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Ecosystem Service Valuation for a Critical Biodiversity Area: Case of the Mphaphuli Community, South Africa

Khangwelo Desmond Musetsho [1,*], Munyaradzi Chitakira [1] and Abel Ramoelo [2]

[1] Department of Environmental Sciences, College of Agriculture and Environmental Sciences, University of South Africa, Florida Campus, Johannesburg 1710, South Africa
[2] Department of Geography, Geoinformatics and Meteorology, Centre for Environmental Studies, University of Pretoria, Hatfield Campus, Pretoria 0083, South Africa
* Correspondence: musetkd@unisa.ac.za; Tel.: +2711-471-3018

Abstract: The study of ecosystem services and the valuation of their contribution to human wellbeing is gaining increasing interest among scientists and decision-makers. The setting of this study was a critical biodiversity area on a portion of land largely presided over by a traditional leadership structure on behalf of a relatively poor local community in South Africa. The study identified several ecosystem services and performed an economic valuation of these services, and their importance both locally and globally using the Co$ting Nature V3 tool. The study identified ecosystem services such as the regulation of air quality, regulation of natural hazards, and provision of water. The economic valuation was carried out for all identified ecosystem services, realised and potential. The total realised economic value of ecosystem services was found to be US$528,280,256.00, whereas hazard mitigation potential was found to be US$765,598,080.00 across the study area. Artisanal fisheries were the least valued ecosystem service at US$5577.54. The values of the ecosystem services differed across the eleven land use land cover classes. The outcomes of the study focused on a very local scale, which was a departure from other studies previously carried out in South Africa, which focused more on the identification and valuation of regional and national scale ecosystem services.

Keywords: biodiversity; wildlife dis-services; ecosystem services; LULC; rural livelihoods

Citation: Musetsho, K.D.; Chitakira, M.; Ramoelo, A. Ecosystem Service Valuation for a Critical Biodiversity Area: Case of the Mphaphuli Community, South Africa. *Land* **2022**, *11*, 1696. https://doi.org/10.3390/land11101696

Academic Editor: Andrea Belgrano

Received: 26 August 2022
Accepted: 26 September 2022
Published: 30 September 2022

1. Introduction

Since the publication of an article that questioned the value of the services derived from nature by Walter E, Westman in 1977, there has been an exponential growth in the amount of research on issues surrounding ecosystem services [1]. The authors of [1–3] noted that in 1938, Arthur Tansley coined the term "ecosystem" and defined it as the collaborative system between non-living and living things, which happens naturally without any human intervention. This understanding strengthened the general agreement among scholars that the environment cannot be perceived as being made up of individual ecological units that work in silos. Instead, it is an all-encompassing structure with chemical, biological, physical, and other related components that influence and are influenced by one another [3,4]. Critical to these observations was the realisation that human beings are entirely dependent on functional ecosystems that provide many services, such as food, shelter, energy, climate regulation, and aesthetic appeal [1]; these are collectively termed ecosystem services.

The Millennium Ecosystem Assessment (MEA) describes ecosystem services as regulating, cultural, provisioning, and supporting services [5]. Regulating services are the processes that occur in nature, such as water cleansing, nutrient filtration, and climate regulation [6]. Cultural services are often intangible services, such as aesthetics, a sense of place, and religious worship, and also include direct uses, such as recreation, ecotourism, and education. Provisioning services are physical products, such as food, feed, fibre, and fuels. Supporting services are the underlying, long-term processes in nature, such as net primary products, soil formation, and climate stability that secure the provision of direct services to humans [7].

The literature shows that many ecosystems across the world are so degraded that they are approaching their tipping points; in other words, they are reaching the thresholds where their capacity to provide services is threatened [8,9]. Therefore, a study of ecosystem services is critical and necessary, so we can gain an understanding of how to ensure ecosystem services can continue to provide such services. The necessity of an ecosystem services study is also because many of the people at the grassroots levels, the poor and the marginalised, still heavily rely on ecosystem services to meet their basic needs.

For these reasons, [10,11] consider the assessment of ecosystem services as a field of ecological economics, which should be of relevance to all humans, as economic activities affect everyone's daily activities. If ecosystems are degraded, the services obtainable from these ecosystems are also impacted. When ecosystems are degraded, they cannot optimally provide essential services to human beings, which often leads to increasing poverty, particularly for marginalised communities [6].

In developing countries, government institutions, traditional leaders, and citizens face unprecedented pressures from population growth and the triple challenge of poverty, inequality, and unemployment, which necessitate an integrated or interdisciplinary solution [12]. According to [4], the dominant environmental and economic priority of these countries is to ensure that people have access to sanitation and clean water without compromising the integrity of key ecosystems or undermining economic growth, infrastructure development, and foreign direct investment, which again points to the need for an interdisciplinary approach. For this purpose, understanding critical biodiversity areas (CBAs) and the natural environment and its processes becomes vital. Understanding the environment has much to do with land-use planning and the associated valuation of ecosystem services for specific development areas.

According to [7,8,13], CBAs are those terrestrial and aquatic areas that must be protected in their natural state because they are important for maintaining ecosystem service functioning. These include areas that require safeguarding in order to meet national biodiversity thresholds, and areas required to ensure the continued existence and functioning of species and ecosystems, including the delivery of ecosystem services or special habitats or locations where species of special concern occur [14].

