuben M. J. Kadigi[1*], Imani R. Nkuwi[2], Fredrick A. Ligate[3], Hamza Kija[4], Emmanuel B. Musamba[5]

[1]Department of Trade and Investment, College of Economics and Business Studies, Sokoine University of Agriculture, CHUO KIKUU, Morogoro, Tanzania
[2]Research and Training Unit, Ministry of Natural Resources and Tourism, Dodoma, Tanzania
[3]Wildlife Division, Ministry of Natural Resources and Tourism, Dodoma, Tanzania
[4]Conservation Information and Monitoring Unit, Tanzania Wildlife Research Institute, Arusha, Tanzania
[5]Tourism and Business Services Directorate, Tanzania Wildlife Management Authority, Morogoro, Tanzania
Email: *rmjkadigi@sua.ac.tz, *rmjkadigi@yahoo.co.uk, imani.nkuwi@maliasili.go.tz, fredrick.ligate@maliasili.go.tz, hamza.kija@tawiri.or.tz, emmanuel.musamba@tawa.go.tz

How to cite this paper: Kadigi, R.M.J., Nkuwi, I.R., Ligate, F.A., Kija, H. and Musamba, E.B. (2023) Economic Valuation of Auctioned Tourist Hunting Blocks in Tanzania. *Open Journal of Ecology*, **13**, 199-228.
https://doi.org/10.4236/oje.2023.134013

Received: March 10, 2023
Accepted: April 18, 2023
Published: April 21, 2023

Abstract

Economic valuation of ecosystems is increasingly being recognized as an important exercise to inform sustainable utilization and conservation of natural assets. It helps in planning and establishing fair profit margins that accrue either directly or indirectly from the consumptive and non-consumptive uses of ecosystem goods and services. This paper is based on a study which estimated the economic values of tourist hunting blocks (HBs) in Tanzania using the Analytic Multicriteria Valuation Method (AMUVAM). The study used a sample size of 12 out of 24 vacant hunting blocks which were to be auctioned to potential hunting companies in December 2022. The economic values of HBs were estimated using the time horizon of 10 years (the mean tenure for winning company). The results show that the economic values ranged from USD 6,215,588 to USD 653,470,695 per hunting block and the Existence Value (EV) constituted about 19% of the Total Economic Value (TEV). EV ranged from USD 632,210 to USD 125,147,285. The study underscores the need for decisions to allocate ecosystems, such as HBs, to both direct and indirect uses, to be guided by a though understanding of their values. We further recommend building the capacity of staff charged with the role of managing and allocating uses of these ecosystems to enable them undertake economic valuation of ecosystems using both simple and more robust analytical tools, such as the GIS, relational databases, and worldwide websites based tools, like InVEST (Integrated Valuation of Environmental Services and Tradeoffs), ARIES (Artificial Intelligence for Ecosystem Services), and Co$ting Nature.

Keywords

Ecosystems, Total Economic Value, Biodiversity Conservation, Analytic Multicriteria Valuation Method, Hunting Blocks

1. Introduction

Sustainable conservation of ecosystems and biodiversity is still a major global challenge [1]. The available information shows that in most landscapes the average abundance of native species has declined by approximately 20% since 1900 [2]. More than 41,000 animals are threatened with extinction [3]. These include 27% of the world's mammals and 13% of all known bird species (ibid). Just as important, the WWF's Living Planet Report 2022 shows that wildlife populations have decreased by an average of 69% in the past 50 years [4]. This is imagined as the world's ecological crisis propelled by unsustainable anthropogenic economic activities and changing climatic conditions leading to environmental degradation [5].

At the same time, recent global reports [2] [6] [7], have attributed this crisis to major knowledge gaps which were supposed to inform sustainable management of ecosystems, including the lack of the estimates for the impacts of global biodiversity loss on ecosystems and people [8]. The most relevant biodiversity policy questions are those linked to land use change; exploitation or overexploitation of animals, plants, and other organisms, mainly via harvesting, hunting, fishing, and logging [9]. Additional information is urgently needed to inform global biodiversity conservation goals or targets [10] [11] [12], as well as the policies and other transformative changes that will be needed to achieve them [7]. This is important because natural assets and biodiversity constitute the engine that drives the flow of benefits from ecosystems to humanity [9]. Thus, the integration of economic value of natural ecosystems (EVNE) into economy-wide analytical frameworks, such as the national income accounting (NIA), should be pursued as an inevitable practice to enhance evidence-based decision-making and sustainable management of ecosystems [13] [14]. EVNE is an approach that integrates the environment into a more holistic policy analysis through the compilation of environmental-economic accounts and is gaining popularity as a systematic approach to recognise the full value of natural assets such as animals, water, biodiversity, soil, and vegetation [15].

EVNE is crucial in informing policy process, both at strategic and implementation levels [16]. At a strategic level, it represents an important element of a national or regional economic growth strategy for sustainable utilisation and management of ecosystems (ibid). It seeks to increase resource use efficiency, raise resource supply security and promote eco-innovation, thereby raising the overall productivity of the economy (ibid). EVNE helps to identify gaps in knowledge and risk registering [16]. It can also provide information on "critical ecosystems" and earlier identification of the pressures, drivers and threats as well as opportunities to natural assets which can facilitate the move to sustainable development paths (ibid). At the implementation level, EVNE can help in the assessment of the effectiveness of prevailing policy instruments and the practicability of policy objectives, or future policy options (ibid).

This paper uses the Analytic Multicriteria Valuation Method (AMUVAM) to estimate the economic values of 12 out of 24 tourist hunting blocks in Tanzania which were planned to be auctioned to potential hunting companies in December 2022. In particular, we use the concept of Total Economic Value (TEV) and its five individual components namely; the Direct Use Value (DUV), Indirect Use Value (IUV), Option/Quasi-option value (O/QV), Existence Value (EV) and Bequest Value (BV). We further decomposed the EV to establish the values of biodiversity (BDV); cultural heritage (CHV) and aesthetic enjoyment (AEV). Estimating the economic value of these HBs was deemed important because the revenues accruing from trophy hunting and photographic tourism constitute one of the important sources of national income in Tanzania. The available statistics show that revenues from these sources range between USD 28,377,000 and USD 37,836,000 per annum [17]. However, decisions to auction or allocate these natural assets to potential outfitters or hunting companies have been reached without a thorough understanding of their values. This implies that the benefits accruing from the HBs were not fully captured in the country's GDP equation. Ignoring these values and omitting them from the accounting framework implicitly assigns a zero value to their stocks and flows. These ecological systems cannot be ignored not least because of their importance as sources of government revenues but because of their role in biodiversity conservation. The next Section presents an overview of the AMUVAM approach. This is followed by Section 3 which presents the study approach and methodology; Sections 4, 5 and 6 which present the results, discussion as well as the key conclusions and recommendations from the study.

