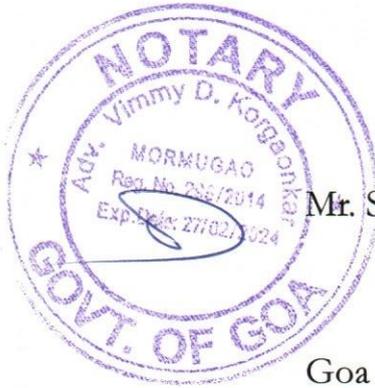


BEFORE THE HON'BLE NATIONAL GREEN
TRIBUNAL, WESTERN ZONE BENCH, PUNE

Execution Application No. 05/2023

In

Appeal No. 16/2022



Mr. Suvarn Rajaram Bandekar ... Applicant

Versus

Goa Coastal Zone Management
Authority & Others ... Respondents

AFFIDAVIT IN REJOINDER

MAY IT PLEASE YOUR LORDSHIPS:

I, Mr. Suvarn R. Bandekar, son of Late Shri Rajaram N.S. Bandekar, Age 70 years, R/o. Raj Tara, F.L. Gomes Road, Vasco-da-Gama, Goa, the Applicant, do hereby on solemn affirmation beg to state and submit as under:

- 1) I say that pursuant to the hearing by this Hon'ble Tribunal on 04.12.2023, the Respondent No. 1 has **partly** complied with the Order dated 25.03.2022 by demolishing the structures from 15.12.2023 to 18.12.2023.
- 2) I say that the Order dated 25.03.2022 apart from ordering demolition also requires and mandates that the land after demolition of structures be restored to its original condition

S. N. Bandekar

besides other directions.

- 3) I say that as the structures were removed/ demolished by the Respondent No. 1 through the Respondent No. 3, the expenditure incurred towards the demolition are to be quantified so as to be recovered from the Respondents 5 to 12 as the arrears of Land Revenue, and not borne by the Government.
- 4) I say that a perusal of the Affidavit dated 30.12.2023 whilst confirming the demolition nowhere indicates as to the time frame or the steps to be taken in respect of the remaining aforesaid directions contained in the Order dated 25.03.2022.
- 5) I say that infact the Order dated 25.03.2022 also requires a compliance report in respect of execution of the Order in its totality to be submitted.
- 6) I say that photographs annexed hereto as Annexure 1 and Annexure 2 clearly shows that whilst the structures have been demolished no steps towards restoration of land to its original condition have been taken till date.
- 7) I say that infact the Respondent No.1 has also not quantified

S. N. B. order



the environmental compensation that would be recoverable from the violator/ Respondents 5 to 12.

- 8) I say that this Hon'ble Tribunal in matter bearing No. O.A. 1 of 2019 had directed the Respondent No. 1 to form a Committee to assess the environmental compensation payable by a violator.
- 9) I say that on perusal of the conduct in the present matter it can be observed that the Respondents 5 to 12 have been able to evade and hoodwink the authorities for more than 20 years by raising false and improbable defenses so as to delay justice being done in respect of the illegal structures existing in Survey No. 16/7 of Sernabatim Village, Salcete, Goa.
- 10) I say that infact the Respondents have done colossal damage to the environment as illegal structures admeasuring more than 760 Sq. Mtrs. were constructed by destroying the naturally occurring environment/ soil in the area and which was compounded by the fact that the said illegalities managed to evade demolition for more than 20 years.
- 11) I say that in terms of the law laid down the damages to the environment have to be recovered from the violators so as to

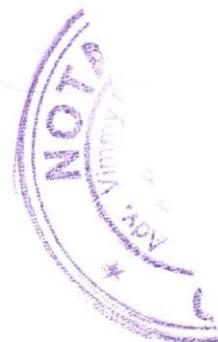
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act as a deterrent as the Respondents 5 to 12 appear to be habitual offenders, this being the second case of environmental destruction done by the said Respondents as in another instance the same said Respondents had illegally constructed a Mud Road of about 80 meters in length, 6 to 8 meters in width and 2 to 3 feet in height by dumping laterite boulders and mud in a CRZ 1 area within 200 meters of HTL.

