

Article

An Estimate of the Economic Value of the Marine and Coastal Ecosystem Services of Algoa Bay, South Africa

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Abstract

Ecosystem services provided by coastal and marine environments are increasingly recognised as of paramount importance for human wellbeing. To inform marine spatial planning and its implementation, as well as to manage conflicts between marine resource beneficiaries, we developed a comprehensive estimate of the economic value of the ecosystem services of Algoa Bay (AB) from 2000 to 2019. This is to assist in the development of effective policies concerning the management of marine resources. We quantified and assessed the monetary value by integrating 15 ecosystem services (ES) across five ecosystems using a range of economic valuation techniques and four scenarios. The scenarios differentiate between the local and global beneficiaries of the services and a conservative and alternative valuation estimate. These latter two valuation benefits are calculated using different sets of valuation estimates. We identified that onshore ecosystems, and recreation and tourism services, hold the most value. We estimated that the value grew from USD 613.4 million to USD 1695.9 million for local beneficiaries and from USD 1127.7 million to USD 2787.9 million for global beneficiaries between 2000 and 2019. The local values are roughly equivalent to the municipal budget, implying that the value of the ES is at least equal to that of the combined value of public service delivery. This highlights the significant economic contributions of marine and coastal ecosystems to local economies. This valuation provides a framework to make explicit the value that beneficiaries derive from marine ecosystems and provides a novel perspective on the valuation of ES in the coastal and marine ecosystems. This framework can be replicated elsewhere where there is a need to develop the ocean economy in an equitable and sustainable way.

Keywords: ecosystem services; valuation; marine and coastal ecosystems; marine spatial planning



Academic Editor: Maria Rosa Trovato

Received: 11 September 2025

Revised: 29 October 2025

Accepted: 18 November 2025

Published: 10 December 2025

Citation: Orolowitz, M.; Blignaut, J.; Lourens, C.; Bentley, M.; Twekye, T.; Rees, P.; Miltz, E.; Peacock, R.; Snow, B.; Lombard, A.T. An Estimate of the Economic Value of the Marine and Coastal Ecosystem Services of Algoa Bay, South Africa. *Sustainability* **2025**, *17*, 11055. <https://doi.org/10.3390/su172411055>

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1. Introduction

Over a third of the global population resides in coastal areas [1]. Communities in these regions and their associated economic activities rely on marine ecosystem services (ES) for their livelihoods and wellbeing [2–4]. Anthropogenic pressures, however, are jeopardising many coastal and marine ecosystems and their benefits [1,5–7], both now and in the future [8]. It is estimated that approximately 60% of major marine ecosystems have either

been exploited unsustainably or degraded [9]. These ever-increasing pressures include fishing, climate change, ocean acidification, pollution and habitat degradation [10]. Altogether, the haphazard development of marine uses, the emergence of new uses and a growing coastal population are expected to intensify the decline of marine ecosystem health [11,12].

Given the growing scarcity of resources, increasing trade-offs and the intricate interplay between natural ecosystems and human activities, coupled with the significant environmental challenges confronting resource management, there is an increasing demand for comprehensive, systematic assessment frameworks [1,13,14]. One such important framework is marine spatial planning (MSP). MSP addresses these environmental challenges and impacts in a strategic and cohesive manner and comprises the process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives to promote sustainable ocean management and governance in coastal and marine ecosystems [15,16]. MSP hence recognises the need for ocean-based development and supports decision-making by facilitating the expansion of marine activities, while aiming to improve social and economic conditions and protect ecosystem integrity [17,18].

To inform an MSP and its implementation, as well as to manage conflicts between marine resource beneficiaries and develop effective policies concerning the management of marine resources, an independent economic basis is required [19]. ES valuation is an approach that incorporates and recognises natural capital in economic development and supports policymaking [3,20]. ES valuation is a tool in MSP as it can assist in developing an understanding of temporal changes and economic trade-offs between different marine ES, plans, policies and scenarios [10]. Moreover, it provides a framework to explicitly measure how policy and decision-making may impact marine ecosystems and their associated costs and benefits to society [4,21–23].

This study seeks to address the dual question of (i) how to apply ES in a comprehensive and replicable manner within a data scarce context so that it can inform MSP by means of a consistent framework, and (ii) what are the ES values for AB and how did they change over time? Question 1 is addressed in Section 3, while question 2 is answered in Section 4. The results are discussed in Section 5. First, however, a review is performed of marine spatial planning and the context thereof in general.

2. Marine Spatial Planning: A Review

MSP is being incorporated into ocean-based development, as many countries seek to adopt ocean-based economic directives [24,25]. In 2014, South Africa launched “Operation Phakisa” with the primary goal of utilising the economic potential of South Africa’s marine ecosystems [26]. This initiative aims to be applied through an integrated ocean governance framework, with MSP forming an integral part of the implementation process [27]. As part of the detailed MSP planning process, South Africa’s ocean space has been divided into four bio-geographic marine areas that serve as planning domains for which marine area plans will be designed and implemented [28]. Moreover, Algoa Bay (AB) in South Africa has been identified as a key node of implementation of MSP within South Africa as it is regarded as one of the best-monitored marine ecosystems on the continent and serves as one of the designated focus areas of the MSP development process [27].

The Algoa Bay Project, a research consortium formed in 2019, has since produced products and frameworks to inform MSP in South Africa [29]. To address the final challenge outlined in the project strategy—namely, the development of scenarios for management strategies to be used in stakeholder engagement—the impact on ES and their use in the project was recognised as an important avenue of inquiry [30]. Although more ecosystem service studies have been conducted in South Africa than any other African country,

almost all ecosystem service valuations in South Africa have been conducted exclusively on terrestrial ecosystems [31–35], with only a couple of studies conducted on a local scale [36,37] and only a single study comparing long-term temporal changes in ES [38]. Furthermore, studies conducted on a local scale are scarce and currently insufficient to inform policy and resource management for local government [35]. Marine ecosystem service valuations in Africa are rare, but do include a few for coastal services [39], large marine ecosystems [40] and kelp forests [41] at continental to country scales, and a few local-scale studies for South [42], East [43] and West Africa [44–46].

Given these gaps in knowledge and the current implementation of the MSP process, there is an urgent need to conduct ecosystem service valuations of marine and coastal ES in South Africa. Therefore, the aim of this study was to develop South Africa's first comprehensive framework and valuation of marine ES in AB to inform the MSP process and contribute to policymaking on a local scale and, later, at a scaled-up national scale.

3. Materials and Methods

3.1. Study Area

Algoa Bay is situated between Cape Recife ($34^{\circ}02' \text{ S}$, $25^{\circ}42' \text{ E}$) and Cape Padrone ($33^{\circ}46' \text{ S}$, $26^{\circ}28' \text{ E}$), on the south-east coast of South Africa, and is one of the largest bays in the country [27]. The study area for our ES valuation framework and subsequent valuation was based on the boundaries delineated for the AB Project [27]. It extends from the high-water mark to 12 nautical miles offshore, and from the western boundary of the Sardinia Bay Marine Protected Area (MPA) to the eastern perimeter of Cannon Rocks, encompassing five estuaries and totalling 448 516 hectares. The study area consists of five broad coastal and marine ecosystems: onshore, coastal, offshore, coral reefs and estuaries (Figure 1) [29,47].

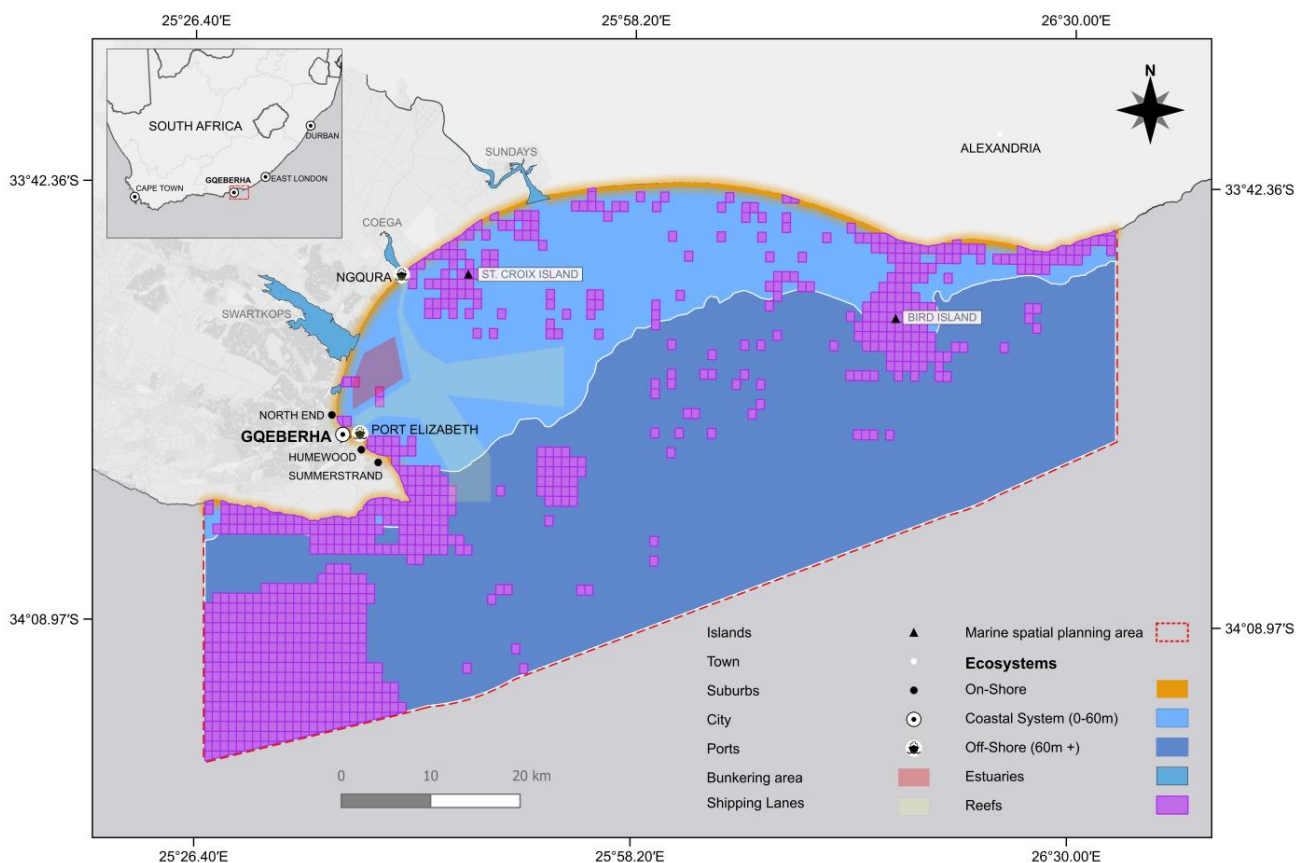


Figure 1. Algoa Bay Project study area showing the five ecosystems included in the valuation. Adapted from the Algoa Bay Project [29].

The Bay is considered a biodiversity hotspot, supporting the largest breeding colonies of critically endangered African Penguin *Spheniscus demersus* and endangered Cape Gannet *Morus capensis* [48–50]. On the western edge of the Bay lies the industrial city of Gqeberha (formerly Port Elizabeth) within the Nelson Mandela Bay Metropole [51]. The local economy is centred around two shipping ports, Ngqura and Port Elizabeth, that are used by the motor industry as well as the agricultural and mining sectors [27,50,52]. Tourism additionally attracts millions of visitors each year and has been recognised as an important economic contributor [53].

Other socio-economic marine activities include commercial fisheries and aquaculture [29]. Gqeberha is South Africa’s third largest coastal city with a population of approximately 1.3 million people. Sixteen percent of the population live in poverty and 37% of the population are unemployed [54]. The average purchase power parity adjusted annual income per person in the metropole is USD 8251 [54]. All nominal ZAR values herein have been converted to USD using the purchase power parity (PPP) exchange rate. The exchange rates used are ZAR2.759:USD (2000), ZAR3.556:USD (2005), ZAR4.62:USD (2010), ZAR5.825:USD (2015), ZAR6.707:USD (2019) [55]. Moreover, the municipal budget has grown from approximately USD 875 million in 2005 to more than USD 1.5 billion in 2019 (purchase power parity adjusted; Table 1). Data for 2000 is unavailable due the fact that the municipality changed reporting systems after 2000, and the prior data is no longer available.

Table 1. Nelson Mandela Bay Municipal revenue and expenditure collated from NMBM annual reports and budgets between 2005 and 2019 (purchase power parity adjusted USD, thousands) [56–59].

Year	2000	2005	2010	2015	2019
Total revenue	-	824,270	1,129,550	1,391,124	1,623,039
Total expenditure	-	843,543	1,238,408	1,431,320	1,621,015
Difference	-	−19,273	−108,858	−40,196	2024

3.2. Ecosystem Services Valuation Framework

The five ecosystems in AB (Figure 1) are diverse and render a range of ES. To capture this range of values, a framework comprising 15 ES, which are grouped into four categories as defined by the MEA [1], have been developed. This framework is based on Blignaut and Lumby [60], De Groot et al. [61], Clifton et al. [14], Blignaut et al. [62] and Blignaut et al. [63].

The valuation of these 15 services, as summarised in Table 2, will subsequently be discussed individually in terms of their definitions and aspects related to their monetary and biophysical boundaries and measures. It should be noted that while all effort has been made to estimate the most appropriate unit values, the unit values are constant per service and ecosystem. Given the scope of five ecosystems and 15 services, no intra-ecosystem variation in unit values were possible. Furthermore, all local benefits, per definition, also accrue to the global population, but not all services render a local value. In those cases, it implies an elevated global value. The sources of data and details concerning the valuation methods are provided in Appendix A, Tables A1 and A2.

Table 2. Demarcation of the ecosystem services by ecosystem and valuation method applied.

	Ecosystem Service	Valuation Method	Onshore	Coastal System	Offshore	Coral Reefs	Estuaries
Provisioning	Right of access (human habitat)	SP	L and G	L and G	L and G		L and G
	Food provisioning (non-cultivated)	MP		L and G	L and G		L and G
	Food and raw materials (cultivated)	MP		L and G			
Regulating	Waste dilution	RC		L and G			
	Air quality regulation	BT	L and G	L and G			
	Climate regulation	BT	L and G	L and G			L and G
	Moderation of extreme events	BT		L and G		L and G	
	Erosion prevention	BT		L and G		L and G	
	Nutrient cycling	BT					L and G
	Water quality	BT					L and G
Supporting	Maintenance and protection of nursery and gene pool and life cycle	BT		G**	G**		
Cultural	Amenity value	PV	L and G				L and G
	Recreation and tourism	MP	L and G*	L and G*	L and G*	L and G*	L and G*
	Spiritual, cognitive and other	BT	L and G	L and G	L and G	L and G	
	Existence and bequest	BT		G**	G**	G**	

Notes: SP = statutory payment; MP = market price; RC = replacement cost; BT = benefit transfer; PV = property value, L = valuation conducted for the local population, G = global values are equal to that of the local estimate; zero marginal addition to the global value, G* = valuation for the global population, but at elevated levels, G** = service rendered to the global population only.

Four scenarios are being presented. They are for local and global beneficiaries, and for each of these two beneficiary groups a conservative and an alternative scenario were estimated. In each ES valuation, the smaller local population forms part of the global beneficiary group; however, some ecosystem services are only derived by the global level and not at the local level. While each of the beneficiary groups proved instrumental within the study, the local NMB residents are of particular importance on account of both the MSP orientation as well as the fact that benefits realised within such a group has direct implications for benefits realised among both the national and international groups. The conservative and the alternative scenarios for these two beneficiary groups refer to different sets of published unit ES values that were available from different sources. These scenarios are therefore not upper and lower scenarios from a single set of unit values, but rather different unit values from different sources, with the conservative scenario using the lowest available value each time.

The ES valuation was conducted in nominal ZAR terms. Where necessary unit values were converted to ZAR using the appropriate PPP rate. All values are reported in nominal USD terms. ZAR values have been converted to USD using the PPP rates highlighted above. Real values were converted to nominal terms using the consumer price index. Having developed a full dataset in ZAR terms, it has been converted to USD using the PPP exchange rates mentioned above.

We turn to the specific method used in performing the various ES valuation estimates.

3.2.1. Right of Access

Definition and Scope

As per He et al. [64], the spatial extent of an ecosystem provides a carrier service allowing a range of economic activities and infrastructure, such as a port wharf and related activities, to exist. The access to natural infrastructure allows the local authorities to extract rent from the users of the carrier service—rent that would not have been possible without the ecological infrastructure and its subsequent carrier service. Statutory prices have been used as an expression of the revealed preference to use the carrier service.

Biophysical and Monetary Boundaries and Measures

With respect to mariculture, the statutory permit fee allowing the right to engage in aquaculture linked to the area assigned was used.

With respect to fishing, the statutory permit and licence fees as attributed to the class of fishery (i.e., small pelagic, traditional line fishing, squid, shark longline and in-shore demersal trawl) were multiplied by the number of vessels permitted to access the resource—see Appendix C.

With respect to industrial sites and ports, the value was determined by multiplying the statutory fee, or rate, for industrial properties with the relevant area they are occupying per ecosystem in hectare.

3.2.2. Food Provisioning (Non-Cultivated)

Definition and Scope

The value of the fish catch, inclusive of all classes as well as that harvested from the estuary, was estimated. Market prices have been used as an expression of the revealed preference.

Biophysical and Monetary Boundaries and Measures

The total fish catch per class of fishery in ton was multiplied by the average annual unit price based on market prices.

3.2.3. Food and Raw Materials (Cultivated)

Definition and Scope

The value of the mariculture production based on yield per hectare and the yield for the respective years was estimated.

Biophysical and Monetary Boundaries and Measures

The annual yield in ton in mariculture was multiplied by the average annual unit price based on market prices.

3.2.4. Waste Dilution

Definition and Scope

Using the replacement cost method, the capital and operating cost of manufactured infrastructure to remove dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP), the value of the waste dilution service of the estuary was estimated.

Biophysical and Monetary Boundaries and Measures

The difference in the DIP and DIN concentration levels between the head and the mouth of the estuaries were calculated. This provides an indication as to the level to which the estuary removed the inorganic material from the body of water. This was multiplied with the cost of manufactured capital to do the same using values from the local wastewater treatment facilities (Appendix A).

3.2.5. Air Quality Regulation

Definition and Scope

Using the benefit transfer method, De Groot and Bönhke-Heinrichs [65] calculated the amount of NO_x, in the form of fine dust, captured by the onshore ecosystem and estimated an amount per kilogram based on the cost that would have arisen from health damage. The values for different biomes within the ecosystem were calculated to estimate a value per hectare.

Jones et al. [66] used a comparison of two scenarios for the coastal system, namely, a 'no vegetation' and 'current vegetation' scenarios. The amount of sulphur dioxide, fine particulate matter, nitrogen dioxide and ozone removed under both scenarios was calculated by assessing the change in concentration, and a monetary benefit was then estimated based on health benefits. The difference equals the value per hectare.

Biophysical and Monetary Boundaries and Measures

The unit values as derived from the international studies were applied on an area basis within this study. Using the benefit transfer mechanism has its disadvantages, namely, among others, a fixed unit rate per ha and the ignorance of the context, but in the absence of any local study, it is considered better than not including a value at all. This applies to all cases using the benefit transfer method.

3.2.6. Climate Regulation

Definition and Scope

This service ensures that the local climate does not significantly vary to opposing extremes. Herein, this service relates to the carbon sequestration ability of the ecosystems.

Biophysical and Monetary Boundaries and Measures

Using the benefit transfer method, the unit values as derived by Christie and Rayment [67], Ganguly et al. [68] and Adams et al. [69] for the onshore, coastal and estuarine areas were applied to the relevant areas (see Figure 1).

3.2.7. Moderation of Extreme Events

Definition and Scope

This service refers to the non-use value derived from ecosystems acting as protection against natural disasters and climate-related events. Using the benefit transfer mechanism unit values were derived from published sources.

Biophysical and Monetary Boundaries and Measures

As with climate regulation, the benefit transfer method was used based on Christie et al. [70] and Samonte et al. [71]. Unit values per ha for the coastal and coral reef systems were derived and applied to the relevant areas.

3.2.8. Erosion Prevention

Definition and Scope

This service refers to the protection of soil and the maintenance of water quality in nearby water bodies and is relevant to the coastal systems and coral reefs.