2. An Overview of AMUVAM

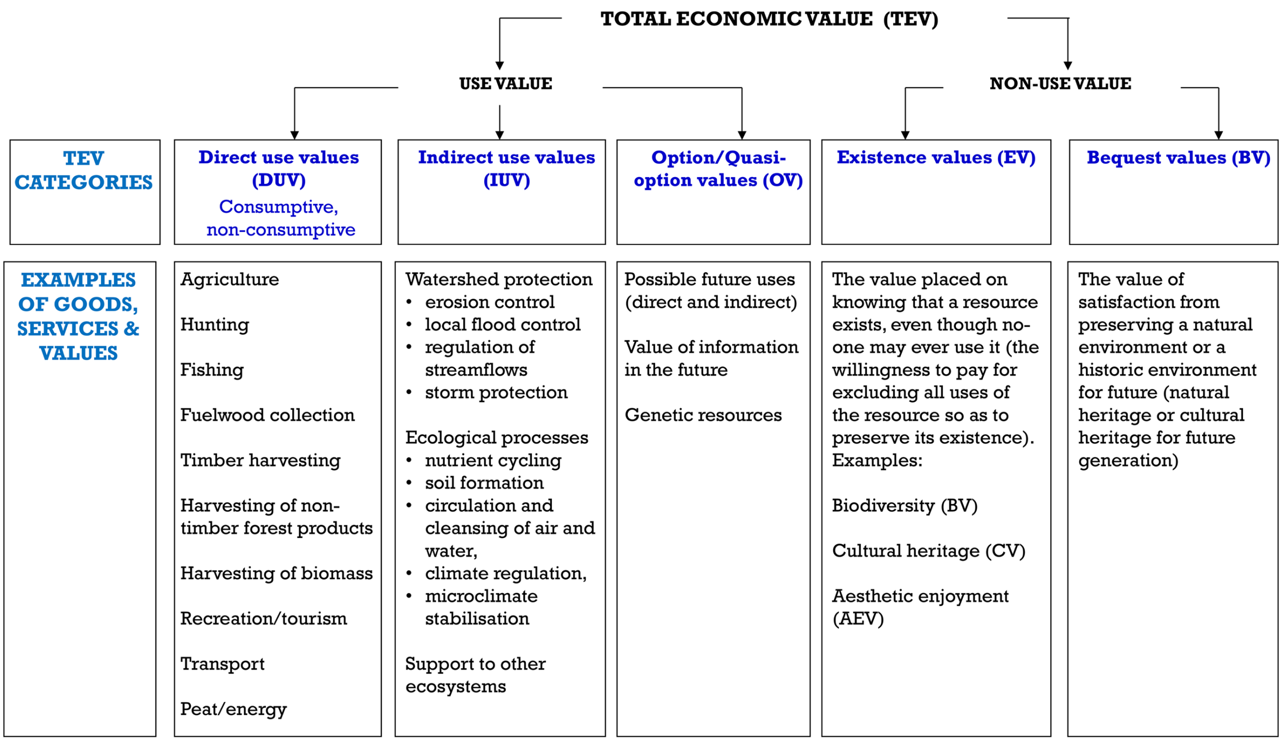
The Analytic Multicriteria Valuation Method (AMUVAM) is an approach that can be successfully used to estimate TEV and its five components. Examples of its application include the study by Estruch-Guitart & Vallés-Planells [18] who estimated the economic value of landscape aesthetics in Albufera National Park (Valencia, Spain). AMUVAM is a combination of two established techniques namely the analytic hierarchy process (AHP) and discount cash flow (DCF). Developed by [19], AHP has been broadly used in different fields [20] [21] [22] [23], and is implemented to obtain the relative weights of the TEV components. DCF is used to determine the economic values of the services associated with DUV [24]. Under AMUVAM, the economic value of non-market benefits is obtained indirectly, by comparing the relative degrees of importance attached to the different components of TEV. In particular, AMUVAM enables the determination of TEV, the relative values of its components (Figure 1) and the relationship between values that lack an associated market (and hence a market price) and values that do have a market price.

In AMUVAM, the known value of some of the components of TEV may be applied to derive the values of the remaining components [18]. The method permits the assessment of the relative importance and the monetary values of all the components of TEV which include the direct use values (DUV), indirect use values (IUV), option/quasi-option values (OV), existence value (EV), and bequest values (BV) [25]. It also allows the valuation of disaggregated components of TEV [18]. It is important to note that, any of these five TEV components can be decomposed further to determine the respective values of goods and services provided by the individual aggregates of the component (ibid). In this paper, we decompose EV into three sub-components namely; biodiversity (BDV), cultural heritage (CHV), and aesthetic enjoyment (AEV) following the procedure used by Estruch-Guitart & Vallés-Planells [18].

3. Study Approach and Methodology

3.1. Selection of Sample Hunting Blocks

An in-depth EVNE (TEV) was carried in 12 sample-hunting blocks out of 24 planned by the Government of Tanzania to be auctioned in December 2022 (Figure 2). The 24 HBs were first stratified into three 3 categories of hunting blocks in Tanzania (I, II, and III) classified based on key attributes, such as size,



Source: Modified from Barbier *et al.* [25].

Figure 1. Components of total economic value (TEV).

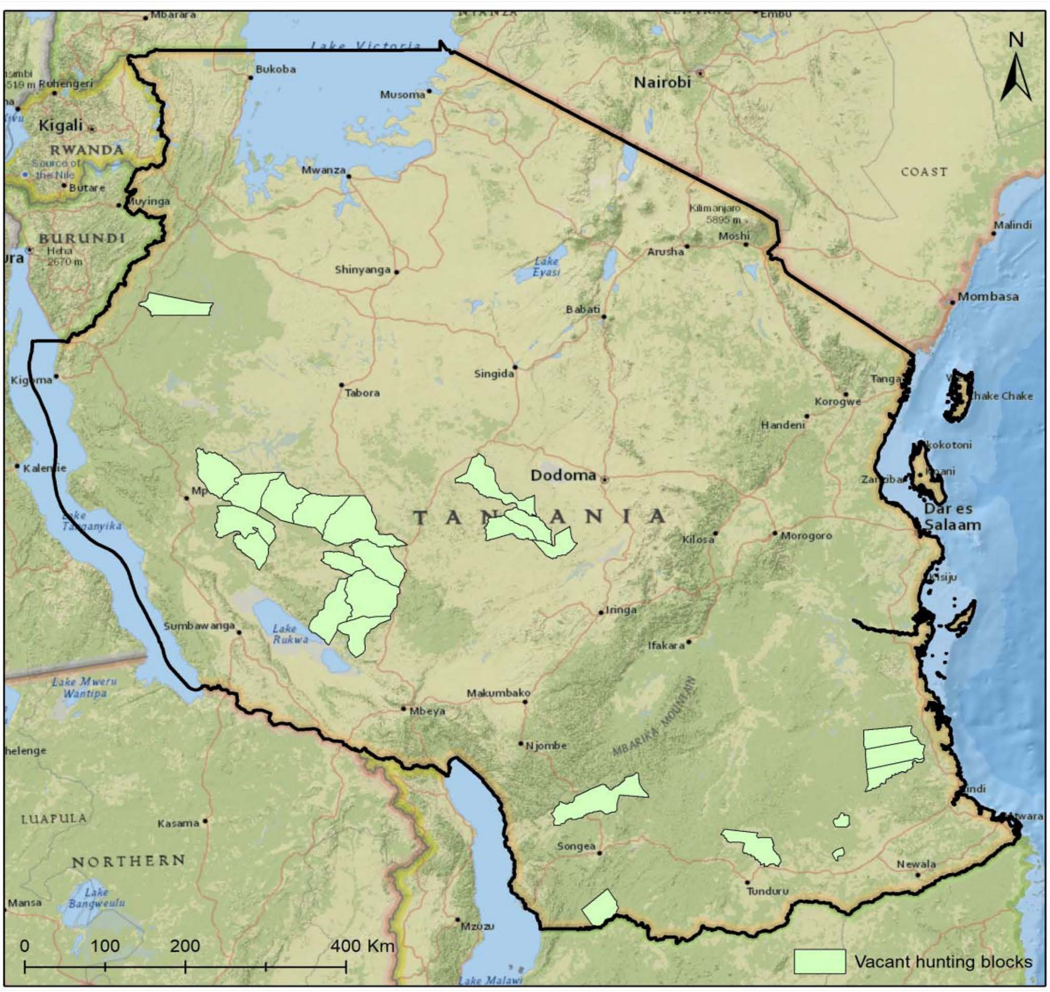


Figure 2. Map of Tanzania showing the vacant hunting blocks planned for auctioning in December 2022. Source: Tanzania Wildlife Research Institute (https://tawiri.or.tz/).

location and the status of wildlife. For each category the sample HBs were then selected based on the availability of cash flow data or possession of similar socioeconomic and ecological contexts to enable adjustment and extrapolation (value transfer) from another HB with cash flow data.

It is important to precisely describe the distinction amongst the three categories of HB here. The HB in Category I have the highest attributes in terms of proximity to Game Reserves and National Parks, habitat quality, and species diversity whereas the ones with the lowest qualities were classified under Category III. In between these two extremes were the hunting blocks classified under Category II. Spatially, the HBs in Tanzania are widely distributed across the country but they are found in three broad eco-zones namely the:

1) Northern Maasailand zone, close to the Serengeti National Park (SNP), Ngorongoro Conservation Area (NCA) and Lake Natron ecosystem;

2) Western Tanzania zone, including the Rungwa, Ugalla, Rukwa, Moyowosi and Biharamulo and Ibanda Game Reserves; and

3) Southern Tanzania zone which is dominated by the Selous Game Reserve

(SGR).

The northern Maasailand zone falls into the Somali-Maasai ecoregion dominated mainly by *Acacia* and *Commiphora* grasslands. This region is drier than the western and southern parts of the country and supports unique large mammals (gerenuk, lesser kudu, dik dik and the gazelles). Many hunting companies struggle to secure blocks in both the wetter *miombo* and drier *acacia* zones to take advantage of species diversity. In western and southern Tanzania the vegetation is dominated by *miombo* woodlands, vast wetlands and open grassland areas (or *mbugas*). Generally, the woodlands are biologically diverse but because of poor soils and high rainfall, they support low densities of large mammals.