12) I say that infact the aforesaid illegal Mud Road was made inoperational by using heavy earthmoving machinery and dumpers as also deep trenching of the laterite boulders and mud on the sides, and in respect of which a matter is presently at large before this Hon'ble Tribunal with the next date fixed on 21.02.2024.

13) I say that fastening of the environmental compensation as quantified by the Committee formed by the Respondent No.1 is essential in fulfilling the Orders passed by this Hon'ble Tribunal so as to act as a deterrent for violators and a remedy towards restoration towards the untold environmental destruction and damage done by the

S. N. D. S. D. S. D.



Respondents 5 to 12 on account of the existence of the illegal structures.

14) I say that the fastening of liability in terms of environmental compensation would infact be in furtherance of the Order dated 25.03.2022 upheld by this Hon'ble Tribunal and the Hon'bl Supreme Court and would infact assist in the restoration of the land to its original condition.

15) I, the Applicant therefore most respectfully urge and request this Hon'ble Tribunal to direct the Respondent No.1 to comply with its own Order dated 25.03.2022 in letter and spirit in totality by ensuring that the restoration of land to its original condition is fulfilled and imposing a penalty as environmental compensation determined by the Respondent No. 1 in terms of the Report for environmental compensation prepared pursuant to directions from this Hon'ble Tribunal so as to impose the same upon the Respondents 5 to 12 and ensure its realization from the said Respondents.

16) I am annexing hereto as Annexure 3 the report prepared by the Committee for calculating the compensation payable for

S. N. S. - del

environmental damage.

17) I, the Applicant therefore state that the Affidavit filed by the Respondent No.1 dated 30.12.2023 may be taken on record only subject to the Respondent No. 1 being directed to file a fresh Affidavit clearly laying down the steps proposed to be taken on account of its failure to fulfill and comply in totality with its own Order dated 25.03.2022 and pointed out above as also in compliance towards environmental compensation payable in terms of the report prepared by the expert Committee and annexed hereto as Annexure 3.

Solemnly affirmed on 13th day of February 2024 at Vasco-da-Gama, Goa.

Date: 13.02.2024

Place: Vasco-da-Gama

S. N. B. S. S. S.
DEPONENT



worn/solemnly affirmed before
 By *Savarn R. Bandalca*
 who is known to me / ~~known~~
 By

Vimmy 13/2/2024
 Adv. VIMMY D. KORGAONKAR
 NOTARY
 1st. Floor, Laxmi Narayan Niwas
 Balabaim, Vasco-da-Gama, Goa
 Reg. No. 249/2024

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ANNEXURE I



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ANNEXURE 2



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GOA COASTAL ZONE MANAGEMENT AUTHORITY

C/o Department of Environment & Climate Change (Govt. of Goa)

Dempo Tower 4th floor, Patta Plaza- Panaji Goa

Website: www.czma.goa.gov.in

ANNEXURE 3

Ref. No. GCZMA/RTI/22-23/01/ 959

Date: 08/08/2022

To,

✓ Tina Kerkar

Suvarn Bandekar Building,

Swatantra Path,

Vasco-Da-Gama, Goa.

403802

Sub: Information under Right to Information Act 2005.

Ref: Your RTI Application dated 08/07/2022 and received by this Authority on 08/07/2022.