Biophysical and Monetary Boundaries and Measures

Using the benefit transfer method, the unit values as estimated by Han et al. [72] and Albert et al. [73] for the coastal and coral reef systems were applied to the relevant areas.

3.2.9. Nutrient Cycling

Definition and Scope

With estuaries supporting the life cycles of such a broad array of organisms and marine animals, the ecosystem service of nutrient cycling proves extremely valuable. The monetary value of this service is estimated by calculating the nursery value of an area. An estuary's nursery value is the ability of the estuary to be in a condition suitable enough to be nursery grounds for marine organisms, specifically the juveniles.

Biophysical and Monetary Boundaries and Measures

A local study by Turpie and Clark [74] estimated nursery values by observing fresh-water flows, frequency and duration of estuary mouth openings. These are the biggest factors affecting estuarine biota. The authors estimated the value of the biota using local and prevailing market prices.

3.2.10. Water Quality

Definition and Scope

Water quality value was estimated as the sum of a cultural use and an infrastructure replacement component. To estimate the cultural use, component benefit transfer was used with reference to Magobiane [75], where the study's aim was to determine how much the users of the estuary value changes (improvements) in water quality to safer levels for other services such as swimming, fishing and maintenance of biodiversity and general human wellbeing. To estimate the infrastructure replacement cost component of the water quality ecosystem service in estuaries, reference was made to the function of estuaries in removing pollutants from water through nitrogen and phosphorous cycles [76]. This function was compared to that of wastewater treatment plants that remove pollutants through industrialised processes.

Biophysical and Monetary Boundaries and Measures

While focussing on estuaries, the unit values as reported in Magobiane [75] and Huang et al. [76] were used and multiplied with the relevant areas.

3.2.11. Maintenance and Protection of Nursery and Gene Pool and Life Cycle

Definition and Scope

This refers to the service provided by ecosystems that supports and maintains biodiversity levels by providing suitable conditions and functioning habitats. Although all five of the ecosystems found in AB provide this service, suitable studies for the benefit transfer could only be found for the coastal systems and offshore ecosystems.

Biophysical and Monetary Boundaries and Measures

Watson et al. [77] and Beaumont et al. [78] estimated unit values for coastal and offshore systems. These values were multiplied with the relevant areas.

3.2.12. Amenity Value

Definition and Scope

Residential properties have amenity premiums above similar properties based on their proximity or access to a given resource, such as enjoying coastal views and access to beaches.

Biophysical and Monetary Boundaries and Measures

Using property values in accordance with the hedonic pricing method, we estimated the average price premium of properties with an ocean view and those without for three

suburbs with close access to the ocean. The price premium per m² was calculated using actual sales data by comparing house prices with the same physical features with or without an ocean view. This premium in m² terms was multiplied by the extent of the area with an ocean view and multiplied by the municipal rate to determine the elevated price people are willing to pay for the amenity service.

3.2.13. Recreation and Tourism

Definition and Scope

Three methods were employed for this valuation: travel cost, total spend and opportunity cost methods. The ecosystems involved in the valuation include onshore, coastal systems, coral reefs and estuaries.

Biophysical and Monetary Boundaries and Measures

The travel cost method uses market prices and is based on the travel expenses incurred in visiting a destination as a proxy for the value of access to the destination. The travel cost was calculated by measuring the total distance travelled and multiplying it with the cost per distance (R/km). The travel cost method has been applied only to the domestic tourists visiting the region, as it is assumed that foreign tourist trips prove insignificant relative to those taken by domestic tourists.

The second method employed in calculating the recreational ecosystem service value was that of direct recreational spend. This method allowed for the calculation of the total amount of money spent by foreign and domestic tourists alike. Domestic tourist spend comprised both day visitors as well as overnight visitors. Day visitors refer to tourists visiting NMB from close proximity and do not require overnight accommodation. The day visitor spend was calculated by multiplying the average spent per visitor per day with the total number of domestic day visitors visiting the Bay. The total overnight spent value was calculated by multiplying the total number of overnight visitors multiplied with the average spend per overnight visitor. To assess foreign tourists, a similar calculation was performed to that of domestic overnight spend, as foreign visitors only visit the Bay for periods longer than a day. The total number of foreign bed nights/visitor days was multiplied with the average spent per foreign visitor per day.

The opportunity cost method calculates the value of income forgone while on holiday. This value is indicative of what the service is worth to the individual. As with the travel cost method, the opportunity cost method was applied only to the domestic tourists visiting the region. The total amount of time spent at the Bay was multiplied with a standardised value of time, i.e., the GDP/capita.

3.2.14. Spiritual, Cognitive and Other

Definition and Scope

The ecosystem service of inspiration for culture, art and design, spiritual experience and information for cognitive development encompasses a range of smaller ES. Inspiration for culture, art and design refers to the enjoyment of individuals when appreciating the aesthetic qualities of nature and the inspiration that results from these aesthetic qualities. Spiritual experience generally refers to the sense of place and sense of experience that ecosystems instil in individuals, as nature can generate feelings of attachment and identity, and individuals place symbolic meaning in ecosystems. Finally, ecosystems can provide the right conditions for learning and the gathering of information. Although all five ecosystems found in AB provide this service, suitable studies could only be found for the onshore, coastal and coral reefs ecosystems.

Biophysical and Monetary Boundaries and Measures

Using the benefit transfer method, the unit values for onshore ecosystems based on Christie and Rayment [67] was used, values for coastal areas were provided by De Groot and Bönhke-Heinrichs [65] and Failler et al. [79] provided unit values for estuarine areas. The unit values remained constant across the relevant ecosystems, irrespective of location, and that is a subject for further research.

3.2.15. Existence and Bequest

Definition and Scope

Individuals derive utility solely from the knowledge that biodiversity exists and place a high value on this existence. Furthermore, bequest values arise from the knowledge that this biodiversity will persist for the enjoyment of future generations. Once again, this service is provided by all the ecosystems which make up AB. However, suitable studies were only found for the coastal systems and coral reefs ecosystems.

Biophysical and Monetary Boundaries and Measures

Similarly, the benefit transfer method was used by applying unit values by Perni et al. [80] for coastal systems and by Turpie [81] for offshore systems. Values for coral reefs were derived from Seenprachawong [82], O'Garra [83], Failler et al. [79], Aanesen et al. [84] and Maynard et al. [85]. These unit values were multiplied with the respective areas.

4. Results

4.1. Value of Ecosystem Services for Various Beneficiaries

Our results indicates that the value of ES in AB increased with time, except for the values between 2010 and 2015. This trend is consistent for the value derived by both local and global beneficiaries under the conservative and alternative scenarios. Under the conservative scenario, the value derived from marine ecosystems services in AB grew, in purchase power parity adjusted terms, from USD 613.4 million in 2000 to USD 1632.1 million in 2019 for the local beneficiaries, while the value grew from USD 1127.3 million in 2000 to USD 2683.1 million in 2019 for the global beneficiaries (Table 3).

Table 3. Economic value of Algoa Bay's ecosystem services for local and global beneficiaries (USD, millions).

Year	Conservative		Alternative	
	Local	Global	Local	Global
2000	613.4	1127.3	724.7	1848.4
2005	805.7	1454.0	923.3	2203.8
2010	1257.3	2073.0	1386.3	2892.7
2015	1037.1	1932.3	1180.6	2796.6
2019	1695.9	2787.9	1859.1	3761.2

4.2. Value of Ecosystem Services for Local Beneficiaries

Differences in values placed on marine and coastal ecosystems in AB by the residents of Nelson Mandela Bay Metropole (local) and the global beneficiaries can be attributed to the supporting (maintenance of genetic diversity and life cycle) and cultural (recreation and tourism; existence and bequest; spiritual cognitive and other) ES. These values are significantly higher at the global than the local level, since existence and bequest services were only included for the global beneficiaries. Moreover, given the international nature of recreation and tourism, additional valuations were included for the global beneficiaries.

Cultural services were the most valuable of the four major types of ES, accounting for approximately three quarters of the value over the past two decades. Recreation and tourism contributed the highest value among the 15 ES, followed by another cultural ecosystem service in the form of spiritual, cognitive and other (Figure 2). Recreation and tourism explain between 54% and 75% of the value for local beneficiaries and between 50% and 71% for global beneficiaries of the value over the past two decades (see Appendix B and especially Figures A1–A10).

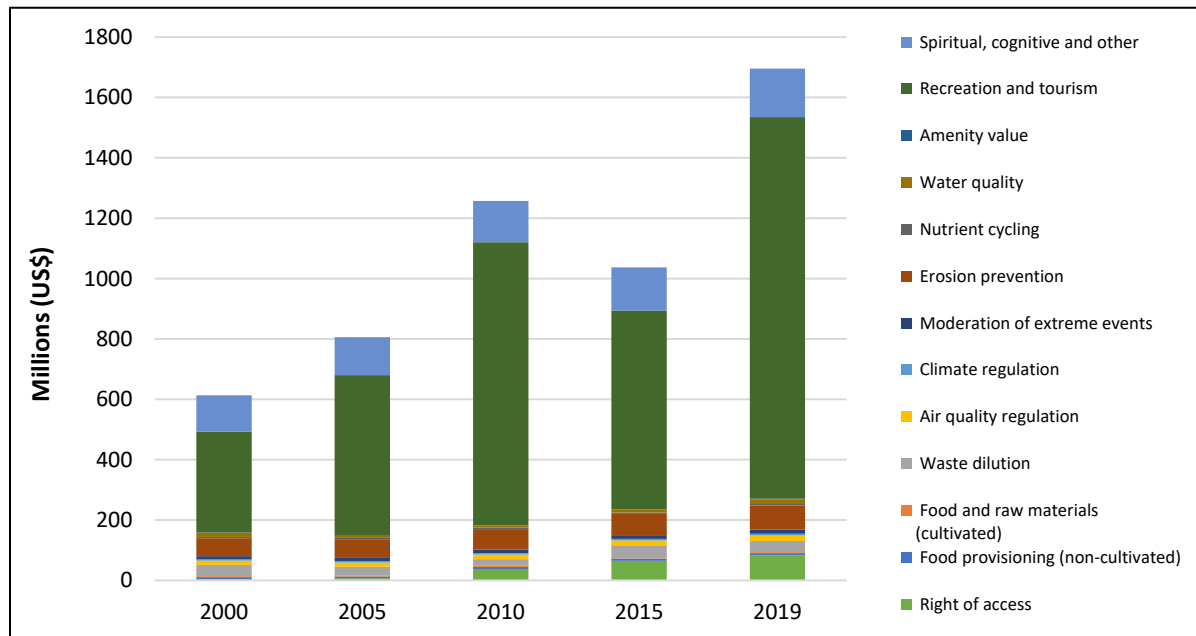


Figure 2. The value of ecosystem services derived by the local beneficiaries.

4.3. Value of Ecosystem Services in Terms of Ecosystems

The onshore ecosystem was the most valuable ecosystem, with the value exceeding the sum of all the other ecosystems combined. This ecosystem also had the greatest increase in value with a three-fold increase in value over the past two decades (Figure 3).

Figure 4 provides a summary of the ecosystem valuation results expressed spatially. The onshore ecosystem had the highest value of all the coastal and marine ecosystems in this study. This is unsurprising, given that many valuations have documented the substantial value that onshore ecosystems provide through amenity and recreational services [62,86]. For example, of the 196 coastal and marine ecosystem studies reviewed, Torres and Hanley [86] found that most of the studies concentrated on beaches. Recreation and tourism ES generate billions in US dollars on an annual basis in Africa [35]. Previous studies in South Africa have also found recreation and tourism to contribute a substantial, if not the largest, portion to overall values [36,87,88]. In this study, recreation and tourism accounted for at least half of the total value for all estimates and beneficiaries over the past two decades, peaking at three quarters of the total value for local beneficiaries in 2010. The rise in the proportionate value of recreation and tourism can be attributed to the 2010 FIFA World Cup, since Gqeberha hosted several of the matches. Mega-events such as this one have been documented to increase the economy of host nations [89]. The 2010 FIFA World Cup attracted 306,600 tourists to the country who spent USD 444 million [90]. This translated to an increase of 24 percent in average visitor spend compared to previous years and would explain the increase in the value of tourism during this time.

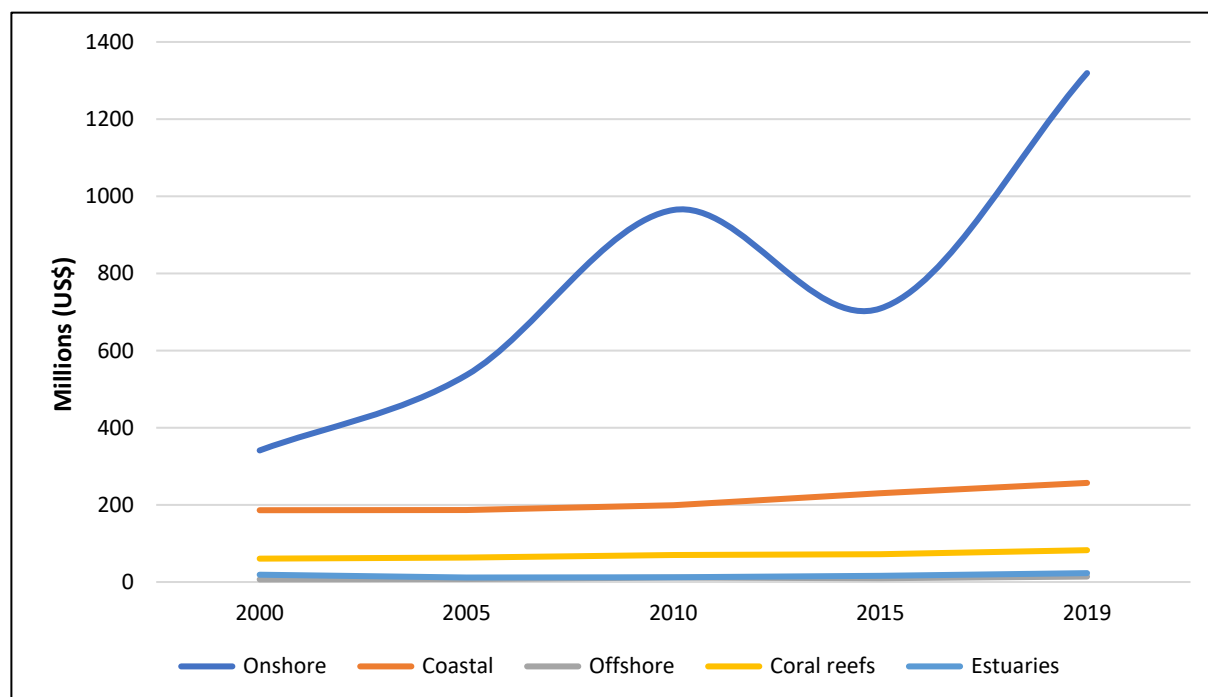


Figure 3. Conservative estimate of the economic value of the ecosystem services rendered by Algoa Bay for the local beneficiaries.

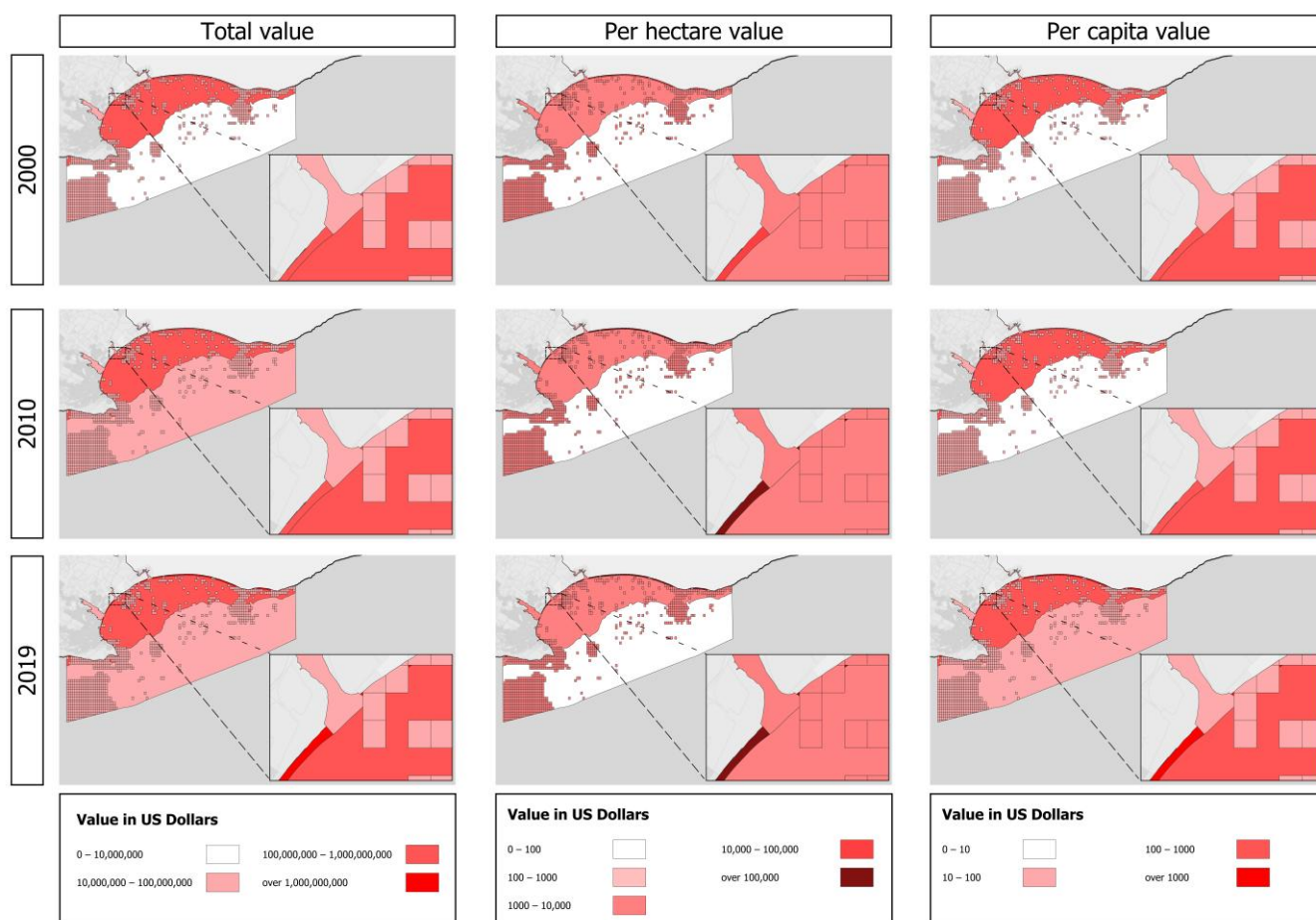


Figure 4. Spatial distribution of valuation results of Algoa Bay's ecosystem services: 2000–2019. Ecosystem delineations are provided in Figure 1.

5. Discussion

This study developed the first comprehensive economic valuation of marine ES in Africa and provides an economic basis to support the implementation of MSP in South Africa. Our study suggests that the overall value of ES in AB has increased over the past two decades and highlights the importance of marine and coastal ecosystems and their associated ES to the local economy. As part of the MSP process, we are able to identify the ecosystems and ES that hold the most value, namely, onshore and recreation and tourism, respectively (Figures 2 and 3). Moreover, our study demonstrates the merit of performing the valuation at multiple time-steps in detecting structural changes in ES.

Our study also revealed that the value of ES has increased over time, with the value of ES growing by over USD 1 billion over the period of two decades. The ES were valued to be equivalent to the municipal revenue of Nelson Mandela Bay Municipality over the past two decades for local beneficiaries (Figure 5), emphasising the substantial value inherent to these marine ecosystems. Similarly, a review by Banela et al. [91] emphasised the importance of integrating ecosystem services, and, in particular, cultural ecosystem services in MSP, to sustain inclusive coastal/marine planning. Moreover, this study valued ES of AB at almost double that of Cape Town over a similar period [36]. Both studies are comparable in scale and geography (coastal cities in South Africa), yet the values are substantially different. These disparities could be attributed to the differences in the selection and classification of ecosystems since De Wit et al. [36] focused predominantly on terrestrial ES (with beaches being the only coastal ecosystem included). This indicates that coastal and marine ecosystems, particularly the onshore ecosystem, holds a substantial value even under varying valuation frameworks. These findings emphasise the growing recognition of the importance of ES and the need to take precaution in the development and expansion of ocean-based activities through initiatives like Operation Phakisa. Moreover, this underscores the necessity for increased conservation and sustainable management efforts to maintain this value amidst the increase in human activities, in line with an ecosystem-based approach to MSP [15] and the work of Holness et al. [92] who developed priority areas for biodiversity and nature-based activities in AB.

