Economic Valuation of Ecosystem Services of Coastal Area of Kinondoni District, Tanzania

Abstract

This study investigates the often overlooked economic values of ecosystem services in the coastal area of Kinondoni District, Tanzania, in the context of spatial and temporal changes in land use and land cover (LULC). The primary objectives were to assess how ecosystem services and functions have been affected by LULC changes over a 30-year period, from 1993 to 2023. The study employs a benefit transfer method, integrating local and global estimations of ecosystem service value (ESV) with field surveys, remote sensing, and GIS techniques. The findings reveal that the annual changes in ESV during the study period are estimated at US$ 0.24 lakh and US$ 0.34 lakh using local and global coefficients, respectively. Over the three decades, there has been a significant annual loss of US$ 7.20 lakhs locally and US$ 21.08 lakhs globally, primarily due to the degradation of mangrove forests and bushland. The decline in ecosystem functions is largely driven by reductions in regulating services, which account for 54.1% of the total decrease in local valuations and 31.6% in global valuations. Supporting services also experienced substantial declines, with reductions of 39.7% in local valuations and 55.8% in global valuations. The study underscores the urgent need to review and enhance management and conservation strategies to ensure the sustainability of the coastal ecosystems in Kinondoni District, Tanzania.

Keywords; Ecosystem services, Ecosystem function, Land use and land cover change (LULCC), Kinondoni

1. Background information

The economic valuation of ecosystem services (ES) has gained significant attention in recent years due to the critical role these services play in supporting life on Earth. Ecosystem services encompass a wide range of benefits that humans derive from nature, including provisioning services (such as food, water, and raw materials), supporting services (such as nutrient cycling and soil formation), regulating services (such as climate regulation and flood control), and cultural services (such as recreation and spiritual benefits) (Millennium Ecosystem Assessment, 2005; Raudsepp-Hearne et al., 2010; Schmidt et al., 2016). Despite their vital importance, the economic values of these services are often underestimated or completely ignored in commercial markets and decision-making processes, leading to inadequate management and potential degradation of natural capital (Kahn, 2005; Pascual, 2010; Schmidt et al., 2016).

In Tanzania, particularly in the coastal areas of Dar es Salaam, ecosystem services are essential for the well-being of local communities, who rely heavily on natural resources for their livelihoods. However, these services are increasingly under threat from land use and land cover changes (LULCC), driven by factors such as urbanization, agricultural expansion, and population growth (Msofe et al., 2020; Tolessa et al., 2017). These changes often result in the loss of ecosystem functions and services, further exacerbating environmental degradation and undermining sustainable development efforts.

The economic valuation of ecosystem services, particularly in regions facing significant LULCC, is crucial for several reasons. First, it raises awareness of the importance of ecosystem services and their contributions to human well-being (Msofe et al., 2020; Gashaw et al., 2018). Second, it provides valuable information on which ecosystem services are most valuable and therefore most in need of conservation (De Groot et al., 2012; Liu et al., 2010). Third, it informs decision-makers by highlighting the trade-offs between different land uses and the potential costs of losing ecosystem services (Costanza et al., 2014; TEEB, 2010). Finally, it supports the development of policies and strategies aimed at ensuring the sustainable management of ecosystems and the efficient allocation of resources for conservation and restoration (Turner & Schaafsma, 2015; Farber et al., 2006).

Economic valuation methods, such as the benefit transfer approach, are often used to estimate the monetary value of ecosystem services in areas where primary data is scarce. This approach, which applies existing valuation data from one area to another with similar characteristics, is particularly useful in developing countries like Tanzania, where data on ecosystem services are limited (De Groot et al., 2012; Msofe et al., 2020). The benefit transfer approach, combined with remote sensing and GIS technologies, allows for the estimation and mapping of ecosystem service values across different biomes and land use types, providing decision-makers with crucial information for sustainable land management (Kindu et al., 2016; Schmidt et al., 2016).

Given the growing pressures on the coastal ecosystems of Dar es Salaam, there is an urgent need to quantify the economic value of the ecosystem services provided by these areas. This study aims to fill the existing gap in knowledge by estimating the economic value of ecosystem services in the coastal areas of Dar es Salaam ecosystem, with a focus on the impacts of LULCC over the past three decades (1993-2023). Specifically, the study seeks to (i) determine the changes in the economic values of ecosystem services resulting from LULCC, and (ii) analyze the changes in the economic values of ecosystem functions based on the LULC types in the study area. Thus, by providing a comprehensive assessment of the economic value of ecosystem services in this critical region, the study aims to inform policy-makers, conservationists, and local stakeholders on the importance of preserving these services and the need for sustainable management practices to safeguard the long-term health of the ecosystem.