Madam,

With reference to above, it is informed as under:

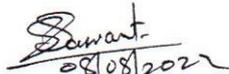
Sr No	Information sought	Reply of PIO
1	Certified copy of the Order in respect of property bearing Survey no. 208/1-C at Khobra Vaddo, Calangute, for illegally carried out by M/s. Ashwin Holding Pvt. Ltd. Within the No Development Zone in GCZMA meeting No.303 in case No. 1.17.	With regards to point no 1 information sought for does not correspond with meeting no 303 your kindly requested to be specific as to what information you required.
2	Certified Copy of the calculation arrived at by this Authority with respect to the Environmental compensation of Rs. 1,28,420/- for Sand Dunes destruction.	As available in office file records enclosed herewith certified copy of the report prepared by 03 Members Committee as directed by Hon'ble NGT, Principal Bench vide Order dated 26/10/2021 and 08/12/2021 in O.A. No. 01 of 2019 titled "Environmental Compensation for Coastal Damage through Total Ecosystem Service Values.
3	Certified Copy of the Resolution wherein the formula for calculating the Environmental Compensation was derived and agreed by this Authority.	You may refer Goa Coastal Zone Management Authority official website (https://czma.goa.gov.in/) Kindly refer the Minutes of Meeting 294 th dated 03/03/2022 at page no. 70 to 73.

The reply/information available with this office may be collected from this office, on payment of Rs.48/- (Rupees forty eight only).

The period within which an appeal against such rejection may be preferred is 30 (Thirty) days and the particulars of the Appellate Authority are as follows:

"The Member Secretary, Goa Coastal Zone Management Authority, who is the First Appellate Authority (FAA) having Office at Dempo Tower 4th floor, Patta Plaza- Panaji Goa."

Yours faithfully



Public Information Officer

(Goa Coastal Zone Management Authority)

Encl:- As above.

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Environmental Compensation for Coastal Damage through Total Ecosystem Service Values

Sujeetkumar M. Dongre, (Expert Member, GCZMA)

Pronoy Baidya (Scientific Consultant)

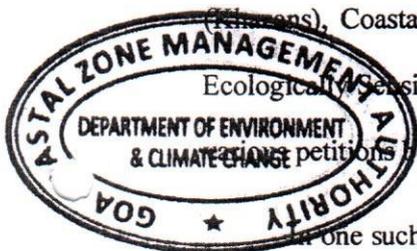
Sávio J. F. Correia (Expert Member, GCZMA)

Introduction.

Apprehension to the damage of the ecology and for preventing irreversible ecological damage of the coastal areas such as Mangroves, Coastal Sand Dunes, Mudflats, Salt Marshes (Mushrooms), Coastal Wetland Habitat, Estuarine Habitat, Turtle Nesting Sites and All Other Ecologically Sensitive Areas in the State of Goa has led to a deep concern leading to filing of petitions before the Hon'ble NGT.

In one such case, the Hon'ble National Green Tribunal (NGT), Principal Bench in the matter of O.A. No. 01 of 2019 filed by *Goa Paryavaran Savrakshan Sangharsh Samiti* vide its Order dated 26.10.2021 and 08.12.2021 has observed that that, compared to the large volume of violations, the recovery of the environmental compensation appears to be a pittance for want of experts so as to assess the environmental damage caused and appropriate compensation to be recovered from the Violator. It was observed that the Goa Coastal Zone Management Authority (GCZMA) in turn approached the State Government for rendering necessary and effective assistance in the process of recovery. Hence the GCZMA made a request to the Hon'ble NGT for forming a Committee in order to assess environmental compensation.

Subsequently, GCZMA formed a committee comprising two Expert Members of the Authority i.e. Mr. Sujeetkumar M. Dongre and Mr. Sávio J. F. Correia and a Scientific



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Consultant Mr. Pronoy Barua for conducting assessment for recovery of damages caused to the Environment by the violator.

The Committee undertook a study and developed a method for assessing environmental compensation to be recovered from the Violators in different areas with respect to the CRZ Violations in areas such as Mangroves, Coastal Sand Dunes, Mudflats, Salt Marshes (Khazans), Coastal Wetland Habitat, Estuarine Habitat, Turtle Nesting Sites and All Other Ecologically Sensitive Areas.

The Report also indicates the process of calculating and levying environmental compensation in cases of violations and the specific procedure to be followed for such recovery of appropriate compensation towards the environmental damage caused to the ecosystem and such funds collected to be used in the action plan for protection of the environment and appropriate restoration of the damaged caused.