3.2. Weighting of TEV Components

In this step, the AHP described by Saaty [19] was applied in order to obtain the relative weights of TEV components and EV components from a group of experts (judges or rankers) who have a deep knowledge of the sample hunting block and represent the different points of view on the valued ecosystem. The experts weighted components at two levels using the conceptual framework we present in **Figure 3**. They started weighing TEV components (level 1 ranking) and then, they weighted EV components (level 2 ranking). The survey started with a brief explanation of the goal of the work and the meaning of the different types of values. Then, experts were asked to compare TEV and EV components by pairs. This comparison was implemented in two steps. First, they were asked to decide which of the two components in **Figure 4** was the most important for each pair. The question posed to the participants was the following: of the two values being compared, *which is considered more important by society with respect to the overall value of the hunting block in question*? Second, they were

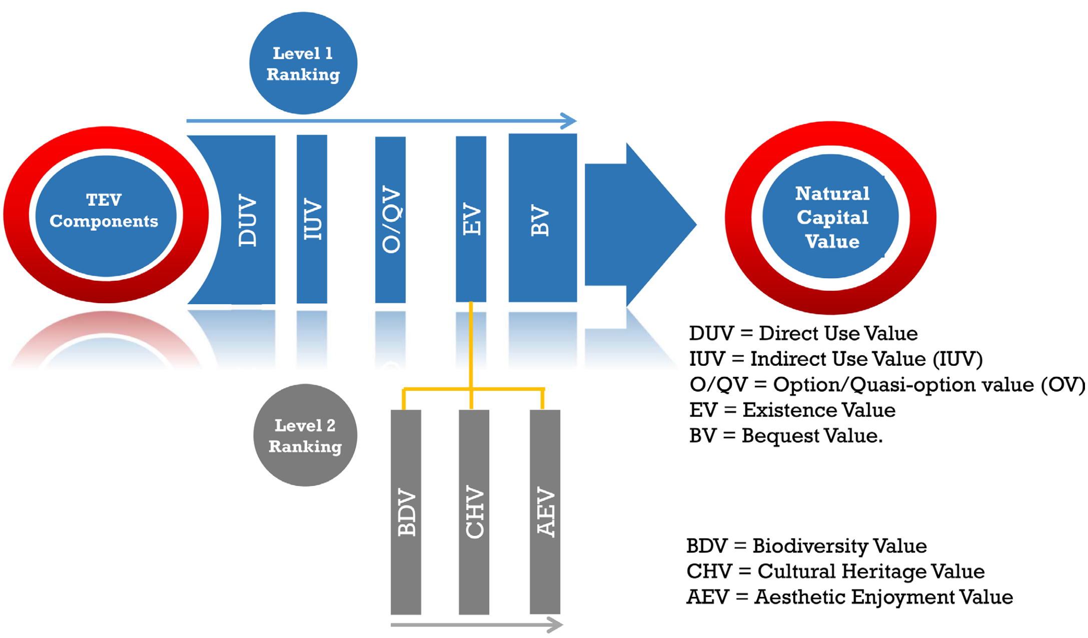


Figure 3. Conceptual framework for ranking TEV and EV components.

asked to express the intensity of importance, using the fundamental scale of comparisons shown in Table 1.

For this study, the set of experts (rankers or judges) included different stakeholders representing the key topics of the area, in terms of exploitation and conservation of ecosystems. Experts (rankers or judges) included representatives of:

1) Local communities who were familiar with the hunting block in question;

2) Technical officers or in charge of hunting blocks;

3) Outfitters who were familiar with the hunting block;

4) Ecologists and Tanzania Wildlife Research Institute (TAWIRI) researchers who were familiar with the hunting block; and

5) University researchers who specialised in landscape planning and wildlife ecology disciplines.

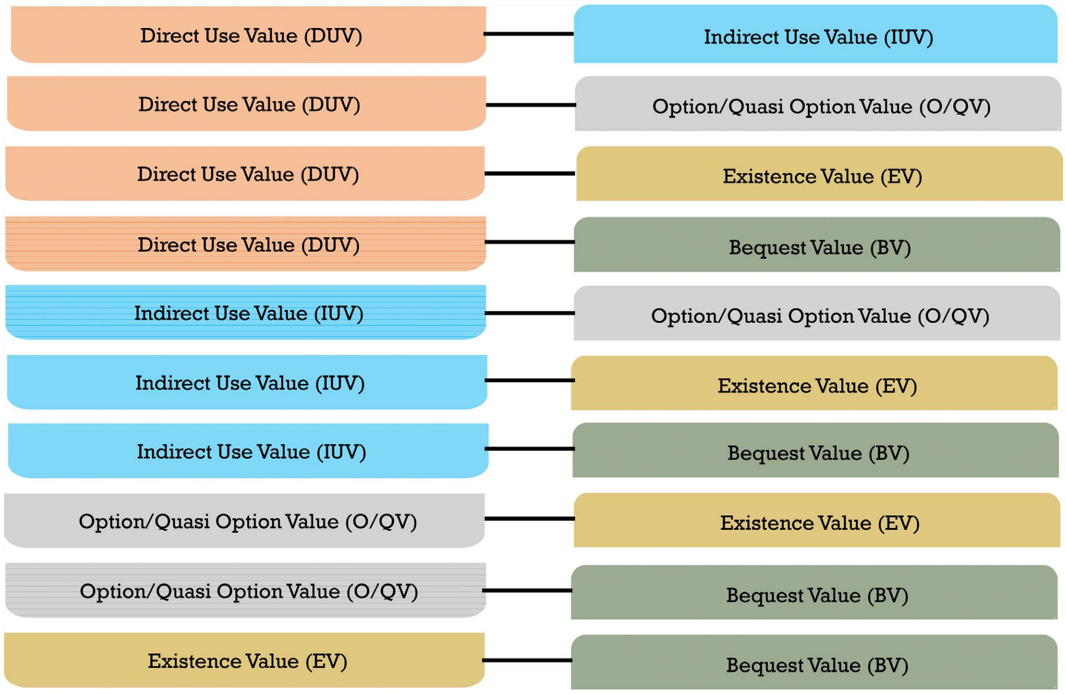


Figure 4. Pairs of TEV components compared based on their importance.

Table 1. The fundamental scale for pairwise comparison of TEV components.

Scale	Definition	Explanation
1	Equal importance	Two elements contribute equally to the property or criterion.
3	Moderate importance	Experience and judgment slightly favour one element over another.
5	Strong importance	Experience and judgment strongly favour one element over another.
7	Very strong importance	Experience and judgment very strongly favour one element over another; it is dominance is demonstrated in practice.
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation.

Source: Saaty [19].

3.3. Calculation of Eigenvalues, Eigenvectors and Component Loading

Prior to conducting EVNE, it is necessary to establish the weights of TEV components [18]. Using IBM SPSS Statistics 26 version and Microsoft Excel 2010 software, these weights were established from the rankings of experts (rankers or judges) following approach used by Estruch-Guitart & Vallés-Planells [18]. In particular, we applied the judges' rankings to construct the comparison matrices, the eigenvalues, and the eigenvectors [18] [26]. The eigenvalues represent the total amount of variance that can be explained by a given principal component [27] [28] [29] [30].

The eigenvalues give the component loadings which can be inferred to as the correlation of each item with principal components [27] [29]. It should be noted here that the eigenvalues can be positive or negative in theory but in practice they explain variance, which is always positive [31]. The following three outcomes are worth noting regarding the eigenvalues (UCLA Statistical Consulting Group, 2021):

1) If they are greater than 0, then it is a good sign;

2) Since variance cannot be negative, negative eigenvalues imply the model is ill-conditioned; and

3) Eigenvalues close to 0 imply there is item multicollinearity, since all the variance can be taken up by the first component.

The eigenvector (v_i) represents a weight of each eigenvalue and the component loading (*L*) can be interpreted as the correlation of each item with the principal component eigenvector times. The eigenvector can be calculated as the ratio of component loading to the square root of eigenvalue ($\sqrt{\lambda}$,) (Equation (1)) [27].

$$v_i = \frac{L}{\sqrt{\lambda}} \tag{1}$$

The square of each loading represents the fraction of variance described by a specific component (the R^2 statistic) [27] [32]. The cumulative sum of the loadings is dubbed the communality (ibid). It is the fraction of each variable's variance that can be described by the factors [27]. It is also defined as the total of squared factor loadings for the variables (ibid).