2. Materials and methods

2.1 Description of the study area

This study was conducted in the coastal wards of Mbweni and Ununio (Figure 1) within the Kinondoni District of Dar es Salaam, Tanzania. Kinondoni, one of the five administrative districts in Dar es Salaam, is strategically located between latitudes 6° 42' 43" S and longitude 39° 07' 54" E, bordered by the Indian Ocean to the east, Ilala District to the south, and Ubungo District to the west, covering approximately 531 square kilometers (URT, 2020). The selection of Mbweni and Ununio was deliberate due to their extensive coastline, which is rich in marine resources and vital for the livelihoods of local communities. These areas rely heavily on marine and coastal ecosystem services for economic activities such as fishing and tourism, making them ecologically and economically significant.

However, the coastal regions of Kinondoni face increasing environmental degradation due to the pressures of rapid urbanization, population growth, and unsustainable economic practices. The district's coastline is part of the larger Western Indian Ocean region, which is renowned for its high biodiversity, including critical habitats such as coral reefs, mangroves, and seagrass beds. These ecosystems play essential roles in maintaining ecological balance and supporting economic activities (Richmond et al., 2017). Despite their importance, these ecosystems are under significant stress from habitat loss, pollution, and overexploitation of resources, exacerbated by the rapid expansion of Dar es Salaam (Mohammed et al., 2021).

The coastal areas of Mbweni and Ununio have been particularly affected, with clear signs of environmental degradation, including erosion, declining fish populations, and the destruction of mangrove forests. These challenges highlight the urgent need for an economic valuation of the ecosystem services provided by these areas. By quantifying the economic benefits, this study aims to advocate for the conservation of these ecosystems, balancing developmental needs with environmental sustainability.

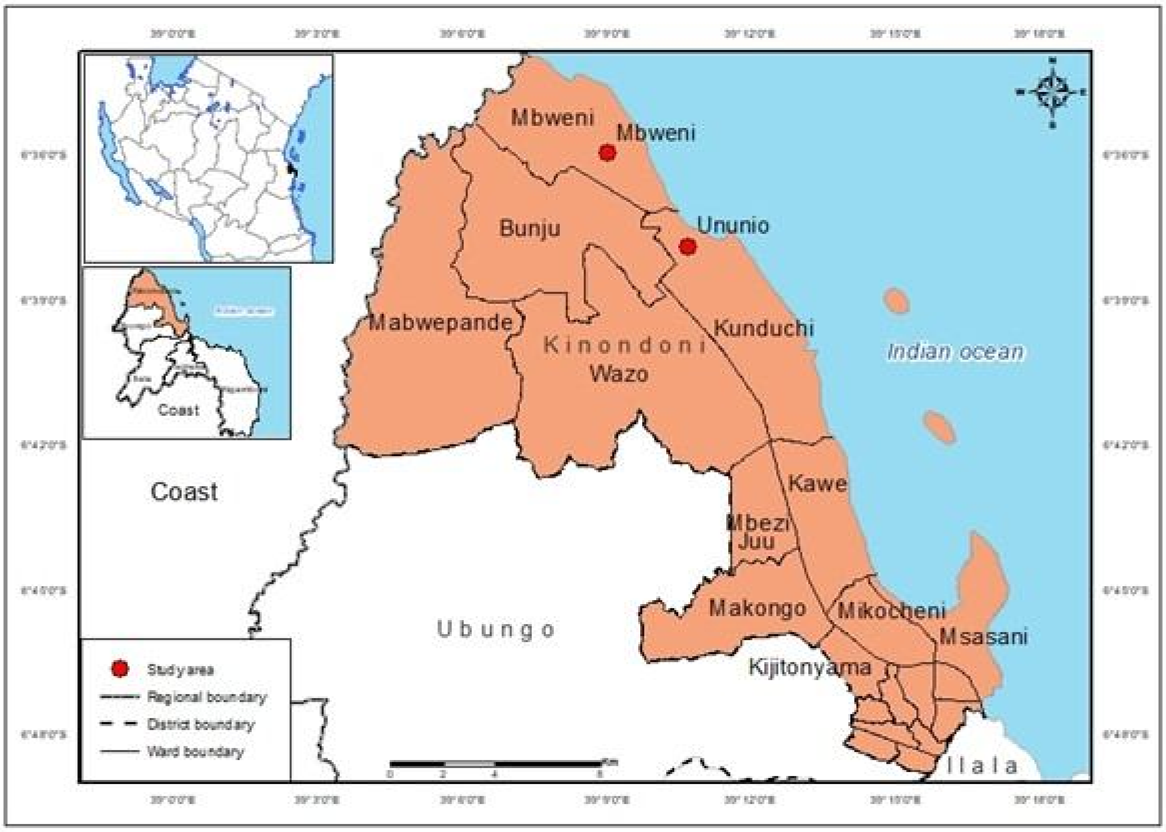

Figure 1: The Map of the study area

2.2. Data Used and Methods

Figure 2 below shows the flow chart of the methodological approach used in this study for the estimation of the ecosystem service values (ESVs) for 1993, 2003, 2013 and 2023 years and the computation of changes between studies periods.