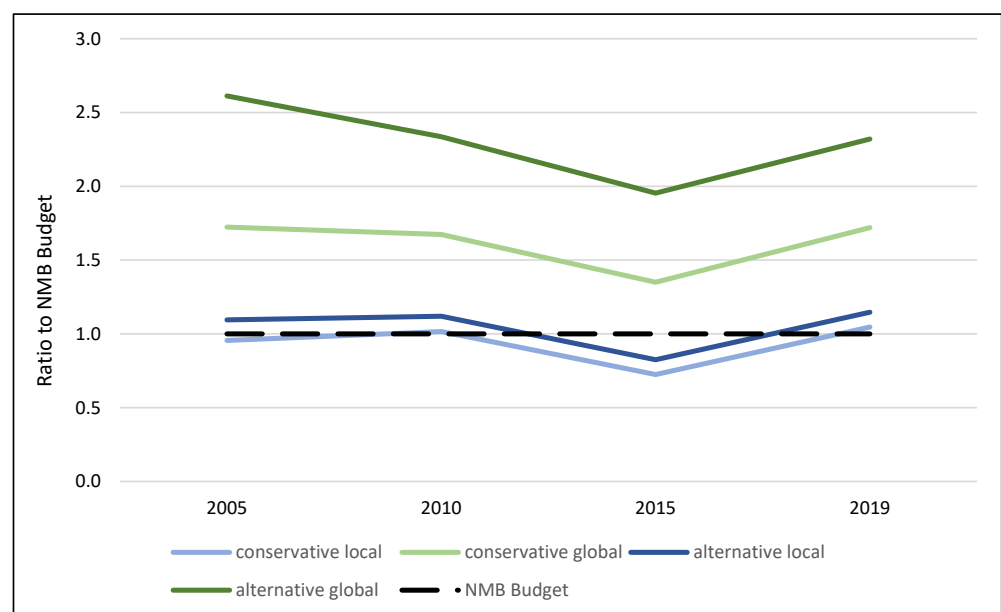


Figure 5. The estimated value of Algoa Bay's ecosystem services relative to the municipal budget.

This increase in the value of recreation and tourism reveals that our valuation was able to detect structural changes in ES over the 20 years and emphasises the dynamic

nature of ES. Moreover, this dynamism demonstrates the importance of using multiple timesteps to develop meaningful policy interventions for ES. For example, tourism is sensitive to declines in environmental quality, which may incentivise policymakers and governments to invest, regulate and conserve marine and coastal systems [93]. This further encourages policymakers to assess synergies and conflicts between activities and the marine environment, and to reduce those that may negatively impact the value of these ES. It is recommended that policy and implementation incorporate ES in planning, inclusive of tourism, an important income-generating activity in AB, and other services that would support sustainable development in the area, particularly when including stakeholders in the process [29]. Further, to determine the impact of policy and regulations on ES requires additional research to investigate the feedback relationships and changes thereof under alternative management scenarios as tested in Vermeulen-Miltz [94].

An additional limitation of this study is that the valuation of ES is based solely on the spatial extent of the ecosystem and does not account for the ecological condition or health of the underlying ecosystems. As a result, observed increases in ES value reflect increased human use or demand for these services, rather than an improvement in the ecosystems' capacity to provide them. For example, the existence value associated with declining species such as African penguins will likely diminish, yet this is not captured directly in the valuation [95]. Similarly, for the non-cultivated food provisioning service, the unchanging trend may also indicate that the ecosystem is operating at or near its provisioning capacity, and that the sector is either unable or unwilling to pay more for this service.

Therefore, if both ecosystem extent and condition had been integrated into the valuation framework, different trends may have emerged. Importantly, this means that increases in ES value cannot be interpreted as evidence of improving marine ecosystem health.

Using both conservative and alternative values as well as local and global beneficiaries, we were able to give a range of values and deal with uncertainty. Moreover, we were faced with a lack of well-developed frameworks when attempting to value the marine ecosystems in this study. For onshore and estuaries, most of the ES were valued using a range of valuation methods (mostly non-transfer), whereas the marine ecosystems were mostly valued using benefit transfer, owing to the lack of information and studies in the study area. The benefit transfer method is not without challenges and limitations (see Pascual et al. [21] for a more detailed description of the challenges). However, owing to resource and data constraints, it was the most pragmatic means of estimating the value of these marine ecosystems and including them in the study. Ignoring them would signal a nil value, which is per definition incorrect. Using the benefit transfer method is thus, despite its obvious weakness, superior to no value [96–98].

6. Conclusions

In conclusion, this is the first comprehensive economic valuation to consider multiple marine ES and provides a transparent approach to inform MSP in AB. Our study contributes to the very sparse literature of marine ES on the African continent at the local scale. This is notwithstanding the various limitations that had to be breached with respect to data. Data had to be collated from various sources and over a long period of time. That complicated matters since definitions of variables and the spatial scales thereof changed occasionally and had to be corrected to keep the integrity of the data and the variable intact. An advantage, however, is that the largest ecosystem service—namely, recreation and tourism services—also have the best and most complete set of data, and these are all market-based. Likewise, the cultivated and non-cultivated provisioning services made use of quality market-based data. The benefit transfer method, however, had to be used for supporting services, some of the cultural services, and all but waste dilution of the regulating services. This is due to the

absence of reliable data and is a source of concern. Using the benefit transfer mechanism is more desirable than entering no data, but is a weak proxy, especially related to services that are highly context- and site-specific such as cultural and regulatory services. It is strongly recommended that a thorough local assessment of these is undertaken.

Our implementation of an ES valuation has provided a framework to make explicit the value that beneficiaries derive from marine ecosystems in an African context and provides a novel perspective on the valuation of ES in the coastal and marine ecosystems within South Africa. This framework can be replicated elsewhere in Africa, where there is a need to develop the ocean economy in an equitable and sustainable way. Moreover, it can be applied in other coastal and embayment areas for a comparative analysis and to support the national MSP process. This type of marine ecosystem valuation method can be used to support ocean planning at both national global scales and can contribute to measuring progress towards United Nations Sustainable Development Goal 14.

Author Contributions: Conceptualization, M.O., J.B., B.S. and A.T.L.; methodology, M.O., J.B., R.P., C.L., M.B., T.T., P.R. and R.P.; validation, E.M. J.B., M.O. and R.P.; formal analysis, M.O., J.B., R.P., C.L., M.B., T.T., P.R. R.P. and E.M.; investigation, M.O., J.B., R.P., C.L., M.B., T.T., P.R. and R.P.; data curation, M.O., J.B., R.P., C.L., M.B., T.T. and R.P.; writing—original draft preparation, M.O., J.B.; writing—review and editing, all authors; visualisation, M.O., J.B. and R.P.; supervision, J.B.; project administration, J.B.; funding acquisition, B.S. and A.T.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work is part of the Algoa Bay Marine Spatial Planning Community of Practice project supported by the DSI/NRF South African Research Chair in Marine Spatial Planning [grant number 98574], the Belmont Forum for the MARISCO project (Belmont Forum Award 03F0836A) and One Ocean Hub [UKRI GCRF grant no. NE/S008950/1].

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Nelson Mandela University (H20-BES-DEV-003) on 7 December 2021.

Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Acknowledgments: We would like to thank Leandri van der Elst for her editorial work throughout the project. We wish to also thank Anne Lemahieu and Hannah Truter for their valuable contributions and inputs. Finally, we would like to thank all stakeholders for their valuable insight along with the respective communities of practice.

Conflicts of Interest: Authors Matthew Orolowitz, James Blignaut, Chase Lourens, Matthew Bentley, Twesigye Twekye, Pablo Rees and Rozanne Peacock were employed by the company ASSET Research. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Appendix A

Table A1. Population of Nelson Mandela Bay, South Africa, and of the globe between 2000 and 2019 (people, millions) [52,99–106].

Beneficiaries	2000	2005	2010	2015	2019
Local	1.00	1.09	1.15	1.24	1.27
Global	6108	6517	6942	7383	7805

Table A2. Data sources.

	Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Right of access	Industrial site values (A1) [107–113]: $\text{Industrial site values} = \text{Average site value} \times \text{Size} \times \text{rates}$ Initial research into directly obtaining the actual site values were unsuccessful. A proxy was used, in which the average site values per hectare were obtained and multiplied by the size of the ports. To obtain the right to access the port for each timestep on an annual basis, the previous calculation was multiplied by industrial property rates.	Port dues (A2) [[114,115] Appendix C]: The actual port dues were obtained directly from Transnet through the Promotion of Access to Information Act (PAIA) process. Port limits were obtained from the Department of Transport and were used to calculate the per hectare value and value per ecosystem of the port dues (accounting for MPAs and mariculture). Mariculture permits (A3) [116–121]: $\text{Mariculture permits} = \text{application fee} + \text{permit fee} + \text{right to engage in mariculture}$ Licencing and permits fees were obtained in the Marine Living Resources Act of 1998 and subsequent iterations for the past 20 years. This right-of-access ecosystem service consists of fees to conduct mariculture operations. These values were summed. Only companies that actively partook in mariculture were included. Therefore, these values were only applied to for the Knysna Oyster Company. Fishing permits (A4): See offshore ecosystem for a summary of the valuation.	Port dues (A2): See coastal ecosystem for a summary of the valuation. Fishing Permits (A4) [Appendix C, [117–129]]: $\text{No. of right holders in AB} = \text{No. of vessels in AB} \times \text{Right holder: vessels in RSA}$ The number of fishing vessels for the five commercial fisheries operating in Algoa Bay were obtained from the Department of Forestry, Fisheries and the Environment (DFFE) through the PAIA process. However, the right-of-access fees are based on right holders rather than on vessel. The national ratio of right holders to vessels was obtained from various sources and assumed to be constant. This ratio was multiplied by the number of vessels in Algoa Bay to obtain the number of right holders in bay. $\text{Total fees per fishery} = \text{Right holders} \times (\text{Application fee} + \text{permit fee}) + \text{no. of vessels in AB} \times \text{licence fees}$ To get the total value per fishery, these right holders were subsequently multiplied by sum of the permit and application fees and added to the product of the number of vessels and licence fees of the vessels.		Industrial Site values (A1) [108–110,130]: $\text{Industrial Site values} = \text{Average site value} \times \text{Size} \times \text{rates}$ The Coega and Baakens estuaries both occupy areas within port bounds. This area was taken out of the onshore ecosystem and reallocated to the estuary value. The same method was employed as in the onshore ecosystem.

Table A2. Cont.

Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Food provisioning (non-cultivated)	Commercial fishing price (B1) [[55,129,131–134], Appendix C]: Market prices for each commercial fishery were obtained from the sources listed above. The value was deflated and inflated to the different timesteps. However, in some instances, market values were indicated in US dollars. These values were converted to rand-equivalent values using the PPP [55]. Catch data: See offshore ecosystem for a summary of the valuation.	Commercial fishing price (B1): See coastal ecosystem for a summary of the valuation. Catch data [Appendix C]: Total catch volumes (in tons) were obtained from the DFFE through the PAIA process for each fishery.		Subsistence fishing value (B2) [74]: The two estuaries identified, the Sundays and Swartkops estuaries, provide a subsistence fishing value estimate of the estuaries. The final annual estimate was used across all five timesteps by inflating and deflating the values to the various years.
Food and raw materials (cultivated)	Mariculture gross income (C1) [116]: Revenue = Total annual yield × price per yield The revenue was calculated by multiplying the total annual yield by the price per yield. These estimates were provided by the Knysna Oyster Company.			
Waste dilution	Waste dilution (D1) [[135–144], Appendix D]: Waste water dilution value = nutrient load entering coastal area × Cost of removing kg pollutant by WWTW The ocean's ability to dilute wastewater is estimated by taking the capital replacement cost for wastewater treatment plants operating in Algoa Bay in treating the nutrient loads from untreated dissolved inorganic nitrogen and phosphorous discharged from wastewater treatment works as well as from the concentrations found at estuary mouths.			

Table A2. Cont.

	Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Air quality regulation *	Air quality regulation (E1): ESVD [145]: Value = value per hectare (R/ha) × area (ha) This study calculated the amount of NO_x in the form of fine dust, captured by the ecosystem and estimated an amount per kilogram based on the cost that would have arisen from health damage. The values for the different biomes within the ecosystem were then averaged across to arrive at a final value per hectare for the onshore ecosystem.	Air quality regulation (E1): ESVD [66]: This study measured the amount of sulphur dioxide, fine particulate matter, nitrogen dioxide and ozone removed under ‘no vegetation’ and ‘current vegetation’ scenarios by assessing the change in concentration, and a monetary benefit was then estimated on the basis of health benefits. The ‘no vegetation’ monetary value was then subtracted from the ‘current vegetation’ monetary value to reach a value per hectare amount.			
Climate regulation *	Climate regulation (F1): ESVD [67]: This study employed a choice experiment to derive a value for the climate regulation service. A ‘series of CE choice tasks’ were presented to the participants, in which hypothetical scenarios were posed. From the answers of the participants, the authors estimated a value for the climate regulation service using a conditional logit model.	Climate regulation (F1): ESVD [68]: This study measured carbon sequestration from biomass samples. A one-way analysis of variance (ANOVA) was then used, which took seasonal variation into account, to value the amount of carbon sequestered and stored.			Climate regulation (F1): ESVD [69]: The paper provided an in-depth assessment of carbon sequestration of salt marshes in South Africa and gave the range of values for the annual carbon dioxide equivalent reduction per hectare in salt marshes.
Moderation of extreme events *		Moderation of extreme events (G1): ESVD [70]: This study developed a three-step approach to value the moderation of extreme events in the UK. A public survey was conducted, in which the choice experiment method was used. Participatory workshops were used to overcome the complexity of the different policy scenarios. Following the collection of responses, an ecological weighting matrix was used to pool the judgement of experts over the “relative level of ecosystem services delivered by habitats”.		Moderation of extreme events (G1): ESVD [71]: This study estimated the value provided by the Danojon Reef in the Philippines for its ability to moderate extreme events using the contingent valuation method. A questionnaire was issued to a variety of individuals, such as tourists, residents, etc. The questionnaire elicited a willingness to pay (WTP) for this ecosystem service. The WTP measure provided by respondents was then manipulated to reflect all individuals who make use of the ecosystem services.	

Table A2. Cont.

Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Erosion prevention *	Erosion prevention (H1): ESVD [72]: This study used the “expert survey” method to provide values for several services for the coastal system found in Guangxi Province, China. In total, 300 questionnaires were sent out to experts in the region. From these responses, the percentage of reduction in costs attributable to the erosion prevention was calculated.		Erosion prevention (H1): ESVD [73]: This study conducted interviews with reef users in the Solomon Islands, in which the WTP of interviewees were derived to construct an “artificial market for ecosystem services”.	
Nutrient cycling *				Nutrient cycling (I1) [74]: This study was used to value the top twenty temperate estuaries in terms of nursery values by observing freshwater flows, the frequency and duration of the estuary mouth openings, which are considered to be the biggest factors affecting the estuarine biota.
Water quality*				Water quality (J1) [[75,135–144,146–153], Appendix D]: Water quality value = (pollutant concentration estuary head-pollutant concentration estuary mouth) $\times$ molar mass $\times$ Mean annual runoff $\times$ Cost of removing kg pollutant by WWTW The extent of phosphorous and nitrogen cycles operating in estuaries to remove dissolved inorganic nitrogen (DIN) and phosphorous (DIP) is estimated by taking the difference in average concentrations at the estuary mouth and head. A reduction in DIP and DIN is considered the treatment of the estuary in sinking these pollutants. The equivalent cost of treating similar nutrient loads with wastewater treatment plants is used to estimate value.

Table A2. Cont.

	Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Maintenance and protection of nursery and gene pool and life cycle *		Maintenance and protection of nursery and gene pool and life cycle (K1): ESVD [72]: This study focused on an area spanning 876 hectares in the Cairns Harbour Bay in Australia. A deterministic simulation model was employed to estimate the ability of the coastal system to maintain the stocks of different species living in the Bay.	Maintenance and protection of nursery and gene pool and life cycle (K1): ESVD [78]: This study estimated the value of the offshore ecosystem in the UK, arising from its ability to maintain its level of marine biodiversity. Using a goods and services approach, in which the goods and services produced by the offshore ecosystem's marine biodiversity are valued.		
Amenity value	Statutory payments (L1) [130,154–156]: Premium in property value = (amenity premium $\times$ Housing Price Index) $\times$ suburb extent The amenity values were adjusted using the FNB Housing Price Index. These premiums were summed providing a total amenity premium. The total amenity premium was multiplied by the total extent of three suburbs (Humewood, Northend and Summerstrand). Statutory payment = Premium in property value $\times$ ratio. Statutory payments were calculated by multiplying the premium in property value that was calculated in the previous step by the ratio of property rates to land value. Willingness to pay [108,109,157,158]: The willingness to pay premium for amenity values was calculated by collating sales transactions data from Property24 for each of the three suburbs where properties sold were counted and property value for each year summed. The number of properties sold was multiplied by the average property size to give the total extent of properties sold for that year. This extent of properties sold was then multiplied by the amenity value to provide the premium paid in the property sale (willingness to pay).				Amenity value (L1) [58,59,74,107–109,158]: Estimates for property values were obtained from Turpie and Clark [74] for the Sundays and Swartkops estuaries and were subsequently inflated/deflated. Amenity value = property value $\times$ ratio of property rate to land value $\times$ municipal rates Property rates were multiplied by the ratio of property rate to land value and then by the municipal rates to obtain the amenity value.

Table A2. Cont.

	Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Recreation and tourism	Travel cost (M3) [101–104,159–175]: Travel cost = total distance travel $\times$ rate per km The travel cost was calculated by measuring the total distance travelled by all domestic tourists each year from each of their respective provinces and multiplying it with the cost per distance (R/km). Opportunity cost (Residents) (M2) [52,105,176]: Opportunity cost = Residents using the beach $\times$ hours spent at beach $\times$ GDP/capita/hour The number of residents using the beach was multiplied by hours spent at the beach and cost of time (measured by the GDP per capita per hour). Opportunity cost (Domestic) (M2) [160,176]: Opportunity cost = domestic bed nights or visitor days $\times$ GDP/capita/day $\times$ moderation value GDP per capita per day was multiplied by both the visitor days and bed nights to give a total opportunity cost value. The opportunity cost of overnight visitors was moderated by 70% since had the tourists been at work, income would have been earned strictly during working hours, and not 24 h per day. Day visitors were moderated by 20%. Direct recreational spend (M1): See offshore ecosystem for a summary of the valuation.	Direct recreational spend Travel cost (M1) [160]: Direct recreational spend: Overnight value = overnight visitors $\times$ average spend overnight visitors. The total overnight spend value was calculated by multiplying the total number of overnight visitors multiplied with the average spend per overnight visitor. Tourists were separated into domestic and foreign tourists, with the average spend and duration of stay differing between the two.	Direct recreational spend (M1): See offshore ecosystem for a summary of the valuation.	Direct recreational spend (M1): See offshore ecosystem for a summary of the valuation.	Recreational fishing (M4) [177,178]: Fishing value = annual no. of hours $\times$ ratio of population To calculate the value of fishing along the estuaries, the annual number of fishing hours for the Sundays and Swartkops estuaries was then multiplied by the ratio of the year of interest to the population of NMB in 2007. The opportunity cost method was used to value this service to these fishermen. The GDP per capita per hour value was multiplied by the total annual fishing hours to generate an annual value per estuary. Recreational boating (M4) [179,180]: Annual no. of boating hours = boats per weekend day $\times$ boating days per year $\times$ people per boat $\times$ hours per trip To calculate the value of boating along the Swartkops and Sundays estuaries, the number of boats was multiplied by the number of boating days (weekend days and public holidays for each year) and then multiplied by both the average number of people per boat and the assumed duration of the trip (2 h). Value of boating = annual no. of boating hours $\times$ GDP/capita/hour The same opportunity cost method was applied to the total annual number of boating hours as was performed with the annual fishing hours (see the previous section) to obtain the annual value per estuary.

Table A2. Cont.