This study was an attempt to identify and conduct a valuation of ecosystem services across various land use land cover (LULC) classes. This included establishing the economic variances in ecosystem service values across the different LULC classes. Our research questions included: (i) What are the different ecosystem services in the study area? (ii) What is the baseline value of the identified ecosystem services? (iii) Are there any variances in ecosystem service values across different LULC classes?

Investigations of the state of the ecosystem services in the area have previously been undertaken by scholars such as [15,16]; however, no study has attempted to analyse variances in ecosystem service values across different LULC classes, which could be critical for future planning scenarios. Most of the previous studies concentrated on extensive areas, on a national or regional level. This study concentrated on a local scale valuation of ecosystem services. The study aims to contribute to the body of knowledge around ecosystem service values in CBAs by analysing the values of the different services across different LULC classes, particularly in rural communities where communal land and natural resources management systems still prevail, on local scale. Filling these gaps could significantly contribute to our understanding of ecosystem values, which in turn could contribute to sociocultural, economic, and environmental improvements, which ultimately addresses the transdisciplinary nature of ecosystem services. Effective land-use regulation is critical for the security of investing in the land [17]. An understanding of sustainable land management leads to the appropriate management of environmental assets, such as ecosystem services, which are beneficial for human beings [18]. This understanding could include economic incentives, where payment for these services is designed into a scheme for the local people [7,19]. It is only through concrete scientific evidence on the spatial distribution of ecosystem service values and the associated LULC activities that sound decisions can be made [20].

2. Materials and Methods

Ecosystem services and other environmental resources are categorised into services and goods that could be traded in the market and provide immense value to the livelihood of poor communities [21,22]. According to the United Nations [cited by 16], the creation of a common method to value and classify ecosystem services is deemed essential to advancing sustainable development strategies and remains a serious challenge worldwide.

Due to the diverse nature of the services and goods, several methods exist that could be used for the valuation of ecosystem services, with each focusing on specific services. When deciding on the method to apply in this study, several other methods were identified and reviewed for their suitability. These included: (a) the MEA [23,24], (b) TEEB [8,24], (c) IPBES [25,26], (d) Toolkit for Ecosystem Service Site-based Assessment (TESSA) [27,28], (e) Co$ting Nature [29], (f) Artificial Intelligence for Ecosystem Services (ARIES) [30,31], and (f) Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) [32].

In the end, Co$ting Nature was chosen because it provides a platform to assess multiple ecosystem services all at once, whereas most of the other valuation methods only attempt to value a few of the services. Co$ting Nature also enables identification and valuation on a local scale, whereas the other methods look at regional, national, and international scales. Gómez-Baggethun et al. [33] argued that an integrated approach may be better for the successful valuation of ecosystem services, instead of using many individual tools that work in silos.

The identification and valuation of ecosystem services in this study were performed using the Co$ting Nature V3 software (Co$ting Nature). Co$ting Nature (www.policysupport.org/costingnature (accessed on 25 August 2022)) is a tool used to spatially characterise conservation priority, from local to global scales. It uses remote sensing and global databases to map the spatial distribution of 13 ecosystem services and 4 other conservation-relevant factors, such as biodiversity, current human pressure on the land, and future threats [34]. Previous valuations of ecosystem services were performed on the Vhembe Biosphere Reserve by scholars such as [35], which included portions of the current study area. Only two services were valued by the previous study. The current study is an improvement on earlier valuations, which were conducted using a different tool, InVEST. The Co$ting Nature technique identified and valued ecosystem services from three categories of services: provisioning, regulation, and cultural, whereas the InVEST technique that was previously used did not cover all three categories.

Mulligan [29] summarises the inner workings of the tool/software by explaining the datasets that were used in setting up the tool. A shortened process flow is depicted in Figure 1. The Co$ting Nature platform not only considers the economic values of the ecosystem services, but provides an opportunity for long-term scenario planning towards conservation and better land planning. It lumps together the magnitude and geographical patterns (both potential and realised) of beneficiaries of ecosystem services, at global and local scales [36]. The mapping of ecosystem services and ultimate valuation by the Co$ting Nature platform also identifies far-reaching implications for beneficiaries [37].

By default, all outputs were expressed in normalised biophysical units in relative terms, as indices from 0 to 1, within the study area: the higher the values, the greater the index. Normalisation ensures that very different services and preferences can be combined into aggregate indices, to which the user can then apply specific weights under a policy option [24]. In relative units, Co$ting Nature mapped 13 potential and 13 realised services. In economic units, Co$ting Nature mapped 22 potential and 22 realised ecosystem services values. For ecosystem service identification and valuation, the following process was implemented using a hyper user status account of Co$ting Nature V3 software.