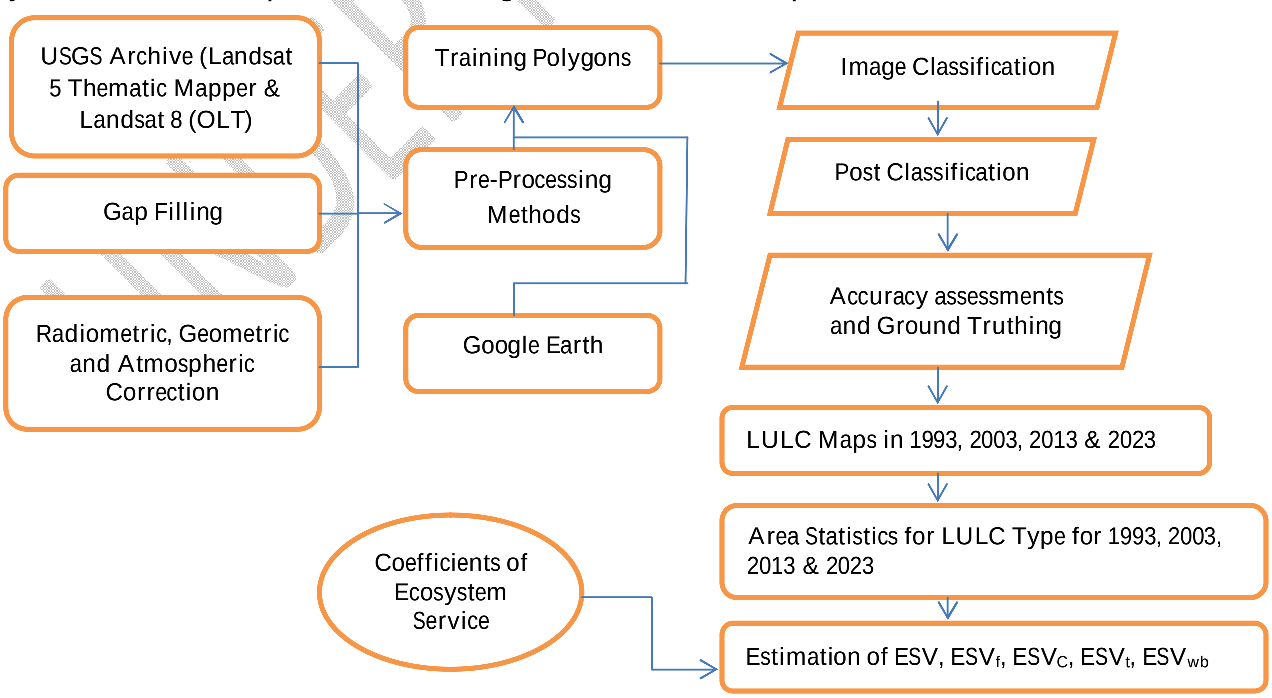

Figure 2: Flowchart of the methodological approach for this study

The land cover classification and change analysis in this study employed a systematic approach to assess changes in land use and land cover (LULC) over time. The process began with the creation of false color composites (FCC) using visible green, red, and near-infrared bands, enhancing the differentiation of vegetation and other land cover types (Smith et al., 2023). High-resolution satellite images from Google Earth were used to collect 200 to 250 training samples per target year, which were essential for training the Support Vector Machine (SVM) classifier. SVM, known for its accuracy in handling diverse datasets, was used to classify the images, followed by post-classification processing to refine the results. The images were categorized into six LULC classes: built-up areas, shrubland, water bodies, forest, cultivated land, and bare areas, consistent with NAFORMA guidelines.

The final stage involved using ArcGIS Pro software for change detection analysis, comparing images from 1993 to 2003 and 2013 to 2023 (Jones & Wang, 2023; Msofe et al., 2024). This analysis revealed significant shifts in LULC, driven by urban expansion and agricultural encroachment, highlighting the importance of geospatial technologies in environmental monitoring and sustainable management practices (Katikiro, 2023). The LULC datasets and biome equivalents with their corresponding ecosystem service value coefficients (VC) in 1994 US$ $ha^{-1}year^{-1}$ for local and global VC shown in Table 1 and Figure 3 as adapted from Kindu et al. (2016), Constaza et al. (1997 &2014), Msofe et al. (2020) and Zella (2021).

Table 1: Land use and land cover (LULC) types and biome equivalents with their corresponding ecosystem service value coefficients (VC)

LULC Type	Year & Area (ha) 1993	2003	2013	2023	Equivalent Biome	Local (VC) 1994 US$ $ha^{-1}year^{-1}$ a	Global (VC) 1994 US$ $ha^{-1}year^{-1}$ b
Mangrove forest	1837.99	1062.96	1502.09	1100.37	Tropical Forest	987	2008
Shrub land	739.47	479.31	502.34	193.06	Tropical Forest	987	244
Bare area	515.86	812.09	169.91	113.75	Sand	0	0
Water	2171.41	2264.01	2214.18	2243.63	Fresh water	8103	8498
Built up area	124.20	797.75	1136.17	1905.14	Urban	0	0
Cultivated land	172.90	145.71	37.13	5.88	Cropland	226	92

This study employed the benefit transfer approach to estimate economic values of ecosystem services based on the adapted local and global VC of the ecosystem services for the targeted LULC types. Detailed ecosystem service functions and their global and modified local value coefficients of each LULC type are shown in Tables 2 & 3 below as adapted from Zella (2021) and Constaza et al. (1997 &2014).