	Onshore	Coastal	Offshore	Coral Reefs	Estuaries
Spiritual, cognitive and other *	Spiritual, cognitive and other (N1): ESVD [67]: See onshore climate regulation for more detail explanation. This study employed a “series of CE choice tasks”, where hypothetical scenarios were posed to participants. From their answers, a value for the sense of place individuals felt using a conditional logit model was estimated.	Spiritual, cognitive and other (N1): ESVD [175]: This study gathered information about a knowledge network of universities, NGOs and public authority companies that made use of the coastal systems. The authors estimated the annual revenue of this knowledge network and calculated a percentage of this revenue that could be attributed to the coastal systems ecosystem in Holland.		Spiritual, cognitive and other (N1): ESVD [79]: This study investigated the opportunities that coral reefs provide for research and education in Martinique. They assessed the level of public spending that was directed towards providing opportunities for research and maintaining the reef so that knowledge could be gained from a well-functioning reef.	
Existence and bequest *		Existence and bequest (O1): ESVD [80]: This study employed a contingent valuation method to provide a value for the coastal systems located in Spain. Both an “open format” survey, in which participants were only asked their WTP, as well as a “binary format”, in which interviewers offer a “guideline value” and participants indicate whether or not they would be willing to pay this amount for the continued existence of the coastal system, were used. From these responses, the authors estimated a binary logit model to derive values.	Existence and bequest (O1) [81]: This study estimated the value placed on the marine biome in the Western Cape, arising from individuals knowing the marine ecosystems are healthy. They used the contingent valuation method to elicit individual’s WTP to maintain the condition of the marine biome. Participants were asked how much they would be willing to contribute towards conservation efforts aimed at preserving the biodiversity in South Africa.	Existence and bequest (O1): ESVD [79,82–85]: Analogous studies on coral reefs found in Algoa Bay were not found. Therefore, values from a suite of different papers estimating the existence and bequest values for coral reefs around the world was used. Thus, an array of values was created. Quartiles were then calculated from the distribution of values, from which the second and third quartiles were used for the conservative and alternative values.	

* Denotes that these ecosystem services employed the benefit transfer method. The studies were obtained from the Ecosystem Services Valuation Database. The per hectare values were converted from USD to ZAR using PPP [55] and deflated to each timestep using the consumer price index [181]. All studies used in the benefit transfer were selected based on the comparability of scale and how recent the study was published (with more recent studies being favoured).

Appendix B

Appendix B.1. Local Beneficiaries

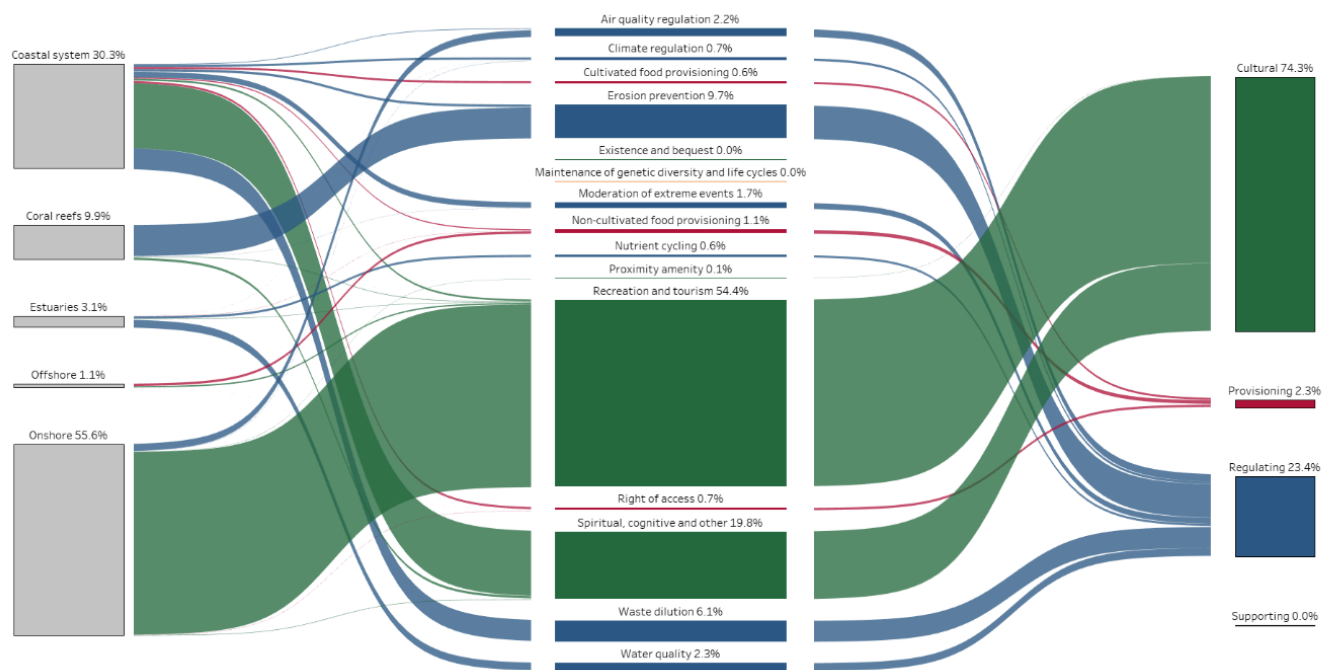


Figure A1. Sankey diagram depicting the value of ecosystem services derived by the local beneficiaries for the year 2000 (Total value: USD 613.4 million).

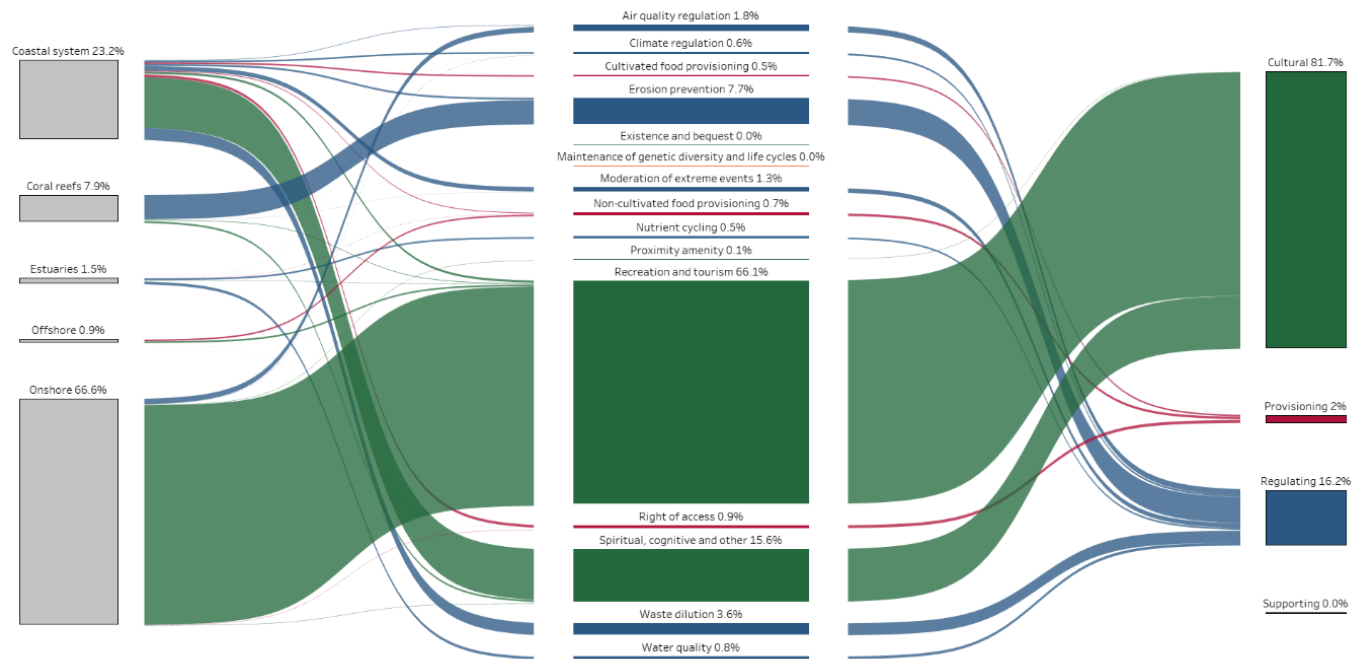


Figure A2. Sankey diagram depicting the value of ecosystem services derived by the local beneficiaries for the year 2005 (Total value: USD 805.7 million).

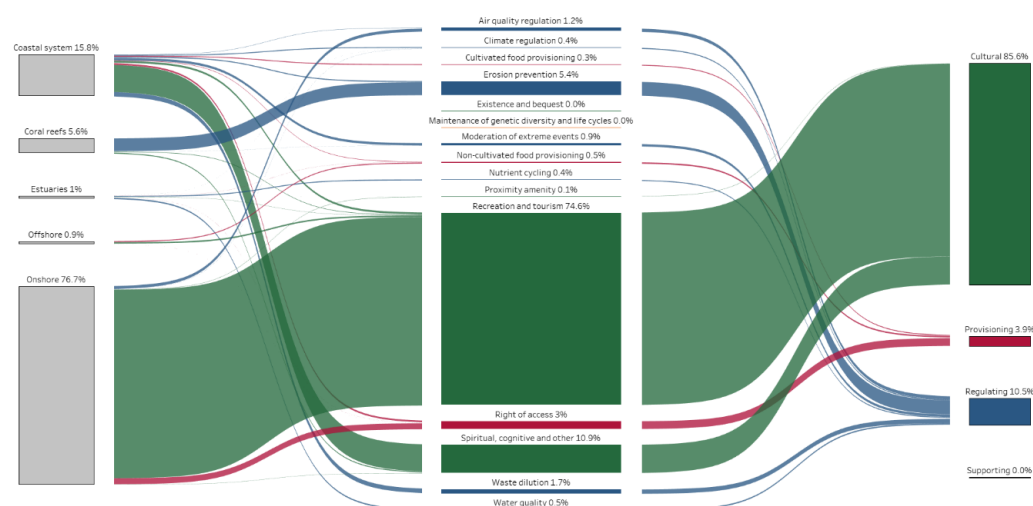


Figure A3. Sankey diagram depicting the value of ecosystem services derived by the local beneficiaries for the year 2010 (Total value: USD 1257.3 million).

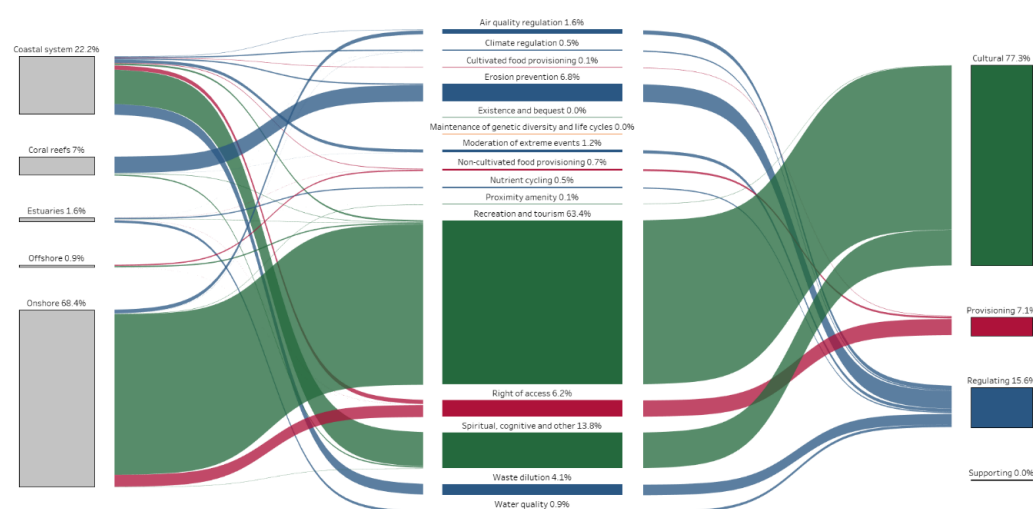


Figure A4. Sankey diagram depicting the value of ecosystem services derived by the local beneficiaries for the year 2015 (Total value: USD 1 037.1 million).

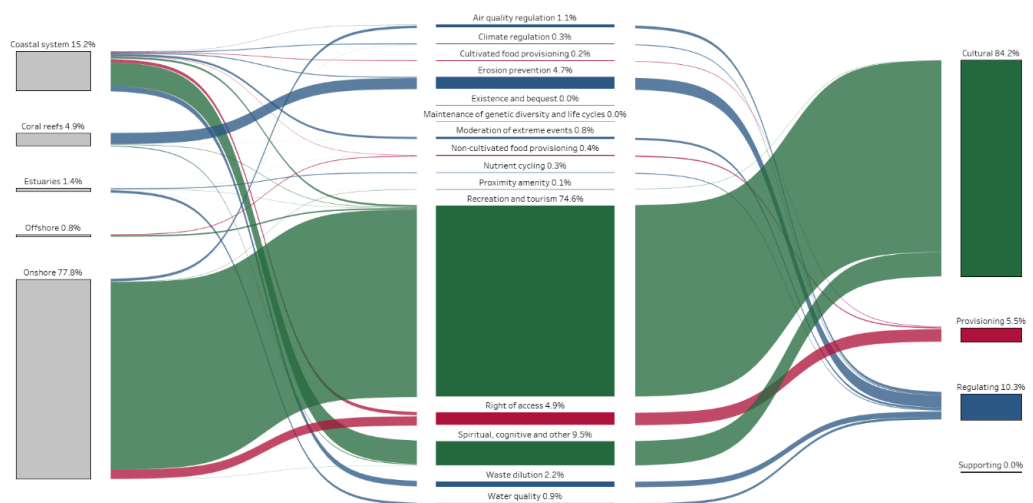


Figure A5. Sankey diagram depicting the value of ecosystem services derived by the local beneficiaries for the year 2019 (Total value: USD 1695.9 million).

Appendix B.2. Global Beneficiaries

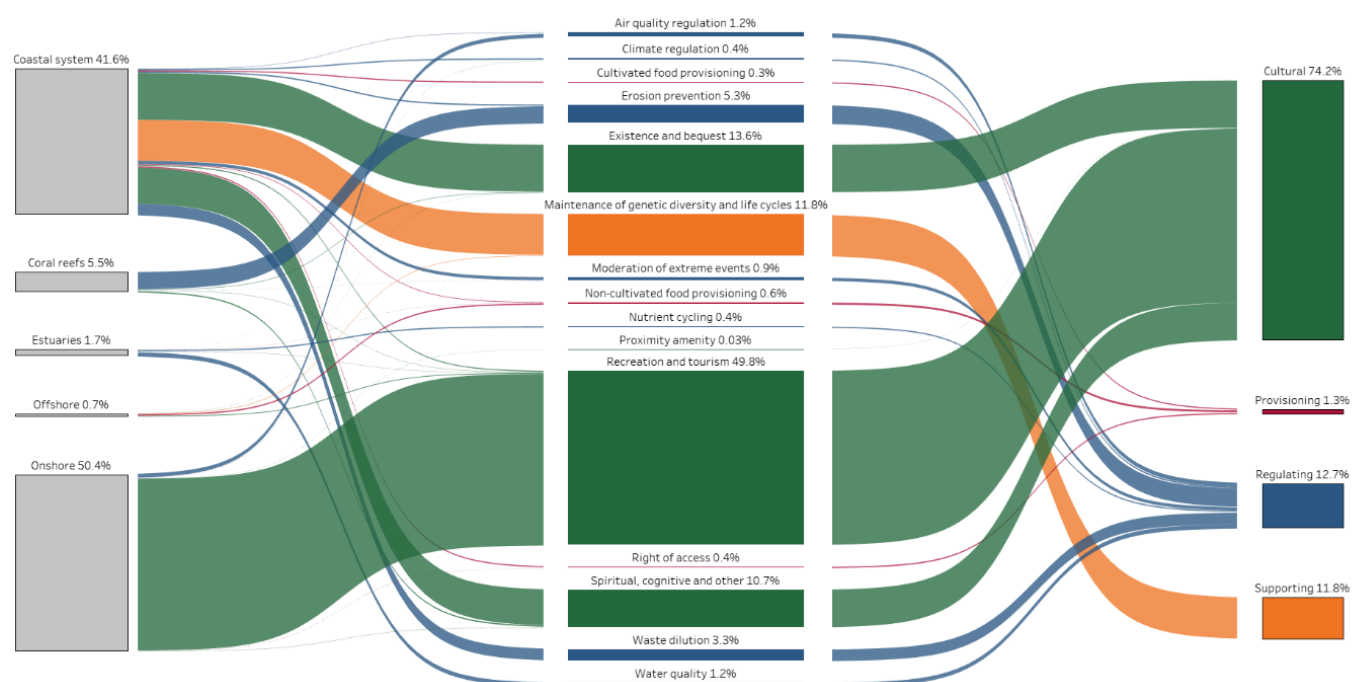


Figure A6. Sankey diagram depicting the value of ecosystem services derived by the global beneficiaries for the year 2000 (Total value: USD 1127.3 million).

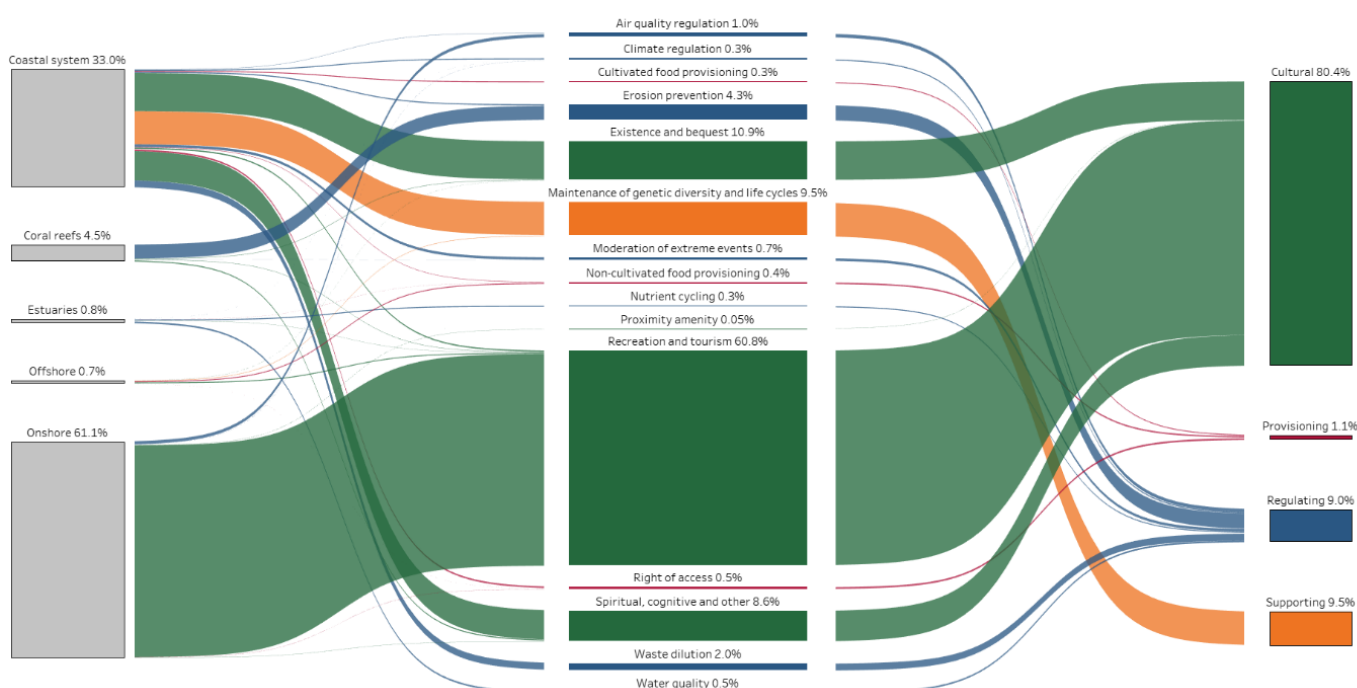


Figure A7. Sankey diagram depicting the value of ecosystem services derived by the global beneficiaries for the year 2005 (Total value: USD 1454.0 million).