3.4. Determination of Fair Prices and Profits

Prior to conducting EVNE it was important to establish the fair price which would lead to fair profit from tourist hunting business for each hunting block [33]. A fair price is defined as a price which customers are ready to pay it (ibid). It is a price that it will be accepted by customers personally because it is based on what they consider morally right and equitable [33] [34] [35] [36]. A "fair profit" can therefore be defined as "the maximum margin a business can achieve in its market to pay for the services it provides to customers based on its volume of purchases and service needs" [37].

Economists have recommended down that a "fair" and reasonable return on investment is 2% after income tax and inflation [38]. In this paper we apply the matrix of income tax and inflation rate (**Table 2**) suggested by St. Clair Partners [38] to determine the range of fair profits for the auctioned hunting blocks. Using the country's inflation rate, which was approximately 3% and the tax rate of 30% in 2022, then operators of hunting blocks or outfitters must earn approximately 7.1% per annum in order to show a 2% real growth after adjusting for both income taxes and inflation. Assuming an investment of $100 the fair real income to the investor or outfitter can be calculated as shown in **Table 3** and the real income (rounded after income tax and inflation) would be $2. However, in recognition of the government's recent desire to promote investment opportunities particularly in the tourism and hospitality sector [39] and based on the results of sensitivity analysis our paper uses the maximum fair profit margin of up to 30%.

3.5. Calculation of Pivot Value

The DUV in the AMUVAM is dubbed the pivot value [18]. It is called pivot value because it associates economic functions with market values (ibid). The pivot value is based on both present and future revenues derived from the exploitation of these resources and discounted over a period of time [24]. This approach assumes that the value of an ecosystem corresponds to the present value (PV) of the sum of the future revenues derived from this asset [18] [24]. The PV of future expected net cash flows is calculated using a discount rate that converts a future monetary sum into present value and the cash flows (ibid). In our study,

Table 2. Matrix of income tax and inflation rate.

Income tax rate	Inflation rate										
	2%	**3%**	**4%**	**5%**	**6%**	**7%**	**8%**	**9%**	**10%**	**11%**	**12%**
60%	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0
46%	7.4	9.3	11.1	13.0	14.8	16.7	18.5	20.4	22.2	24.1	25.9
40%	6.7	8.3	10.0	11.6	13.3	15.0	16.7	18.4	20.0	21.7	23.3
30%	5.7	7.1	8.6	10.0	11.4	12.9	14.3	15.7	17.1	18.6	20.0
20%	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5

Source: St. Clair Partners [38].

Table 3. Calculation of real income based on investment of $100.

Gross Income	7.10
Less: Inflation rate	3.00
	4.10
Less Income tax (30% of $7.10)	2.13
Real income (rounded after income tax & inflation)	2.00

the pivot value was derived from trophy hunting and photographic tourism cash flows and the annual revenues earned from the incomes and expenditures of these activities were calculated following the procedure by Florio *et al.* [40]. Then, this cash flow was updated using a social discount rate (SDR) of 3% (*i.e.* the country's inflation rate at the time of the study) to convert future costs and benefits into present values [38] (Equation (2)).

$$\text{NPV} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1-r)^t} \tag{2}$$

where; B_t and C_t represent the total benefits and total costs respectively; and t is the time horizon or years of hunting offered to the hunting block (10 years in this study).

In addition, we calculated the Benefit Cost Ratio (BCR), that is, the present value of project benefits divided by the present value of project costs using the expressions given in Equation (3).

$$\text{BCR} = \frac{\sum_{t=0}^{n} \frac{B_t}{(1-r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1-r)^t}} \tag{3}$$

We also computed the Internal Rate of Return (IRR), that is, the discount rate that zeroes out the NPV of flows of costs and benefits of an investment [40]. IRR is the discount rate at which it would be just worthwhile doing the project (Equation (8)). So the IRR is the discount rate, r^*, at which:

$$\text{NPV} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1-r^*)^t} = 0 \tag{4}$$

Different discount rates are proposed in the literature [41] [42] [43] [44]. The European Commission for example, suggests a benchmark real Financial Discount Rate (FDR) of 5% which is widely accepted as the opportunity cost of capital or sacrificed return on another project or an implicit cost or sink capital invested into a project [42]. In economic analysis, the social discount rate (SDR) is recommended that reflects the social viewpoint on how future benefits and costs are to be valued against the present ones and it can be established using different methods (ibid). One of the key theoretical approaches needs that SDR is derived from the projected long-term development in the economy (ibid). However, the Social Time Preference Rate (STPR) approach, which is based on the long term rate of growth in the economy is the most preferable discount rate [41] [43] [44]. STPR (r), is usually estimated using the Ramsey formula presented in Equation (5) [45].

$$r = p + e * g \tag{5}$$

The STRP formula (Equation (5)) can also be expressed in terms of consumption [42]. However, the analyst must know not only the growth rate of consumption (g) but also the elasticity of marginal utility to consumption (e) and the inter-temporal preference rate (p) (ibid). The first item of the STPR equation (Equation (5)) represents the utilitarian preference and the second one (p) is the pure time preference (ibid). It should be noted here that all the values in Equation (4) are country specific, especially those of consumption growth (g) which is directly reliant on GDP (ibid). Social and private preferences affect the marginal utility parameter (e) (ibid). Life expectancy and other individual characteristics are considered to influence the time preference parameter (p) (ibid). If income tax structures were assumed to be at least roughly centred on the principle of equal absolute sacrifice of satisfaction, then the extent of progressiveness in the tax structure would provide a metric for e as shown in Equation (6) (ibid).

$$e = \frac{\log(1-t)}{\log\left(1-\frac{T}{Y}\right)} \tag{6}$$

where; t is the marginal rate of income tax; T is the total income tax liability and Y the total taxable income.

In the empirical research literature, a wide range of STPR figures has been used. For example Pearce and Ulph [46] suggested that a range of 2% - 4% probably sets the upper and lower bounds of what is a credible SDR. Elsewhere in the literature, Evans and Sezer [47] and Evans [48] have argued for a standard benchmark European discount rate of around 3% - 4% based on STPR. This rate is somewhat lower than the 5% rate suggested by EC [49] and, as such, its application should result in a more generous EVNE of longer time horizons. In the same vein, Lopez [50] offered empirical estimates of SDRs for nine Latin American countries based on the STPR hypothesis. He highlighted the fact that, depending on the growth expectations of the social planner, these DRs can vary from about 3% - 4% in a future low growth scenario to 5% - 7% in a high, but still reasonable, growth scenario.

3.6. TEV and Estimation of Its Components

Once the pivot value (DUV) is known, the other components of TEV and their sub-components (IUV, O/QOV, EV, BV) are estimated, using the eigenvalue determined through the AHP method, so that the relative weights of the TEV components are defined (Equations (7)-(10)). The economic value of a hunting block is then determined by adding up all the partial values (Equation (11)). The value thus obtained indicates the TEV of the hunting block as an ecosystem. Then, the existence value (EV) was further decomposed into its three major components (*i.e.* biodiversity, cultural heritage and aesthetic enjoyment) using their weights and the known economic value of the EV (Equations (12)-(14)).

$$\text{IUV} = \frac{\text{DUV}}{\text{DUV weight}} * \text{IUV weight} \tag{7}$$

$$\text{O/QV} = \frac{\text{DUV}}{\text{DUV weight}} * \text{O/QV weight} \tag{8}$$

$$EV = \frac{DUV}{DUV\ weight} * EV\ weight \tag{9}$$

$$BV = \frac{DUV}{DUV\ weight} * BV\ weight \tag{10}$$

$$TEV = DUV + IUV + O/QV + EV + BV \tag{11}$$

$$BV = EV * BV\ weight \tag{12}$$

$$CH\ value = EV * CH\ weight \tag{13}$$

$$AE\ value = EV * AE\ weight \tag{14}$$

3.7. Sensitivity Analysis and Statistical Tests

3.7.1. Sensitivity Analysis

The NPVs for sample hunting blocks were calculated based on what was considered to be a fair profit margin (30%) [38]. The calculated NPVs were meant to give relative efficiencies of outfitters or operators of hunting blocks given the data on cash flows and the assumed social discount rate (*i.e.* the inflation rate of 3% used in this study). However, any of these data might change due to uncertainty. Thus, the NPVs were recalculated by changing the key parameter (*i.e.* the discount rate for this case) from 3% to 4%, 5%, 6%, 7%, 8%, 9% and 10%. The idea was to discover which one(s) of the NPV was most sensitive to the change in discount rate. The resultant NPVs are presented together with the respective cash flows, BCR and IRR in Appendix 1.

