A Framework for Ecosystem Services Valuation into Coastal Landscape Design: A Case Study of Bentota River Estuary

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Abstract

The Coastal ecosystems provide important ecological and social and economic services. Rapid urbanization, over tourism, and climate change are degrading the eco systems. The study investigates how ecosystem services assessment (ESV) can be effectively integrated into coastal landscape design to address this issue. The research applies valuation methods to assess the ecological and economic value of key ecosystem services, maps their spatial distribution to identify high-value and vulnerable zones, and formulates a practical framework to guide landscape architects in incorporating ESV . The research is a case study of the Bentota River estuary in Sri Lanka. The study follows a mixed-methods approach that combines geographic modeling with socio economic assessment by capturing both ecological and human perspectives. Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) carbon storage and sequestration model was used for biophysical assessment. The results highlight the tension between environmental conservation and tourism based development, while also pointing up opportunities for conservation zoning and nature integrated design. The socio economic dimension was captured through a willingness to pay (WTP) survey. Findings indicated significant support for structured mechanisms such as taxation and entrance fees at higher WTP levels whereas voluntary donations were more common at lower levels. By integrating ecological data with socio economic valuation the research proposes an actionable framework for landscape architects and policymakers. The framework links carbon mapping and WTP analysis with space design recommendations, policy prescriptions, and community based conservation frameworks. It can be cascaded to other coastal regions of Sri Lanka and supported with climate resilience, biodiversity conservation, and sustainable development.

Keywords: Ecosystem Services Valuation, Coastal Landscape Design, Carbon Sequestration, Willingness to Pay, Bentota River Estuary

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Introduction

Coastal landscapes are complex and dynamic interfaces between terrestrial and marine ecosystems. Those landscapes offer a diverse range of ecological, economic, and cultural benefits. The richness of biodiversity is very high because of the services provided by coastal landscapes, such as coastal protection, water purification, habitat provision, and carbon sequestration. In addition, there are unique cultural values associated with tourism and marine industries. However, due to active human activities like urbanization and intensive tourism, as well as passive human activities like climate change, these ecosystems are degraded day by day.

The concept of ecosystem services has emerged as a framework to better understand, quantify, and communicate the value of natural systems to human well-being. The ecosystem services valuation (ESV) concept was developed to assign measurable economic or social value to ecological processes that are often overlooked in infrastructure development. ESV is effective in conservation policy making and spatial design. Regarding the new trends of sustainable development in landscape architecture and landscape planning, quantifying ecosystem services is as important as the aesthetic value of the landscape. Landscape architecture, which traditionally emphasizes the aesthetic and functional dimensions of space, is now faced with the opportunity and responsibility to evolve into a performance based practice that aligns with environmental and economic realities. Estuaries, lagoons, coral reefs, and sandy beaches are some ecosystems in Sri Lanka. They are hotspots of biodiversity and socio-economic assets by supporting local livelihoods, national GDP, food security, and disaster risk reduction. These environments are also hubs of eco-tourism and cultural heritage. Coastal ecosystems act as natural barriers to extreme weather events and erosion. Their conservation is essential for the ecological balance and long-term sustainability of coastal development. Despite their importance, they are undervalued and not generally integrated into formal spatial planning frameworks.

Ecosystems in coastal landscapes are essential to ecological well-being and human livelihoods. They are rarely valued or systematically incorporated into landscape architecture and spatial planning practices in Sri Lanka. Contemporary design goals tend to emphasize visual and recreational functions, while ignoring measurable environmental functions such as carbon sequestration, coastal protection, and cultural value. This incompatibility leads to the underestimation and degradation of natural systems, especially in places undergoing tourism and urban development. An ESV integration framework is urgently needed to improve the planning process to guide the development of more resilient, sustainable and place-sensitive coastal landscapes.

The research seeks to address several key questions central to integrating ecosystem services valuation into coastal landscape design in Sri Lanka. It first investigates how ecosystem services within coastal landscapes can be assessed and quantified to support sustainable and evidence based design decisions. It then explores how stakeholders such as local communities, policymakers, and tourism operators perceive and value the cultural and recreational benefits provided by coastal environments. Furthermore, the study examines the spatial patterns of ecosystem service delivery within the landscape and how these relate to existing land uses and development pressures. It aims to determine what type of framework can effectively assist landscape architects in integrating ecosystem service data into real-world planning and design processes within Sri Lanka’s coastal zones. The questions guide the research toward developing a holistic, design oriented framework that bridges ecological assessment, socio economic valuation, and spatial planning for sustainable coastal management.

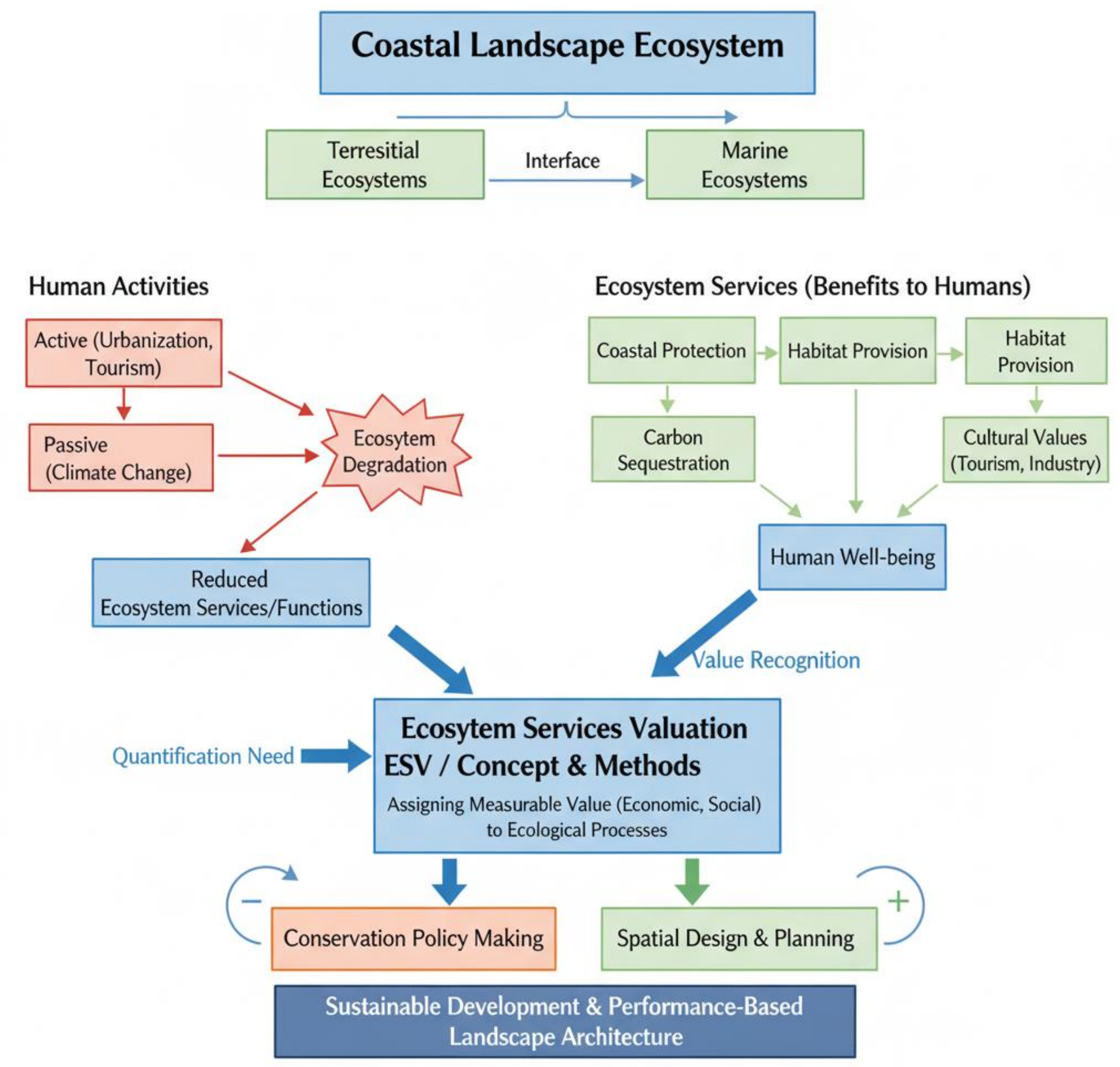

Fig. 1: Background of study
Source: author

Literature Review

The coastline of Sri Lanka stretches for about 1,600 kilometers. It is with various geomorphological formations like sandy beaches, dunes, lagoons, estuaries, coral reefs, and mangrove forests. These ecosystems play a special role in Sri Lanka's economic well-being, particularly regarding fisheries, tourism, and coastal security (World Bank. 2017, n.d.). Quaternary sea level fluctuations, sedimentation patterns, and ocean currents caused by monsoon storms develop unique coastal morphologies in the island's four major quadrants (Adikaram et al., 2018). For example, the southwestern coast has transverse sandy bays protected by rocky headlands, while large lagoon systems, spits, and sand dunes characterize the northwest and southeast coasts (Coast Conservation and Coastal Resource Management Department (CCCRMD), 2024). Coral reefs, such as the Bar Reef Marine Sanctuary in the northwest and Hikkaduwa in the southwest, not only provide refuge for biodiversity but also stabilize coastlines against wave action .Coastal ecosystems provide important ecological and economic services sustaining biodiversity, protecting coastlines, and enabling human livelihoods. Ecologically, coastal ecosystems such as mangroves, coral reefs, seagrass beds, salt marshes, and sand dunes serve critical habitat for marine and terrestrial species, enable nutrient cycling, and govern biophysical functions such as erosion protection, water filtering, and carbon sequestration (Barbier et al., 2011) . These ecosystems produce interlinked seascapes whose spatial and temporal diversity determines the provision and resilience of ecosystem services by highlighting the importance of integrated coastal management (Barbier et al., 2011).