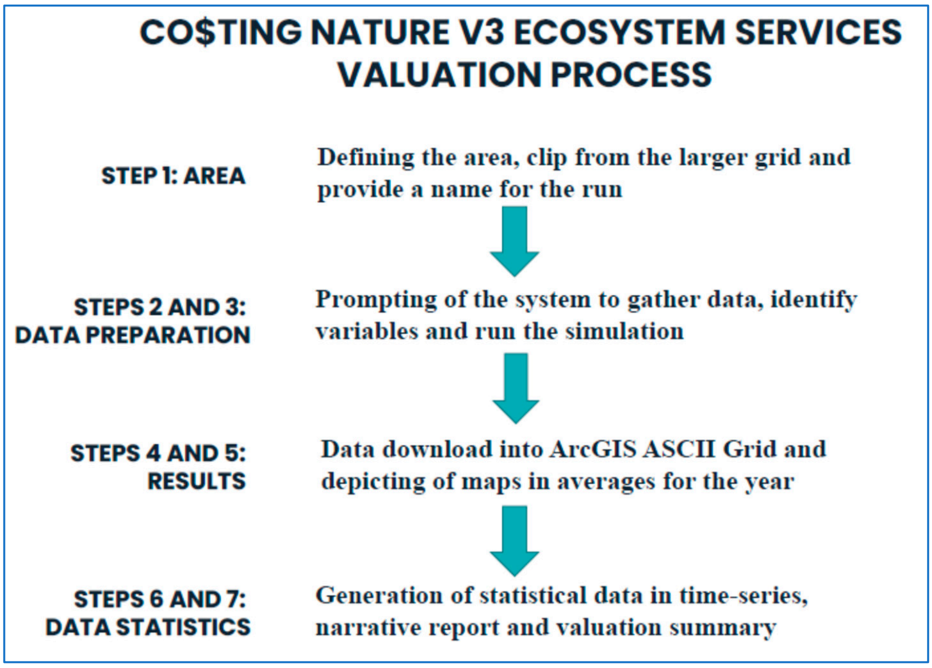

Figure 1. Co$ting Nature V3 valuation process flow.

The valuation of ecosystem services was based on the default values of the valuation matrix made available in Co$ting Nature V3 software. No external datasets were used during the model simulation stage because the pre-processes and preloaded data were comprehensive and useful enough to achieve the objectives of the study. The 2020 land-cover map for South Africa was used to summarise the aggregate economic values.

For the post-processing and geographical information system mapping section, the major results were depicted in maps that gave spatial-explicit information about the ecosystem service valuations, such as their total economic value, contribution to local communities, relative pressure, threats, etc. The modelling of ecosystem services used a specific predefined grid and were summarised per zone of interest. The resulting maps from Co$ting Nature were further processed using the ArcGIS tool. The extraction tools in ArcGIS were used to clip the ecosystem service valuation products to the study area, creating layouts or maps.

The next step was to summarise two aggregate economic values per current land-cover class: (1) the total economic value representing the sum of all 22 valued ecosystem services, and (2) the local contribution value to poor livelihoods. This latter value represented a ratio of the value of ecosystem services to the fraction of poor beneficiaries and the gross domestic product (GDP) of the poor, expressed as a percentage; thus, this value is the percentage contribution of ecosystem service value to the total economic GDP of the poor. When this value exceeds 100%, this means that nature provides greater value to the livelihoods of the poor than the GDP. This value is a hidden subsidy that underpins the livelihoods of the poor [25]. These aggregate economic values were summarised from the current land-cover map using the zonal statistics tool in ArcGIS.

The main data sources [38] used to identify the LULC classes were the National Land Cover (NLC) products (1990 and 2018) of the South African government. NLC data sets from 1990 were derived from Landsat images at 30 m spatial resolution. Land-cover information for the 2018 period was obtained from Sentinel-2 images at a spatial resolution of 20 m [39]. The 20 m spatial resolution images were then resampled at 30 m for compatibility and comparability with that of the 1990 NLC. The 1990 and 2018 land-cover maps had 72 classes, which were then grouped into a more manageable 11 classes, relevant to the study area (Table 1). The original land-cover map reports and legend are at https://egis.environment.gov.za/ (accessed on 25 August 2022).

Table 1. Standardised land-cover classes for changes between 1990 and 2018 [39].

Land-Cover Type	New Classes	NLC 1990	NLC 2018
Waterbodies	1	1–2	14–21
Wetlands	2	3	22–23, 73
Indigenous forest	3	4	1
Thicket and dense bush	4	5	2, 24
Woodlands	5	6	3–4, 42–43
Grasslands	6	7	12, 13, 44
Commercial agriculture	7	10–12, 26–31	32–40
Subsistence agriculture	8	23–25	41
Forest plantations	9	32–34	5–7
Bare areas	10	40–41	25–31, 45
Built-up areas	11	35–39, 42–72	47–72

Variances in ecosystem service values were then compared for the rearranged LULC classes. Co$ting Nature V3 (economic valuation of ecosystem services) and analysis of variance (testing for significant variance between total economic value and LULC types) were performed in line with the process depicted in Figure 1.

The study area forms part of the Vhembe Biosphere Reserve (VBR) [40], the eastern part of the Soutpansberg mountains under both Collins Chabane and Thulamela local municipalities, of the Vhembe district in the Limpopo province of South Africa (Figure 2). The eastern sections of the study area are bordered by Kruger National Park. Unemployment is rife in this area, estimated to be at 44% [41], and the majority of people still rely on the natural environment for their basic needs, such as water and energy. The study area is under the jurisdiction of the local traditional leadership structure, the Mphaphuli Royal Council.