3.7.2. Statistical Tests

In this study, the Kendall's coefficient of concordance, W was used to test and establish pairwise rankings for both TEV and EV components compared according to their importance as well as their intensity of importance. Their respective codes were used to compute the Kendall's coefficient of concordance, W, which is defined as expressed in Equation (15). The idea was to identify the highly ranked TEV and EV components and test for agreement or disagreement among rankers.

$$W = \frac{\text{Variance of overall column totals}}{\text{Maximum possible variance over column totals}} \tag{15}$$

Another measure of concordance is the average over all possible Spearman correlations among all [51]. It can be calculated from Kendall's W using the formula expressed in Equation (16).

$$\bar{R}_S = \frac{kW - 2}{W - 1} \tag{16}$$

where $\bar{R}_S$ denotes the average Spearman correlation and k the number of rankers.

The current study applied the Kendall's measure of concordance, W, to test if the rankers of about both TEV and EV components did not agree or agreed among themselves. The values of Kendall's W always fall between 0 and 1 with the value of 0 implying perfect disagreement because the column totals will be equal and the variance will be 0 and the value of 1 implying perfect agreement amongst the rankers. In this later case, the variance among column total will be equal to maximum possible variance. The study used the coefficient (W) values of 0.4 and above to ascertain if the rankings of respondents agreed with each other.

4. Results

4.1. Results of Statistical Tests

The results of analysis of the Kendall's W test and the estimated coefficient of concordance are presented in Appendices 4 and 5 for mean ranks of TEV components considered to be important and the intensity of importance respectively. The test results vary among hunting blocks with test statistics for pairwise comparison of pairwise mean ranks of importance (Appendix 2) suggesting that the rankers of hunting blocks 2 (HB2), 3 (HB3) and 10 (HB10) agreed with each other to a reasonable though not super high extent (Kendall's W of about 0.4 or slightly more), registering Chi-squares of (χ^2) (7) = 26.526, p = 0.000); (χ^2) (7) = 28.656, p = 0.001); and (χ^2) (7) = 24.267, p = 0.001) respectively. In fact, the asymptotic p-values of 0.001 and 0.000 strongly suggest that the coefficient of concordance was not zero, meaning that there was some agreement among rankers in terms of which of the paired TEV components was considered of more importance by the communities. The pairwise test statistics of mean ranks of intensity of TEV components (Appendix 3) also differ among hunting blocks. More interesting, the rankers of hunting blocks 3 (HB3) and 4 (HB4) strongly agreed with each other regarding the comparison of the intensity of importance with Kendall's W higher than 0.4 (*i.e.* 0.648 and 0.565 respectively).

The results of pairwise comparison of importance between TEV components (Appendix 2) show that OV versus EV as well as DUV versus BV were rated most favourably with mean ranks of 5.78 and 4.73 respectively. In terms of intensity of importance (Appendix 3) the results of pairwise comparison between DUV and OV as well as DUV and BV were also rated most favourably with mean ranks of 5.47 and 5.27 respectively.

4.2. Summary of Annual Income and Cost Structure

The estimates of safari income and net profit calculated using the cash flow data and a "fair" profit margin of 30% are summarised in **Table 4** for each of the sample-hunting block. The values of undiscounted "fair" net profits for the sample hunting blocks are portrayed in **Figure 5**. These net profits range from the lowest of USD 29,786 (for hunting block 6, coded as HB6) to the highest of USD 304,878, (for hunting block 12, coded as HB12).

4.3. Pivot Values, BCRs and IRR

The estimates of pivot values (NPVs); Benefit Cost Ratios (BCRs); and the Internal

Rates of Return (IRR) for the sample hunting blocks are summarised in Table 5.

As shown in Table 5 and Figure 6, the discounted pivot values (NPVs) ranged from the lowest of USD 191,515 to the highest of USD 2,184,342 for hunting blocks 6 and 12 respectively.

4.4. TEV of Hunting Blocks

The estimates of TEV components of the sample hunting blocks are presented in

Table 4. Summary of annual income and cost structures of hunting blocks (undiscounted USD).

HB code	CAT	Safari income	Operational cost	Net profit
HB1	II	340,010.67	238,007.47	102,003.20
HB2	II	200,286.79	140,200.75	60,086.04
HB3	II	340,010.67	238,007.47	102,003.20
HB4	II	340,010.67	238,007.47	102,003.20
HB5	II	340,010.67	238,007.47	102,003.20
HB6	III	99,285.02	69,499.52	29,785.51
HB7	II	340,010.67	238,007.47	102,003.20
HB8	II	613,014.92	429,110.45	183,904.48
HB9	II	496,691.74	347,684.22	149,007.52
HB10	II	644,799.33	451,359.53	193439.798
HB11	I	766,724.46	536,707.12	230,017.34
HB12	I	1,016,260.55	711,382.39	304,878.17

CAT = Category of hunting block.

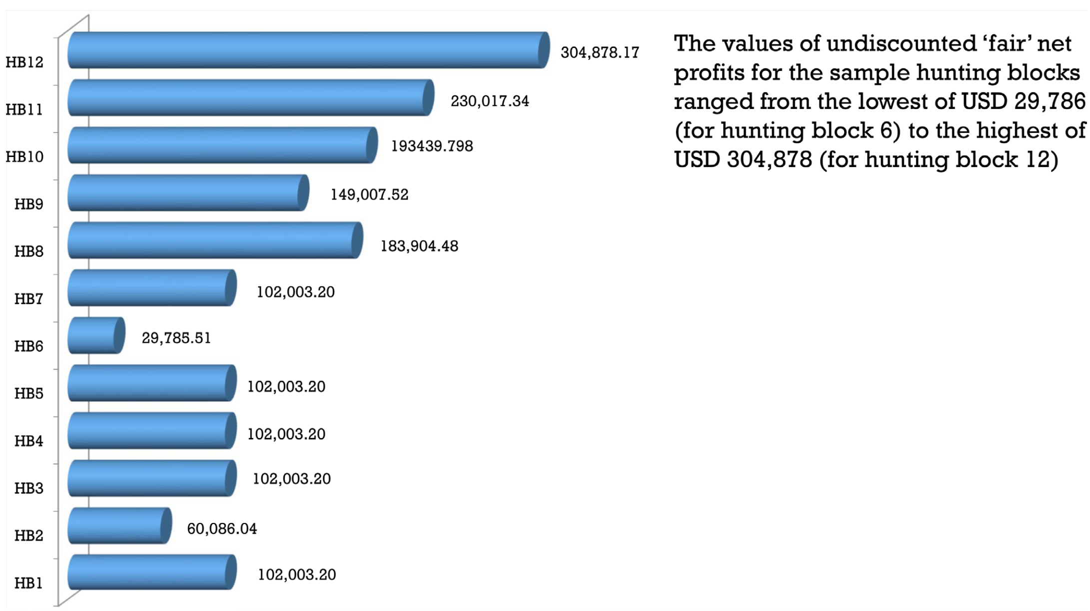


Figure 5. Undiscounted net profits by sample hunting block.

Table 5. Pivot values, BCRs and IRRs of hunting blocks (discount rate = 3%).

HB code	CAT	NPVs (Pivot values in USD)	BCR	IRR
HB1	II	1,279,472.04	1.30	91%
HB2	II	386,341.02	1.30	52%
HB3	II	1,127,794.69	1.22	50%
HB4	II	1,334,145.79	1.30	94%
HB5	II	1,334,145.79	1.30	94%
HB6	III	191,514.76	1.33	52%
HB7	II	1,334,145.79	1.30	94%
HB8	II	1,182,468.44	1.30	52%
HB9	II	893,460.57	1.28	41%
HB10	II	1,261,437.59	1.31	54%
HB11	I	1,182,468.44	1.33	52%
HB12	I	2,184,342.32	1.35	87%

CAT = Category of hunting block.