Fig. 2: Ecological and Economic Importance
Source: author

Rapid and unregulated tourism development, river sand mining, and coral reef destruction have led to significant changes in coastal landscapes, especially in high-tourism zones such as Unawatuna (Wasana S.G.S. and Thennakoon, T.M.S.P. K., 2018). Such activities have led to coastal erosion and habitat loss, undermining both environmental stability and community livelihoods. The impact of coastal infrastructure is clearly visible in areas like Oluvil. Coastal retreat has accelerated due to port construction, which is destroying agricultural lands and customary livelihoods (Shifqa & Gamage, 2024).

The concept of ecosystem services (ES) offers a fundamental framework for understanding how natural systems support human well being. It became public with the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005). This highlighted the benefits that ecosystems provide to humans and the need to safeguard these services in the face of increasing environmental degradation. The ES approach shifts the focus from conserving nature for its own sake to conserving it for social benefits. Ecosystem services are generally characterized as the direct and indirect contributions of ecosystems to human survival and quality of life. They include everything from food and water supply to cultural identity to climate regulation. This idea has been revolutionary in both environmental economics and environmental policy, allowing policymakers, planners, and designers. It is helpful for quantify and communicate the benefits of nature in formats that make sense.

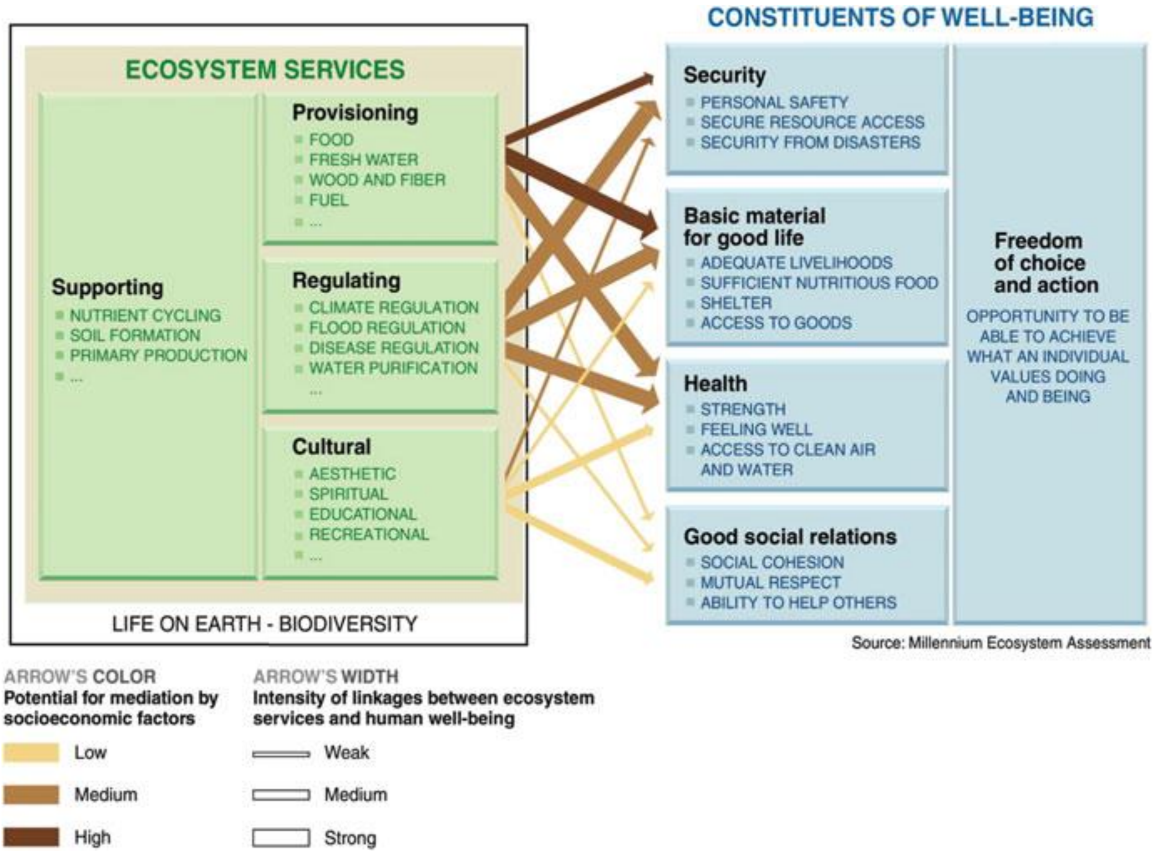

Fig. 3: Ecosystem Services
Source: Millennium Ecosystem Assessment

Table 12: Categorization of Ecosystem Services

Category	Description	Eco System Services
Provisioning Services	Products obtained from ecosystems	Food, Fresh water, Fuelwood, fiber, and genetic resources
Regulating Services	Benefits obtained from the regulation of ecosystem processes	Climate regulation, Flood regulation, Disease control, and Water purification
Supporting Services	Necessary to produce all other services	Soil formation, photosynthesis, Nutrient cycling
Cultural Services	Non-material benefits such as aesthetic values	Spiritual enrichment, Tourism, Recreation, Educational experiences

ESV is the process of quantifying the economic, social and ecological values of ecosystem services. Valuation approaches aim to make the benefits of ecosystems explicit in decision making, resource management and policy development. ESV frameworks include biophysical, socio-cultural and monetary assessments (Costanza et al., 1997; Wang et al., 2016).

1. Biophysical assessments quantify the supply of services (e.g., carbon stored, water purified).
2. Monetary valuation translates benefits into economic terms using market or surrogate pricing.
3. Socio-cultural valuation captures community perceptions, preferences, and non-market values.

Ecosystem Services Valuation as a Decision-Making Tool for Landscape Architecture

Increasing research in landscape architecture now seeks to demonstrate the practical and economic value of designed landscapes. The use of performance-based metrics has been proposed to assist practitioners (Wang et al., 2016). However, these landscape performance frameworks operate independently of ecosystem value systems, with limited guidance on how to incorporate carbon, cultural value, or ecological resilience data into planning processes. Unchecked Sri Lanka development continues to degrade ecological well-being through the absence of considered. This omission is particularly significant in nations such as Sri Lanka, where landscape architecture is an emerging profession.

Notwithstanding the expanding global literature on ESV, there is no overarching framework in Sri Lanka linking ecosystem services valuation to practical tools and procedures employed by landscape architects. Most of the existing research work has been conservation or policy-oriented economic valuation with fewer translations into site-specific design requirements. The valuable services like carbon sequestered in mangroves, the amenity value of lagoons or natural cover flood buffering are not accounted for within planning strategies.