The coastal ecosystems of the world form a narrow interface zone between marine and terrestrial areas which provide habitat for a variety of marine plants and animals, where large growing proportions of the human population and global economic activity are located (Ramesh et al. 2015). Coastal ecosystems include estuaries, coastal waters, and lands located at the lower end of drainage basins, where stream and river systems meet the sea and are mixed by tides. These systems include saline, brackish (mixed saline and fresh), and fresh waters, as well as coastlines and the adjacent lands (Convertino et al. 2013). All these water and landforms interact as integrated ecological units. Together, shorelands, dunes, offshore islands, barrier islands, headlands, lagoons, and freshwater wetlands within estuarine drainages are included in the definition of coastal ecosystem.

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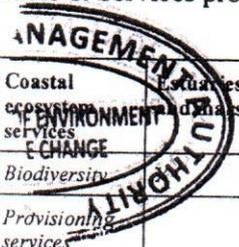
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Coastal zones encompasses 2% of the earth's terrestrial area (McGranahan et al. 2007) and is home to roughly 815 million people globally (MacManus et al. 2021). The coastal ecosystems around the world harbour sensitive ecosystems and provide critical habitats for several endangered species and perform important ecosystem services. These include regulation services such as shoreline stabilization, nutrient regulation, carbon sequestration, and both detoxification of polluted waters and waste disposal; provisioning services such as supplying food, fuelwood, energy resources, and natural products; and amenity services such as coastal livelihoods, shipping, domestic tourism and recreation, and international tourism and recreation (Table 1) (Béné et al. 2011).

Table 1. Services provided by coastal ecosystems (adapted from: Hassan et al. 2005)

Coastal ecosystem services	Estuaries and marshes	Mangroves	Lagoons and salt ponds	Intertidal	Kelp	Rock and shell reefs	Seagrass	Coral reefs	Inner shelf
Biodiversity		X	X	X	X	X	X	X	X
Provisioning services									
Food	X	X	X	X	X	X	X	X	X
Fiber, timber, fuel	X	X	X						X
Medicines, other resources	X	X	X		X			X	X
Regulating services									
Biological regulation	X	X	X	X		X		X	
Freshwater storage and retention	X		X						
Hydrological balance	X		X						
Atmospheric and climate regulation	X	X	X	X		X	X	X	X
Human disease control	X	X	X	X		X	X	X	
Waste processing	X	X	X				X	X	



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Coastal ecosystem services	Estuaries and marshes	Mangroves	Lagoon and salt ponds	Seagrass	Rock and shell reefs	Seagrass	Coral reefs	Inner shelf
Food/storm protection	X	X	X	X	X	X	X	
Erosion control	X	X	X			X	X	
<i>Cultural services</i>								
Cultural and amenity	X	X	X	X	X	X	X	X
Recreational	X	X	X	X	X		X	
Aesthetics	X		X	X			X	
<i>Supporting services</i>								
Biochemical	X	X			X		X	
Nutrient cycling and fertility	X	X	X	X	X	X	X	X

Despite decades of scientific research establishing that coastal habitats comprise one of the most productive and valued ecosystems of the world (Costanza et al. 1997) many coastal ecosystems are heavily degraded, with human pressure on coastlines steadily increasing (Millennium Ecosystem Assessment 2005). As a result of rising human activities both at land and sea, several negative impacts and threats on coastal marine environments have been identified and focused in several high-impact reports (Panetta 2003, United States Commission on Ocean Policy 2004, Millenium Ecosystem Assessment 2005). Coastal marine ecologists, managers, policymakers and most importantly dependents on this ecosystem are concerned about the threats to coastal ecosystems and how these habitats can be protected. Central to this effort is a need to understand and perform economic valuation of ecosystem services that coastal habitats provide.

Coastal habitats can broadly be classified as vegetated (mangroves, salt marshes, and sea grass beds) and unvegetated (mudflats and sand beaches) (Fig. 1).