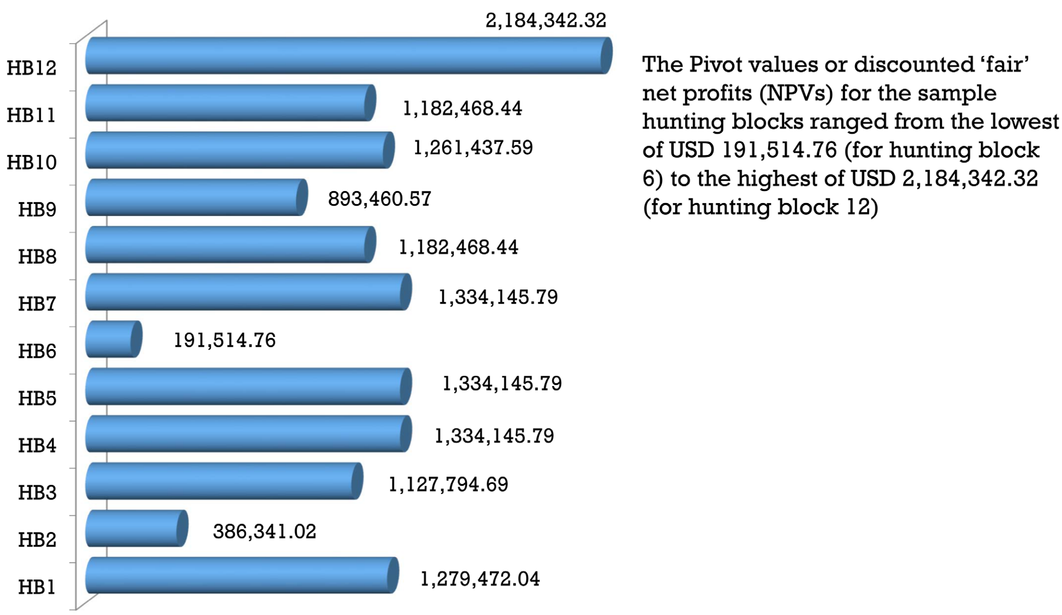


Figure 6. Discounted net profits by sample hunting block.

Table 6. These were calculated using a discount rate of 3% to the pivot values of hunting blocks (*i.e.* the DUV). Hunting block 12 registered the highest TEV (USD 653,470,695), followed by hunting blocks 3 (USD 122,550,672), 5 (USD 67,712,613), and 9 (USD 62,869,829). Of the entire sample of hunting blocks, block 2 realized the lowest value of NC (USD 6,215,588).

4.5. Decomposition of EV component

A further disaggregated analysis of EV enabled the estimation of discounted

Table 6. Estimates of values of NC components by hunting blocks at discount rate of 3% (USD).

Code	CAT	DUV	IUV	O/QV	EV	BV	Total TEV
HB1	II	1,279,472	4,616,897	4,757,813	2,796,103	6,368,994	19,819,280
HB2	II	386,341	559,269	658,937	1,319,280	3,291,761	6,215,588
HB3	II	1,127,795	3,948,392	16,465,328	20,936,870	80,072,287	122,550,672
HB4	II	1,334,146	2,692,687	3,505,070	5,870,384	6,081,298	19,483,585
HB5	II	1,334,146	6,495,510	7,942,106	4,350,992	47,589,858	67,712,613
HB6	III	191,515	786,323	909,112	632,210	8,175,020	10,694,181
HB7	II	1,334,146	3,005,233	4,345,433	3,133,326	14,925,784	26,743,922
HB8	II	1,359,755	2,376,302	1,759,910	15,435,380	39,427,838	60,359,186
HB9	II	893,461	7,450,555	11,215,194	20,182,428	23,128,192	62,869,829
HB10	II	1,261,438	2,027,362	2,799,426	7,235,806	12,652,532	25,976,564
HB11	I	1,182,468	7,976,115	9,256,084	4,463,599	29,002,685	51,880,951
HB12	I	2,184,342	72,786,681	72,497,104	125,147,282	380,855,285	653,470,695
Average		1,155,752	9,560,111	11,342,627	17,625,305	54,297,628	93,981,422

CAT = Category of hunting block.

Table 7. Estimates of EV components by hunting blocks at discount rate of 3% (USD).

Code	CAT	BCV	CHV	AEV	Total (EV)
HB1	II	563,419	945,114	1,287,571	2,796,103
HB2	II	567,020	752,260	-	1,319,280
HB3	II	8,188,155	12,748,715	-	20,936,870
HB4	II	1,121,558	1,826,003	2,922,823	5,870,384
HB5	II	1,414,359	2,936,633	-	4,350,992
HB6	III	278,859	353,351	-	632,210
HB7	II	773,471	2,359,855	-	3,133,326
HB8	II	3,810,270	11,625,111	-	15,435,380
HB9	II	8,868,912	11,313,516	-	20,182,428
HB10	II	3,678,514	3,236,260	321,032	7,235,806
HB11	I	1,716,557	2,747,042	-	4,463,599
BB12	I	17,650,462	55,718,308	51,778,512	125,147,282
Average		4,052,630	8,880,181	4,692,495	17,625,305

CAT = Category of hunting block.

values of biodiversity conservation (BDV), cultural heritage (CHV) and aesthetic enjoyment (AEV) for each hunting block (Table 7). Overall, hunting block 12 yielded the largest discounted EV of USD 125,147,282; followed by hunting block 3 (USD 20,936,870), 9 (USD 20,182,428), and 10 (USD 7,235,806). Hunting block 6 yielded the smallest EV figure (USD 632,210).

4.6. Proportions of TEV and EV Components

According to the results (Figure 7), the BV (bequest value) or the value of satisfaction from preserving an ecosystem for future generations corresponded to 35% of TEV. It should be noted here that the mean TEV of the sample hunting blocks was estimated to amount to USD 93,981,422 and the EV (existence value) averaged at USD 17,625,305 constituting about 19% of the total value of NC. The O/QV (option/Quasi option value), IUV (indirect use value), and DUV (direct use value) corresponded to 12%, 10%, and 1% of the TEV. A further decomposition of EV indicated that BDV (biodiversity value) constituted 23% of EV. CHV (cultural heritage value) and AEV (aesthetic enjoyment value) corresponded to 50% and 27% of total EV.

5. Discussion

The statistical analysis of expert weights revealed the existence of distinct patterns in TEV and EV components which could be attributed to the existence of different interests and attitudes towards the valued ecosystems. These patterns are common in economic valuation studies [22]. In their study of modelling for future camp development, for example, Chow and Sadler (ibid) also reported differences in weight assignment among different expert groups. In this way, this study provides, together with the average value, a range of values that reflect the different sensitivities of society for the TEV and its components. The fact that valuation in AMUVAM is comparison-based also allows the gaining of knowledge about the relationships among the different relationships among the different components of TEV.

Based on the results of test statistics, we rejected the null hypothesis that there

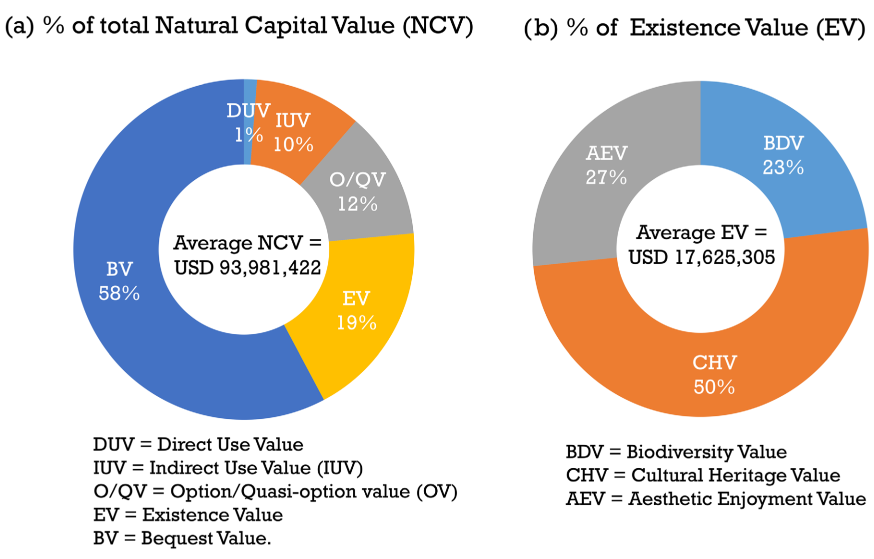


Figure 7. The proportions of individual values of TEV and EV components.

was perfect disagreement among the experts (judges or rankers) because the Kendall's *W* was not equal to zero. It is important to note that, the Kendall's *W* was also not equal to 1 implying that the rankers did not perfectly agree amongst themselves. However, this does not imply that they did not rank the TEV components in the same order but each component fared well at the hands of some rankers and poorly at the hands of others. Under perfect disagreement, each TEV component would fare the same overall and would thereby produce identical values for equal total rankings for all TEV components, consequently, the Kendall's *W* would be equal to zero.

It should also be noted that, the test-statistic, Chi-square (χ^2) is synonymous to variance over the mean ranks and it is zero when the mean ranks are exactly equal and it becomes larger as they lie further apart. In many cases, the asymptotic significance (*i.e.* the *p*-values) were less than 0.05 confirming that the rankings were statistically significantly different for all the eight paired TEV components.