Table 2: Details of the ecosystem service functions and their modified local value coefficients for each LULC type (adapted from Zella, 2021)

Ecosystem Services	Mangrove forest	Shrub land	Water	Cultivated land
Provisioning services:				
Water supply	8	8	2117	
Food production	32	32	41	187.56
Raw material	51.2	51.2		
Genetic resources	41	41		
Medical services				
Sub-total	**132.2**	**132.2**	**2158**	**187.56**
Regulating services:				
Water regulation	6	6	5445	
Waste treatment	136	136	431.5	
Erosion control	245	245		
Climate regulation	223	223		
Biological control				24
Gas regulation	13.68	13.68		
Disturbance regulation	5	5		
Sub-total	**628.68**	**628.68**	**5876.5**	**24**
Supporting services:				
Nutrient cycling	184.4	184.4		
Pollination	7.27	7.27		14
Soil formation	10	10		
Habitat / refugia	17.3	17.3		
Sub-total	**218.97**	**218.97**		**14**
Cultural services:				
Recreation	4.8	4.8	69	
Cultural	2	2		
Sub-total	**6.8**	**6.8**	**69**	
Grand-total	**986.69**	**986.69**	**8103.5**	**225.56**

Table 3: Details of the ecosystem service functions and their global value coefficients for each LULC type (adapted from Constaza *et al*., 1997)

Ecosystem services	Mangrove forest	Shrub land	Water	Cultivated land
Provisioning services:				
Water supply	8	8	3800	
Food production	32	32	258	54
Raw material	315	315		
Genetic resources	41	41		
Medical services				
Sub-total	**396**	**396**	**4058**	**54**
Regulating services:				
Water regulation	6	6	15	
Waste treatment	87	87	4177	
Erosion control	245	245		
Climate regulation	223	223		
Biological control				24
Gas regulation			133	
Disturbance regulation	5	5	4539	
Sub-total	**566**	**566**	**8864**	**24**

Supporting services:				
Nutrient cycling	922	922		
Pollination				14
Soil formation	10	10		
Habitat / refugia			304	
Sub-total	**932**	**932**	**304**	**14**
Cultural services:				
Recreation	112	112	574	
Cultural	2	2	881	
Sub-total	**114**	**114**	**1455**	**0**
Grand-total	**2008**	**2008**	**14681**	**92**

2.2.1 Data analysis

To determine changes of economic values of ecosystem services resulted from LULCC of the study area for the period 1993 - 2023

The Land Use and Land Cover (LULC) datasets presented in Table 1 were used to calculate the total value of ecosystem services in the study area for the years 1993, 2003, 2013, and 2023. This calculation was performed by multiplying the area of each LULC type by the corresponding modified ecosystem service value coefficients. These coefficients were derived from the ecosystem service value per hectare for each biome, as specified in equation (1), adapted from Zella (2021) and Costanza et al. (1997, 2014).

$$ESV = \sum_{k=0}^{k}(Ak + VCk) \quad \text{……………………..……………(1)}$$

where ESV represents the total estimated ecosystem service value, Ak is the area (in hectares) of LULC type 'k,' and VCk is the value coefficient (US\$ ha^{-1} $year^{-1}$) associated with that LULC type. The ESVs for all LULC types were computed accordingly. Additionally, changes in the ESVs were determined by calculating the differences between the estimated values for each LULC category in 1993, 2003, 2013, and 2023. The percentage changes in ESVs between these years were computed using the following equation:

$$\text{Percentange ESV} = \frac{(ESVt_2 - ESVt_1)}{ESVt_1} \times 100 \quad \text{…………………..…..……………(2)}$$

where ESV_{t2} (US\$ ha^{-1} $year^{-1}$) = the estimated ecosystem service value in the most recent year, and ESV_{t1} (US\$ ha^{-1} $year^{-1}$) = the estimated ecosystem service value in the previous year. Positive values suggest an increase in the ESVs, whereas negative values imply a decrease in the ESVs.

To analyse changes of economic values of ecosystem functions based on LULC type of the study area for the period 1993 - 2023

Estimated values of the services provided by individual ecosystem functions within the study area using the following equation:

$$ESVf = \sum_{k=0}^{k}(Ak * VC_{fk}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where ESV_f is the estimated ecosystem service value of function f, Ak is the area (ha) and VC_{fk} is the value coefficient of the function (US\$ ha^{-1} $year^{-1}$) for LULC category 'k'. The contributions of the individual ecosystem functions to the overall value of the ecosystem services per year were calculated and summarized in the tables.