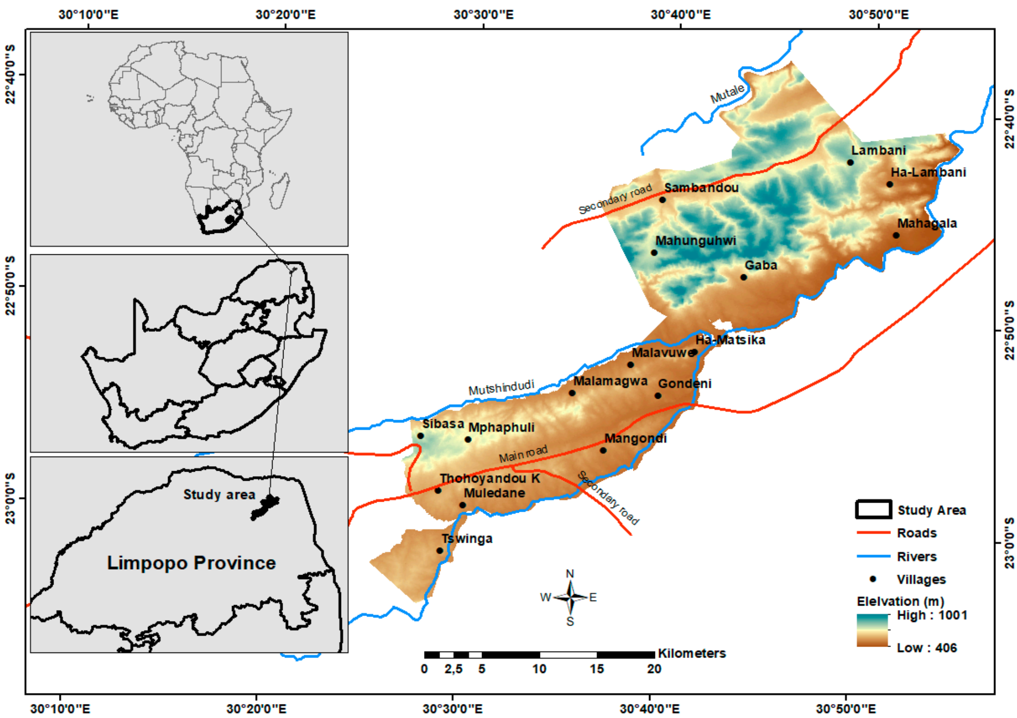

Figure 2. Location map of the study area [39].

The total area under study is approximately 67,000 ha, with an even distribution of hills, plains, and mountains. The area is characterised by unimodal rainfall distributions, where the rainy season is between October and January, with an average annual rainfall of between 200 and 400 mm [42–44].

3. Results and Discussion

3.1. Identified Ecosystem Services

The study identified 13 potential and realised ecosystem services in the area, and they are shown in Table 2. Tables 3 and 4 show the identified ecosystem services, with corresponding descriptive statistics. In relative units, Co$ting Nature mapped 13 potential and 13 realised services.

Table 2. Ecosystem services Identified by Co$ting Nature.

Category of Service	Characteristics and Examples
Provisioning services	Freshwater and food Fuelwood and fibre Fodder and grazing
Regulatory services	Regulation of air quality Regulation of climate (precipitation, temperature, and sequestration of greenhouse gases) Regulation of water (scale of runoff, timing, and flooding) Regulation of natural hazards Disease, pest, and erosion regulation Purification of water, pollination, and waste management
Cultural services	Recreation, cultural heritage, and tourism Spiritual, aesthetic, and religious value Inspiration of art, folklore, and architecture
Supporting services	Formation of soil, nutrient cycling, primary production, photosynthesis, water recycling, and habitat provision

Table 3. The economic value of selected ecosystem services.

Economic Values of Mphaphuli Ecosystem Services		
Economic Value	**United States Dollar (US$)**	**South African Rand**
Total realised economic value	528,280,256.00	9,509,044,608.00
Global economic value	1,000,003.69	18,000,066.38
National economic value	1,134,667,776.00	20,424,019,968.00
Hazard mitigation	765,598,080,00	13,780,765,440.00
Wildlife services	38,720,851,968,00	696,975,335,424,00
Wildlife disservices	−39,763,148,800.00	−715,736,678,400.00
Non-wood forest products	362,623,31	6,527,219.63
Commercial timber	797,300.50	14,351,409.00
Domestic timber	6,084,366.00	109,518,588.00
Artisanal fisheries	5577.54	100,395.79
Fuelwood	2,472,220.75	44,499,973.50
Grazing/fodder	58,344,568.00	1,050,202,224.00
Nature-based tourism	107,998,664.00	1,943,975,952.00
Culture-based tourism	254,993,408.00	4,589,881,344.00
Forest carbon	1,000,003.69	18,000,066.38
Water (all)	368,468,864.00	6,632,439,552.00
Water (quality, rural)	1,185,155.88	21,332,805.75
Water (quality, intakes)	128,340,240.00	2,310,124,320.00
Water (quantity, intakes)	239,621,920.00	4,313,194,560.00

From the identified services, economic valuations returned results for hazard mitigation; wildlife services; non-wood forest products; commercial timber; domestic timber; artisanal fisheries; fuelwood; grazing/fodder; nature-based tourism; culture-based tourism; forest carbon; water quality in rural areas; water quality intakes; and water quantity intakes ecosystem services.