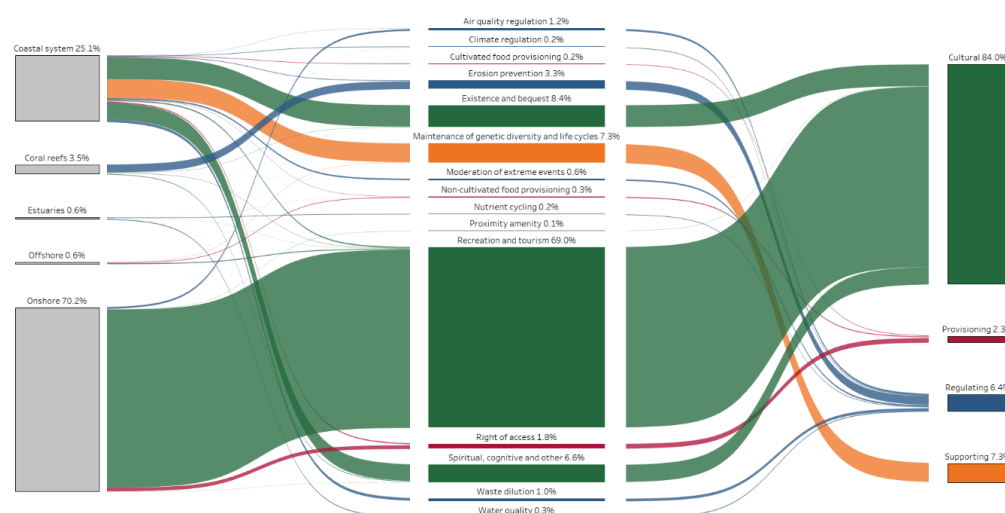


Figure A8. Sankey diagram depicting the value of ecosystem services derived by the global beneficiaries for the year 2010 (Total value: USD 2073.0 million).

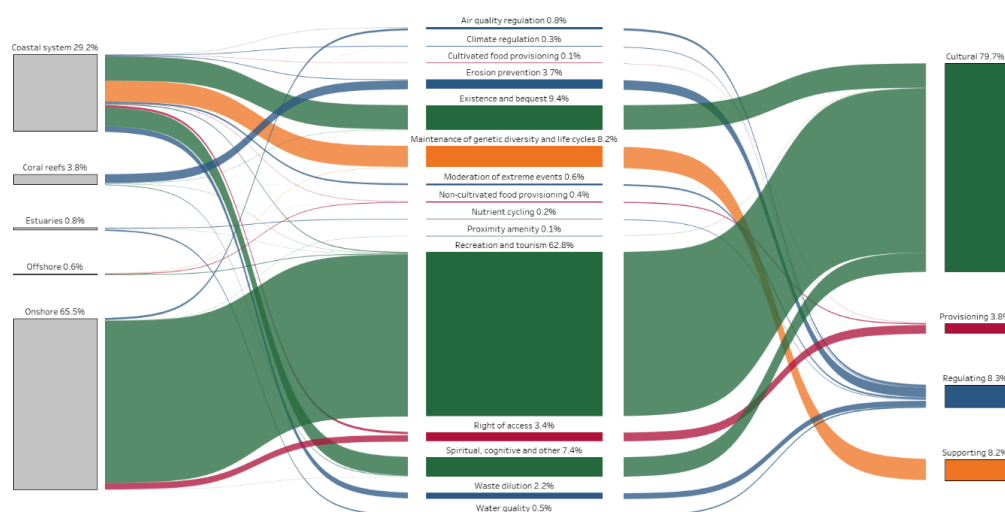


Figure A9. Sankey diagram depicting the value of ecosystem services derived by the global beneficiaries for the year 2015 (Total value: USD 1932.3 million).

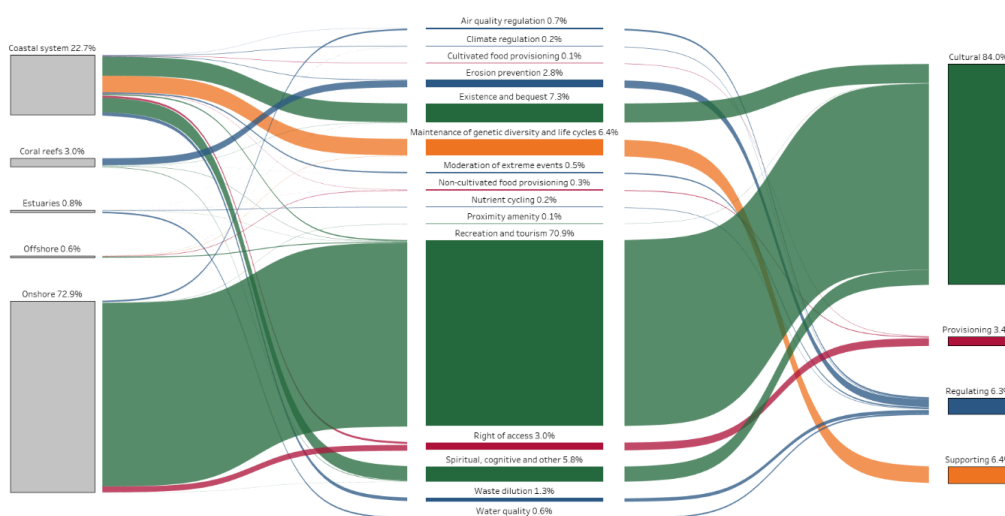


Figure A10. Sankey diagram depicting the value of ecosystem services derived by the global beneficiaries for the year 2019 (Total value: USD 2787.9 million).

Appendix C. Data and Values Used to Estimate the Right-of-Access Values with Respect to the Fishing Values

	Annual Catch of Shallow-Water Hake <i>Merluccius capensis</i> and Deep-Water Hake <i>M. paradoxus</i>	Squid Jig	Small Pelagic	Shark Longline	Inshore Trawl	Licence	Permits	Levy	Application Fees
Year	Tons	No. of Vessels	No. of Vessels	No. of Vessels	No. of Vessels	ZAR	ZAR	ZAR	ZAR
	a	b	c	d	e	(b + c + d + e) × Licence Fee of ZAR1318	(b + c + d + e) × Permit Fee of ZAR831	(a) × Offshore Hake Trawl Levy of ZAR227	(b + C + e) × Commercial Permit of ZAR 240 + (d) × Large Pelagic Licence of ZAR9123
2000	710.0	60	2	1	7	92,260	58,170	161,170	25,683
2001	790.0	64	2	0	11	101,486	63,987	179,330	18,480
2002	1000.0	68	5	0	9	108,076	68,142	227,000	19,680
2003	850.0	72	8	3	9	121,256	76,452	192,950	48,729
2004	700.0	76	10	4	8	129,164	81,438	158,900	59,052
2005	400.0	80	8	4	7	130,482	82,269	90,800	59,292
2006	338.6	82	15	6	16	156,842	98,889	76,857	81,858
2007	310.8	87	14	4	18	162,114	102,213	70,551	65,052
2008	1415.3	101	9	4	15	170,022	107,199	321,282	66,492
2009	1042.3	111	8	5	13	180,566	113,847	236,611	77,295
2010	1011.4	117	9	4	11	185,838	117,171	229,587	69,372
2011	824.6	121	6	3	9	183,202	115,509	187,173	60,009
2012	482.4	112	7	1	9	170,022	107,199	109,512	39,843
2013	286.7	94	7	1	8	144,980	91,410	65,080	35,283
2014	529.3	94	5	4	4	141,026	88,917	120,157	61,212
2015	1198.4	100	5	3	3	146,298	92,241	272,036	53,289
2016	1531.4	101	3	3	6	148,934	93,903	347,617	53,769
2017	2024.3	97	4	2	3	139,708	88,086	459,510	43,206
2018	2945.6	99	9	3	6	154,206	97,227	668,647	54,729
2019	934.3	113	5	3	8	170,022	107,199	212,096	57,609
2020	543.9	98	7	2	13	158,160	99,720	123,465	46,566

Symbols a–e in line 1 refer to column numbers and as applied in the subsequent formulas. Data sourced from the Transnet National Ports Authority (TNPA). Unpublished data relating to port dues for Ngqura and Port Elizabeth for 2000–2020 accessed online via <https://www.gov.za/documents/promotion-access-information-act>, accessed on 10 September 2025. TNPA, Gqeberha, 2023. TNPA PAIA number 002, 27 November 2023. Department of Forestry, Fisheries and the Environment. Unpublished data relating to number of vessels fishing and catch data per year in Algoa Bay for each of the five commercially important fisheries from 2000 to 2020 accessed online via <https://www.gov.za/documents/promotion-access-information-act>, accessed on 10 September 2025. DFFE, Pretoria, 2023. DFFE PAIA numbers 233246/227791/227792/227793/227796/227795, 21 August 2023.

Appendix D. Data and Values Used to Estimate the Waste Dilution Values

Physical Data			Nutrient Data				
Sample ID	Date	Site	Phosphate (umol/L)	Silicate (umol/L)	Nitrate (umol/L)	Nitrite (umol/L)	Ammonium (umol/L)
Swartkops S1S1	2019/04/24	S1	0.73	5.50	1.69	0.30	1.89
Swartkops S1S2	2019/04/24	S1	0.71	4.30	2.01	0.24	1.76
Swartkops S1S3	2019/04/24	S1	0.76	4.24	2.09	0.21	1.68
Swartkops S1M1	2019/04/24	M1	0.85	4.61	2.46	0.25	2.65
Swartkops S1M2	2019/04/24	M1	0.66	4.79	2.54	0.23	2.17
Swartkops S1M3	2019/04/24	M1	0.67	4.43	2.57	0.21	1.83
Swartkops S1B1	2019/04/24	B1	0.61	4.63	2.26	0.23	2.09
Swartkops S1B2	2019/04/24	B1	0.56	4.18	2.53	0.25	1.36
Swartkops S1B3	2019/04/24	B1	0.46	4.53	2.45	0.19	1.78

Physical Data			Nutrient Data				
Sample ID	Date	Site	Phosphate ($\mu\text{mol/L}$)	Silicate ($\mu\text{mol/L}$)	Nitrate ($\mu\text{mol/L}$)	Nitrite ($\mu\text{mol/L}$)	Ammonium ($\mu\text{mol/L}$)
Swartkops S6S1	2019/04/24	S6	0.00	0.00	0.00	0.00	0.00
Swartkops S6S2	2019/04/24	S6	0.00	0.00	0.00	0.00	0.00
Swartkops S6S3	2019/04/24	S6	0.00	0.00	0.00	0.00	0.00
Swartkops S1S1	2019/07/24	S1	0.55	4.86	3.17	0.49	3.24
Swartkops S1S2	2019/07/24	S1	0.91	5.04	3.60	0.45	2.70
Swartkops S1S3	2019/07/24	S1	0.70	4.21	3.15	0.37	3.35
Swartkops S1M1	2019/07/24	M1	0.67	3.62	2.78	0.36	2.46
Swartkops S1M2	2019/07/24	M1	0.71	5.05	3.62	0.45	3.26
Swartkops S1M3	2019/07/24	M1	0.78	5.42	4.04	0.44	2.60
Swartkops S1B1	2019/07/24	B1	0.87	4.84	3.53	0.39	3.16
Swartkops S1B2	2019/07/24	B1	0.73	4.92	3.61	0.44	3.65
Swartkops S1B3	2019/07/24	B1	0.85	5.11	3.92	0.44	3.04
Swartkops S6S1	2019/07/24	S6	55.64	63.59	91.40	8.69	13.12
Swartkops S6S2	2019/07/24	S6	58.89	58.79	97.17	9.96	23.64
Swartkops S6S3	2019/07/24	S6	52.83	44.70	56.92	5.39	26.82
Swartkops S1S1	2019/11/04	S1	0.75	3.01	0.96	0.16	1.57
Swartkops S1S2	2019/11/04	S1	0.75	2.78	1.04	0.13	1.50
Swartkops S1S3	2019/11/04	S1	0.81	3.13	1.26	0.19	1.31
Swartkops S1M1	2019/11/04	M1	0.79	2.85	0.97	0.15	1.99
Swartkops S1M2	2019/11/04	M1	0.75	2.89	1.14	0.17	1.43
Swartkops S1M3	2019/11/04	M1	0.75	4.49	1.12	0.16	1.13
Swartkops S1B1	2019/11/04	B1	0.80	3.73	1.12	0.19	1.79
Swartkops S1B2	2019/11/04	B1	0.74	3.06	1.06	0.17	1.36
Swartkops S1B3	2019/11/04	B1	0.83	3.19	1.16	0.19	1.80
Swartkops S6S1	2019/11/04	S6	93.06	35.00	16.07	7.19	3.75
Swartkops S6S2	2019/11/04	S6	94.15	35.01	15.33	7.49	0.90
Swartkops S6S3	2019/11/04	S6	75.91	34.41	12.10	5.92	1.54
Swartkops S1S1	2020/02/04	S1	0.70	2.42	1.92	0.68	1.52
Swartkops S1S2	2020/02/04	S1	0.77	2.14	2.15	0.74	1.29
Swartkops S1S3	2020/02/04	S1	0.79	1.71	1.90	0.67	1.51
Swartkops S1M1	2020/02/04	M1	0.70	1.59	1.81	0.63	1.20
Swartkops S1M2	2020/02/04	M1	0.70	1.56	1.87	0.63	1.33
Swartkops S1M3	2020/02/04	M1	0.72	1.20	2.01	0.66	1.31
Swartkops S1B1	2020/02/04	B1	0.67	1.10	1.60	0.59	0.97
Swartkops S1B2	2020/02/04	B1	0.65	1.21	1.73	0.63	0.98
Swartkops S1B3	2020/02/04	B1	0.68	1.35	1.80	0.64	1.03
Swartkops S6S1	2020/02/04	S6	73.85	35.62	59.50	25.51	8.46
Swartkops S6S2	2020/02/04	S6	74.33	42.75	72.14	26.36	11.44
Swartkops S6S3	2020/02/04	S6	86.07	43.18	73.95	25.73	11.52
Swartkops S1S1	2020/06/05	S1	7.86	23.04	10.42	1.91	9.05
Swartkops S1S2	2020/06/05	S1	7.90	23.09	10.39	1.91	9.35
Swartkops S1S3	2020/06/05	S1	7.96	23.23	10.53	1.97	9.79
Swartkops S1M1	2020/06/05	M1	7.77	22.38	9.96	1.76	8.59
Swartkops S1M2	2020/06/05	M1	7.84	22.48	10.05	1.78	8.18
Swartkops S1M3	2020/06/05	M1	7.92	22.50	10.12	1.80	8.21
Swartkops S1B1	2020/06/05	B1	7.71	21.87	10.21	1.92	9.17
Swartkops S1B2	2020/06/05	B1	7.75	21.77	10.03	1.91	7.75
Swartkops S1B3	2020/06/05	B1	7.52	21.77	9.93	1.89	8.21
Swartkops S6S1	2020/06/05	S6	71.01	147.94	61.19	24.02	61.87
Swartkops S6S2	2020/06/05	S6	69.72	148.96	60.51	23.29	62.50
Swartkops S6S3	2020/06/05	S6	70.47	148.87	59.75	23.68	61.13
Swartkops S1S1	2020/06/25	S1	1.57	7.52	4.54	0.65	2.30
Swartkops S1S2	2020/06/25	S1	1.51	7.85	4.26	0.60	1.19
Swartkops S1S3	2020/06/25	S1	1.56	7.52	4.39	0.62	2.24
Swartkops S1M1	2020/06/25	M1	1.55	7.65	4.06	0.56	1.52
Swartkops S1M2	2020/06/25	M1	1.52	7.80	4.16	0.58	3.19
Swartkops S1M3	2020/06/25	M1	1.54	7.93	4.46	0.60	2.37
Swartkops S1B1	2020/06/25	B1	1.46	8.20	4.23	0.59	1.11
Swartkops S1B2	2020/06/25	B1	1.42	7.84	4.27	0.60	1.43
Swartkops S1B3	2020/06/25	B1	1.38	7.83	4.31	0.59	1.19

Physical Data			Nutrient Data				
Sample ID	Date	Site	Phosphate (umol/L)	Silicate (umol/L)	Nitrate (umol/L)	Nitrite (umol/L)	Ammonium (umol/L)
Swartkops S6S1	2020/06/25	S6	63.09	128.08	65.68	23.89	60.61
Swartkops S6S2	2020/06/25	S6	62.90	129.02	64.91	23.92	61.18
Swartkops S6S3	2020/06/25	S6	62.36	129.30	67.17	24.00	56.54
Swartkops S1S1	2020/09/22	S1	0.97	6.19	4.30	0.68	2.88
Swartkops S1S2	2020/09/22	S1	1.03	6.61	4.63	0.71	2.96
Swartkops S1S3	2020/09/22	S1	1.04	6.52	4.66	0.70	2.92
Swartkops S1M1	2020/09/22	M1	1.00	6.31	4.49	0.65	2.82
Swartkops S1M2	2020/09/22	M1	1.01	6.50	4.64	0.67	3.03
Swartkops S1M3	2020/09/22	M1	1.09	7.13	5.10	0.74	2.91
Swartkops S1B1	2020/09/22	B1	1.00	7.56	4.59	0.64	3.40
Swartkops S1B2	2020/09/22	B1	1.04	6.50	4.39	0.64	2.99
Swartkops S1B3	2020/09/22	B1	1.03	6.30	4.31	0.65	3.01
Swartkops S6S1	2020/09/22	S6	78.43	28.64	136.74	24.98	73.34
Swartkops S6S2	2020/09/22	S6	81.35	28.53	136.54	24.51	78.93
Swartkops S6S3	2020/09/22	S6	77.49	28.67	126.92	24.01	77.94
Swartkops S1S1	2020/11/12	S1	4.17	10.64	3.29	0.32	0.66
Swartkops S1S2	2020/11/12	S1	4.45	11.11	3.51	0.34	0.79
Swartkops S1S3	2020/11/12	S1	4.44	10.27	2.62	0.36	0.16
Swartkops S1M1	2020/11/12	M1	3.77	8.92	2.02	0.25	0.30
Swartkops S1M2	2020/11/12	M1	3.87	12.04	3.16	0.27	0.88
Swartkops S1M3	2020/11/12	M1	3.82	8.72	1.87	0.22	0.30
Swartkops S1B1	2020/11/12	B1	4.37	10.19	2.26	0.29	0.38
Swartkops S1B2	2020/11/12	B1	4.86	11.97	2.78	0.34	0.50
Swartkops S1B3	2020/11/12	B1	4.88	11.89	2.70	0.34	0.46
Swartkops S6S1	2020/11/12	S6	62.00	59.35	68.13	23.83	98.75
Swartkops S6S2	2020/11/12	S6	62.35	59.51	67.11	23.48	95.79
Swartkops S6S3	2020/11/12	S6	61.80	58.70	66.51	23.26	97.04
Swartkops S1S1	2021/01/26	S1	10.46	24.83	−0.45	0.24	1.16
Swartkops S1S2	2021/01/26	S1	10.49	24.43	−0.22	0.20	1.14
Swartkops S1S3	2021/01/26	S1	10.69	24.60	−0.61	0.16	0.94
Swartkops S1M1	2021/01/26	M1	10.58	25.67	0.99	0.19	0.74
Swartkops S1M2	2021/01/26	M1	10.86	25.46	0.91	0.18	1.13
Swartkops S1M3	2021/01/26	M1	10.39	24.21	0.75	0.16	0.78
Swartkops S1B1	2021/01/26	B1	10.22	26.76	−0.55	0.15	0.94
Swartkops S1B2	2021/01/26	B1	10.30	23.44	−0.63	0.13	0.94
Swartkops S1B3	2021/01/26	B1	10.12	23.91	−0.76	0.14	1.14
Swartkops S6S1	2021/01/26	S6	94.69	130.09	41.99	18.84	196.84
Swartkops S6S2	2021/01/26	S6	95.97	123.32	37.17	17.68	198.14
Swartkops S6S3	2021/01/26	S6	98.47	123.84	33.71	16.19	195.07
Sunday's S1S1	2021/03/26	S1	1.58	98.92	3.31	0.30	2.88
Sunday's S1S2	2021/03/26	S1	1.10	77.62	3.57	0.27	1.65
Sunday's S1S3	2021/03/26	S1	1.74	75.95	4.06	0.29	1.77
Sunday's S1B1	2021/03/26	B1	1.56	73.21	4.46	0.31	1.34
Sunday's S1B2	2021/03/26	B1	1.48	77.12	3.30	0.22	0.95
Sunday's S1B3	2021/03/26	B1	1.29	71.28	3.07	0.31	1.30
Sunday's S6S1	2021/03/26	S6	3.68	127.53	22.48	0.58	1.05
Sunday's S6S2	2021/03/26	S6	3.76	154.67	32.82	0.65	1.23
Sunday's S6S3	2021/03/26	S6	4.08	224.58	35.31	0.73	1.24
Sunday's S6B1	2021/03/26	B6	3.96	289.23	31.69	1.07	1.97
Sunday's S6B2	2021/03/26	B6	3.28	261.72	16.88	0.53	0.96
Sunday's S6B3	2021/03/26	B6	4.08	284.38	29.21	0.73	1.36
Swartkops S1S1	2021/05/07	S1	5.40	17.41	5.02	1.06	4.30
Swartkops S1S2	2021/05/07	S1	4.67	14.13	4.48	0.85	3.85
Swartkops S1S3	2021/05/07	S1	5.88	18.60	5.68	1.11	4.58
Swartkops S1M1	2021/05/07	M1	8.47	27.05	7.87	1.51	6.01
Swartkops S1M2	2021/05/07	M1	9.12	29.64	8.59	1.63	6.46
Swartkops S1M3	2021/05/07	M1	10.36	34.06	9.60	1.83	7.14
Swartkops S1B1	2021/05/07	B1	2.49	8.54	2.75	0.46	2.55
Swartkops S1B2	2021/05/07	B1	2.18	5.84	2.38	0.41	2.26
Swartkops S1B3	2021/05/07	B1	2.63	6.84	2.82	0.48	2.58