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Fig. 1. Schematic of the components of the coastal ecosystem

These are critical transition zones between land, freshwater habitats, and the sea. In the case of tidal marshes, productivity can equal that of highly fertile agricultural lands, and plants growing in tidal marshes serve as natural water filters (Daiber 1986). In addition, organically rich tidal mud flats, estuaries and their surrounding wetlands provide the spawning grounds and nurseries for many fisheries, and they support shell-fishery industries in many coastal zones. Inter-tidal mud flats also provide feeding grounds for a variety of birds including migratory birds that use them as roosting areas, and they act as storm buffers because they efficiently dissipate wave energy (French 2002). Mangrove forests protect inland communities and freshwater resources from saltwater intrusion during storms, and they protect near shore settlements from erosion (Rao et al. 2015). Coral reefs also minimize the impact of storms by reducing wind action, wave action, and currents and coral reef structures buffer shorelines against waves, storms and floods (Adger et al. 2005). Coastal dunes are dynamic systems which provide essential benefits to society and supply ecosystem services that can have a clearly recognized market value (Drius et al. 2019).

Economic valuation of ecosystem services is becoming an important tool to understand multiple benefits that ecosystems provide (Guo et al. 2001). Ecosystem services are the many

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and varied benefits provided to humans by the natural environment. Ecosystem services are grouped into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits (Millennium Ecosystem Assessment 2005). Economic valuation of ecosystem services is an economic process which assigns a value (either monetary, biophysical, or other) to an ecosystem and/or its ecosystem services. This economic valuation revolves around assigning values to the four ecosystem services provided by ecosystems (Fig. 2).

- Water
Filtration,
Storm Surge
Protection
- Supporting
indigenous
fishing
practices



Mangrove Ecosystem

- Timber, food
and other
secondary
produce
- Habitat for
biodiversity

Fig. 2. An example of economic valuation of ecosystem services provided by Mangroves.

Studies employ several methods for economic valuation of ecosystem services. These include avoided cost, replacement cost, factor income, travel cost, hedonic pricing, and contingent valuation. Using such methods, in 1997 the estimated value of the world's

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ecosystem services was pegged between US\$16–54 trillion per year, with an average of US\$33 trillion per year (Costanza et al. 1997). Such values, though can best be termed as rough estimates of the actual value of the true ecosystem services that are provided by ecosystems to humans, provides economists and policy makers a base for estimation of service value of ecosystems through ecosystem services and provides an opportunity to evaluate the losses incurred, when ecosystem services are disrupted through ecosystem damage and degradation.

The coastline of Goa is 105 km long, with more than 70 km comprising of linear and wide sandy beaches, that are interrupted by rocky shores, headlands backed by high dunes, sandy pockets and secluded coves backed by rocky cliffs. The coastal habitats also include tidal mud flats, estuarine zones of west flowing rivers and lush patches of mangroves through the estuarine region. Several inland estuarine areas and salt marshes have been recovered in the past for agriculture activities, and such zones are referred to as *Khazans*. Some regions also have been managed for salt production, through construction of salt pans. Several of the inland rivers in Goa are heavily influenced by tidal fluxes and salinity gradients are maintained by traditional networks of sluice gates and bunds. The entire 70 km stretch of sandy beaches along with the estuarine and mangrove habitats are important zones for economic, recreational, cultural, and provisioning activities. This zone also has four identified and protected turtle nesting sites viz. Mandrem, Morjim, Agonda and Galgibag. Further the Agaçaim tidal mudflats is also identified as an important wintering and staging grounds for migratory coastal birds. To protect these important values, the CRZ notification, 2011, sought to protect a specified width of the coast by restricting the setting up and expansion of any industry, operation or process and manufacture or handling or storage or disposal of hazardous substances. The objective of the CRZ 2011 Notification is to ensure livelihood security to the fisher communities and other local communities living in the coastal areas; to conserve and protect coastal stretches, its unique environment, and its marine area and to promote development in a sustainable manner



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based on scientific principles considering the dangers of natural hazards in the coastal areas and sea level rise due to global warming.