Table 4. Economic values summarised per land-cover class.

	Total Economic Value (US$/year) 2020				
	Land-Cover Type	**Minimum**	**Maximum**	**Mean**	**Sum**
1.	Waterbodies	2392.14	651,166.81	132,550.10	1,192,950.88
2.	Wetlands	43,105.57	43,105.57	43,105.57	43,105.57
3.	Indigenous forest	8737.92	8737.92	8737.92	8737.92
4.	Thickets and dense bush	10,832.87	30,422.47	24,863.77	124,318.86
5.	Woodlands	2250.15	2,046,738.63	134,780.06	79,789,794.60
6.	Grasslands	13,601.17	756,037.00	365,242.50	1,460,970.00
7.	Commercial agriculture	13,249.27	174,378.78	49,459.61	247,298.06
8.	Subsistence agriculture	3255.82	794,031.56	163,674.80	8,511,089.49
9.	Forest plantations	21,558.40	582,474.25	302,016.32	604,032.65
10.	Bare areas	22,746.18	110,374.60	65,803.44	197,410.33
11.	Built-up areas	2417.03	1,650,256.75	231,616.12	40,764,437.45

One ecosystem disservice, i.e., wildlife disservices, was also identified for valuation. The selection was based on service concentration and the intended benefits from such valuation, especially for a poor community in the study area. Previous valuations of ecosystem services have been performed on the VBR by scholars, such as [16,35], which included portions of the current study area. Only two services were valued in the previous study. This study is an improvement on the earlier valuations, which were conducted using a different tool, namely InVEST, compared with our usage of Co$ting Nature. The current valuation examined services from three categories of services, i.e., provisioning, regulation, and cultural services.

3.2. Economic Values for Ecosystem Services

The economic value for the identified ecosystem services totalled $528,280,256,00, as summarised in Table 3. It is worth noting that hazard mitigation was at the top of the valued services, with a value of $765,598,080.00. The value of hazard mitigation was higher than the total economic value. Still, it should be noted that while identifying ecosystem services, some ecosystem disservices were also identified and valued, which reduces the overall economic value (see local economic value and wildlife disservices in Table 4). The economic values of ecosystem services are summarised per area of land use and land-cover type in Table 4. This is where the ecosystem service values varied across the LULC types, which is why computing the minimum, maximum, and sum (representing the total economic value) was possible. Commercial timber ($791,300.50), non-wood forest products ($362,623.31), and artisanal fisheries ($5577.54) were found to be the least valued ecosystem services.

The overall potential value of economic services related to water in the area was $368,468,864.00. Water quality for rural areas ($1,185,155.87), water quality intakes ($128,340,240.00), and water quantity intakes ($239,621,920.00) were the three water services that were subjected to valuation in this study. The value of water services depended on the intensity of downstream use measured as the normalised area of irrigation, the number of people, and the number of dams. The results point to massive potential for continued water provisioning and regulation services by the environment. The Nandoni Dam and rivers such as the Luvuvhu, Mutshindudi, Tshinane, and Mbwedi are the major sources of water in the area. This water provisioning and regulation service will continue to exist in the area, provided that policy positions around LULC remain focused on ensuring that there are no adverse or unnecessary disturbances to ecosystems that feed these water reservoirs, such as wetlands and springs.

The study area was considered very rural, as many households still rely heavily on natural water sources, such as rivers and springs, for their daily water. Many of the communities did not have sanitation infrastructure; the primary use of water was for drinking and livestock. In the long run, the provisioning and regulatory services of water are intertwined with the survival of the community. If these services were to cease, the poor communities, such as the Sambandou and Madandila communities, would be negatively affected. Ecosystems that provide this valuable resource (water), such as rivers, wetlands, and springs, must be protected at all costs.

The level of LULC changes noted in this study also pointed to the urgent need for acute policy interventions to protect water resources. Although this was identified in this valuation exercise as a potential service, water quality could be under potential future threat due to changes to LULC in the area. The future trajectories of LULC changes point to serious policy changes because ecosystems responsible for cleaning water, such as wetlands, are declining.

Culture-based tourism ranked third for the most valuable service of the area, with a value of $254,993,408.00 that the local community could tap into. The communities in the study area are rooted in their cultural beliefs and norms, which are unique to the area. The untapped potential for tourism associated with the area requires further exploration. For example, the Sundarbans Mountain Reserve in Bangladesh was found to have an enormous economic estimation of provisioning and cultural services, which were later cultivated and realised [45]. The famous Domba, Tshikona, Tshigombela, and Malende cultural dances, only found to this Venda area, are just some examples of cultural activities that could lead to serious returns in the area. If culture-based tourism services were to be realised, a great deal of work is necessary for the preservation and promotion of cultural activities that are said to be in danger of being lost [46,47].