Physical Data			Nutrient Data				
Sample ID	Date	Site	Phosphate (umol/L)	Silicate (umol/L)	Nitrate (umol/L)	Nitrite (umol/L)	Ammonium (umol/L)
Swartkops S6S1	2021/05/07	S6	117.97	208.28	26.09	20.65	93.93
Swartkops S6S2	2021/05/07	S6	118.27	223.37	19.95	17.11	91.92
Swartkops S6S3	2021/05/07	S6	116.87	213.69	24.09	19.86	91.63
Sunday's S1S1	2021/06/10	S1	0.65	34.22	2.64	0.27	1.54
Sunday's S1S2	2021/06/10	S1	1.07	66.19	4.27	0.45	1.12
Sunday's S1S3	2021/06/10	S1	1.02	58.42	3.74	0.37	1.58
Sunday's S1B1	2021/06/10	B1	0.87	43.62	3.37	0.33	1.46
Sunday's S1B2	2021/06/10	B1	0.77	34.79	2.74	0.26	1.30
Sunday's S1B3	2021/06/10	B1	0.97	61.01	3.90	0.41	1.38
Sunday's S6S1	2021/06/10	S6	2.53	219.99	27.02	0.33	0.99
Sunday's S6S2	2021/06/10	S6	2.33	183.35	24.30	0.28	1.16
Sunday's S6S3	2021/06/10	S6	2.01	158.78	24.39	0.30	1.07
Sunday's S6B1	2021/06/10	B6	2.59	221.48	24.29	0.31	1.02
Sunday's S6B2	2021/06/10	B6	2.38	210.05	19.06	0.26	1.04
Sunday's S6B3	2021/06/10	B6	2.43	226.63	18.97	0.26	1.22
Swartkops S1S1	2021/07/12	S1	1.18	4.63	2.05	0.37	3.88
Swartkops S1S2	2021/07/12	S1	1.23	4.84	2.49	0.32	3.58
Swartkops S1S3	2021/07/12	S1	1.28	4.91	2.88	0.33	3.92
Swartkops S1M1	2021/07/12	M1	1.37	5.35	2.92	0.33	3.02
Swartkops S1M2	2021/07/12	M1	1.34	4.97	3.17	0.32	3.49
Swartkops S1M3	2021/07/12	M1	1.16	4.39	2.46	0.27	2.87
Swartkops S1B1	2021/07/12	B1	0.90	2.82	1.58	0.17	2.31
Swartkops S1B2	2021/07/12	B1	1.22	5.06	2.43	0.30	3.00
Swartkops S1B3	2021/07/12	B1	1.48	5.50	3.52	0.36	4.23
Swartkops S6S1	2021/07/12	S6	102.28	151.85	102.21	30.28	61.79
Swartkops S6S2	2021/07/12	S6	101.26	124.84	92.49	27.97	60.26
Swartkops S6S3	2021/07/12	S6	105.42	165.33	94.12	29.73	62.07
Sunday's S1S1	2021/09/28	S1	0.40	8.49	0.24	0.08	0.79
Sunday's S1S2	2021/09/28	S1	0.46	22.72	0.26	0.07	0.66
Sunday's S1S3	2021/09/28	S1	0.32	10.00	0.17	0.05	0.48
Sunday's S1B1	2021/09/28	B1	0.28	4.57	0.11	0.05	0.30
Sunday's S1B2	2021/09/28	B1	0.28	5.43	0.17	0.05	0.30
Sunday's S1B3	2021/09/28	B1	0.25	4.64	0.03	0.03	0.52
Sunday's S6S1	2021/09/28	S6	2.78	132.82	15.82	0.22	1.72
Sunday's S6S2	2021/09/28	S6	2.87	132.05	15.86	0.47	2.38
Sunday's S6S3	2021/09/28	S6	2.82	134.16	15.41	0.49	1.85
Sunday's S6B1	2021/09/28	B6	2.86	132.48	15.12	0.51	1.91
Sunday's S6B2	2021/09/28	B6	2.84	137.34	14.88	0.50	1.97
Sunday's S6B3	2021/09/28	B6	2.81	132.50	14.79	0.50	1.95
Swartkops S1S1	2021/10/20	S1	3.52	2.65	0.42	0.23	2.55
Swartkops S1S2	2021/10/20	S1	4.62	6.49	0.90	0.28	2.33
Swartkops S1S3	2021/10/20	S1	3.66	2.88	0.36	0.09	2.21
Swartkops S1M1	2021/10/20	M1	4.15	4.80	0.67	0.16	1.80
Swartkops S1M2	2021/10/20	M1	4.67	5.88	0.92	0.29	2.65
Swartkops S1M3	2021/10/20	M1	4.55	6.20	1.11	0.26	2.66
Swartkops S1B1	2021/10/20	B1	4.80	6.70	0.67	0.20	1.83
Swartkops S1B2	2021/10/20	B1	4.98	7.05	0.75	0.23	1.95
Swartkops S1B3	2021/10/20	B1	4.13	4.00	0.45	0.11	1.83
Swartkops S6S1	2021/10/20	S6	126.35	121.31	88.16	40.80	107.97
Swartkops S6S2	2021/10/20	S6	131.09	91.53	73.90	34.83	95.39
Swartkops S6S3	2021/10/20	S6	135.23	124.38	80.91	39.08	107.69
Swartkops S1S1	2022/01/27	S1	0.37	3.77	0.24	0.27	8.95
Swartkops S1S2	2022/01/27	S1	0.25	3.63	−0.07	0.16	13.60
Swartkops S1S3	2022/01/27	S1	0.18	0.68	−0.19	0.14	4.31
Swartkops S1M1	2022/01/27	M1	0.27	2.58	−0.44	0.10	3.49
Swartkops S1M2	2022/01/27	M1	0.85	5.31	−0.48	0.21	35.79
Swartkops S1M3	2022/01/27	M1	0.73	5.07	−0.17	0.18	24.13
Swartkops S1B1	2022/01/27	B1	0.29	1.32	−0.67	0.07	3.41
Swartkops S1B2	2022/01/27	B1	0.84	3.50	−0.65	0.12	10.90
Swartkops S1B3	2022/01/27	B1	0.56	2.91	−0.39	0.11	5.78

Physical Data			Nutrient Data				
Sample ID	Date	Site	Phosphate (umol/L)	Silicate (umol/L)	Nitrate (umol/L)	Nitrite (umol/L)	Ammonium (umol/L)
Swartkops S6S1	2022/01/27	S6	85.71	118.59	44.45	13.66	152.02
Swartkops S6S2	2022/01/27	S6	92.12	96.86	68.65	14.00	151.57
Swartkops S6S3	2022/01/27	S6	84.95	105.04	73.57	12.81	156.09
Sunday's S1S1	2022/03/16	S1		45.74	0.87	0.22	9.20
Sunday's S1S2	2022/03/16	S1		34.76	0.21	0.08	3.03
Sunday's S1S3	2022/03/16	S1		43.73	0.29	0.12	3.96
Sunday's S1B1	2022/03/16	B1		36.67	0.18	0.11	3.01
Sunday's S1B2	2022/03/16	B1		42.72	0.29	0.14	4.20
Sunday's S1B3	2022/03/16	B1		47.83	0.29	0.14	5.60
Sunday's S6S1	2022/03/16	S6		115.06	2.57	0.27	2.33
Sunday's S6S2	2022/03/16	S6		82.71	2.83	0.36	3.20
Sunday's S6S3	2022/03/16	S6		94.56	2.22	0.22	2.02
Sunday's S6B1	2022/03/16	B6		93.82	2.42	0.25	1.69
Sunday's S6B2	2022/03/16	B6		75.49	0.85	0.12	1.65
Sunday's S6B3	2022/03/16	B6		160.25	3.49	0.32	1.80
Swartkops S1S1	2022/05/05	S1	0.56	7.63	−0.33	0.11	1.28
Swartkops S1S2	2022/05/05	S1	0.38	13.38	0.14	0.12	0.24
Swartkops S1S3	2022/05/05	S1	0.59	13.45	−1.02	0.01	−0.43
Swartkops S1M1	2022/05/05	M1	0.54	6.17	−0.88	0.11	0.82
Swartkops S1M2	2022/05/05	M1	0.17	5.49	0.24	0.18	4.09
Swartkops S1M3	2022/05/05	M1	0.02	3.45	−0.72	−0.15	−0.37
Swartkops S6S1	2022/05/05	S6	100.65	190.21	62.12	48.74	136.77
Swartkops S6S2	2022/05/05	S6	101.22	192.12	65.34	50.58	141.13
Swartkops S6S3	2022/05/05	S6	102.68	189.87	63.56	49.03	140.10
Sunday's S1S1	2022/06/22	S1	2.65	119.31	1.49	0.36	2.75
Sunday's S1S2	2022/06/22	S1	3.12	147.11	1.83	0.46	2.90
Sunday's S1S3	2022/06/22	S1	2.22	92.16	1.20	0.24	1.89
Sunday's S1B1	2022/06/22	B1	2.56	103.39	1.39	0.28	2.17
Sunday's S1B2	2022/06/22	B1	2.95	124.36	2.95	0.44	2.89
Sunday's S1B3	2022/06/22	B1	2.99	128.60	2.94	0.45	2.82
Sunday's S6S1	2022/06/22	S6	2.76	273.49	3.98	0.33	0.90
Sunday's S6S2	2022/06/22	S6	3.22	267.05	3.87	0.32	0.92
Sunday's S6S3	2022/06/22	S6	2.90	275.85	4.20	0.39	0.88
Sunday's S6B1	2022/06/22	B6	3.01	271.77	3.75	0.34	0.88
Sunday's S6B2	2022/06/22	B6	3.18	266.07	4.06	0.40	0.92
Sunday's S6B3	2022/06/22	B6	3.09	272.63	4.63	0.41	0.98
Swartkops S1S1	2022/07/15	S1	5.14	16.38	23.80	1.73	6.13
Swartkops S1S2	2022/07/15	S1	2.36	13.49	2.01	1.05	6.73
Swartkops S1S3	2022/07/15	S1	2.75	11.13	1.90	1.10	5.11
Swartkops S1M1	2022/07/15	M1	3.16	12.77	2.13	1.34	6.15
Swartkops S1M2	2022/07/15	M1	2.28	14.35	2.39	1.37	4.32
Swartkops S1M3	2022/07/15	M1	2.36	11.43	1.76	1.06	4.74
Swartkops S6S1	2022/07/15	S6	113.70	173.14	92.04	56.40	134.94
Swartkops S6S2	2022/07/15	S6	112.81	192.17	112.56	56.34	143.43
Swartkops S6S3	2022/07/15	S6	119.07	171.56	113.49	58.06	147.76
Sunday's S1S1	2022/09/19	S1		21.95	0.62	0.21	3.87
Sunday's S1S2	2022/09/19	S1		22.06	0.57	0.18	2.84
Sunday's S1S3	2022/09/19	S1		42.22	1.68	0.57	7.84
Sunday's S1B1	2022/09/19	B1		16.36	0.68	0.20	3.22
Sunday's S1B2	2022/09/19	B1		16.06	0.65	0.21	4.02
Sunday's S1B3	2022/09/19	B1		21.63	1.02	0.34	6.62
Sunday's S6S1	2022/09/19	S6		152.80	8.12	0.86	3.09
Sunday's S6S2	2022/09/19	S6		168.35	7.69	0.74	3.19
Sunday's S6S3	2022/09/19	S6		180.79	7.89	0.72	3.14
Sunday's S6B1	2022/09/19	B6		165.66	7.06	0.77	3.37
Sunday's S6B2	2022/09/19	B6		85.24	4.81	0.96	4.85
Sunday's S6B3	2022/09/19	B6		168.24	5.69	0.58	2.67
Swartkops S1S1	2023/06/07	S1	1.68	8.31	5.26	0.89	13.45
Swartkops S1S2	2023/06/07	S1	1.79	7.54	7.06	0.78	8.67
Swartkops S1S3	2023/06/07	S1	1.66	6.52	5.49	0.70	7.29

Physical Data			Nutrient Data				
Sample ID	Date	Site	Phosphate (umol/L)	Silicate (umol/L)	Nitrate (umol/L)	Nitrite (umol/L)	Ammonium (umol/L)
Swartkops S1B1	2023/06/07	B1	1.67	7.91	7.24	0.87	20.41
Swartkops S1B2	2023/06/07	B1	1.48	6.90	6.62	0.79	8.98
Swartkops S1B3	2023/06/07	B1	1.42	6.60	6.53	0.76	8.66
Swartkops S6S1	2023/06/07	S6	30.85	126.55	69.22	22.62	164.55
Swartkops S6S2	2023/06/07	S6	26.25	105.49	56.27	18.19	149.43
Swartkops S6S3	2023/06/07	S6	39.58	135.82	65.38	21.70	165.06
Swartkops S1S1	2023/08/01	S1	7.69	25.66	22.52	4.53	15.11
Swartkops S1S2	2023/08/01	S1	8.26	28.62	22.25	4.15	13.92
Swartkops S1S3	2023/08/01	S1	7.46	26.23	25.39	4.59	14.75
Swartkops S1B1	2023/08/01	B1	7.63	27.18	26.28	4.72	15.56
Swartkops S1B2	2023/08/01	B1	9.08	32.78	33.67	6.05	19.83
Swartkops S1B3	2023/08/01	B1	8.77	26.50	29.32	5.01	16.31
Swartkops S6S1	2023/08/01	S6	11.36	107.70	48.70	10.62	35.17
Swartkops S6S2	2023/08/01	S6	11.41	105.50	46.88	10.30	34.62
Swartkops S6S3	2023/08/01	S6	11.33	105.22	48.37	10.69	34.72

Note: Site S1 referred to what scientists identified as head of estuary, S6 referred to what researchers identified as mouth of estuary. Data sourced from the Department of Science, Technology and Innovation. Unpublished data relating to the nutrient concentrations in the Swartkop and Sundays River estuaries over the period 2019–2023 accessed through data requests made to the South African Environmental Observation Network (SAEON). DSTI, Pretoria, 2023. Data supplied by email by the Science and Data co-ordinator of SAEON, dated 20 October 2023.

References

1. Millenium Ecosystem Assessment (MEA). *Ecosystems and Human Well-Being: Synthesis*; Island Press: Washington, DC, USA, 2005.
2. Worm, B.; Barbier, E.B.; Beaumont, N.; Duffy, J.E.; Folke, C.; Halpern, B.S.; Jackson, J.B.; Lotze, H.K.; Micheli, F.; Palumbi, S.R.; et al. Impacts of biodiversity loss on ocean ecosystem services. *Science* **2006**, *314*, 787–790. [\[CrossRef\]](#)
3. Barbier, E.B. Progress and challenges in valuing coastal and marine ecosystem services. *Rev. Environ. Econ. Pol.* **2012**, *6*, 1–19. [\[CrossRef\]](#)
4. Schuhmann, P.W.; Mahon, R. The valuation of marine ecosystem goods and services in the Caribbean: A literature review and framework for future valuation efforts. *Ecosyst. Serv.* **2015**, *11*, 56–66. [\[CrossRef\]](#)
5. Lotze, H.K.; Lenihan, H.S.; Bourque, B.J.; Bradbury, R.H.; Cooke, R.G.; Kay, M.C.; Kidwell, S.M.; Kirby, M.X.; Peterson, C.H.; Jackson, J.B.C. Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* **2006**, *312*, 1806–1809. [\[CrossRef\]](#)
6. Halpern, B.S.; McLeod, K.L.; Rosenberg, A.A.; Crowder, L.B. Managing for cumulative impacts in ecosystem-based management through ocean zoning. *Ocean Coast. Manag.* **2008**, *51*, 203–211. [\[CrossRef\]](#)
7. Worm, B.; Hilborn, R.; Baum, J.K.; Branch, T.A.; Collie, J.S.; Costello, C.; Fogarty, M.J.; Fulton, E.A.; Hutchings, J.A.; Jennings, S.; et al. Rebuilding global fisheries. *Science* **2009**, *325*, 578–585. [\[CrossRef\]](#) [\[PubMed\]](#)
8. Vargas-Fonseca, O.A.; Frazier, M.; Lombard, A.T.; Halpern, B.S. Knowns and unknowns in future human pressures on the Ocean. *Earth's Future* **2024**, *12*, e2024EF004559. [\[CrossRef\]](#)
9. Halpern, B.S.; Frazier, M.; Afflerbach, J.; Lowndes, J.S.; Micheli, F.; Hara, C.O.; Scarborough, C.; Selkoe, K.A. Recent pace of change in human impact on the world's ocean. *Nat. Sci. Rep.* **2019**, *9*, 11609. [\[CrossRef\]](#)
10. Börger, T.; Beaumont, N.J.; Pendleton, L.; Boyle, K.J.; Cooper, P.; Fletcher, S.; Haab, T.; Hanemann, M.; Hooper, T.L.; Hussain, S.S.; et al. Incorporating ecosystem services in marine planning: The role of valuation. *Mar. Policy* **2014**, *46*, 161–170. [\[CrossRef\]](#)
11. Foley, M.M.; Halpern, B.S.; Micheli, F.; Armsby, M.H.; Caldwell, M.R.; Crain, C.M.; Prahler, E.; Rohr, N.; Sivas, D.; Beck, M.W.; et al. Guiding ecological principles for marine spatial planning. *Mar. Policy* **2010**, *34*, 955–966. [\[CrossRef\]](#)
12. Halpern, B.S.; Frazier, M.; O'Hara, C.C.; Vargas-Fonseca, O.A.; Lombard, A.T. Cumulative impacts to global marine ecosystems projected to more than double by mid-century. *Science* **2025**, *389*, 1216–1219. [\[CrossRef\]](#) [\[PubMed\]](#)
13. Atkins, J.P.; Burdon, D.; Elliott, M.; Gregory, A.J. Management of the marine environment: Integrating ecosystem services and societal benefits with the DPSIR framework in a systems approach. *Mar. Pollut. Bull.* **2011**, *62*, 215–226. [\[CrossRef\]](#) [\[PubMed\]](#)
14. Clifton, J.; Cullen-Unsworth, L.C.; Unsworth, R.K.F. Valuing and evaluating marine ecosystem services: Putting the right price on marine environments? *Environ. Soc. Adv. Res.* **2014**, *5*, 66–85. [\[CrossRef\]](#)
15. Ehler, C.; Douvère, F. *Marine Spatial Planning: A Step-By-Step Approach Toward Ecosystem-Based Management*. Intergovernmental Oceanographic Commission and Man and Biosphere Programme; IOC Manual and Guides No 53, ICAM Dossier No 6; UNESCO: Paris, France, 2009; pp. 571–592. [\[CrossRef\]](#)