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An important aspect of implementing CRZ 2011 is the ability to identify the total ecosystem, service value of our coastal ecosystems, where the maximum human activities take place. In this document, the total ecosystem service value of Goa's coastal ecosystem is calculated using a holistic approach.

Methodology:

In this study we follow the standard meta-analysis approach, that combines results of multiple scientific studies. Meta-analyses can be performed when there are multiple scientific studies addressing the same question, with each individual study reporting measurements that are expected to have some degree of error. We refer to the methodology used by the National Centre for Sustainable Coastal Management in their assessment of coastal and marine ecosystem goods and services - linking coastal zone management to ecosystem services in India: sand dunes. We define Ecosystem Service Value (*ESV*) of an ecosystem as the sum of ecosystem services in different habitats within an ecosystem (*ESV_h*) within an ecosystem using the following equation:



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$$ESV = \sum (ESV_h)$$

Ecosystem Service Value of a habitat (*ESV_h*) can in turn be calculated as the sum of individual service values within a habitat.

$$ESV_h = \sum (A_k \times VC_f)$$

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where A_k is the area (ha) and VC_f the value coefficient of function f (\$/ha/yr) for habitat category 'k'. To adjust for inflation rates since most of the studies used in the meta-analysis have historical data, we used the formula:

$$\frac{CIP \text{ in } 2022}{CIP \text{ in } Study \text{ Year}} \times Study \text{ Year } US\$ \text{ Value} = Current \text{ Value}$$

where CIP is the U.S. Consumer Price Index values obtained from the U.S. Bureau of Labour Statistics.

Result: Habitat wise Ecosystem Service Value (ESV_h)

1. Mangrove Habitat (ESV_{mg}):

The economic values of the mangrove ESV standardized for the 2007 international dollar is

Table 2. According to the existing peer-reviewed literature, ecotourism and fisheries generated the highest economic value (including subsistence) based on the 2007 estimates.

These estimates are based on Delphi Technique method used in this study (Table 2)

(Mukherjee et al. 2014).

Table 2. Ecosystem services provided by mangroves sorted according to their mean economic values (2007 \$/ha*yr).

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Delphi technique categories	Mean economic value (2007 int\$/ha*yr)	No. of estimates	Economic rank	Delphi technique rank
Fisheries (nursery and aquaculture)	17090.1	25	1	1
Ecotourism and recreation	14072.14	10	2	7
Coastal protection	8459.12	9	3	2
Pollution abatement	7859.92	2	4	8
Food	1535.21	16	6	6
Protection from sedimentation	579.28	1	7	3
Energy resources	306.92	8	8	12
Wood and timber	247.34	3	9	3
Carbon sequestration	195.23	3	10	4
Honey	4.23	2	11	9
Fodder	0	0	0	13
Water bio-remediation	0	0	0	10
Protection from salt intrusion	0	0	0	11
Aesthetic value	0	0	0	5
Pharmaceuticals	0	0	0	14
Environmental risk indicator	0	0	0	4

Six of the 16 ecosystem services (highlighted in bold and italics) identified by experts do not have adequate valuations in the peer-reviewed ecological economic literature.
 doi:10.1371/journal.pone.0107706.t002

Table 3. Adjusted and non-adjusted ESVs of different land classes in the Sundarbans

biosphere region.