In terms of profitability, none of the sample-hunting blocks yielded negative NPV and all resulted in "fair" BCRs ranging from 1.22 to 1.33 and the IRR values greater than the default or test discount rate of 3% (41% for HB9 to 94% for HB4, HB5, and HB7). However, caution needs to be taken here, especially when using BCR and IRR to rank mutually exclusive HBs in terms of project worthiness. For example, if HB6 and HB9 are compared based on the formal decision criterion of BCR, the former (HB6) will be preferred to the latter (HB9) because the former gives a BCR of 1.33 versus 1.28 for the latter, HB9 (**Table 5**). Similarly, if the IRR alone is used for comparing these two HBs, again this would lead to erroneous project choice because one would choose to invest in HB6 (with IRR of 52%) over HB9 (which has a smaller IRR of 41%). This mistake can be avoided most easily by using the NPV criterion for mutually exclusive HBs. Based on this yardstick; the most profitable hunting block was HB12 which yielded the highest pivot value (DUV) and TEV of about USD 2,184,342 and USD 653,470,695 respectively.

Based on the results of decomposition analysis, the CHV constituted about half of the total EV. The AEV and BDC corresponded to 27% and 23% of the total EV respectively. Borrowing from the UNESCO Institute for Statistics [52] definition of cultural heritage, the communities in the study area considered HBs as part and parcel of the values they bestow on. They considered HBs as sites that have a diversity of values including the symbolic, historic, artistic, aesthetic, ethological or anthropological, scientific and social significance. They include tangible heritage (movable, immobile and underwater), intangible cultural heritage (ICH) embedded into cultural, and natural heritage artefacts, sites or monuments. Thus the uses of HBs as for other natural assets, both direct and indirect uses, should be guided by a thorough understanding of their values.

It is important to note the following limitations regarding our study: firstly we used the AMUVAM approach to determine the TEV and relative values of five TEV components for 12 sample HBs. While this valuation approach is relatively quicker and cheaper than most of the conventional approaches its effectiveness and reliability depend on the level of knowledge required by the experts (the rankers). The experts should have a thorough knowledge of the HBs in question, enabling them to make credible comparisons. They should have a wide understanding of the functions as well as the goods and services involved in each value component. In addition, they must have knowledge of the procedures, the importance, and purpose of the comparisons.

Secondly, the data for AMUVAM were gathered from only 12 out of 24 vacant hunting blocks planned to be auctioned in December 2022. While the 12 HBs were taken as a fair representation of all the 24 HBs (*i.e.* a sample size slightly more than 50%), the better approach would be to cover all the 24 hunting blocks and value them separately using their respective cash flow information which normally differs between hunting blocks. Due to resource limitations, especially time and funds, this was not possible; thirdly, some of the previous HB outfitters or operators were not willing to disclose their business cash flows making it difficult to enable the discounting of the costs and benefits of all the 24 hunting blocks. Because of limited resources again the on-ground verification of available data and findings was not possible.

Notwithstanding the time and financial resource shortfalls mentioned in the foregoing paragraph, the use of AMUVAM in the current study still remains appropriate and reasonable, but it may have some shortcomings. A central idea of most Multi-Criteria Decision Analysis (MCDA) approaches is that one can combine all of the criteria into a single scalar objective function and the "best" solution is the alternative with the highest score. However, the key characteristic of most MCDA challenges is that they generally do not have conclusive or unique solutions [53]. As such the complex multidimensional decision problem is thereby reduced to a single number. A more robust alternative would be the use of new generations of approaches, such as the Integrated Valuation of Environmental Services and Trade-offs (InVEST), the Artificial Intelligence for Ecosystem Services (ARIES), and Co$ting Nature. These take into account the multiple dimensions of ecosystem goods and services. However, it should be noted here that these approaches generally need more resources to apply than the MCDAs.

6. Conclusions and Recommendations

There is increasing interest to understand the economic value of ecosystems and establish some estimates of "fair" returns that can directly or indirectly accrue from the consumptive and non-consumptive uses of goods and services provided by natural assets. This is becoming even more imperative now given the increasing trends in the decline and deterioration of natural systems. This paper applies the AMUVAM procedure to estimate the TEV for 12 sample-hunting blocks in Tanzania. The main purpose of the exercise was to inform the process of auctioning of 24 vacant HBs in the country to potential hunting companies.

Most importantly the study aimed at providing information which would help policy makers to integrate natural capital (NC) into economy-wide analytical frameworks. In sense, we underscore the fact that accounting for NC would offer a way to embed the existing natural assets within the realm of political and economic decision making; it cannot only improve natural resource governance but it can also permit the development of environmentally adjusted macroeconomic indicators to serve as complements to GDP. EVNE (TEV) can also help tag of "fair" auction prices and profit margins accruing either directly or indirectly from the consumptive and non-consumptive uses of goods and services provided by HBs, including trophy hunting and photographic tourism.

Based on the understanding of the economic activities that take place in HBs and the respective cost and benefit structures of hunting companies we estimated the TEV and EV to average at USD 93,981,422 and USD 17,625,305 per hunting block respectively. The highest TEV per HB was USD 653,470,695 and the lowest was USD 6,215,588. The EV ranged from the lowest of USD 632,210 to the highest of USD 125,147,282. Of all the TEV components, the bequest value (BV) corresponded to the largest proportion (58% or USD 54,297,628) while the DUV formed only about 1% (USD 1,155,752) of the total TEV. The EV composed about 19% of TEV (USD 17,625,305). This range of values corresponded to the different patterns of valuation by experts or rankers which in turn reflected the diversity of sensitivities within the communities regarding the various TEV components. Above all, our findings illustrate the fact that the use of national income accounting (NIA) system alone leaves out a huge proportion of TEV unaccounted which may mislead decision making for sustainable utilisation and management of natural assets. We provide the following three key recommendations from our study:

1) EVNE must be carried out as part of economy wide analytical frameworks in all countries to enhance evidence-based decision making and sustainable management of natural resources, especially in countries that are highly endowed with stocks and flows of natural assets;

2) Building the capacity of staff charged with the role of managing and allocating uses of natural resources, such as HBs to undertake economic valuation of natural assets using both simple and more robust analytical tools, such as InVEST, ARIES and Co$ting Nature; and

3) Ensuring effective engagement of all the key actors in the natural resource-based value chains, including those involved in ivory hunting and photographic tourism. This engagement is important not only in bargaining for 'fair prices' and margins but also in building trust between the public and private stakeholders and winning their support for sustainable utilisation and management of existing natural assets. Most importantly, we underscore the need to build a sense of openness and readiness in providing information that will identify the win-win solutions, including the willingness of hunting companies to disclose their business cash flows when needed during the review of TEV of HBs.

Acknowledgements

This paper is based on the data which were collected by a team of five researchers nominated by the Ministry of Natural Resources and Tourism (MNRT) of Tanzania to carry out an economic valuation of hunting blocks (HBs) which were planned for auction in December 2020. The authors are grateful to the MNRT, for financing the study, and to the Trade, Development and the Environment (TRADE) Hub project for providing technical support in economic valuation of HBs. TRADE Hub (Project number ES/S008160/1) runs from February 2019 to 31st March 2024. It is financed by the United Kingdom Research and Innovation (UKRI)—re-presented by the Research Councils UK (RCUK) Economic and Social Research Council (ESRC) with funds from the Global Challenges Research Fund (GCRF), A UKRI Collective Fund. We are grateful to the funder and to the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) for leading the consortium members and to all project partners who participated in reviewing the initial draft of this paper.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendices

Appendix 1. Net Cash Flows, NPV, BCR, IRR and Results of Sensitivity Analysis Using Different Discount Rates

(a) Discount rate (r = 3%)

HB code	Category	Net annual inflows ($)	NPV ($)	BCR	IRR
HB1	II	102,003.20	1,279,472.04	1.30	91%
HB2	II	60,086.04	386,341.02	1.30	52%
HB3	II	102,003.20	1,127,794.69	1.22	50%
HB4	II	102,003.20	1,334,145.79	1.30	94%
HB5	II	102,003.20	1,334,145.79	1.30	94%
HB6	III	29,785.51	191,514.76	1.33	52%
HB7	II	102,003.20	1,334,145.79	1.30	94%
HB8	II	183,904.48	1,182,468.44	1.30	52%
HB9	II	149,007.52	893,460.57	1.28	41%
HB10	II	193439.798	1,261,437.59	1.31	54%
HB11	I	230,017.34	1,182,468.44	1.33	52%
HB12	I	304,878.17	2,184,342.32	1.35	87%

(b) Discount rate (r = 4%)