3. Results and Discussion

3.1 Changes of economic values of ecosystem services resulted from LULCC of the study area for the period 1993 - 2023

3.1.1 Status of economic values of ecosystem services for biome in each LULC type of the study area for the period 1993 - 2023

This section examines the status of the economic values of ecosystem services (ESV) for different biomes across various land use and land cover (LULC) types in the study area over the period from 1993 to 2023. The analysis uses both local and global value coefficients to assess the ESV, highlighting variations and trends that have emerged over the past three decades. The economic values of ecosystem services based on local value coefficients for each biome in different LULC types for the years 1993, 2003, 2013, and 2023 are detailed in Table 4. The analysis reveals that there has been a gradual decline in the overall economic value of ecosystem services in the study area. Specifically, the total ESV decreased by approximately 3.7% over the 30-year period, equating to a reduction of around US$ 720,000. This decline reflects the cumulative impact of land use changes, resource exploitation, and environmental degradation on the ecosystem's capacity to provide valuable services.

In contrast, Table 5 presents the economic values of ecosystem services calculated using global value coefficients. The results show more significant variations in ESV compared to those observed using local coefficients. Over the same period, the total ESV decreased by approximately 4.5%, amounting to a loss of about US$ 1.02 million. Notably, the global ESV figures were higher than the local ESV values by 10.71% (US$ 2.16 million) in 1993, 8.06% (US$ 1.60 million) in 2003, and 10.19% (US$ 2.03 million) in 2013. However, by 2023, the global ESV had fallen below the local ESV by 9.59% (US$ 1.87 million).

The observed differences between local and global ESV calculations underscore the complexities and uncertainties involved in decision-making for sustainable ecosystem management. The higher global ESV figures in earlier years suggest that global valuation frameworks may place a greater emphasis on the broader, often intangible, benefits that ecosystems provide at a regional or global scale. These benefits include climate regulation, biodiversity conservation, and other services that may not be immediately visible at the local level. However, the decline in global ESV relative to local ESV by 2023 suggests a potential undervaluation of the local ecosystem services when applying global coefficients. This discrepancy raises concerns about the adequacy of global valuation models in capturing the full range of ecosystem services that are crucial for local communities, particularly in regions where livelihoods are closely tied to the health and productivity of local ecosystems. The divergence between local and global ESV highlights the need for a balanced approach in ecosystem management that accounts for both local and global perspectives. While local value coefficients are essential for understanding the direct economic benefits to local populations, global coefficients provide a broader view of the ecological and environmental significance of these ecosystems. Effective decision-making should consider both scales to ensure that conservation efforts adequately protect ecosystem services that are vital both locally and globally.

Given the uncertainties associated with ESV calculations, particularly when comparing local and global values, it is imperative that decision-makers prioritize the conservation of natural capital. This approach will help mitigate the risks associated with the potential undervaluation of ecosystem services and ensure that the benefits of ecosystem preservation are fully realized. By integrating both local and global ESV into environmental policies and planning, stakeholders can develop more comprehensive strategies that support the sustainable management of ecosystems, balancing social, economic, and environmental needs.

Table 4: Local ESV (Million US$ $year^{-1}$) distribution for the period 1993 - 2023

LULC	1993		2003		2013		2023	
	(ESV)	(%)	(ESV)	(%)	(ESV)	(%)	(ESV)	(%)
Mangrove forest	1.81	8.99	1.05	5.27	1.48	7.44	1.09	5.58
Shrub land	0.73	3.62	0.47	2.38	0.50	2.49	0.19	0.98
Bare area	0	0.00	0	0.00	0	0.00	0	0.00
Water	17.60	87.20	18.35	92.19	17.94	90.03	18.18	93.43
Built up area	0	0.00	0	0.00	0	0.00	0	0.00
Cultivated land	0.04	0.19	0.03	0.17	0.01	0.04	0.01	0.01
Total	20.18	100.00	19.90	100.00	19.93	100.00	19.47	100.00

Table 5: Global ESV (Million US$ $year^{-1}$) distribution for the period 1993 – 2023

LULC	1993		2003		2013		2023	
	(ESV)	(%)	(ESV)	(%)	(ESV)	(%)	(ESV)	(%)
Mangrove forest	3.69	16.52	2.13	9.93	3.02	13.74	2.21	10.36
Shrub land	0.18	0.81	0.12	0.54	0.12	0.56	0.05	0.22
Bare area	0	0.00	0	0.00	0	0.00	0	0.00
Water	18.45	82.60	19.24	89.47	18.82	85.69	19.07	89.41
Built up area	0	0.00	0	0.00	0	0.00	0	0.00
Cultivated land	0.02	0.07	0.01	0.06	0.03	0.02	0.01	0.00
Total	22.34	100.00	21.50	100.00	21.99	100.00	21.34	100.00