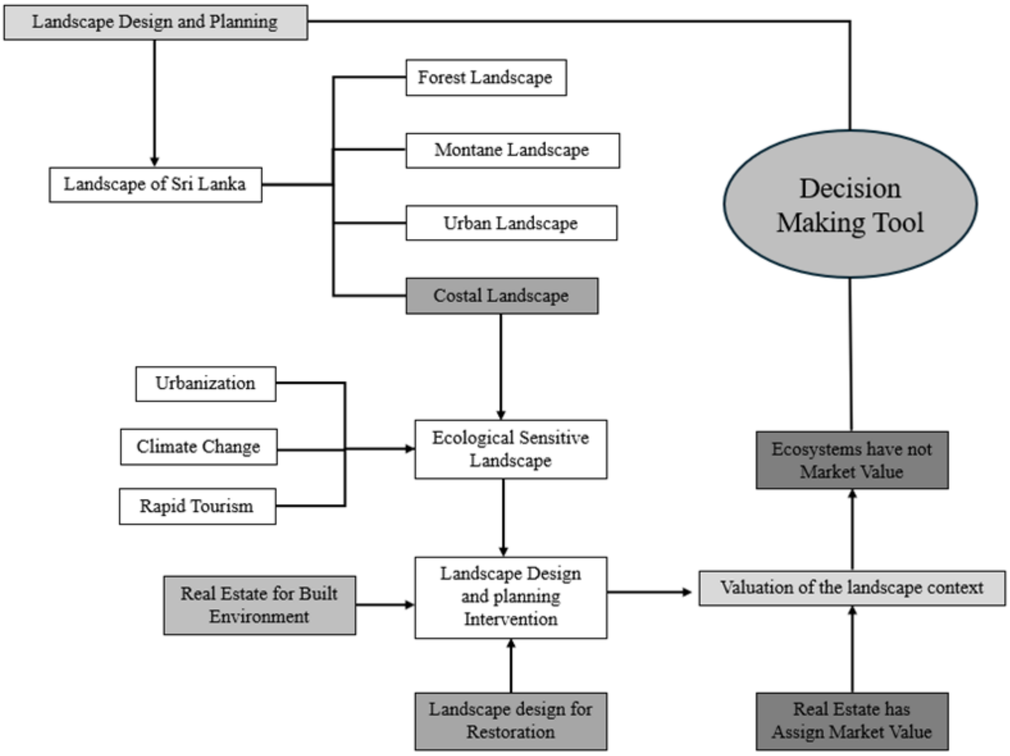

Fig. 4: Connection of Landscape Design and ESV
Source: author

METHODOLOGY

The research follows a mixed-methods methodology to combine quantitative geospatial modeling as well as primary collection of socioeconomic data. The process is encouraged in literature related to environmental valuation. The mixed methods design allows for the triangulation of both biophysical and socioeconomic components of ecosystem services for improving the combined analysis.

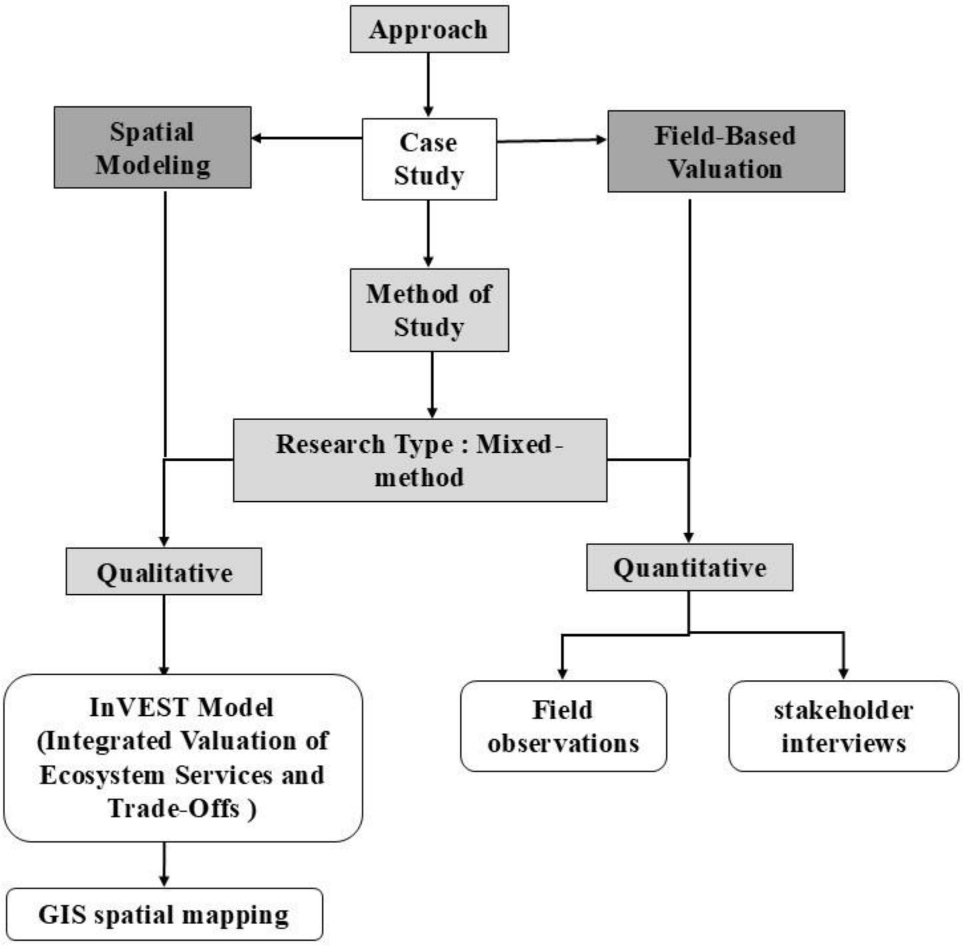

Fig. 5: Research Approach
Source: author

The methodological limitations of the study primarily stem from data availability, temporal scale, and generalizability. The InVEST carbon storage and sequestration model relies on secondary carbon pool data and default coefficients due to the absence of site-specific biomass measurements for the Bentota River Estuary. While these parameters are based on reliable global and regional sources, such as IPCC and previous Sri Lankan studies, they may not fully capture local variations in vegetation density, soil composition, and land management practices. Similarly, the socio-economic data collected through the Willingness to Pay (WTP) survey, though statistically valid for the case study area, represent a localized perspective and may not be directly transferable to other coastal contexts without cultural or economic calibration.

Another challenge lies in the integration of biophysical and socio-economic datasets which operate on different spatial and temporal resolutions. Aligning spatial carbon maps with survey based valuation data introduces analytical complexity and potential uncertainty when drawing policy or design inferences. Additionally, the research focuses primarily on carbon sequestration and cultural services, excluding other vital ecosystem services such as water regulation, habitat provision, and nutrient cycling, which could influence the holistic understanding of ecosystem value. Furthermore, financial and policy mechanisms to operationalize ecosystem service valuation, such as Payment for Ecosystem Services (PES) or REDD+ (Reducing Emissions from Deforestation and Forest Degradation) schemes, are still underdeveloped in Sri Lanka.

Bentota River Estuary was selected for the analysis because the river is extremely crucial for nature, offers numerous services, and is subject to increasing human pressures. The river estuary consists of varying habitats such as mangroves, wetlands, and riverbank forest that are crucial for wildlife, carbon sequestration, flood management, as well as providing employment through tourism and fishing. Now the river is threatened by fast urban development, land use change, as well as destruction of the environment, providing an appropriate location for the application of a mix of approaches for ecosystem service valuation.

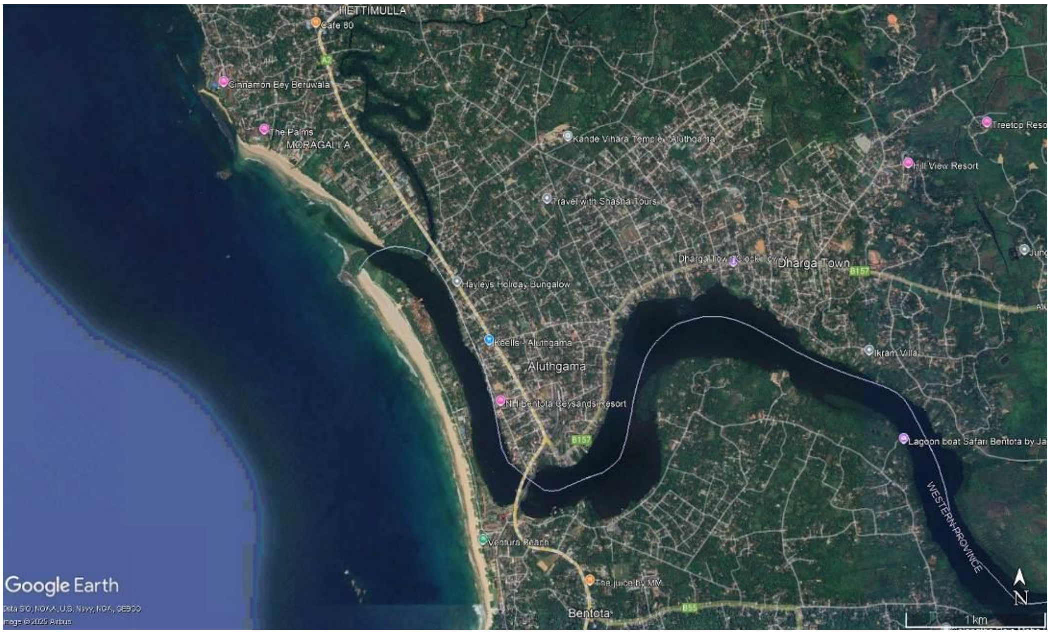

Fig. 6: Bentota River Estuary
Source: Google Earth

The Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) Carbon Storage and Sequestration Model is a spatial model of the Natural Capital Project used to quantify landscapes' carbon storage capacity under different land use and land cover (LULC) options. The model holds that any LULC has a varying capacity to store carbon in four large carbon pools, including aboveground biomass, belowground biomass, dead organic matter, and soil organic carbon.