Nature-based tourism follows behind culture-based tourism, valued at $107,998,664.00. This amount represents the potential value that nature-based tourism could bring to the area if pursued as an economic activity. Currently, there are several activities that may be considered tourism-related; however, many of them are not nature-based activities. The Mphaphuli Cycad Nature Reserve is the only form of nature-based tourism in the area. Nature-based and culture-based services are tightly linked. Both can be classed as cultural services and are often considered together as recreational services [29]. It is imperative to realise the potential of recreational services for places such as the Mphaphuli Cycad Reserve, Dungudzivha pools, and Tshaulu Musununu, which are areas in the core of the CBA under study. The land around the Mphaphuli Cycad Nature Reserve remains relatively intact and would be suitable for expansion of the reserve.

The potential economic value of grazing and fodder services in the area was $58,344,568.00. The community under study, similar to many other communities in South Africa and the African continent at large, relies heavily on livestock [48]. Cattle, in particular, are a source or symbol of status in the community [49]. For the grazing and fodder ecosystem service to continue flowing through the study area, the fodder that nature provides for free must be appropriately managed; otherwise, the locals would need to start purchasing their feed if none are available in the wild. Similar to nature-based tourism, it is critical for the community to put measures in place to protect this service at all costs, as it is intertwined with cultural practices in the area. If this service ceases to exist in the community, the traditions and customs in the area would also be severely affected.

Livestock and grazing, by extension, contribute significantly to rural livelihoods as they provide basic income and employment for the locals. They are a crucial asset and safety net for the poor, especially for women and pastoralist groups, and they provide an essential source of nourishment for billions of rural and urban households [49]. This is the current situation of the community in and around the CBA.

Domestic timber was valued at $6,084,366.00, whereas fuelwood was valued at $2,472,220.75. The local community relies heavily on fuelwood for energy security associated with cooking and heating. It is argued that the Co$ting Nature tool may have undervalued this service in the area, because the community is largely rural, and some villages towards the east such as Sambandou, Mahunguwi, and Ha-Lambani are still almost entirely dependent on fuelwood as a source of energy.

The potential economic value of forest carbon sequestration services was found to be $1,000,003.68. Carbon storage and sequestration are critical ecosystem services that humanity relies upon [34,50]. The local community or beneficiaries can also benefit from carbon storage and sequestration through carbon finance mechanisms [29,51]. Carbon stored in vegetation is locked out of the atmospheric system for a period, which contributes to there being less carbon in the atmosphere [34,52]. The potential economic value of the carbon sequestration service will continue to be realised where forests are conserved. The study area has seen a decline in thickets and forests between 1990 and 2018. There is a dire need for policy directions to shift if carbon sequestration services are to continue flowing in the community. According to Govender [38], the carbon in the atmosphere contributes to global climate change, which affects many in deprived areas, such as the community in this study.

Although many of the services mentioned above are considered to have potential economic value, the Co$ting Nature exercise also recognised several activities that had already-realised economic importance taking place in the area under study, such as infrastructure, residential areas, and changes in land cover. These activities confirm that some services have been realised. This represents the total value of all ecosystem services to all beneficiaries in the area.

Beneficiaries of ecosystem services in the CBA derive these benefits mainly from the woodlands, grasslands, built-up areas, subsistence agriculture, and waterbodies. The pressure placed on thickets and dense bush between 1990 and 2018 came full circle as indicated by the realised economic values. Woodlands gained 71% in terms of land-cover change by reducing thickets and dense bush. Woodlands are not shown as providing the most significant value to beneficiaries in the year 2020. This trend is, however, not sustainable as said woodlands fall in areas that show the most intense pressure and rank high on the conservation priority index. If these woodlands were to disappear due to the current rate of deforestation, the community would ultimately suffer. Between 1990 and 2018, the agricultural land-cover class was reduced by almost 5%. Even with a reduction in agricultural practices, this land cover still returned one of the highest economic values to the local beneficiaries in the year 2020. Built-up areas in the developed portions of the study area, mainly to the west, also exhibited traits of returning top economic benefits, which have been realised. The land has almost been fully utilised, which explains the recognised values to the beneficiaries.

Grasslands returned high economic values to the beneficiaries as well, which could be a result of the change from dense thickets and woodlands to bare and open spaces, making these areas accessible for grazing purposes. The trends between 1990 and 2018 were that grasslands reduced from 800 to 255 ha, but this land cover still managed to garner good economic value.

Although the main focus has been on ecosystem services derived from nature, it is important to bear in mind that the environment also provides a range of disservices that can have negative impacts on people, especially in rural areas. These include pests, diseases, and crop raiding, as well as other forms of human–wildlife conflict [29]. Although wildlife services are known to benefit croplands only, wildlife disservices tend to affect both croplands and pastures. The value of the wildlife disservices (calculated for non-urban areas only) is assumed to be proportional to the inverse of the productivity of non-agricultural (i.e., non-cropland and non-pasture) land, on the basis that the low productivity of natural land will tend to drive wildlife into agricultural areas, bringing disease and the raiding of crops and livestock [29]. This study found this disservice for the study area to have a value of $39,763,148,800.00.