3.1.2 Changes of economic values of ecosystem services of LULCC biomes of the study area for the period 1993 - 2023

The economic values of ecosystem services (ESV) associated with land use and land cover change (LULC) biomes were analyzed for the period between 1993 and 2023. The analysis included changes in ESV, percentage changes in ESV, and the percentage annual rate of change, as summarized in Tables 6 and 7. Positive (+) and negative (-) signs were used to indicate increases and decreases, respectively. The findings presented in Table 6 reveal a decrease in the total ESV for the period from 1993 to 2003, amounting to a reduction of approximately US$ 278,000. This trend reversed slightly during the period from 2003 to 2013, with a modest increase in total ESV of about US$ 27,000. However, the period from 2013 to 2023 saw a more significant decline, with the total ESV decreasing by approximately US$ 470,000. Table 7, which follows a similar trend, shows a more pronounced change, with the ESV decreasing by nearly four times more from 1993 to 2003, 17 times more from 2003 to 2013, and 1.4 times more from 2013 to 2023, compared to the values in Table 6.

These findings underscore the importance of incorporating local and global valuation coefficients into national environmental policies to develop robust decision-making models. The overall trend indicates a decline in total ESV, with a reduction of US$ 720,000 and US$ 1.03 million for the local and global coefficients, respectively, over the 1993-2023 period. This corresponds to an annual rate of decline of US$ 24,000 and US$ 34,000, respectively. The analysis also highlights that mangrove forests and bushland were the most dynamic LULC types during this period. The increase in ESV observed between 2003 and 2013 can be attributed to concerted efforts by stakeholders to protect marine resources, coupled with the variability in water bodies driven by climate change. These fluctuations suggest that targeted interventions and adaptive management strategies are essential to safeguarding the economic value of ecosystem services, particularly in response to changing environmental conditions and anthropogenic pressures.

Thus, the overall decline in ESV over the past three decades calls for urgent action to integrate ecosystem service valuation into environmental policies. Such integration is crucial for maintaining the ecological and economic sustainability of the study area's LULC biomes, ensuring that the benefits provided by these ecosystems continue to support local communities and biodiversity conservation efforts.

Table 6: Changes in Local ESV (in lakhs US$) for the period 1993 - 2023

LULC	1993 – 2003			2003 – 2013			2013 – 2023		
	Change in ESV	% change	ARC	Change in ESV	% change	ARC	Change in ESV	% change	ARC
Mangrove forest	7.65	275.62	0.76	-4.33	1556.81	-0.43	3.97	84.33	0.40
Shrub land	2.57	92.52	0.26	-0.23	81.65	-0.02	3.05	64.92	0.30
Bare area	0	0.00	0	0	0.00	0	0	0.00	0
Water	-7.50	-270.35	-0.75	4.04	-1450.32	0.40	-2.39	-50.75	-0.24
Built up area	0	0.00	0	0	0.00	0	0	0.00	0
Cultivated land	0.06	2.21	0.01	0.25	-88.14	0.03	0.07	1.50	0.01
Total	**2.78**	**100.00**	**0.28**	**-0.27**	**100.00**	**-0.02**	**4.70**	**100.00**	**0.47**

ARC = Annual Rate of Change **(ESV year^{-1})**

Table 7: Changes in Global ESV (in lakhs US$) for the period 1993 - 2023

LULC	1993 – 2003			2003 – 2013			2013 – 2023		
	Change in ESV	% change	ARC	Change in ESV	% change	ARC	Change in ESV	% change	ARC
Mangrove forest	15.56	186.31	1.56	-8.82	194.25	-0.88	8.06	127.09	0.81
Shrub land	0.64	7.60	0.06	-0.56	1.24	-0.06	0.76	11.89	0.07
Bare area	0	0.00	0	0	0.00	0	0	0.00	0
Water	-7,87	-94.20	-0.79	4.25	-93.28	0.42	-2.50	-39.43	-0.25
Built up area	0	0.00	0	0	0.00	0	0	0.00	0
Cultivated land	0.03	0.30	0.03	1.00	-2.20	0.10	0.03	0.45	0.01
Total	**8-35**	**100.00**	**0.84**	**-4.54**	**100.00**	**-0.45**	**6.35**	**100.00**	**0.64**

ARC = Annual Rate of Change **(ESV year^{-1})**

3.2 Changes of economic values of ecosystem functions based on LULC type of the study area for the period 1993 - 2023

This section analyses changes in the economic values of ecosystem functions of the study area from 1993 to 2023. The evaluation, using both local and global biome coefficients, focuses on different land use and land cover (LULC) types within the study area. The findings, documented in Tables 8 and 9, highlight significant shifts in the economic values associated with various ecosystem functions over the three-decade period. The results indicate a notable loss in the economic value of ecosystem functions, with a decline of US$ 720,000 and US$ 2.108 million for local and global biome coefficients respectively. This loss was predominantly observed in mangrove forests and shrub land, which are critical for ecological balance and biodiversity in the region. Conversely, there was an economic gain associated with water-related ecosystem functions, reflecting perhaps an increased valuation or restoration of water bodies over the study period.