Table 2 : Required two primary inputs

LULC Raster Map	Classified raster where each pixel represents a land-cover type identified by a unique LULC code
Carbon Pool Table	CSV file assigning carbon density values (in megagrams of carbon per hectare) for each carbon pool corresponding to each LULC class

Following processing, the model calculates the total carbon stored in the landscape by multiplying the carbon density values with the area of each LULC class. When sequestration is being estimated, the model may compare future and baseline LULC maps so that it can estimate the net change in carbon storage over time. In this instance, the InVEST Carbon Storage and Sequestration Model was used to calculate the baseline carbon storage in the Bentota River Estuary by using literature based, Sri Lankan coastal and wetland ecosystem-specific carbon density values. These findings formed the biophysical foundation for linking ecological value and stakeholders' willingness to pay for conservation, informing the ultimate proposed coastal landscape design framework.

As required by the InVEST Carbon Storage and Sequestration Model, LULC data to be analyzed were treated in the format of a single-band classified raster map. The LULC dataset was treated with QGIS. Initially, Sri Lanka's digital LULC shapefile was obtained from Sri Lanka's Survey Department. The shapefile was clipped to get the LULC of Bentota River Estuary because it spread over Galle District as well as Kalutara District. The clipped polygon layer was converted to raster dataset by utilizing

Rasterize in QGIS. That all LULC classes were assigned a unique LULC code. These codes directly translate into carbon pool values in the carbon storage table. It is required to run the InVEST model (Sharp et al., 2018).

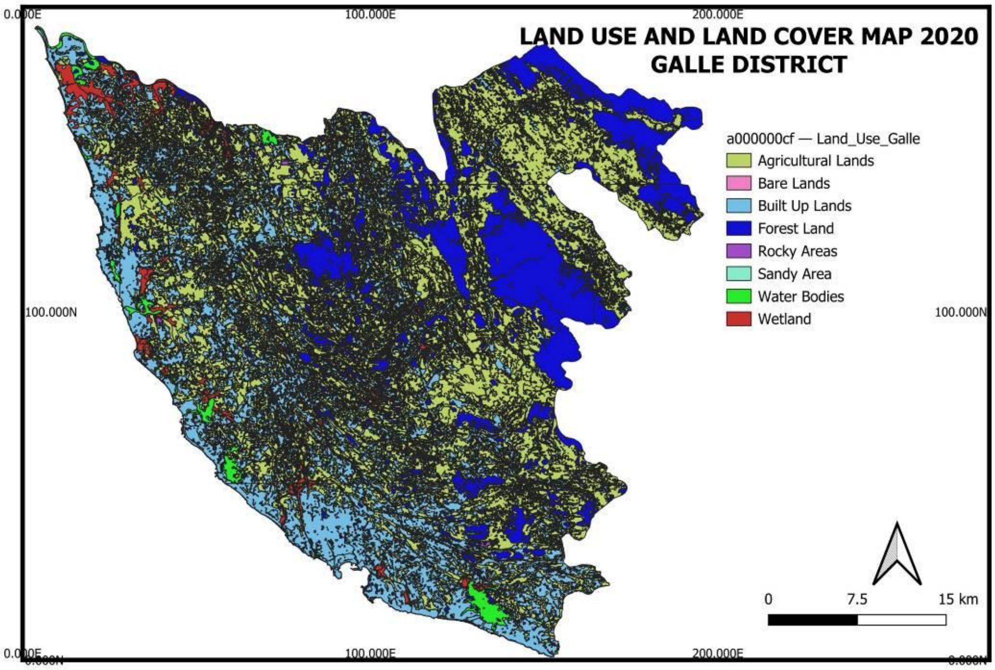

Fig.7: Land Use and Land Cover Map 2020 of Galle District
Source : National Physical Planning Department

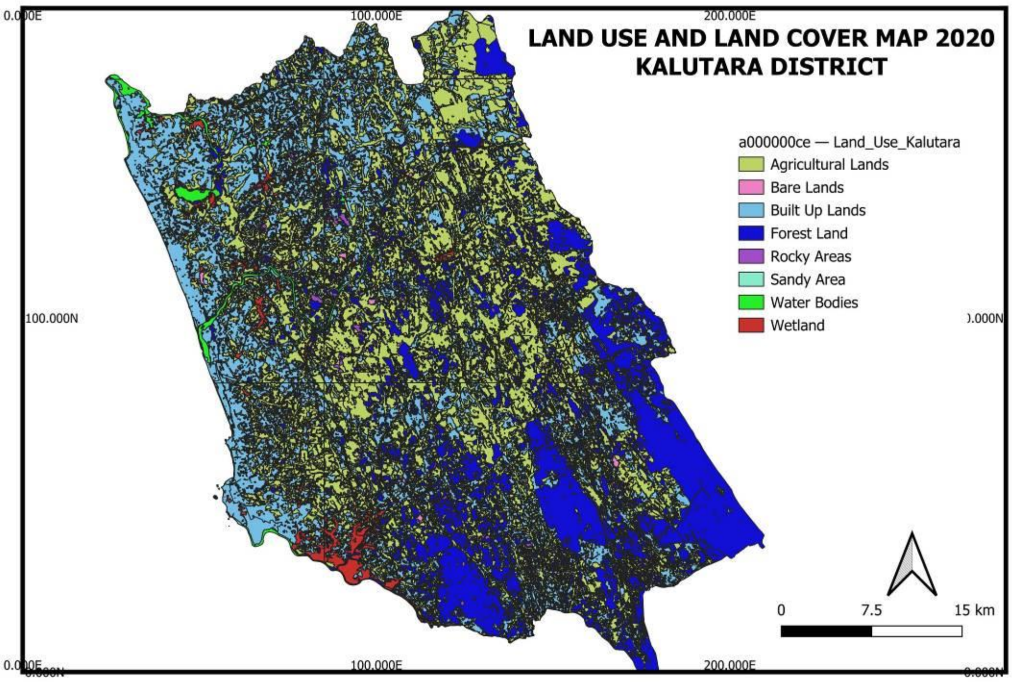

Fig.8: Land Use and Land Cover Map 2020 of Galle District
Source : National Physical Planning Department

A comma-separated value (CSV) file was created to represent carbon density values for every land use and land cover (LULC) class. It covers the four major carbon reservoirs aboveground biomass, belowground biomass, dead organic matter, and soil organic carbon. The carbon density values were compiled from reputable, peer-reviewed publications and global datasets relevant to the ecological context of Sri Lanka. Carbon values for aboveground and belowground sources were largely derived from the Intergovernmental Panel on Climate Change (IPCC, 2006) Guidelines for National Greenhouse Gas Inventories. It has been supplemented by data from regional studies (Brown, 1997; Coomes et al., 2002; Grace et al., 2006; Malhi, 2006; Socolow & Pacala, 2006). Belowground carbon storage estimates in woody vegetation were computed using the root-to-shoot ratio approach (Cairns et al., 1997).

Table 3 : Carbon Pool Data (tons/ha)

LULC Name	Carbon above	Carbon below	Carbon soil	Carbon dead
Agricultural Lands	10	3	40	2
Bare Lands	0	0	5	0
Built Up Lands	3	0	10	0
Forest Land	120	30	90	12
Rocky Areas	1	0	3	0
Sandy Area	1	0	5	0
Water Bodies	0	0	0	0
Wetland	160	50	300	20
Others	0	0	0	0

Willingness to pay (WTP) is the maximum amount an individual is ready to pay in order to obtain a good or a service and reflects both the assigned and perceived utility by the individual (Mitchell, 2013). WTP is widely used in environmental economics to obtain estimates of ecosystem services' nonmarket value, calling forth public preferences for conservation, restoration, or sustainable management practices (Hanemann, W. M, 1991). Stated preference methods such as contingent valuation questionnaires or choice experiments can be employed to elicit WTP values by presenting the respondent with hypothetical scenarios together with payment instruments (Carson, 2012). Empirical studies have found socio-economic factors such as income, level of education, and environmental concern to significantly influence WTP values (Loomis et al., 2000). Along coastal areas, WTP studies provide valuable insights into stakeholders' willingness to pay for measures like wetland restoration, mangrove conservation, and climate change adaptation efforts, and hence enable public preferences to be brought into policy and design schemes (Barbier et al., 2011).