	MV		CL		CE		MA		IW		UB	
	NAD	AD	NAD	AD	NAD	AD	NAD	AD	NAD	AD	NAD	AD
GR	2	0	0	0	0	0	0	0	0	0	0	0
CR	8	6	303	215	173	125	17	12	18	13	36	26
DR	0	0	0	0	0	0	1399	1006	110	81	0	0
WR	1	0	0	0	0	0	0	0	206	166	1	1
WS	12	10	295	234	0	0	318	253	15	12	0	0
EC	9	8	79	74	9158	8540	1028	959	96	88	0	0
SF	0	0	392	370	0	0	0	0	0	0	0	0
NC	0	0	0	0	0	0	12	9	63	51	0	0
WT	16	11	292	208	0	0	42,401	30,476	111	82	0	0
POLL	7	5	16	12	0	0	0	0	0	0	0	0
BC	5	5	24	17	0	0	0	0	35	26	0	0
HA	184	0	0	0	70	50	4482	3222	90	66	0	0
FP	246	181	1712	1269	861	636	291	214	23	17	0	0
RM	11	8	161	115	4	3	94	67	20	15	0	0
GEN	251	184	768	546	65	47	81	58	4	3	0	0
REC	5	4	60	43	92	67	574	412	81	60	225	166
CUL	30	25	0	0	16	11	0	0	73	54	0	0



MV = Mixed Vegetation; CL = Cropland; CE = Coastal Estuary; MA = Mangrove; IW = Inland Wetland; UB = Urban Built-up; NAD = Non Adjusted; AD = Adjusted; GR = Gas Regulation; CR = Climate Regulation; DR = Disturbance Regulation; WR = Water Regulation; WS = Water Supply; EC = Erosion Control; SF = Soil Formation; NC = Nutrient Cycling; WT = Waste Treatment; POLL = Pollination; BC = Biological Control; HA = Habitat Service; FP = Food Production; RM = Raw Material; GEN = Genetic Service; REC = Recreation; CUL = Cultural Service.

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Finally, the most comprehensive global meta-analysis on mangroves was done in 2012 (Table 5) (Salem and Mercer 2012).

Table 5. Summary statistics for mangrove valuations by type of service (in US\$ ha⁻¹.yr⁻¹).

Service	Obs.	Mean	Min	Max	Median
Fisheries	51	23 613	10.05	555 196	627
Forestry	35	38 115	18.00	1 267 701	576
Coastal protection	29	3 116	10.45	8 044	3 904
Recreation & tourism	14	37 927	1.74	507 358	1 079
Nutrient retention	-	44	-	-	-
Carbon sequestration	7	967	39.89	4 265	217
Nonuse	6	17 373	3.77	50 737	15 212
Ecodiversity	-	52	-	-	-
Water and air purification/waste assimilation	4	4 748	12.43	7 379	5 807
Traditional uses	-	114	-	-	-
Total	149				

Summary of various studies and their respective ESV_h are presented below for mangroves (Table 6). We see that ESV_h varies based on the studies considered since different studies used differing number of parameters for the calculation of ESV_h . Following the methodology of National Centre for Sustainable Coastal Management, we further calculate average values from the studies to arrive at the ESV_h for mangroves.

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Table 6. Summary of various studies and their respective ESV_h

S.No	Study	ESV_{mg} adjusted for US\$ Inflation in 2022 \$/ha/yr
1	Mukherjee et al. 2014	68,474.99
2	Sannigrahi et al. 2019	41,080.48
3	Salem and Mercer 2012	1,53,805.40
4	Costanza et al. 1997	18,981.00
5	Khaleel 2012	13,570.06
Average		59,182.39

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The ecosystem services of sandy coastline can be broadly classified into provisioning, regulatory, cultural, and supporting services. The most important provisioning service provided by sandy coastline and associated sand dunes is supply of groundwater. Sand dunes, act as a barrier between inland and sea, thus regulate water quality and pollution of the region (Carter 1988). It has been estimated that the total provisioning service value of sandy coasts and sand dunes is INR 35,29,800/- per hectare per year [adjusted for USD inflation value as of January 2022] (NCSCM, 2019).

Similarly, regulation service provided by sandy coast and sand dunes are inland protection, disturbance regulation and carbon sequestration service (Table 1). Cultural service provided by this ecosystem is through recreational worth derived from tourism while supporting services are the total biodiversity value and associated services (Table 1) (NCSCM,

Based on the report of National Centre for Sustainable Coastal Management, the indirect use values derived through ecosystem services have been calculated by adjusting for USD inflation value as of January 2022.