3.3. Variances in Ecosystem Services across Different LULC Classes

There were significant and insignificant variances between total economic value and LULC types, as reflected in Figure 3, a box plot summarising the variances. Figure 3 is to be read together with Table 4. Figure 3 shows the variations in economic value between the 11 land-cover classes across the entire study area. There was significant variability in economic values among the different land-cover classes. The woodlands class was associated with significantly higher economic value ($p < 0.05$) than indigenous forests.

Similarly, built-up areas showed a significantly greater economic value compared with wetlands. The grasslands class was associated with significantly higher economic value than the thickets/dense bush class.

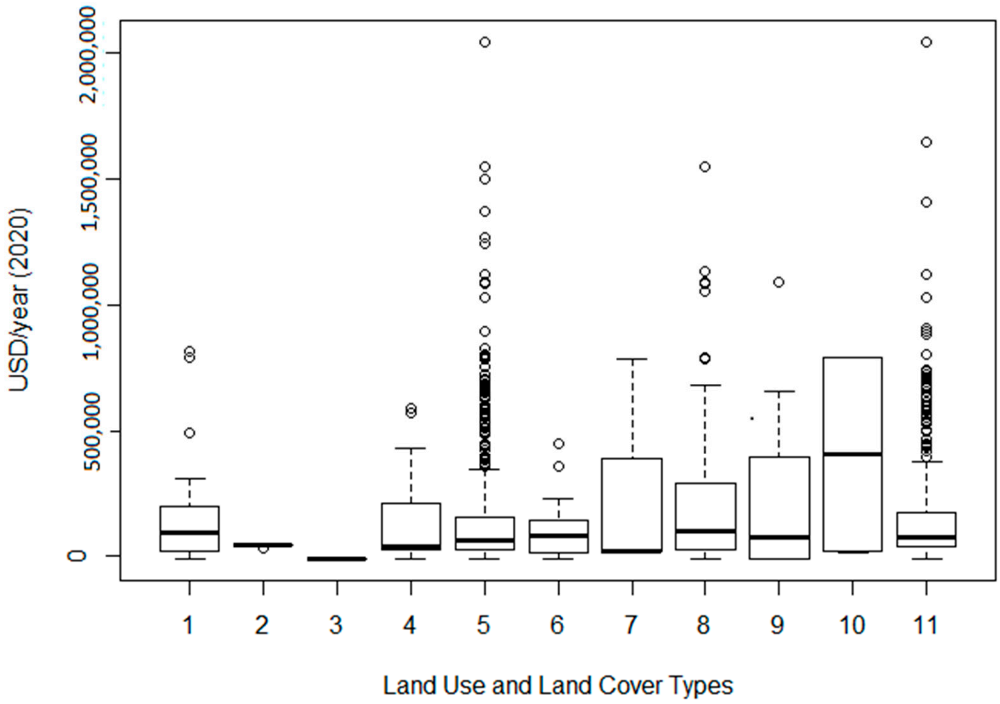

Figure 3. Box plot showing the variance between total economic value and LULC types. 1 = Waterbodies, 2 = Wetlands, 3 = Indigenous forest, 4 = Thicket and dense bush, 5 = Woodlands, 6 = Grasslands, 7 = Commercial agriculture, 8 = Subsistence agriculture, 9 = Forest plantations, 10 = Bare areas, and 11 = Built-up areas.

There was nonsignificant variability between bare areas and thickets. As economic values vary between the different land-cover classes, the level of intensity related to management efforts would differ. This is because there is a very close relationship between economic value and contribution to livelihoods for different land-cover classes. It is essential to assess the extent to which development policy, planning, and practice can adequately respond to the inherent demographic and economic forces that underpin urbanisation taking place at any given time [39]. This view is supported by the assertions and findings of Davids et al. [53], who insisted that policies need to assist in the management of the environment, based on their assessment of ecosystem service hotspots in Durban, South Africa.

Development should be prioritised by taking a cue from the spatial extent of the ecosystem services, especially in rural areas where locals are almost entirely dependent on ecosystem services for their survival. Biodiversity priority indexing was based on the relative endemism of reptiles, red-listed mammals, amphibians, and birds [29]. There is an inverse relationship between this index and development, relative pressure, and threat indices. Biodiversity hotspots are in areas that are the least developed, which, by implication, require protection. These are areas mostly located to the central and eastern portions of the study area, surrounding the only local nature reserve, Mphaphuli Cycad Nature Reserve. Most of the thicket and dense bush deterioration or changing of woodlands are concentrated in and around these sections.

The findings of this assessment presents an opportunity for the locals, through their leadership structures, to realise that the land parcels marked in red are perfect targets for biodiversity conservation, even though the poor benefit the most from the woodlands in the area,. These said land parcels house many of the cycad species (*Encephalartos transvenosus*), which are globally threatened. Many of these specimens are located outside of the Cycad Nature Reserve [54]. The survival of *E. transvenosus* is uncertain due to various threats, such as illegal collection, habitat destruction, fire, and grazing [55].