Table 4 : Survey indicators

Dimensions	Indicator	Option with Score in structural equation
Personal Objective Conditions	Gender	Male (1), female (2)
	Age	16-25 (1), 26-35 (2), 36-45 (3), 46-60 (4), > 60 (5)
	Education	Primary / Junior School (1), High School / Technical School (2), Bachelor's Degree (3)
	Job	Government / Institutional staff (1), Company Staff (2), Student (3)Farmer/ Worker and Other (4)
	Monthly Income (LKR/month)	< 20,000 (1), 20,000-50,000 (2), 50,000-100,000 (3), 100,000-200,000 (4), < 200,000 (5)

	Residency	Domestic Tourist (1) , Foreign Tourist (2)
Subjective Perceptions on WTP	Entrance experience	0 times (1), 1-2 times (2), 3-5 times (3), > 5 times (4)
	Know Bentota	Professional (5), familiar (4), know something (3), know a little (2), know nothing (1)
	Benefits	Scenic Beauty (1), Bird Watching (2), Boat Rides (3), Recreation (4), Biodiversity (5)
	Do you like to pay small amount?	Yes (2) No (1)
	WTP for Bentota	Strongly willing (5), willing (4), not care (3), refuse (2), strongly refuse (1)
	WTP represents importance	LKR500 (1) LKR 1000 (2) LKR 1500 (3) LKR 2000 (4) >LKR 2500 (5)
	WTP represents importance	Very important (5), important (4), common (3), unimportant (2), completely unimportant (1)
Intentions towards Ecosystem Management	Payment Method	Donation to environmental agency (1), Public donation (2), Taxation (3), Entrance fee
	Motivator for payment	Bird Watching (1), Eco-tourism benefits (2), Tax incentives (3), Recognition/certification (4), Personal satisfaction (5)

Data Analysis

The InVEST carbon storage model results for the Bentota River Estuary reveal clear spatial variations in carbon density across different land use and land cover (LULC) types. By overlaying the carbon storage map with the classified LULC dataset, it becomes evident that mangrove forests, riverine wetlands, and dense coastal forest patches are the dominant carbon storage units within the estuary. These areas exhibit significantly higher aboveground and soil carbon values compared to other LULC types, reflecting their dense biomass and high organic matter content in saturated soils.

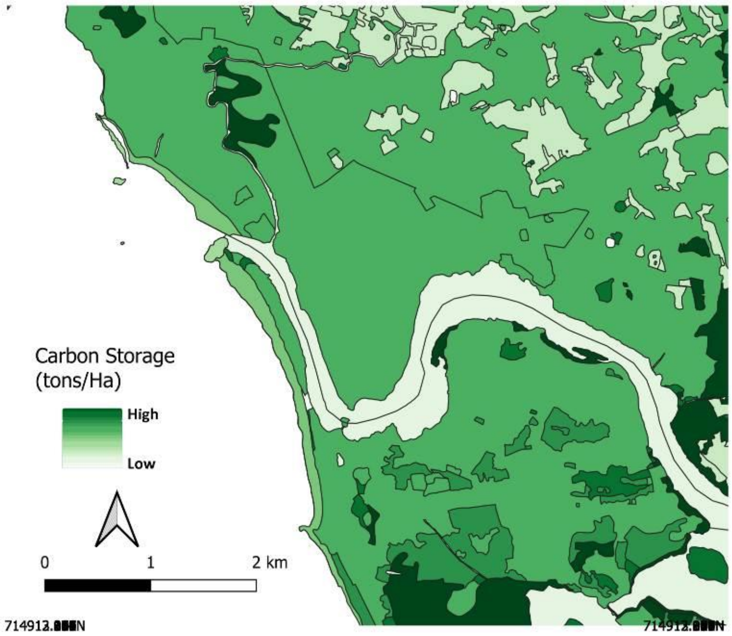

Fig. 9: Carbon Storage Map
Source: Author

Conversely, built up urban areas, sandy beaches, and bare lands register minimal carbon storage, indicating their limited role in climate regulation services. Agricultural lands within the estuary, particularly coconut plantations and paddy fields, show intermediate carbon values, with aboveground carbon largely dependent on vegetation maturity and cropping cycles. Carbon hotspot analysis highlights the mangrove belts along the lower estuary and the upstream forested riparian zones as the most valuable zones for carbon sequestration. These hotspots are critical not only for their climate regulation benefits but also for supporting biodiversity, protecting against coastal erosion, and sustaining fish breeding habitats.

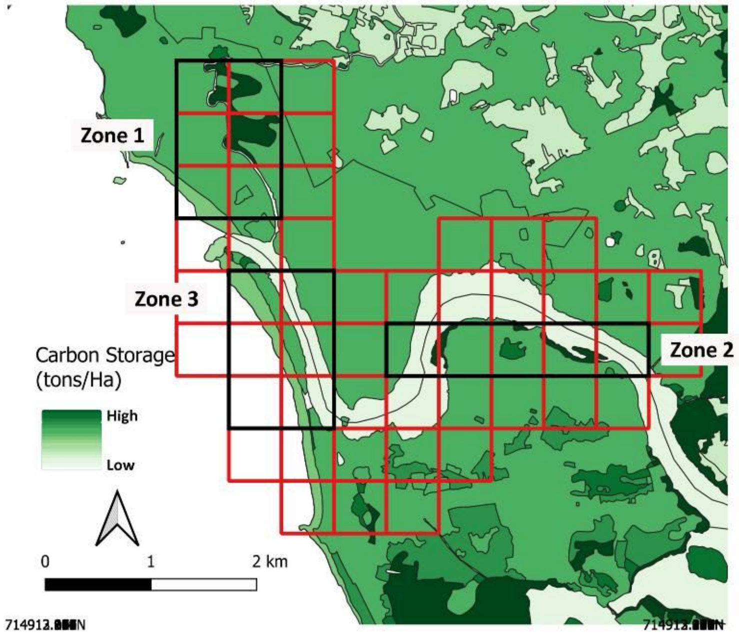

Fig. 10: Case Study Demarcations
Source: Author

The spatial distribution of carbon storage in the Bentota River Estuary was assessed using a grid-based approach, where the study area was divided into uniform red grids. Each grid represents a spatial sampling unit that allows comparison of carbon stock values across different land cover types. The shading of the map illustrates variations in carbon sequestration, with darker tones corresponding to high-carbon ecosystems (mangroves and dense riverine vegetation) and lighter tones representing low carbon areas (urban settlements, bare land, and built environments). Mangrove dominated grids in the estuary show the highest carbon stock values, averaging approximately 3713 tons/ha, consistent with the global recognition of mangroves as blue carbon ecosystems. These high-density carbon grids align with intact mangrove belts along the riverbanks, providing critical ecological services such as flood regulation, salinity buffering, and biodiversity support. In contrast, grids corresponding to built-up and heavily disturbed areas exhibit the lowest carbon stock values, approaching near zero in some patches due to vegetation clearance and impervious surfaces. The grid analysis not only quantifies carbon variation but also highlights spatial fragmentation. Clusters of high carbon grids are separated by medium and low-carbon areas, reflecting the tension between ecological conservation and tourism-driven development in Bentota. This spatial insight emphasizes the need for targeted conservation strategies, such as strengthening mangrove cores, restoring degraded buffers, and integrating carbon smart tourism design.