16. Frazão Santos, C.; Ehler, C.N.; Agardy, T.; Andrade, F.; Orback, M.K.; Crowder, L.B. Marine spatial Planning. In *World Seas: An Environmental Evaluation*; Sheppard, C., Ed.; Academic Press: Cambridge, MA, USA, 2019; pp. 571–592. [\[CrossRef\]](#)
17. Hattam, C.; Atkins, J.P.; Beaumont, N.; Börger, T.; Böhnke-Henrichs, A.; Burdon, D.; De Groot, R.; Hoefnagel, E.; Nunes, P.A.; Piwowarczyk, J.; et al. Marine ecosystem services: Linking indicators to their classification. *Ecol. Indic.* **2015**, *49*, 61–75. [\[CrossRef\]](#)
18. Silver, J.J.; Gray, N.J.; Campbell, L.M.; Fairbanks, L.W.; Gruby, R.L. Blue economy and competing discourses in international oceans governance. *J. Environ. Devel.* **2015**, *24*, 135–160. [\[CrossRef\]](#)
19. Millenium Ecosystem Assessment (MEA). *Ecosystems and Human Well-Being: A Framework for Assessment*; Island Press: Washington, DC, USA, 2003.
20. Munda, G. *Conceptualising and Responding to Complexity*; Environmental Valuation in Europe (EVE), Policy Research Brief No. 2; Cambridge Research for the Environment: Cambridge, UK, 2000.
21. Pascual, U.; Muradian, R.; Brander, L.; Gomez-Baggethun, E.; Martín-López, B.; Verma, M.; Armsworth, P.; Christie, M.; Cornelissen, J.; Eppink, F.; et al. The economics of valuing ecosystem services and biodiversity. In *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*; Kumar, P., Ed.; Routledge: London, UK, 2010; pp. 183–256. [\[CrossRef\]](#)
22. Fisher, B.; Bateman, I.; Turner, R.K. Valuing ecosystem services: Benefits, values, space and time. In *Values, Payments and Institutions for Ecosystem Management*; Kumar, P., Thiaw, I., Eds.; UNON: Nairobi, Kenya, 2013; pp. 58–69. [\[CrossRef\]](#)
23. Milon, J.W.; Alvarez, S. Coastal resources economics and ecosystem valuation. *Water* **2019**, *11*, 2206. [\[CrossRef\]](#)
24. Halpern, B. Set rules so the ocean economy will help the planet. *Nat. Int. Wkly. J. Sci.* **2022**, *608*, 451.
25. Winther, J.G.; Dai, M.; Rist, T.; Hoel, A.H.; Li, Y.; Trice, A.; Morrissey, K.; Juinio-Meñez, M.A.; Fernandes, L.; Unger, S.; et al. Integrated ocean management for a sustainable ocean economy. *Nat. Ecol. Evol.* **2020**, *4*, 1451–1458. [\[CrossRef\]](#)
26. National Planning Commission. National Development Plan 2030: Our Future—Make It Work. 2012. Available online: https://www.gov.za/sites/default/files/gcis_document/201409/ndp-2030-our-future-make-it-workr.pdf (accessed on 10 September 2025).
27. Dorrington, R.A.; Lombard, A.T.; Bornman, T.G.; Adams, J.B.; Cawthra, H.C.; Deyzel, S.H.P.; Goschen, W.S.; Liu, K.; Mahler-Coetzee, J.; Matcher, G.F.; et al. Working together for our oceans: A marine spatial plan for Algoa Bay, South Africa. *S. Afr. J. Sci.* **2018**, *114*, 2–7. [\[CrossRef\]](#)
28. DFFE Operation Phakisa—Oceans Economy. 2019. Available online: <https://www.dffe.gov.za/projectsprogrammes/operationphakisa/oceanseconomy#introduction> (accessed on 10 September 2025).
29. Carpenter-Kling, T.; Truter, H.; Lemahieu, A.; Snow, B.; Strand, M.; Rivers, N.; Nupnau, L.; Lombard, A.T. Scenario planning from the bottom up: Supporting inclusive and ecosystem-based approaches to marine spatial planning. *npj Ocean Sustain.* **2025**, *4*, 45. [\[CrossRef\]](#)
30. Lombard, A.T.; Dorrington, R.A.; Reed, J.R.; Ortega-Cisneros, K.; Penry, G.S.; Pichegru, L.; Smit, K.P.; Vermeulen, E.A.; Witteveen, M.; Sink, K.J.; et al. Key challenges in advancing an ecosystem-based approach to marine spatial planning under economic growth imperatives. *Front. Mar. Sci.* **2019**, *6*, 146. [\[CrossRef\]](#)
31. Turpie, J.K.; Marais, C.; Blignaut, J.N. The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. *Ecol. Econ.* **2008**, *65*, 788–798. [\[CrossRef\]](#)
32. Egoh, B.N.; Reyers, B.; Carwardine, J.; Bode, M.; O’Farrell, P.J.; Wilson, K.A.; Possingham, H.P.; Rouget, M.; De Lange, W.; Richardson, D.M.; et al. Safeguarding biodiversity and ecosystem services in the Little Karoo, South Africa. *Conserv. Biol.* **2010**, *24*, 1021–1030. [\[CrossRef\]](#)
33. O’Farrell, P.J.; De Lange, W.J.; Le Maitre, D.C.; Reyers, B.; Blignaut, J.N.; Milton, S.J.; Atkinson, D.; Egoh, B.; Maherry, A.; Colvin, C.; et al. The possibilities and pitfalls presented by a pragmatic approach to ecosystem service valuation in an arid biodiversity hotspot. *J. Arid. Environ.* **2011**, *75*, 612–623. [\[CrossRef\]](#)
34. Davenport, N.A.; Shackleton, C.M.; Gambiza, J. The direct use value of municipal commonage goods and services to urban households in the Eastern Cape, South Africa. *Land. Use Policy* **2012**, *29*, 548–557. [\[CrossRef\]](#)
35. Wangai, P.W.; Burkhard, B.; Müller, F. A review of studies on ecosystem services in Africa. *Int. J. Sust. Built Environ.* **2016**, *5*, 225–245. [\[CrossRef\]](#)
36. De Wit, M.; van Zyl, H.; Crookes, D.; Blignaut, J.; Jayiya, T.; Goiset, V.; Mahumani, B. Including the economic value of well-functioning urban ecosystems in financial decisions: Evidence from a process in Cape Town. *Ecosyst. Serv.* **2012**, *2*, 38–44. [\[CrossRef\]](#)
37. Schäffler, A.; Swilling, M. Valuing green infrastructure in an urban environment under pressure—The Johannesburg case. *Ecol. Econ.* **2013**, *86*, 246–257. [\[CrossRef\]](#)
38. Abd Elbasit, M.A.; Knight, J.; Liu, G.; Abu-Zreig, M.M.; Hasaan, R. Valuation of ecosystem services in South Africa, 2001–2019. *Sustainability* **2021**, *13*, 1262. [\[CrossRef\]](#)
39. Trégarot, E.; Touron-Gardic, G.; Cornet, C.C.; Failler, P. Valuation of coastal ecosystem services in the Large Marine Ecosystems of Africa. *Environ. Dev.* **2020**, *36*, 100584. [\[CrossRef\]](#)

40. Sumaila, U.R. Socio-economic benefits of large marine ecosystem valuation: The case of the Benguela current Large marine ecosystem. *Environ. Dev.* **2016**, *17*, 244–248. [CrossRef]
41. Blamey, L.K.; Bolton, J.J. The economic value of South African kelp forests and temperate reefs: Past, present and future. *J. Mar. Syst.* **2018**, *188*, 172–181. [CrossRef]
42. Laing, S.C.S.; Schleyer, M.H.; Turpie, J.K. Ecosystem service values of sediment generation and entrapment by marginal coral reefs at Sodwana Bay, South Africa. *Afr. J. Mar. Sci.* **2020**, *42*, 199–207. [CrossRef]
43. Lange, G.M.; Jiddawi, N. Economic value of marine ecosystem services in Zanzibar: Implications for marine conservation and sustainable development. *Ocean Coast. Manag.* **2009**, *52*, 521–532. [CrossRef]
44. Gnansounou, S.C.; Salako, K.V.; Sagoe, A.A.; Mattah, P.A.D.; Aheto, D.W.; Glèlè Kakai, R. Mangrove ecosystem services, associated threats and implications for wellbeing in the Mono Transboundary Biosphere Reserve (Togo-Benin), West-Africa. *Sustainability* **2022**, *14*, 2438. [CrossRef]
45. Afonso, F.; Felix, P.M.; Chainho, P.; Heumüller, J.A.; De Lima, R.F.; Ribeiro, F.; Brito, A.C. Assessing ecosystem services in mangroves: Insights from São Tomé Island (Central Africa). *Front. Environ. Sci.* **2021**, *9*, 501673. [CrossRef]
46. Sagoe, A.A.; Aheto, D.W.; Okyere, I.; Adade, R.; Odoi, J. Community participation in assessment of fisheries related ecosystem services towards the establishment of marine protected area in the Greater Cape Three Points area in Ghana. *Mar. Policy* **2021**, *124*, 104336. [CrossRef]
47. Sink, K.; Van der Bank, M.; Majiedt, P.; Harris, L.; Atkinson, L.; Kirkman, S.; Karenyi, N. *South African National Biodiversity Assessment 2018; Technical Report Volume 4: Marine Realm*; South African National Biodiversity Institute: Pretoria, South Africa, 2019.
48. DEAET. *Algoa Bay Island Nature Reserve Management Plan*; Unpublished Report; Directorate of Nature Conservation, Department of Economic Affairs, Environment and Tourism: Bisho, South Africa, 1996.
49. Pichegru, L.; Gnémillat, D.; Crawford, R.J.M.; Ryan, P.G. Marine no-take zone rapidly benefits endangered penguin. *Biol. Lett.* **2010**, *6*, 498–501. [CrossRef]
50. Maphoto, T. Spatial Analysis of the Impact of Human Activities on the Marine Environment in Algoa Bay, South Africa. Master's Thesis, Rhodes University, Grahamstown, South Africa, 2021.
51. Davies-Coleman, M.T.; McPhail, K.L.; Parker-Nance, S. A Quarter Century of Marine Biodiscovery in Algoa Bay, South Africa. *J. Nat. Prod.* **2023**, *86*, 638–652. [CrossRef]
52. Eastern Cape Socio Economic Consultative Council. *Nelson Mandela Bay Metro Municipality Socio Economic Review and Outlook, 2017*; ECSECC: Eastern Cape, South Africa, 2017.
53. Vermeulen-Miltz, E.; Clifford-Holmes, J.K.; Lombard, A.T.; Snow, B. Coastal Tourism Recovery amid COVID-19: Insights from a Participatory System Dynamics Approach. *Tour. Hosp.* **2023**, *4*, 435–450. [CrossRef]
54. Department of Cooperative Governance and Traditional Affairs. *Nelson Mandela Bay Municipality: Profile and Analysis*; Gqeberha, COGTA, Department of Cooperative Governance and Traditional Affairs: Pretoria, South Africa, 2020.
55. OECD. *Purchasing Power Parities (PPP)*, Available at Conversion rates—Purchasing power parities (PPP)—OECD Data; OECD: Rome, Italy, 2022.
56. Nelson Mandela Bay Municipality. NMB 2009/10—2011/12 Approved Budget. 2009. Available online: <https://archive.org/search?query=Nelson+Mandela+Bay+Adopted+budget> (accessed on 10 September 2025).
57. Nelson Mandela Bay Municipality. NMB 2011/12—2013/14 Approved Budget. 2011. Available online: <https://archive.org/search?query=Nelson+Mandela+Bay+Adopted+budget> (accessed on 10 September 2025).
58. Nelson Mandela Bay Municipality. NMB 2014/15–2016/17 Approved Budget. 2014. Available online: https://www.nelsonmandelabay.gov.za/datarepository/documents/8kIP9_2014-15%20Draft%20Budget%20Report%20Version2.pdf (accessed on 10 September 2025).
59. Nelson Mandela Bay Municipality. NMB 2019/20–2021/22 Approved Budget. 2019. Available online: <https://www.nelsonmandelabay.gov.za/datarepository/documents/2019-20-to-2021-22-draft-budget-report-tabled-draft-final.pdf> (accessed on 10 September 2025).
60. Blignaut, J.N.; Lumby, A. Economic valuation. In *Sustainable Options: Economic Development Lessons from Applied Environmental and Resource Economics in South Africa*; Blignaut, J.N., De Wit, M.P., Eds.; UCT Press: Cape Town, South Africa, 2004.
61. De Groot, R.S.; Groot, R.; Brander, L.; Van Der Ploeg, S.; Costanza, R.; Bernard, F.; Braat, L.; Christie, M.; Crossman, N.; Ghermandi, A.; et al. Global estimates of the value of ecosystems and their services in monetary units. *Ecosyst. Serv.* **2012**, *1*, 50–61. [CrossRef]
62. Blignaut, J.; Mander, M.; Inglesi-Lotz, R.; Glavan, J.; Parr, S. The amenity value of Abu Dhabi's coastal and marine resources to its beach visitors. *Ecosyst. Serv.* **2016**, *19*, 32–41. [CrossRef]
63. Blignaut, J.; Mander, M.; Inglesi-Lotz, R.; Glavan, J.; Parr, S. Economic value of the Abu Dhabi coastal and marine ecosystem services: Estimate and management applications. In *Sustainability in the Gulf*; Azar, E., Raouf, M.A., Eds.; Routledge: New York, NY, USA, 2017; pp. 210–227.
64. He, Y.; Kuang, Y.; Zhao, Y.; Ruan, Z. Spatial Correlation between Ecosystem Services and Human Disturbances: A Case Study of the Guangdong–Hong Kong–Macao Greater Bay Area, China. *Remote Sens.* **2021**, *13*, 1174. [CrossRef]

65. De Groot, R.S.; Bohnke-Henrichs, A. *A Pilot Study on the Consequences of an Open Haringvliet-Scenario for Changes in Ecosystem Services and Their Monetary Value*; Wageningen University, Environmental Systems Analysis Group: Wageningen, The Netherlands, 2011.
66. Jones, L.; Vieno, M.; Morton, D.; Hall, J.; Carnell, E.; Nemitz, E.; Beck, R.; Reis, S.; Pritchard, N.; Hayes, F.; et al. *Developing Estimates for the Valuation of Air Pollution Removal in Ecosystem Accounts*; Final report; Office for National Statistics: Fareham, UK, 2017.
67. Christie, M.; Rayment, M. An economic assessment of the ecosystem service benefits derived from the SSSI biodiversity conservation policy in England and Wales. *Ecosyst. Serv.* **2012**, *1*, 70–84. [[CrossRef](#)]
68. Ganguly, D.; Singh, G.; Purvaja, R.; Bhatta, R.; Paneer Selvam, A.; Banerjee, K.; Ramesh, R. Valuing the carbon sequestration regulation service by seagrass ecosystems of Palk Bay and Chilika, India. *Ocean. Coast. Manag.* **2017**, *159*, 26–33. [[CrossRef](#)]
69. Adams, J.B.; Raw, J.L.; Riddin, T.; Wasserman, J.; Van Niekerk, L. Salt marsh restoration for the provision of multiple ecosystem services. *Diversity* **2021**, *13*, 680. [[CrossRef](#)]
70. Christie, M.; Hyde, T.; Cooper, R.; Fazey, I.; Dennis, P.; Warren, J.; Colombo, S.; Hanley, N. *Economic Valuation of the Benefits of Ecosystem Services Delivered by the UK Biodiversity Action Plan*; Final report; Department for Environment, Food and Rural Affairs: London, UK, 2011.
71. Samonte, G.P.B.; Eisma-Osorio, R.; Amolo, R.; White, A. Economic value of a large marine ecosystem: Danajon double barrier reef, Philippines. *Ocean. Coast. Manag.* **2016**, *122*, 9–19. [[CrossRef](#)]
72. Han, Q.; Huang, X.; Shi, P.; Zhang, J. Seagrass Bed Ecosystem Service Valuation—A case research on Hepu seagrass bed in Guangxi Province. *Mar. Sci. Bull.* **2008**, *10*, 87–96.
73. Albert, J.A.; Cruz-Trinidad, A.; Cabral, R.B.; Boso, D. *Economic Value of Coral Reefs in Solomon Islands: Case-Study Findings from Coral Trade and Non-Coral Trade Communities*; Technical report; The WorldFish Center: Penang, Malaysia, 2012.
74. Turpie, J.; Clark, B. *Development of a Conservation Plan for Temperate South African Estuaries on the Basis of Biodiversity Importance; Ecosystem Health and Economic Costs and Benefits-Final Report*; CAPE Regional Estuarine Management Programme: Cape Floristic Region, South Africa, 2007.
75. Magobiane, S.E. Willingness to Pay for Water Quality Changes in the Swartkops Estuary. Masters' Thesis, Faculty of Business and Economic Sciences, Nelson Mandela Metropolitan University, Gqeberha, South Africa, 2011.
76. Huang, F.; Lin, X.; Yin, K. Effects of marine produced organic matter on the potential estuarine capacity of NO_x-removal. *Sci. Total Environ.* **2022**, *812*, 151471. [[CrossRef](#)]
77. Watson, R.A.; Coles, R.G.; Lee Jong, W.J. Simulation estimates of annual yield and landed value for commercial penaeid prawns from a tropical seagrass habitat, northern Queensland, Australia. *Mar. Freshw. Res.* **1993**, *44*, 211–219. [[CrossRef](#)]
78. Beaumont, N.J.; Austen, M.C.; Mangi, S.C.; Townsend, M. Economic valuation for the conservation of marine biodiversity. *Mar. Pollut. Bull.* **2008**, *56*, 386–396. [[CrossRef](#)] [[PubMed](#)]
79. Failler, P.; Petre, E.; Binet, T.; Marechal, J.P. Valuation of marine and coastal ecosystem services as a tool for conservation: The case of Martinique in the Caribbean. *Ecosyst. Serv.* **2015**, *11*, 67–75. [[CrossRef](#)]
80. Perni, A.; Martinez-Carrasco, F.; Martinez-Paz, J.M. Economic valuation of coastal lagoon environmental restoration: Mar Menor (SE Spain). *Environ. Sci.* **2011**, *37*, 175–190. [[CrossRef](#)]
81. Turpie, J. The existence value of biodiversity in South Africa: How interest, experience, knowledge, income and perceived level of threat influence local willingness to pay. *Ecol. Econ.* **2003**, *46*, 199–216. [[CrossRef](#)]
82. Seenprachawong, U. *An Economic Analysis of Coral Reefs in the Andaman Sea of Thailand*; EEPSEA Research Report rr2001092; Economy and Environment Program for Southeast Asia (EEPSEA): Ho Chi Minh City, Vietnam, 2001.
83. O'Garra, T. Bequest Values for Marine Resources: How important for indigenous communities in less-developed economies? *Environ. Resour. Econ.* **2009**, *44*, 179–202. [[CrossRef](#)]
84. Aanensen, M.; Armstrong, C.; Czajkowski, M.; Falk-Petersen, J. Willingness to pay for unfamiliar public goods: Preserving cold-water coral in Norway. *Ecol. Econ.* **2015**, *112*, 53–67. [[CrossRef](#)]
85. Maynard, N.; Chateau, P.A.; Ribas-Deulofeu, L.; Liou, J.L. Using internet surveys to estimate visitors' willingness to pay for coral reef conservation in the Kentin National Park, Taiwan. *Water* **2019**, *11*, 1411. [[CrossRef](#)]
86. Torres, C.; Hanley, N. *Economic Valuation of Coastal and Marine Ecosystem Services in the 21st Century: An Overview from a Management Perspective*; University of St. Andrews: Saint Andrews, Scotland, 2016; p. 75.
87. Turpie, J.K.; Forsythe, K.J.; Knowles, A.; Blignaut, J.; Letley, G. Mapping and valuation of South Africa's ecosystem services: A local perspective. *Ecosyst. Serv.* **2017**, *27*, 179–192. [[CrossRef](#)]
88. 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. [[CrossRef](#)]
89. Antón, A.J.M.; Alonso, J.J.M.; Rodriguez, G.S. Mega-events impact on economic growth: Analysis of the South African World Cup. *Afr. J. Bus. Man.* **2011**, *5*, 6940–6947.