The data further reveal a significant decline in regulating services, accounting for 54.1% of the total decrease according to local valuations and 31.6% according to global valuations. Supporting services also saw substantial declines, with local valuations indicating a 39.7% reduction and global valuations showing a 55.8% decrease. These services include vital ecological processes such as nutrient cycling, soil formation, and habitat provision. The reduction in the economic values of regulating and supporting services is a clear indicator of the degradation of natural capital within the Kinondoni District's coastal ecosystems. These declines are largely attributed to increased anthropogenic pressures, including urban development, pollution, and unsustainable resource extraction. The local communities' heavy reliance on these coastal resources for their livelihoods further compounds the impact, leading to overexploitation and environmental degradation. The observed losses in ecosystem functions underscore the urgent need for enhanced management strategies and policy interventions aimed at conserving and restoring these critical areas. The results suggest that without significant efforts to mitigate these impacts, the ecological health and economic viability of the region's ecosystems could continue to deteriorate, with long-term consequences for both biodiversity and community well-being.

Furthermore, the study highlights the importance of integrating ecosystem function values into local and national environmental planning and policy-making. By quantifying the economic losses and gains in ecosystem services, decision-makers are provided with a clear indication of the areas where intervention is most needed and where investments in conservation and restoration can yield significant economic and environmental returns. Thereof, the Kinondoni District represents a crucial case study for understanding the dynamics of coastal ecosystems under pressure. The findings from this study offer valuable insights into the sustainable management of coastal resources in Tanzania and similar regions facing analogous challenges. These insights are essential for developing strategies that balance economic development with environmental sustainability, ensuring the preservation of vital ecosystem functions for future generations.

Table 8: Local economic values of ecosystem functions (in lakhs US$) for the period 1993 - 2023

LULC	Ecosystem services	1993	2003	2013	2023	Relative change
Mangrove forest	Provisioning services	2.43	1.42	1.99	1.46	0.97
	Regulating services	11.56	6.68	9.44	6.92	4.64
	Supporting services	4.03	2.33	3.29	2.41	1.62
	Cultural services	0.13	0.07	0.10	0.08	0.05
	Sub-total	**18.15**	**10.50**	**14.82**	**10.87**	**7.28**
Shrub land	Provisioning services	0.98	0.64	0.67	0.26	0.72
	Regulating services	4.65	3.01	3.16	1.21	3.44
	Supporting services	1.62	1.05	1.10	0.42	1.20
	Cultural services	0.05	0.03	0.03	0.01	0.04
	Sub-total	**7.30**	**4.73**	**4.96**	**1.90**	**5.40**

Water	Provisioning services	46.86	48.88	47.78	48.42	(1.56)
	Regulating services	127.60	133.05	130.12	131.85	(4.25)
	Supporting services	-	-	-	-	-
	Cultural services	1.50	1.56	1.53	1.55	(0.05)
	Sub-total	**175.96**	**183.49**	**179.43**	**181.82**	**(5.86)**
Cultivated land	Provisioning services	0.33	0.29	0.07	0.01	0.32
	Regulating services	0.04	0.04	0.01	-	0.04
	Supporting services	0.02	0.02	-	-	0.02
	Cultural services	-	-	-	-	-
	Sub-total	0.39	0.35	0.08	0.01	0.38
GRAND TOTAL		**201.80**	**199.07**	**199.29**	**194.60**	**7.20**

Table 9: Global economic values of ecosystem functions (in lakhs US$) for the period 1993 – 2023

LULC	Ecosystem services	1993	2003	2013	2023	Relative change
Mangrove forest	Provisioning services	7.28	4.21	5.95	4.36	2.92
	Regulating services	10.40	6.02	8.50	6.23	4.17
	Supporting services	17.13	9.91	13.20	10.26	6.87
	Cultural services	2.10	1.21	1.71	1.25	0.85
	Sub-total	**36.91**	**21.35**	**29.36**	**22.10**	**14.81**
Shrub land	Provisioning services	2.93	1.20	1.99	0.77	2.16
	Regulating services	4.19	2.71	2.84	1.09	3.10
	Supporting services	6.89	4.47	4.68	1.80	5.09
	Cultural services	0.84	0.55	0.57	0.22	0.62
	Sub-total	**14.85**	**8.93**	**10.08**	**3.88**	**10.97**
Water	Provisioning services	88.12	91.87	89.85	91.05	(2.93)
	Regulating services	19.25	20.07	19.63	19.89	(0.64)
	Supporting services	6.60	6.88	6.73	6.82	(0.22)
	Cultural services	31.59	32.94	32.22	32.65	(1.06)
	Sub-total	**145.56**	**151.76**	**148.43**	**150.41**	**(4.85)**
Cultivated land	Provisioning services	0.09	0.08	0.02	-	0.09
	Regulating services	0.04	0.04	-	-	0.04
	Supporting services	0.02	0.02	0.01	-	0.02
	Cultural services	-	-	-	-	-
	Sub-total	0.15	0.14	0.03	-	0.15
GRAND TOTAL		**197.47**	**182.18**	**187.90**	**176.39**	**21.08**