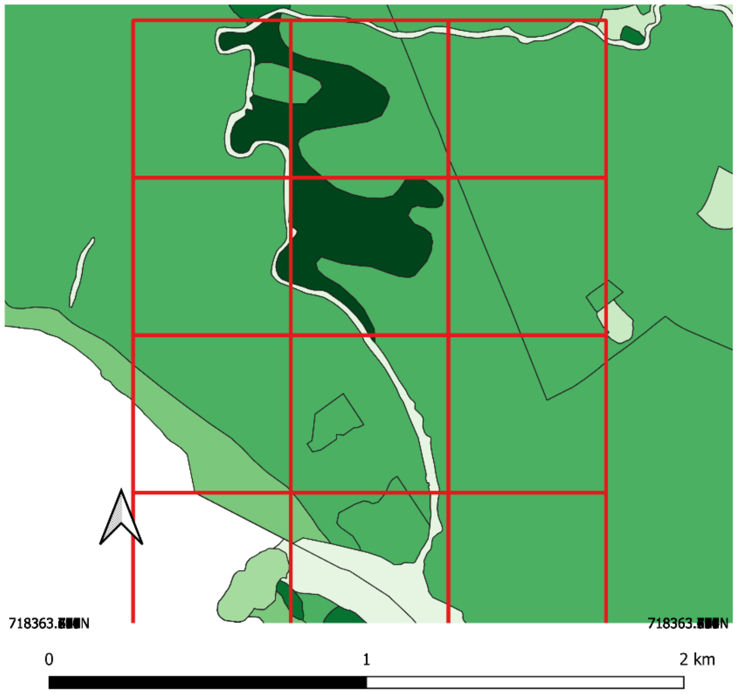

Fig. 11: Carbon Storage of Zone 1
Source: Author

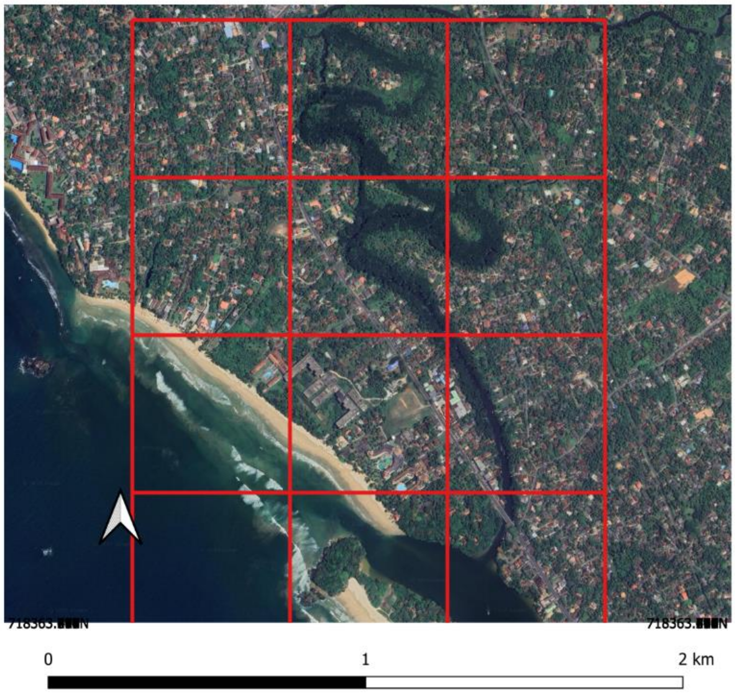

Fig. 12: Satellite Image of Zone 1
Source: Author

The high density carbon zones correspond primarily to mangrove ecosystems, dense riverine vegetation, and forest patches. Mangroves are globally recognized as highly efficient blue carbon ecosystems due to their ability to store carbon both aboveground, through dense woody biomass, and belowground, through organic rich soils. In the Bentota estuary, these zones exhibited the highest carbon storage potential, with average stock values surpassing 3,700 tC/ha in some mangrove patches. Beyond their role in carbon sequestration, these areas function as natural flood buffers, salinity regulators, and biodiversity refuges, supporting migratory birds, fish habitats, and shoreline stabilization. Low impact strategies such as mangrove boardwalks, interpretive trails, and birdwatching towers can integrate eco-tourism without compromising carbon storage or ecological integrity.

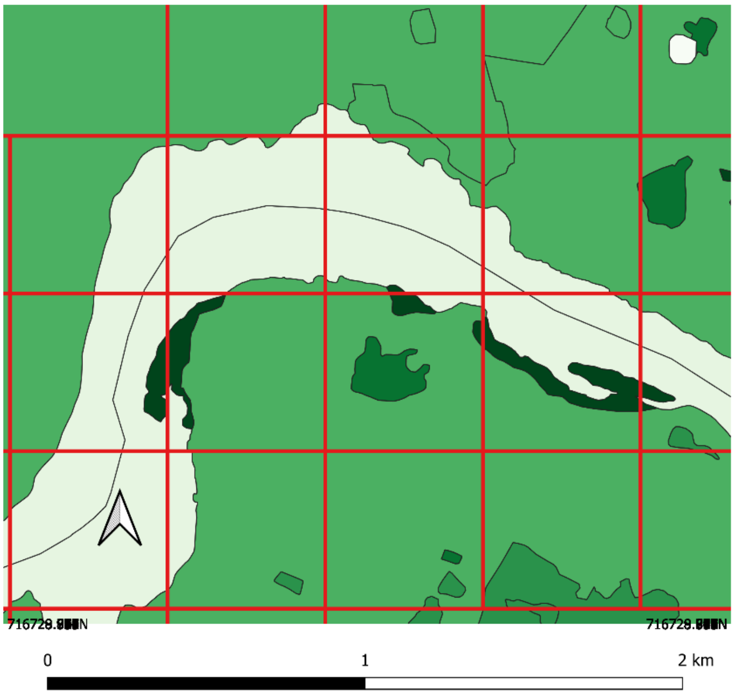

Fig. 13: Carbon Storage of Zone 2
Source: Author

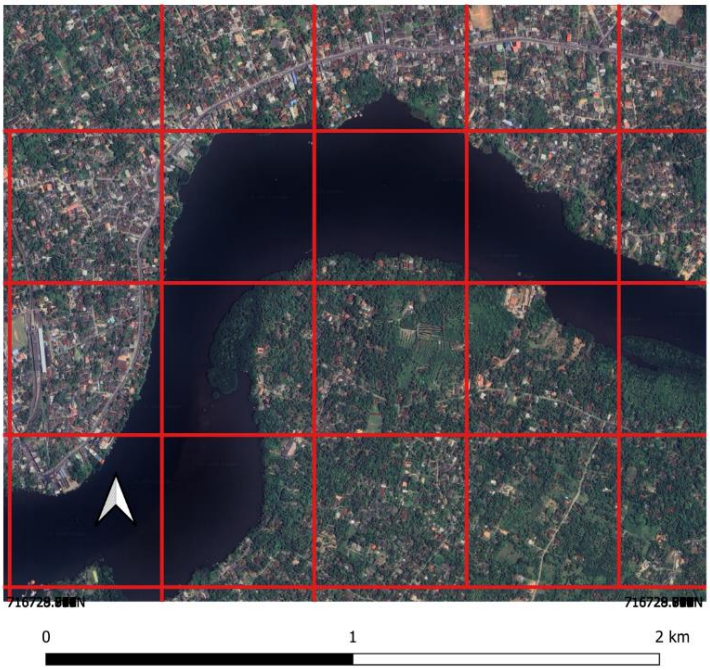

Fig. 14: Satellite Image of Zone 2
Source: Author

Sub-carbon zones include agricultural lands (paddy, coconut plantations), home gardens, and transitional vegetation patches. These areas demonstrated moderate carbon storage potential, higher than urban lands but considerably lower than mangroves or forests. Their carbon contribution arises mainly from perennial crops and scattered tree covers. Ecologically, these are multifunctional landscapes that combine livelihood support with some level of carbon sequestration, although their fragmented and disturbed character reduces their overall ecological value. From a landscape architectural lens, these areas serve as buffer landscapes that can be enhanced through sustainable agroforestry practices, eco-friendly farming, and the incorporation of green infrastructure such as bioswales, hedgerows, and wetland farming edges.

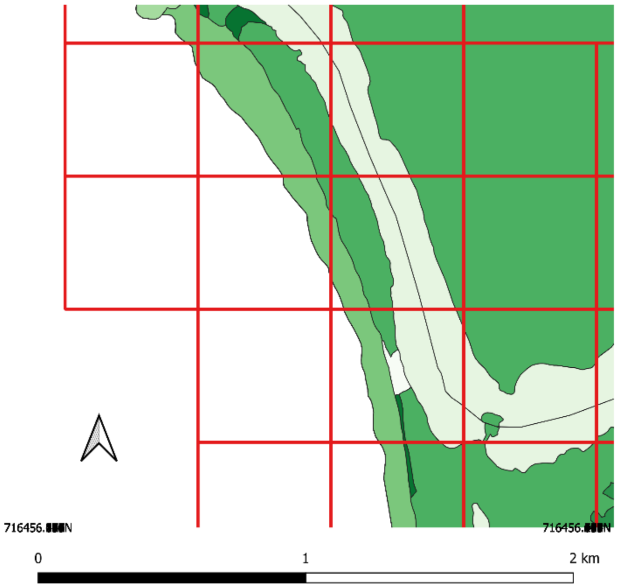

Fig. 15: Carbon Storage of Zone 3
Source: Author

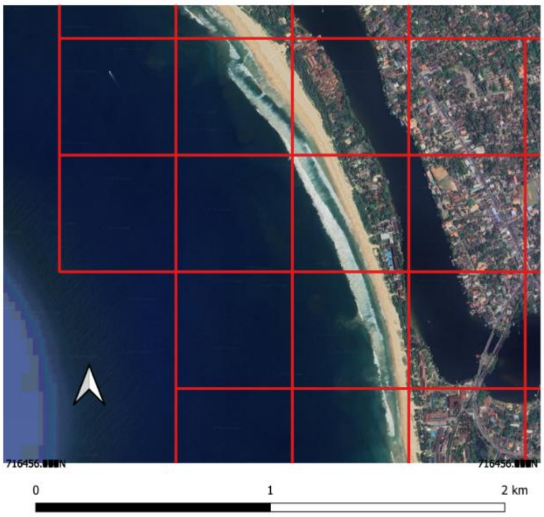

Fig. 16: Satellite Image of Zone 3
Source: Author

The low-carbon zones are concentrated in built-up areas, including hotels, boat jetties, and heavily modified stream edges. These landscapes exhibit very low carbon storage potential due to vegetation clearance, soil compaction, and conversion to impervious surfaces. Urban expansion and tourism driven infrastructure development have fragmented carbon rich habitats, reducing their ecological resilience. Despite their limited carbon storage function, these areas remain socio economically significant, as they support livelihoods through tourism and hospitality industries. In landscape design terms, this zone provides opportunities for nature integrated tourism development, including green roofs, vertical gardens, and riparian planting. Policy tools such as carbon offset schemes can be linked to hotels and tourism operators, encouraging them to reinvest in mangrove restoration and carbon-neutral operations.