90. Matsuoka De Aragao, M. Economic Impacts of the FIFA World Cup in Developing Countries. Honor's Thesis, Western Michigan University, Kalamazoo, MI, USA, 2015. Available online: https://scholarworks.wmich.edu/honors_theses/2609 (accessed on 10 September 2025).
91. Banela, M.; Kyvelou, S.S.; Kitsiou, D. Mapping and Assessing Cultural Ecosystem Services to Inform Maritime Spatial Planning: A Systematic Review. *Heritage* **2024**, *7*, 697–736. [CrossRef]
92. Holness, S.D.; Harris, L.R.; Chalmers, R.; De Vos, D.; Goodall, V.; Truter, H.; Oosthuizen, A.; Bernard, A.; Cowley, P.D.; da Silva, C.; et al. Using systematic conservation planning to align priority areas for biodiversity and nature-based activities in marine spatial planning: A real-world application in contested marine space. *Biol. Conserv.* **2022**, *271*, 109574. [CrossRef]
93. Hu, Q.; Xiang, L.; Lin, A.; Hou, Y.; Dai, Y. Exploring the spatial configuration of tourism resources through ecosystem services and ethnic minority villages. *Ecol. Inform.* **2024**, *79*, 102426. [CrossRef]
94. Vermeulen-Miltz, E.; Clifford-Holmes, J.K.; Scharler, U.M.; Lombard, A.T. A System Dynamics Model to Support Marine Spatial Planning in Algoa Bay, South Africa. *Environ. Model. Softw.* **2023**, *160*, 105601. [CrossRef]
95. Pichegru, L.; Makoala, M.; Barham, B.J.; Barham, P.J.; Dalton, D.; Ludynia, K.; Freeman, M.; Geldenhuys, D.; Hagen, C.; Harris, G.; et al. A decade of implementing the Biodiversity management plan for African penguins—Successes, failures and lessons learnt. *J. Nat. Conserv.* **2025**, *86*, 126919. [CrossRef]
96. Buonocore, E.; Grande, U.; Franzese, P.P.; Russo, G.F. Trends and evolution in the concept of marine ecosystem services: An overview. *Water* **2021**, *13*, 2060. [CrossRef]
97. Carrasco De La Cruz, P.M. The knowledge status of coastal and marine ecosystem services-challenges, limitations and lessons learned from the application of the ecosystem services approach in management. *Front. Mar. Science* **2021**, *8*, 684770. [CrossRef]
98. Wang, S.; Li, W.; Xing, L. A review on marine economics and management: How to exploit the ocean well. *Water* **2022**, *14*, 2626. [CrossRef]
99. Statistics South Africa. *Mid-Year Population Estimates, South Africa 2004*; Statistical Release P0302; Statistics South Africa: Pretoria, South Africa, 2004. Available online: <https://www.statssa.gov.za/publications/P0302/P03022004.pdf> (accessed on 10 September 2025).
100. Statistics South Africa. *Mid-Year Population Estimates, South Africa 2005*; Statistical Release P0302; Statistics South Africa: Pretoria, South Africa, 2005. Available online: <https://www.statssa.gov.za/publications/P0302/P03022005.pdf> (accessed on 10 September 2025).
101. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2010. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
102. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2011. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
103. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2015. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
104. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2019. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
105. Macrotrends. Nelson Mandela Bay, South Africa Metro Area Population 1950–2024. 2023. Available online: <https://www.macrotrends.net/global-metrics/cities/22499/nelson-mandela-bay/population> (accessed on 10 September 2025).
106. United Nations, Department of Economic and Social Affairs, Population Division. *World Population Prospects 2022*, Online ed.; United Nations, Department of Economic and Social Affairs, Population Division: New York, NY, USA, 2022.
107. Nelson Mandela Bay Municipality. Property Rates Act (Act 6 of 2004). Rates to be levied for financial year 1 July 2009 to 30 June 2010 for Nelson Mandela Bay Metropolitan area. *East. Cape Prov. Gaz.* **2009**, *2154*, 254. Available online: <https://gazettes.africa/gazettes/za-ec/2009> (accessed on 10 September 2025).
108. Nelson Mandela Bay Municipality. Property Rates Act (Act 6 of 2004). Rates to be levied for financial year 1 July 2014 to 30 June 2015 for Nelson Mandela Bay Metropolitan area. *East. Cape Prov. Gaz.* **2014**, *3215*, 199. Available online: <https://gazettes.africa/gazettes/za-ec/2014> (accessed on 10 September 2025).
109. Nelson Mandela Bay Municipality. Property Rates Act (Act 6 of 2004). Rates to be levied for financial year 1 July 2019 to 30 June 2020 for Nelson Mandela Bay Metropolitan area. *East. Cape Prov. Gaz.* **2019**, *4285*, 222. Available online: <https://archive.gazettes.africa/archive/za-ec/2019/za-ec-provincial-gazette-dated-2019-08-05-no-4285.pdf> (accessed on 10 September 2025).
110. Lamprecht, K. (Nelson Mandela Bay Municipality, Gqeberha 6013, South Africa). Personal communication, 2022.
111. Transnet National Ports Authority (TNPA). *Transnet National Ports Authority (TNPA) National Infrastructure Plan: 2009*; TNPA: Cape Town, South Africa, 2009.
112. Transnet National Ports Authority (TNPA). *Transnet National Ports Authority (TNPA) National Ports Plan: 2015*; TNPA: Cape Town, South Africa, 2015; Available online: <https://www.transnetnationalportsauthority.net/Infrastructure%20and%20Port%20Planning/Documents/National%20Port%20Plans%202015.pdf> (accessed on 10 September 2025).

113. Transnet National Ports Authority (TNPA). *Transnet National Ports Authority (TNPA) National Ports Plan: 2019 Update*; TNPA: Cape Town, South Africa, 2019; Available online: [https://www.transnetnationalportsauthority.net/Documents/NPP%202019%20Update%20\(1\).pdf](https://www.transnetnationalportsauthority.net/Documents/NPP%202019%20Update%20(1).pdf) (accessed on 10 September 2025).
114. Department of Transport. *National Ports Act of 2005 (Act No. 12 of 2005): Port Limit Regulations*; Government Notices. No. 32873; Government Printer: Pretoria, South Africa, 2010.
115. South African National Biodiversity Institute. *Technical Report Volume 4: Marine Realm*; South African National Biodiversity Institute: Pretoria, South Africa, 2018.
116. Burton, S. (The Knysna Oyster Company, Gqeberha 6013, South Africa). Personal communication, 2022.
117. Department of Agriculture, Forestry and Fisheries. *Marine Living Resources Act of 1998 (Act No. 18 of 1998): Fees Payable in Respect of Applications and the Issuing of Rights, Permits and Licenses*; Government Gazette. No. 33518:795; Government Printer: Pretoria, South Africa, 2010.
118. Department of Environmental Affairs and Tourism. *Marine Living Resources Act of 1998 (Act No. 18 of 1998)*; Government Gazette. No. 18930:395; Government Printer: Pretoria, South Africa, 1998. Available online: https://www.gov.za/sites/default/files/gcis_document/201610/a18-98.pdf (accessed on 10 September 2025).
119. Department of Environmental Affairs and Tourism. *Marine Living Resources Act of 1998 (Act No. 18 of 1998): Fees Payable in Respect of Applications and the Issuing of Rights, Permits and Licenses*; Government Gazette. No. 27998:878; Government Printer: Pretoria, South Africa, 2005.
120. Department of Environmental Affairs and Tourism. *Marine Living Resources Act of 1998 (Act No. 18 of 1998): Fees Payable in Respect of Applications and the Issuing of Rights, Permits and Licenses*; Government Gazette. No. 32157:397; Government Printer: Pretoria, South Africa, 2009.
121. Department of Forestry, Fisheries and the Environment. *Marine Living Resources Act of 1998 (Act No. 18 of 1998): General Policy on the Allocation and Management of Commercial Fishing Rights: 2021*; Government Notices. No. 45504; Government Printer: Pretoria, South Africa, 2021.
122. Department of Agriculture, Forestry and Fisheries. *Draft Revised Traditional Linefish Policy on the Allocation and Management of Fishing Rights: 2013*; Government Gazette. No. 36460:473; Government Printer: Pretoria, South Africa, 2013.
123. Department of Agriculture, Forestry and Fisheries. *Policy on the Allocation and Management of Commercial Fishing Rights in the Hake Inshore Trawl Fishery: 2015*; Government Gazette. No. 39417:1129; Government Printer: Pretoria, South Africa, 2015.
124. Department of Environmental Affairs and Tourism. *Marine Living Resources Act of 1998 (Act No. 18 of 1998): Fees Payable in Respect of Applications and the Issuing of Rights, Permits and Licenses*; Government Gazette. No. 22516:701; Government Printer: Pretoria, South Africa, 2001.
125. Department of Environmental Affairs and Tourism. *Policy for the Allocation and Management of Commercial Fishing Rights in the Traditional Linefish Fishery: 2005*; Government Gazette. No. 27843:1291; Government Printer: Pretoria, South Africa, 2005.
126. Enviro-Fish Africa. BCLME commercial fisheries rights holder and vessel analysis. In *BCLME Project LMR/SE/03/03*; Enviro-Fish Africa: Cape Town, South Africa, 2006.
127. Maluleke, V.A. The Effects of Boat Mooring Systems on Squid Egg beds During Squid Fishing. Ph.D. Thesis, Cape Peninsula University of Technology, Cape Town, South Africa, 2017.
128. Wilkinson, S.; Japp, D.W. *Proposed Marine Telecommunications Cable System (ACE Cable System), West Coast, South Africa: Specialist Study on the Impact on the Fishing Industry*; Anchor Environmental Consultants: Cape Town, South Africa, 2016; Available online: <https://acerafrica.co.za/wp-content/uploads/2017/09/Fisheries-Specialist-Report.pdf> (accessed on 10 September 2025).
129. Zantsi, B. The Chokka Squid Fisheries in South Africa: Review of the 2005 Policy [Final Project]. 2013. Available online: <https://www.grocentre.is/static/gro/publication/279/document/bongiwe12prf.pdf> (accessed on 10 October 2022).
130. Google Earth. 2022. Available online: <https://earth.google.com/web/> (accessed on 10 February 2022).
131. Hutton, T.; Sumaila, U.R. *Natural Resource Accounting and South African Fisheries: A Bio-Economic Assessment of the West Coast Deep-Sea Hake Fishery with Reference to the Optimal Utilisation and Management of the Resource*; University of Pretoria: Pretoria, South Africa, 2002.
132. Da Silva, C.; Bürgener, M. South Africa's demersal shark meat harvest. *Traffic Bull.* **2007**, *21*, 55–56. Available online: https://wwfeu.awsassets.panda.org/downloads/shark_paper_1.pdf (accessed on 16 October 2022).
133. Hutchings, K.; Clark, B.; Turpie, J. Assessment of the Socio-Economic Implications of a Reduced Minimum Sardine TAC for the Small Pelagics Purse-Seine Fishery. Prepared by Anchor Environmental for the South African Pelagic Fishing Industry Association (SAPFIA). 2015. Available online: https://cer.org.za/wp-content/uploads/2016/08/Socio-economic-Report_Web.pdf (accessed on 10 October 2022).
134. Fish4Africa. Snoek (Previously Frozen). Available online: <https://fish4.africa/product/snoek-previously-frozen/> (accessed on 17 November 2025).

135. Keirungi, J. The Design and Assessment of an Integrated Municipal Waste Beneficiation Facility: Towards Improved Sewage Sludge Management in Developing Countries. Unpublished Masters' Thesis, Rhodes University, Grahamstown, South Africa, 2006.
136. Klages, N.; Jegels, J.; Schovell, I.; Vosloo, M. *Nelson Mandela Bay Municipality State of Environment Report*; [In-house report]; Arcus Gibb Pty Ltd.: Port Elizabeth, South Africa, 2011.
137. Lemley, D.A.; Adams, J.B.; Strydom, N.A. Triggers of phytoplankton bloom dynamics in permanently eutrophic waters of a South African estuary. *Afr. J. Aquat. Sci.* **2018**, *43*, 229–240. [CrossRef]
138. Lemley, D.A.; Adams, J.B.; Bornman, T.G.; Campbell, E.E.; Deyzel, S.H.P. Land-derived inorganic nutrient loading to coastal waters and potential implications for nearshore plankton dynamics. *Cont. Shelf Res.* **2019**, *174*, 1–11. [CrossRef]
139. Li, Y.H.; Li, H.B.; Xu, X.Y.; Xiao, S.Y.; Wang, S.Q.; Xu, S.C. Fate of nitrogen in subsurface infiltration system for treating secondary effluent. *Water Sci. Eng.* **2017**, *10*, 217–224. [CrossRef]
140. Nelson Mandela Bay Municipality. *Sewerage Master Plan: Phase 2 Stage 2 Urban Areas*; Nelson Mandela Bay Municipality: Port Elizabeth, South Africa, 2009.
141. Potgieter, M.J. Water, Salt and Nutrient Budgets of the Swartkops and Sundays River Estuaries using the LOICZ Biogeochemical Budgeting Protocol. Ph.D. Thesis, Nelson Mandela Metropolitan University, Gqeberha, South Africa, 2008.
142. Scharler, U.M.; Baird, D. The influence of catchment management on salinity, nutrient stoichiometry and phytoplankton biomass of Eastern Cape estuaries, South Africa. *Estuar. Coast. Shelf Sci.* **2003**, *56*, 735–748. [CrossRef]
143. Theron, J.G. *Wastewater Risk Abatement Plan: Fishwater Flats Wastewater Treatment Works*; WRC Report No. SP 23/11; Prepared by SSI Engineers and Environmental Consultants (Pty) Ltd.: Johannesburg, South Africa, 2011.
144. Van Niekerk, L.; Taljaard, S.; Adams, J.B.; Fundisi, D.; Huizinga, P.; Lamberth, S.J.; Mallory, S.; Snow, G.C.; Turpie, J.K.; Whitfield, A.K.; et al. Desktop provisional EcoClassification of the temperate estuaries of South Africa. *Water Res. Comm. Rep.* **2015**, *2187*, 15.
145. Bohnke-Henrichs, A.; De Groot, R.S. *A Pilot Study on the Consequences of an Open Haringoliet-Scenario for Changes in Ecosystem Services and Their Monetary Value*; Environmental Systems Analysis Group, Wageningen University: Wageningen, The Netherlands, 2010.
146. De Bièvre, P.; Valkiers, S.; Peiser, H.S.; Taylor, P.D.P.; Hansen, P. Mass-spectrometric methods for determining isotopic composition and molar mass traceable to the SI, exemplified by improved values for nitrogen. *Metrologia* **1996**, *33*, 447–455. [CrossRef]
147. Iheagwara, O.S.; Ing, T.S.; Kjellstrand, C.M.; Lew, S.Q. Phosphorus, phosphorous, and phosphate. *Hemodial. Int.* **2013**, *17*, 479–482. [CrossRef] [PubMed]
148. Human, L.R.; Els, J.; Wasserman, J.; Adams, J.B. Blue carbon and nutrient stocks in salt marsh and seagrass from an urban African estuary. *Sci. Total Environ.* **2022**, *842*, 156955. [CrossRef] [PubMed]
149. Lemley, D.A.; Human, L.R.; Rishworth, G.M.; Whitfield, E.; Adams, J.B. Managing the seemingly unmanageable: Water quality and phytoplankton dynamics in a heavily urbanised low-inflow estuary. *Estuaries Coasts* **2022**, *46*, 2007–2022. [CrossRef]
150. Naidoo, N.; Pearce, D.; Visser, W.; Crafford, J.; Maila, D.; Harris, K. *Setting Effective Wastewater Charges: A Guide for Municipalities*; Water Research Commission: Pretoria, South Africa, 2016.
151. Scharler, U.M.; Baird, D. The filtering capacity of selected Eastern Cape estuaries, South Africa. *Water SA* **2005**, *31*, 483–490.
152. Snow, G.C. Contributions to the Use of Microalgae in Estuarine Freshwater Reserve Determinations. Ph.D. Thesis, Nelson Mandela Metropolitan University, Gqeberha, South Africa, 2007.
153. Whitfield, E.C. *Uptake and Storage of Nutrients by Primary Producers in the Swartkops Estuary*; Nelson Mandela Metropolitan University: Gqeberha, South Africa, 2022.
154. First National Bank. Property Barometer. 2020. Available online: https://www.online.fnb.co.za/downloads/economics/economic-comment/2022/ecoWeekly_7Sep22.pdf (accessed on 10 September 2025).
155. Nelson Mandela Bay Municipality. GIS Repository [Data Set]. NMBM, Gqeberha. 2022. Available online: <https://www.nelsonmandelabay.gov.za/documentslist?catID=66> (accessed on 10 September 2025).
156. Rand International Capital. *Beach Developments Vision 2020*; Rand International Capital: Johannesburg, South Africa, 2006.
157. Property24. Property Values in Port Elizabeth. 2022. Available online: <https://www.property24.com/property-values/port-elizabeth/eastern-cape/270> (accessed on 10 September 2025).
158. Nelson Mandela Bay Municipality. NMB 2020/21–2022/23 Approved Budget. 2020. Available online: https://www.nelsonmandelabay.gov.za/DataRepository/Documents/nmbm-approved-budget-2020-21-to-2022-23_826mc.pdf (accessed on 10 September 2025).
159. Google Maps. 2021. Available online: <https://maps.google.com> (accessed on 1 December 2022).
160. Nelson Mandela Bay Tourism. *Nelson Mandela Bay Tourism Baseline Data [Data Set]*; NMBM: Gqeberha, South Africa, 2023.
161. South African Revenue Service. *Fixing of Rate per Kilometer in Respect of Motor Vehicle for Purposes of Section 8(1)(b)(ii) and (iii) of the Income Tax Act, 1962*; South African Revenue Service: Pretoria, South Africa, 2000. Available online: <https://www.ftomasek.com/archive/m290200b.html> (accessed on 10 September 2025).

162. South African Revenue Service. *Fixing of Rate per Kilometer in Respect of Motor Vehicle for Purposes of Section 8(1)(b)(ii) and (iii) of the Income Tax Act, 1962*; South African Revenue Service: Pretoria, South Africa, 2005. Available online: <https://www.ftomasek.com/archive/g250205a.html> (accessed on 10 September 2025).
163. South African Revenue Service. *Fixing of Rate per Kilometer in Respect of Motor Vehicle for Purposes of Section 8(1)(b)(ii) and (iii) of the Income Tax Act, 1962*; South African Revenue Service: Pretoria, South Africa, 2010. Available online: <https://www.ftomasek.com/g220208a.html> (accessed on 10 September 2025).
164. South African Revenue Service. *Fixing of rate per Kilometer in Respect of Motor Vehicle for Purposes of Section 8(1)(b)(ii) and (iii) of the Income Tax Act, 1962*; South African Revenue Service: Pretoria, South Africa, 2015. Available online: <https://www.ftomasek.com/g270215a.html> (accessed on 10 September 2025).
165. South African Revenue Service. *Fixing of Rate per Kilometer in Respect of Motor Vehicle for Purposes of Section 8(1)(b)(ii) and (iii) of the Income Tax Act, 1962*; South African Revenue Service: Pretoria, South Africa, 2020. Available online: <https://www.ftomasek.com/g060320a.html> (accessed on 10 September 2025).
166. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2008. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
167. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2009. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
168. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2012. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
169. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2013. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
170. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2014. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
171. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2016. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
172. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2017. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
173. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2018. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
174. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2020. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
175. Statistics South Africa. *Domestic Tourism Survey*; Statistics South Africa: Pretoria, South Africa, 2021. Available online: https://www.statssa.gov.za/?page_id=1866&PPN=P0352.1&SCH=73548 (accessed on 10 September 2025).
176. Statistics South Africa. *P0441—Gross Domestic Product (GDP), 2nd Quarter 2022*; Statistics South Africa: Pretoria, South Africa, 2022.
177. Cowley, P.D.; Childs, A.R.; Bennett, R.H. The trouble with estuarine fisheries in temperate South Africa, illustrated by a case study on the Sundays Estuary. *Afr. J. Mar. Sci.* **2013**, *35*, 117–128. [CrossRef]
178. Pradervand, P.; Beckley, L.E.; Mann, B.Q.; Radebe, P.V. Assessment of the linefishery in two urban estuarine systems in KwaZulu-Natal, South Africa. *Afr. J. Mar. Sci.* **2003**, *25*, 111–130. [CrossRef]
179. Hosking, S.G.; Wooldridge, T.H.; Dimopoulos, G.; Mlangeni, M.; Lin, C.H.; Sale, M.; Du Preez, M. The Valuation of Changes to Estuary Services in South Africa as a Result of Changes to Freshwater Inflow. 2004. Available online: <https://saeis.saeon.ac.za/Document/1957> (accessed on 10 September 2025).
180. Lee, D. An Application of the Choice Experiment Method to Estimate Willingness-To-Pay for and Guide Management on Estuarine Recreational Services. Ph.D. Thesis, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa, 2012.
181. Statistics South Africa. *Consumer Price Index*; Statistics South Africa: Pretoria, South Africa, 2022. Available online: https://www.statssa.gov.za/?page_id=1854&PPN=P0441&SCH=73284 (accessed on 10 September 2025).

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