4. Conclusion and Recommendations

4.1 Conclusion

The study provides a comprehensive assessment of the economic values associated with various ecosystem services in this vital coastal area over a 30-year period, from 1993 to 2023. The findings underscore the significant economic contributions of ecosystem services in sustaining local livelihoods, supporting biodiversity, and maintaining ecological balance. However, the study also reveals alarming trends of degradation, particularly in key ecosystems such as mangrove forests and shrublands, which have experienced substantial declines in their economic value due to land use and land cover changes (LULCC). The decline in ecosystem service values, particularly in regulating and supporting services, highlights the growing vulnerability of the Kinondoni District's coastal ecosystems. These services are crucial for the region's resilience against environmental challenges such as climate change, coastal erosion, and biodiversity loss. The reduction in economic value not only reflects the ecological degradation but also signals potential socio-economic impacts, as local communities are heavily dependent on these ecosystems for their livelihoods.

Moreover, the study identifies discrepancies between local and global ecosystem service valuations, emphasizing the complexities and uncertainties involved in valuing ecosystem services across different scales. While global valuations tend to highlight the broader ecological significance of these services, local valuations are more reflective of the immediate benefits to the communities that rely on them. The observed differences between these valuations call for a more nuanced approach to ecosystem management, one that adequately balances local needs with global environmental goals. Therefore, the economic valuation of ecosystem services in the Kinondoni District reveals both the immense value these ecosystems provide and the significant risks they face due to ongoing environmental pressures. The study serves as a crucial reminder of the need to prioritize the conservation and sustainable management of coastal ecosystems to ensure their continued provision of essential services for current and future generations.

4.2 Recommendations

Based on the findings of this study, seven key recommendations are proposed to enhance the conservation and sustainable management of the coastal ecosystems in the Kinondoni District.

Firstly, strengthening policy integration; it is imperative that the economic values of ecosystem services be integrated into national and local environmental policies. By incorporating these values into decision-making processes, policymakers can better prioritize conservation efforts, allocate resources more effectively, and implement policies that balance development with environmental sustainability. This integration should also consider the discrepancies between local and global valuations to ensure that both local needs and broader ecological impacts are addressed.

Secondly, enhanced conservation efforts; targeted conservation strategies should be developed to protect the most vulnerable ecosystems, particularly mangrove forests and shrublands. These ecosystems play a critical role in regulating environmental processes and supporting biodiversity. Conservation efforts should include the restoration of degraded areas, the establishment of protected zones, and the promotion of sustainable land use practices that minimize environmental impact.

Thirdly, community engagement and education; the local communities in the Kinondoni District are both the beneficiaries and custodians of coastal ecosystem services. Therefore, it is essential to involve them in conservation efforts through education and awareness programs. Empowering communities with knowledge about the importance of ecosystem services and sustainable resource management can foster greater stewardship and reduce the pressures on these ecosystems from unsustainable practices.

Fourthly, development of sustainable livelihoods; to reduce the reliance of local communities on environmentally destructive activities, there is a need to develop and promote alternative, sustainable livelihoods. This could include eco-tourism, sustainable aquaculture, and other income-generating activities that do not compromise the integrity of the coastal ecosystems. Supporting these alternatives through training, financial incentives, and market access will be crucial to their success.

Fifthly, monitoring and evaluation; establishing a robust monitoring and evaluation framework is essential for tracking changes in ecosystem service values over time. Regular assessments should be conducted to measure the effectiveness of conservation and management interventions, identify emerging threats, and adjust strategies as needed. This framework should include both biophysical and socio-economic indicators to provide a comprehensive understanding of ecosystem health and community well-being.

Sixly, adapting to climate change; the coastal areas of the Kinondoni District are particularly vulnerable to the impacts of climate change, such as sea-level rise, increased storm intensity, and changes in precipitation patterns. It is crucial to incorporate climate change adaptation strategies into the management of coastal ecosystems. This could involve enhancing natural coastal defenses like mangroves, improving water management, and developing infrastructure that is resilient to climate-related risks.

Seventhly, international collaboration and support; given the global importance of coastal ecosystems, international collaboration should be strengthened to support conservation efforts in the Kinondoni District. This includes technical and financial support from international organizations, knowledge exchange with other coastal regions facing similar challenges, and participation in global environmental initiatives that promote sustainable coastal management.

Therefore, the sustainable management of the coastal ecosystems in the Kinondoni District is not only essential for preserving biodiversity and ecosystem functions but also for securing the livelihoods and well-being of the local communities. By implementing the recommended strategies, it is possible to safeguard these valuable ecosystems for future generations while promoting sustainable development in the region. The findings and recommendations of this study should serve as a foundation for informed policy-making and concerted action towards achieving these goals.

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