Table 5 : Characters of Zones

Carbon Absorption Zone	Typical Land Uses	Carbon Storage Potential	Ecological Role
Zone 1: HighDensity Carbon Areas	Mangroves, dense riverine vegetation, forest patches	Very high	Flood buffer, salinity regulation, biodiversity refuge
Zone 2: Sub Carbon Areas	Agriculture landsc,home gardens, transitional vegetation	Moderate carbon storage	Fragmented, disturbed, minimal ecological value
Zone 3: Low Carbon Areas	Hotels, Jetties, Commercial Areas	Very low carbon storage	Supports livelihoods while providing ecological services

However, fragmentation analysis reveals that these high-carbon areas are discontinuous, especially along the western bank of the estuary where tourism infrastructure and scattered residential developments interrupt natural vegetation corridors. This spatial fragmentation poses a risk to long term carbon storage and ecosystem resilience. Therefore, maintaining connectivity between these carbon rich patches through green corridors, riparian buffers, and targeted restoration in degraded zones is essential for enhancing carbon sequestration potential and ecological integrity.

The statistical analysis of the collected data was carried out in order to evaluate the socio-economic characteristics of respondents, their perceptions of ecosystem services, and their willingness to financially contribute to conservation. Both descriptive and inferential statistical methods were employed to ensure a comprehensive understanding of the data patterns. The analysis was conducted using the Statistical Package for the Social Sciences (SPSS), which enabled the systematic exploration of relationships between variables, identification of significant trends, and testing of hypotheses.

Contingency Tables

	WTP					
Payment_Method	LKR 1000	LKR 1500	LKR 2000	LKR 3000	> LKR 3000	Total
Donation to environmental agency	3	1	1	3	2	10
Public donation	1	1	2	0	1	5
Taxation	3	5	1	3	14	26
Entrance fee	0	1	4	3	1	9
Total	7	8	8	9	18	50

Note. Each cell displays the observed counts

Chi-Squared Tests

	Value	df	p
X^2	21.28	12	.046
N	50		

Note. Continuity correction is available only for 2x2 tables.

Fig. 17: Relationship Between WTP Levels and Payment Method
Source: Author

Contingency table analysis systematically investigated payment modes under Donation to Environmental Agency, Public Donation, Taxation, and Entrance Fee, against willingness to pay (WTP) categories (LKR 1000, 1500, 2000, 3000, and >LKR 3000). The results showed that Taxation was the most favorable payment means to most respondents, as 26 out of 50 respondents (52%) chose it, particularly at higher WTP rates (>LKR 3000). Entrance Fees attracted moderate support as 9 respondents responded. Donations to Environmental Agencies obtained somewhat higher support from 10 respondents. Public Donations were found as least favorable with 5 respondents chose it. It can be observed here that the higher WTP rates were concentrated in Taxation and Entrance Fees. It is suggesting that respondents who pay more in value prefer ordered or compulsory payment.

Chi-square test confirmed an association at a statistically significant level between the willingness to pay (WTP) classes and payment methods utilized. p value is 0.046. The evidence indicates differences in preferences for payment systems across different classes of WTP. Lower WTP groups had a penchant to prefer voluntary payments. As a example, Higher WTP groups had a favorite in form of donations such as taxation and entrance fees. The findings show the importance of adopting hybrid financial strategies to support conservation. It is combining both voluntary and obligatory payment systems to match varied stakeholder preferences and support fair and durable management.

Contingency Tables

Benefits	WTP					Total
	LKR 1000	LKR 1500	LKR 2000	LKR 3000	> LKR 3000	
Scenic beauty	4	0	0	8	3	15
Bird watching	1	2	1	0	2	6
Boat rides	1	3	5	0	4	13
Recreation	1	1	1	1	8	12
Biodiversity	0	2	1	0	1	4
Total	7	8	8	9	18	50

Note. Each cell displays the observed counts

Chi-Squared Tests

	Value	df	p
X^2	36.98	16	.002
N	50		

Note. Continuity correction is available only for 2x2 tables.

Fig. 18: Association Between WTP Levels and Benefits
Source: Author

Cross tabulation analysis of willingness to pay in relation to perceived ecosystem benefits from the Bentota River Estuary showed significant differences in respondents' expressed preferences. Scenic beauty (30%), recreation (24%), and boat rides (26%) emerged as highly valued services, while bird watching and biodiversity conservation elicited comparatively lower choice rates. Notably, WTP categories in higher denominations (above LKR 3000) were significantly associated with recreation and boat rides, suggesting respondents value direct use cultural and recreational services more than nonuse ecological services in monetary terms. The Chi-square analysis confirmed an association between WTP and ecosystem benefits, both statistically significant (X^2 = 36.88, df = 16, p = 0.002), reflecting non uniformity in valuation across different types of services. This observation suggests that ecosystem services related to direct recreational experiences evince stronger incentives for financial support, whereas regulating and supporting services may require different funding schemes or awareness promoting initiatives. On the part of landscape architecture, this highlights an added importance to design estuarine landscapes maintaining ecological integrity and providing accessible cultural and recreational experience, as these dual benefits appear to boost public willingness to support conservation initiatives.

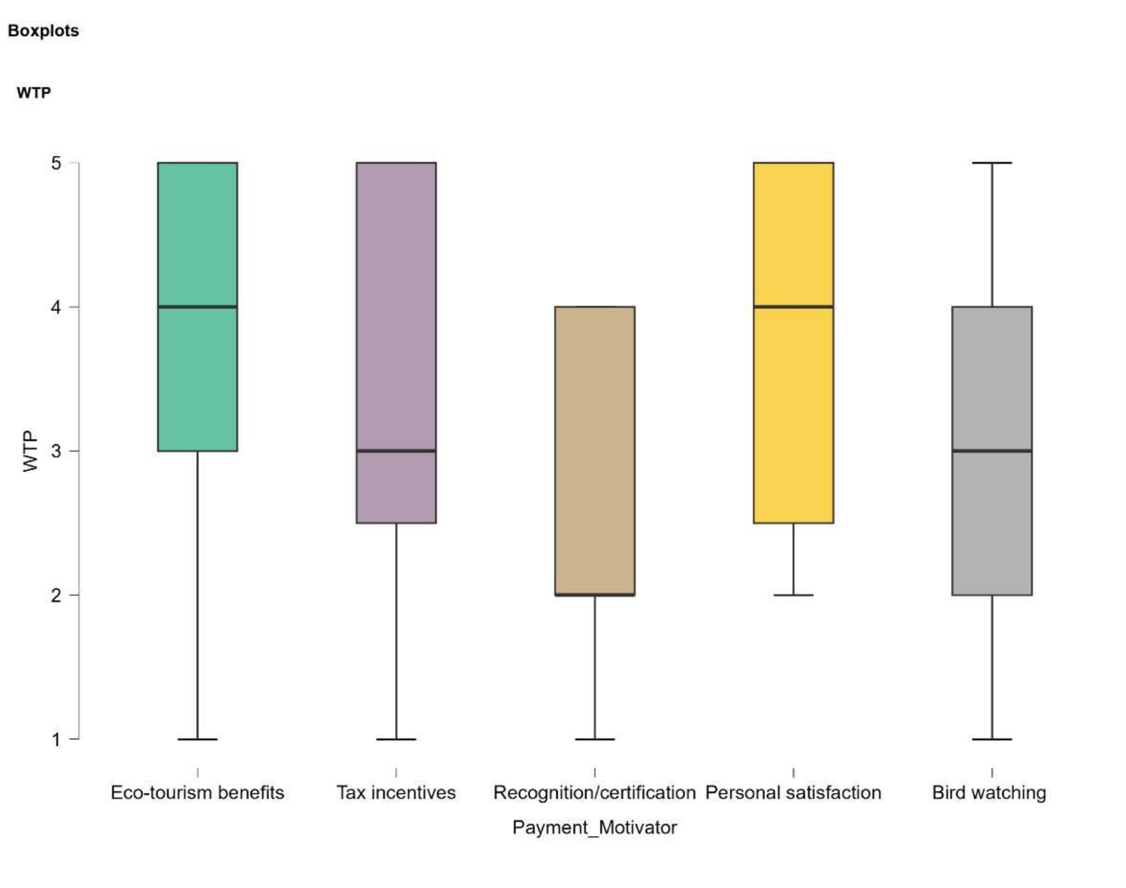

Fig. 19: Analysis of boxplot – WTP to Payment Motivators
Source: Author

The analysis of boxplots regarding willingness to pay (WTP) in relation to various payment motivators offers valuable insights into the determinants of public financial support for conservation efforts in the Bentota River Estuary. The findings reveal that intrinsic motivators, including benefits derived from eco-tourism and personal satisfaction, correspond to the highest median WTP values, indicating that individuals are more willing to provide financial contributions when payments are inner linked to personal experiences and ecological enjoyment. Motivators such as recognition or certification include the lowest median WTP values, signifying a limited public interest in formal acknowledgment as a motivating factor for conservation funding. Tax incentives and bird watching occupy a middle range. However, the broader distribution of responses pertaining to tax incentives illustrates a divergence of opinions, with certain respondents displaying strong support while others express considerable opposition to this strategy. The whiskers across all categories encompass the full range of responses, accentuating the variability in public preferences and highlighting the existence of both highly supportive and non-supportive individuals across all motivational factors. In summary, the analysis emphasizes that strategies for financing conservation should focus on mechanisms that enhance personal and ecological advantages, particularly those related to eco-tourism and recreational activities, while employing recognition and incentive-based strategies solely as supplementary measures.