HB code	Category	NPV ($)	BCR	IRR
HB1	II	1,195,684.52	1.3	91%
HB2	II	358,400.72	1.3	52%
HB3	II	1,045,465.61	1.21	50%
HB4	II	1,247,170.88	1.3	94%
HB5	II	1,247,170.88	1.3	94%
HB6	III	177,664.36	1.33	52%
HB7	II	1,247,170.88	1.3	94%
HB8	II	1,096,951.97	1.3	52%
HB9	II	824,792.77	1.27	41%
HB10	II	1,171,317.35	1.30	54%
HB11	I	1,096,951.97	1.32	52%
HB12	I	2,040,418.29	1.35	87%

(c) Discount rate (r = 5%)

HB code	Category	NPV ($)	BCR	IRR
HB1	I	1,017,836.73	1.29	58%
HB2	II	1,118,583.43	1.29	91%

Continued

HB3	II	332,717.73	1.29	52%
HB4	II	969,795.18	1.2	50%
HB5	II	1,167,132.66	1.29	94%
HB6	II	1,167,132.66	1.29	94%
HB7	III	164,932.93	1.32	52%
HB8	II	1,167,132.66	1.29	94%
HB9	II	1,018,344.41	1.29	52%
HB10	II	761,711.04	1.26	41%
HB11	II	1,088,467.47	1.30	54%
HB12	I	1,018,344.41	1.32	52%
HB13	I	1,907,988.93	1.34	87%

(d) Discount rate ($r = 6\%$)

HB code	Category	NPV ($)	BCR	IRR
HB1	II	1,047,539.09	1.29	91%
HB2	II	309,078.89	1.29	52%
HB3	II	900,154.5	1.19	50%
HB4	II	1,093,377.95	1.29	94%
HB5	II	1,093,377.95	1.29	94%
HB6	III	153,214.82	1.31	52%
HB7	II	1,093,377.95	1.29	94%
HB8	II	945,993.36	1.29	52%
HB9	II	703,687.11	1.26	41%
HB10	II	1,012,201.65	1.29	54%
HB11	I	945,993.36	1.31	52%
HB12	I	1,785,971.54	1.34	87%

(e) Discount rate ($r = 7\%$)

HB code	Category	NPV ($)	BCR	IRR
HB1	II	981,988.86	1.28	91%
HB2	II	287,293.78	1.28	52%
HB3	II	835,981.69	1.18	50%
HB4	II	1,025,323.14	1.28	94%
HB5	II	1,025,323.14	1.28	94%
HB6	III	142,415.63	1.31	52%
HB7	II	1,025,323.14	1.28	94%
HB8	II	879,315.97	1.28	52%

Continued

HB9	II	650,249.05	1.25	41%
HB10	II	941,906.72	1.29	54%
HB11	I	879,315.97	1.31	52%
HB12	I	1,673,398.74	1.33	87%

(f) Discount rate ($r = 8\%$)

HB code	Category	NPV ($)	BCR	IRR
HB1	II	921,429.29	1.27	91%
HB2	II	267,192.00	1.27	52%
HB3	II	776,774.05	1.17	50%
HB4	II	962,446.00	1.27	94%
HB5	II	962,446.00	1.27	94%
HB6	III	132,450.89	1.3	52%
HB7	II	962,446.00	1.27	94%
HB8	II	817,790.75	1.27	52%
HB9	II	600,974.63	1.24	41%
HB10	II	877,034.06	1.28	54%
HB11	I	817,790.75	1.30	52%
HB12	I	1,569,404.91	1.33	87%

(g) Discount rate ($r = 9\%$)

HB code	Category	NPV ($)	BCR	IRR
HB1	II	865,409.27	1.27	91%
HB2	II	248,620.90	1.27	52%
HB3	II	722,081.14	1.16	50%
HB4	II	904,278.58	1.27	94%
HB5	II	904,278.58	1.27	94%
HB6	III	123,244.93	1.29	52%
HB7	II	904,278.58	1.27	94%
HB8	II	760,950.44	1.27	52%
HB9	II	555,485.57	1.23	41%
HB10	II	817,092.12	1.27	54%
HB11	I	760,950.44	1.30	52%
HB12	I	1,473,214.41	1.33	87%

(h) Discount rate (r = 10%)

HB code	Category	NPV ($)	BCR	IRR
HB1	II	813,523.99	1.26	91%
HB2	II	231,443.50	1.26	52%
HB3	II	671,498.84	1.15	50%
HB4	II	850,400.97	1.26	94%
HB5	II	850,400.97	1.26	94%
HB6	III	114,729.85	1.29	52%
HB7	II	850,400.97	1.26	94%
HB8	II	708,375.82	1.26	52%
HB9	II	513,442.47	1.23	41%
HB10	II	761,639.84	1.27	54%
HB11	I	708,375.82	1.29	52%
HB12	I	1,384,131.22	1.32	87%

Appendix 2. Pairwise Comparison of Mean Ranks of TEV Components Considered to Be More Important by Communities

Pairs	HB1	HB2	HB3	HB4	HB5	HB6	HB7	HB8	HB9	HB10	HB11	HB12	Mean
DUV and IUV	6.25	4.3	3.2	4.5	4.9	4.35	4.35	3.8	4.25	4.65	4.2	4.69	4.45
DUV and O/QV	4.85	4.3	3.2	4.15	4.9	4.35	4.35	4.6	4.75	5.05	4.6	4.69	4.48
DUV and EV	4.45	4.3	4.4	4.9	4.5	4.35	4.35	4.6	3.75	5.45	4.6	4.69	4.53
DUV and BV	4.85	4.3	4	3.8	5.3	4.75	4.75	4.6	4.4	5.45	5.4	5	4.72
IUV and O/QV	4.45	3.9	3.6	3.4	3.3	3.55	3.55	4.2	4.15	3.05	3.4	3.46	3.67
IUV and EV	3.7	4.3	5.6	3.75	3.3	4.35	4.35	4.6	4.8	3.05	3.8	3.77	4.11
IUV and BV	3.35	3.9	5.6	4.95	4.1	4.35	4.35	4.2	4.15	3.45	3.8	4.08	4.19
O/QV and EV	4.1	6.7	6.4	6.55	5.7	5.95	5.95	5.4	5.75	5.85	6.2	5.62	5.85
N	10	10	10	10	10	10	10	10	10	10	10	13	
Kendall's W	0.259	0.379	0.409	0.25	0.231	0.206	0.206	0.086	0.181	0.37	0.306	0.192	
Chi-Square	18.16	26.526	28.656	17.69	16.136	14.455	14.455	6.045	12.659	25.928	21.429	17.47	
Df	7	7	7	7	7	7	7	7	7	7	7	7	
Asymp. Sig.	0.011	0	0	0.013	0.024	0.044	0.044	0.534	0.081	0.001	0.003	0.015	

Appendix 3. Pairwise Comparison of Mean Ranks of Intensity of Importance for TEV Components

Pairs	HB1	HB2	HB3	HB4	HB5	HB6	HB7	HB8	HB9	HB10	HB11	HB12	Mean
DUV and IUV	2.25	3.3	7.4	6.25	4.55	4.14	4.95	4.4	4.45	5.6	4.4	4.92	4.72
DUV and O/QV	4.7	4.95	5.95	6.13	5.4	5.23	5.65	4.9	6.45	5.4	5.4	5.35	5.46
DUV and EV	4.4	4.4	5.5	6.13	4.05	3.73	4.75	4	3.7	5.1	4.25	4.35	4.53
DUV and BV	4.6	6.5	5.3	5.25	4.9	6.05	5.25	4.9	4.95	5.45	6	5.35	5.38
IUV and O/QV	5.7	5.25	4.15	4.5	4.2	3.91	4.4	3.9	3.65	4.05	4.15	4.31	4.35
IUV and EV	4.4	3.45	2.6	3.13	4.9	4.45	3.8	4.65	4.25	4.25	4.55	4.15	4.05
IUV and BV	4.35	3.9	2.65	2.75	5.05	5.27	3.85	4.4	4.2	4.65	4.6	4.62	4.19
O/QV and EV	5.6	4.25	2.45	1.88	2.95	3.23	3.35	4.85	4.35	1.5	2.65	2.96	3.34
N	10	10	10	4	10	11	10	10	10	10	10	13	
Kendall's W	0.196	0.201	0.648	0.565	0.106	0.159	0.116	0.031	0.153	0.322	0.173	0.109	
Chi-Square	13.71	14.073	45.336	15.81	7.403	12.27	8.107	2.162	10.693	22.533	12.132	9.91	
Df	7	7	7	7	7	7	7	7	7	7	7	7	
Asymp. Sig.	0.057	0.05	0	0.027	0.388	0.092	0.323	0.95	0.153	0.002	0.096	0.194	