Villages such as Mutoti, Budeli, Dumasi, and Mphego were among those whose poor populations were benefitting from ecosystem services, mainly aligned to the emergence of the Nandoni Dam. The Malamangwa, Mahunguwi, Mukomaasinanndu, and Tshamutilikwa villages appeared to be the main beneficiaries of the services provided by the woodlands. In the same vein, villages such as Dimani, Tshifudi, and Tshaulu appeared to benefit the most from subsistence agriculture. These values were calculated as the percentage contribution of local service value to the livelihood of the local poor population (GDP of the poor).

Members of the local community, particularly in Sambandou, Mahunguwi, Mavunde, and surrounding villages, were the primary beneficiaries of ecosystem services aligned with woodlands, with values estimated at $24,597.53. Other services contributed immensely to the livelihoods of the poor in built-up areas, such as Thohoyandou and Makwarela, with values determined at $2525.51. Services aligned to subsistence agriculture were found mainly in the Dimani, Tshaulu, Tshifudi, and Matsika villages, with values determined at $1942.90.

According to Mucova et al. [56], South Africa is besieged with serious challenges around the management of protected areas, rural development, and addressing sustainable development challenges in general. This is accelerated by the ever-growing population and overexploitation of natural resources.

The fact that the rural poor are benefitting immensely from the woodlands does not mean much if such utilisation of the woodlands is not controlled or is not taking place sustainably. The woodland resources would eventually be depleted, and the same communities would be requiring financial interventions from the traditional leadership and central government. Reyers et al. [57] argue that co-production of knowledge and agreements could be valuable in steering policy directions, in spite of the inherent complexities of ecosystem services and their management. Local communities have lived in this environment for many years and they understand the intricacies that define the ecosystem services in their area. Their knowledge should be recognised when decisions are made, instead of using top-down approaches in decision-making.

This view is supported by the findings of Murata et al. [58] from an analysis of the communities and ecosystem services around the Eastern Cape province of South Africa. These assertions were also validated by Langhans et al. [59], who suggested using multi-criteria decision analysis to formally integrate community values into ecosystem-based management. Conservation priority has been considered by overlapping of endemic bird areas that are recognised by globally as important bird areas and CBAs, according to the International Union for Conservation of Nature [29,60]. According to Duarte et al. [61], policymakers and conservationists find it difficult to motivate the prioritisation of conservation areas if they cannot show how human beings will benefit. In this case, the financial values associated with ecosystem services and the potential that biodiversity has should be motivation enough to protect the area.

4. Conclusions

This study focused on the identification and valuation of ecosystem services for a CBA. The total realised economic value for ecosystem services was found to be US$528,280,256.00, whereas hazard mitigation potential was found to be worth US$765,598,080.00 across the study area. Artisanal fisheries were the least valued ecosystem services, valued at US$5577.54. A striking finding was the wildlife disservices, which were found to be valued at -US$39,763,148,800.00. We further analysed the variances in ecosystem values across different LULC classes for the study area, and found that services aligned to subsistence agriculture were mainly realised in the Dimani, Tshaulu, and Matsika villages, with values determined at US$1942.90. It is believed that the successful identification, mapping, and valuation of ecosystem services at a CBA such as the one in this study positively contributes to the attainment of the Sustainable Development Goals, particularly in poor local communities. At the same time, the findings provide a solid basis for policy directions around LULC planning. Co$ting Nature V3 software is one of many tools used in the identification and valuation of ecosystem services. Other tools such as TESSA and InVEST can also be used for the same purpose. The outcomes of this study pointed to several areas requiring urgent attention from the leadership, such as those in the local government and the house of traditional leadership responsible for the management of the land resources.

We recommend that the local community, through its traditional leadership structures and with the provincial environmental department, formalise the expansion of the Mphaphuli Cycad Nature Reserve as a critical habitat for the cycads in the area as soon as possible. The formalisation should include increasing the nature reserve by at least 5500 ha, from the current 1080 ha. This will assist in the protection of the many cycads that are outside the reserve's boundaries. This will also protect the thickets that are under tremendous pressure from deforestation. Once the reserve has been established, a Payment for Ecosystem Services (PES) scheme should be used to support the poor who will no longer be able to access fuelwood and other materials from the protected reserve. The traditional authorities should pursue alternative payments or rewards for maintaining ecosystem services, such as the sale of carbon credits.

Author Contributions: Conceptualisation: K.D.M. and M.C.; methodology: K.D.M. and A.R.; software: K.D.M. and A.R.; validation: K.D.M.; formal analysis: K.D.M.; investigation: K.D.M.; resources: K.D.M.; data curation: K.D.M.; writing—original draft preparation: K.D.M.; writing—review and editing, K.D.M., M.C., and A.R.; visualization, K.D.M. and A.R.; supervision: M.C. and A.R.; project administration: K.D.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the UNISA-CAES Health Research Ethics Committee of the University of South Africa, reference number 2020/CAES-HREC/039 on 16 March 2020.

Data Availability Statement: Not applicable.

Acknowledgments: The following are acknowledged for the various roles they played: Co$ting Nature PSS for the software platform; The Department of Forestry, Fisheries and the Environment, for land-cover data; The University of South Africa, for funding the editing of this manuscript; Naledzi Environmental Consultants (Pty) Ltd., for technical input.

Conflicts of Interest: The authors declare no conflict of interest.

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