Final Framework Overview

The conceptual framework developed here seeks to apply ecosystem services valuation (ESV) to coastal landscape design in Sri Lanka by creating a pragmatic, design based approach that synthesizes ecological appraisal, socio-economic assessment, and spatial design interventions. Centering on the case study of the Bentota River Estuary, the framework integrates two primary sources of information. They are spatially explicit biophysical data related to carbon stock and connected regulating services from InVEST and land use and land cover (LULC) maps, and socio economic preferences and financing abilities from willingness to pay (WTP) survey data. Rather than conceptualizing valuation as an abstract economic idea alone, the framework translates valuation results into usable design and policy options that landscape architects and planners can use at both the sub region and site level. The approach is systematically organized over seven iterative stages.

1. Baseline Assessment
2. Service Prioritization
3. Spatial-Economic Integration
4. Design Translation
5. Financing
6. Governance Mechanisms
7. Implementation and Stakeholder Engagement
8. Monitoring and Adaptive Management

Each of these stages has clearly defined inputs, outputs, and decision points. The baseline assessment will bring together spatial land use & land cover data, carbon pool inventories, habitat quality assessment and existing human use. Service Prioritization will combine ecological value and social value, which will be assessed in terms of willingness to pay (WTP) and qualitative observations from stakeholders. Spatial Economic Integration will overlay maps detailing ecosystem hotspots with socio-economic data to identify high conservation priority areas. Design Translation will convert high priority areas into implementable design prescriptions that include conservation zones, restoration corridors, eco buffer areas, and nature integrated tourism nodes. Finally, Financing and Governance will align payment streams of entrance fees, special taxes, voluntary offerings and payments for ecosystem services appropriate for each zone's service benefit profiles. Implementation and Stakeholder Engagement will translate physical actions by phased projects and shared management agreements.

The great news about the framework is that it can make trade-offs visible and actionable. For example, if a prospective tourist development zone overlaps with a carbon heavy mangrove patch that also has high WTP for recreation and scenic beauty. The framework provides a decision pathway, conserve the mangrove as a conservation core, develop low impact visitor accessibility in and adjacent to the mangrove and connect a portion of the visitor revenue to a conservation trust that will invest in ongoing protection. If there is high WTP from the community but only medium level ecological value. Then the framework allows for investment in restoration that could deliver both ecological function and cultural experience enhancement. The ultimate framework is deliberately modular. The components provide independent utility, but they can be brought together to provide systemic design and policy approaches.

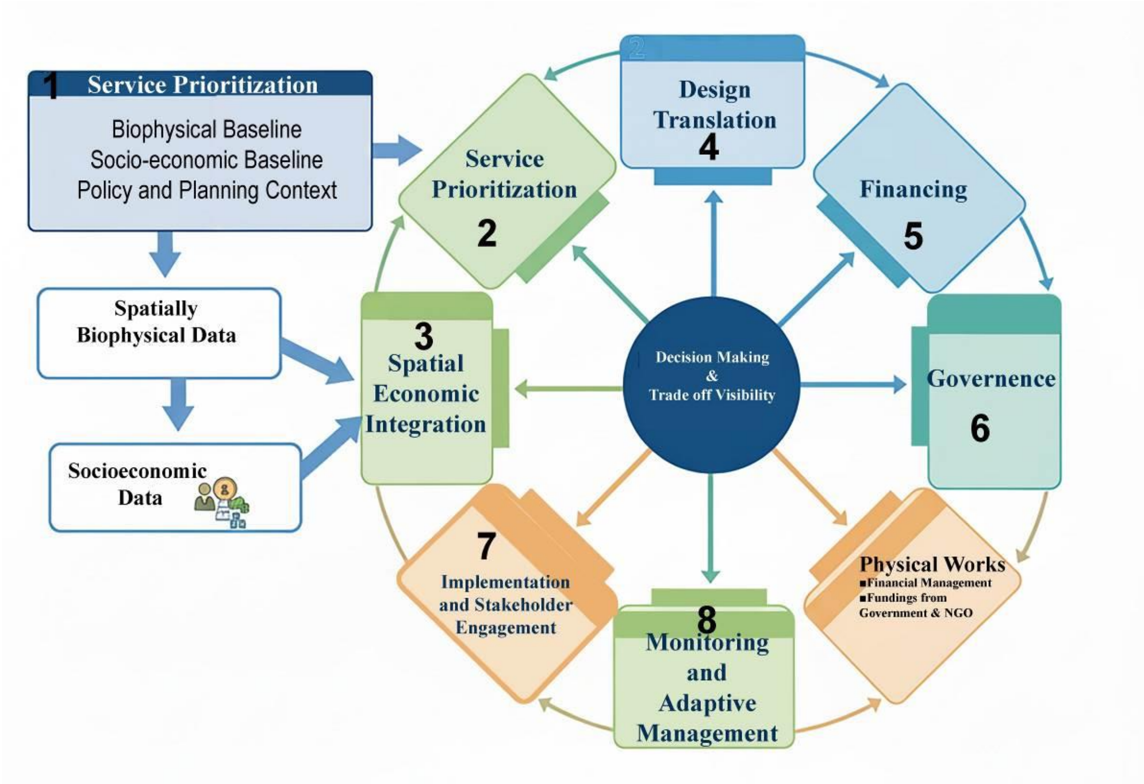

Fig. 19: Framework Overview
Source: Author

Conclusion

The framework presented in study offers a practical and holistic strategy for fixing ecosystem services valuation into coastal landscape practice. The method incorporates spatial carbon based assessments, willingness to pay policy analysis and the translation of design to support evidence based prioritization. The case study of the Bentota River Estuary demonstrated the value of integrated method by showing how to protect and restore high carbon mangrove cores, how buffer zones can support livelihood without compromising ecological function and how tourism infrastructure can be re directed to support conservation.

Research findings form for some recommendations. The application of Ecosystem Service Valuation (ESV) in coastal planning procedures is important at both municipal and provincial scales and can be achieved by integrating the framework in environmental impacts assessment and approval of development. Various mechanisms for funding conservation must go through pilots to establish alternatives. They are feasible both socially and administratively. Building capacity for landscape architects and local authorities is essential to provide with more expertise in using valuation tools like InVEST. Monitoring programs are of a participatory nature should be established to quantify ecological indicators (such as carbon stocks and species richness), social indicators (such as household income from conservation enterprises) and monetary indicators (such as fee revenue and funds for conservation) and in the process, inform adaptive management. Finally, the framework should cover broader coastal systems in Sri Lanka, necessitating appropriate contextual refinements, such as carbon pool data that is localized and socio cultural valuation related inputs.

The research shows that merging ESV into landscape design is not a single technical exercise. It combines assessment, design, finance, and governance. Sri Lanka can enhance ecological resilience, strengthen climate adaptation and align human development with long term sustainability. The study also emphasizes the need to expand the framework to include other critical ecosystems. It combines future climate scenarios. The framework highlights the importance of recognizing social and cultural dimensions of ecosystem services. WTP provides economic evidence, cultural values, spirituality, and community identity demand approaches. Valuation outcomes are engaging with practical financing mechanisms. Eco tourism fees, hotel linked carbon offsets, and community conservation funds will further strengthen the translation of ESV into actionable strategies.

In conclusion, this framework come up with a replicable and adaptive model for integrating ecosystem services valuation into coastal landscape design in Sri Lanka. Framework promotes cross discipline between ecologists, economists, planners, and landscape architects. These strategies will be essential for protecting ecosystem services that support biodiversity, climate resilience, and community wellbeing. The framework helps as a model for sustainable coastal management.

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