Ecosystem Service	Study	ESV_{sd} adjusted for US\$ Inflation in 2022 \$/ha/yr
Provisioning	Barbier et al., 2011	92,835.00
Regulation	Mendoza Gonzalez. 2012; Jorge Brenner et.al. 2010; Pompe and Rinehart 1999; PosfordDuvivier, 1997; Beaumont et.al. 2014	79,061.32
Cultural	Jorge Brenner et.al., 2010; Mendoza Gonzalez., 2012	31,339.97
Supportive	Bhagya and Sridhar., 2009; NOAA, 1997	24,483.58
Total ESV_{sd}		2,27,719.87

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3. Mudflats, Salt Marshes (Khazans) and Coastal Wetland Habitat (ESV_{mf}):

Salt marshes are intertidal grasslands that form in low-energy, wave-protected shorelines along continental margins. Extensive salt marshes (>2 km in width) establish and grow both behind barrier-island systems and along the wave-protected shorelines of bays and estuaries. Salt marshes are characterized by sharp zonation of plants and low species diversity, but extremely high primary and secondary production. The structure and function of salt marsh plant communities (and thus their services) were long thought to be regulated by physical processes, such as elevation, salinity, flooding, and nutrient availability. Below the average adjusted ESV_h have been calculated.



S.No	Study	ESV_{mf} adjusted for US\$ Inflation in 2022 \$/ha/yr
	Ghermandi et al. 2016	10,831.92
	Raj and Azeez 2009	14,571.13
	Costanza et al. 1997	37,202.00
	Average	20,868.35

4. Estuarine Habitat (ESV_{es}):

Estuarine habitats are formed at the mouth of a river, whose environmental factors (such as salinity, temperature, nutrient content, etc.) often fluctuate due to the influence of both tides and rivers. The upper limit of an estuary is referred to as its head, while the lower limit is called the mouth of the estuary. Between the freshwater head and the saline mouth of the estuary lie several zones corresponding to intermediate salinity ranges. Below the average adjusted ESV_h have been calculated.

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S.No	Study	<i>ESV_{es}</i> adjusted for US\$ Inflation in 2022 \$/ha/yr
1	Zhao et al. 2004	49,088.89
2	Ghermandi et al. 2016	18,810.09
3	Costanza et al. 1997	43,380.80
Average		37,093.26

Total Ecosystem Service Value (*ESV*)

Based on the habitat-wise ecosystem service values calculated, using the meta-analysis approach the total ecosystem service value can be calculated using the below formula:

$$ESV = ESV_{mg} + ESV_{sd} + ESV_{mf} + ESV_{es}$$

The above equation is nothing but an expanded version of:

$$ESV = \sum (ESV_h)$$



Habitat Based <i>ESV</i>	Average <i>ESV_h</i> adjusted for US\$ Inflation in 2022, units - \$/ha/yr
<i>ESV_{mg}</i>	59,182.39
<i>ESV_{sd}</i>	2,27,719.87*
<i>ESV_{mf}</i>	20,868.35
<i>ESV_{es}</i>	37,093.26
<i>ESV</i>	3,44,863.87

* This value is a total of average *ESV*'s across different ecosystem services from NCSCM
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Conclusion:

The total *ESV* calculated from the meta-analysis stands to a tune of US\$ 3,44,863.87/ha/yr. Converted to Indian rupees as on the current exchange rate of 75.12 INR/US\$ (17/02/2022), stands to a tune of INR 2,59,06,173.91/ha/yr. When converted in terms of SI units for area, the value stands at INR 2,590.62/m²/yr.

As in is the definition of a coastal ecosystem, the various habitats within this ecosystem: Shorelands, dunes, offshore islands, barrier islands, headlands, lagoons, and freshwater wetlands within estuarine drainages are all interconnected habitats and are crucial to coastal wildlife and their habitats. Damage to any of these interconnected habitats can have cascading effect on other habitats. Hence, the *ESV* calculated through this study can guide the process of environmental compensation for coastal damage recovery caused under the ambit of CRZ 2011



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