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CIRCULARECONOMYAPPROACHESFORMARINEWASTEANDOCEAN PLASTIC MANAGEMENT

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ABSTARCT

Marine waste and ocean plastic pollution have emerged as severe environmental challenges, threatening marine ecosystems, biodiversity, and coastal livelihoods. The rapid increase in single-use plastics, inadequate waste management systems, and limited recycling infrastructure have significantly contributed to the accumulation of plastic debris in marine environments. In this context, the circular economy offers a sustainable framework by emphasising waste reduction, reuse, recycling, and resource recovery. The present study examines circular economy approaches for marine waste and ocean plastic management by identifying major pollution sources, evaluating existing circular practices, assessing stakeholder roles, and proposing effective plastic reduction strategies. The study adopts a mixed-methodsresearchdesign,utilisingbothprimaryandsecondarydata.Primarydatawere collected from 200 respondents representing coastal communities, local authorities, NGOs, and recycling and plastic industries through structured questionnaires and interviews. Statisticaltools suchaspercentageanalysis,meanscores,ANOVA, correlation, andregression were applied for data analysis. The findings reveal that single-use plastics and fishing gear waste are the primary contributors to marine pollution. Circular economy practices such as recycling, eco-design, and ExtendedProducer Responsibilityshowhigh effectiveness inmarine waste management. The study also establishes a strong positive relationship between

stakeholder participationandsustainable plasticmanagement.Overall, theresearchconcludes that integrating circular economy principles with coordinated stakeholder involvement provides a practical and long-term solution for reducing marine plastic pollution and promoting sustainable ocean ecosystems.

KEYWORDS: Circular Economy, Marine Waste, Ocean Plastic Pollution, Stakeholder Participation, Sustainable Waste Management.

1. INTRODUCTION

Marinewasteandoceanplasticpollutionhaveemergedascriticalglobalenvironmental challenges, posing serious threats to marineecosystems, biodiversity, and coastallivelihoods. Rapid industrialisation, urbanisation, and increased reliance on single-use plastics have significantly intensified the accumulation of plastic waste in oceans. Inefficient waste managementsystems,improperdisposalpractices,andlimitedrecyclinginfrastructurefurther contribute to the growing volume of marine debris. As plastics are durable and non-biodegradable, they persist in marine environments for decades, breaking down into microplasticsthatenterthefoodchainandendanger humanandecologicalhealth.Inresponse to these challenges, the circular economy has gained attention as a sustainable alternative to thetraditionallinear modelof “take-make-dispose.” Circular economy approaches emphasise resourceefficiency,wastereduction,reuse,recycling,andrecovery,aimingtoretainmaterials within the economic system for as long as possible. When applied to marine waste and ocean plastic management, these approaches encourage innovative product design, extended producerresponsibility,closed-looprecyclingsystems,andsustainableconsumptionpractices. Suchstrategiesnotonlyreduceplasticleakageintooceansbutalsocreateeconomicvaluefrom waste materials. Effective implementation of circular economy principles in marine waste managementrequirestheactiveinvolvementofmultiplestakeholders,includinggovernments, industries, local communities, and non-governmental organisations. Policy frameworks, technologicalinnovations, publicawareness, andcollaborativegovernanceplay avitalrolein ensuring sustainable outcomes. This study focuses on identifying major sources of marine waste, examining existing circular economy practices, evaluating stakeholder participation, and proposing strategic measures for plastic reduction. By integrating environmental sustainabilitywitheconomicviability,circulareconomyapproachesofferapromisingpathway for addressing marine waste and promoting long-term ocean health.

2. PROBLEMIDENTIFICATION

Theescalating accumulationofmarinewaste,particularlyplasticdebris,hasbecome a pressingenvironmentalandsocio-economic concern globally. Oceans areincreasingly polluted by plastics from land-based sources, fisheries, shipping activities, and coastal industries, leading tohabitatdegradation,biodiversity loss,and adverseeffectsonhumanhealth.Despite various conventional waste management practices, the persistence of plastics in marine environments highlights the inadequacy of linear disposal systems. Furthermore, fragmented governance, limited recycling infrastructure, and insufficient stakeholder coordination exacerbatethechallengeofsustainableoceanplasticmanagement. Inthiscontext,thecircular economy offers a transformative approach, emphasising waste reduction, material reuse, and sustainableresourcemanagement.However,theapplicationofcirculareconomyprinciplesin marine waste management remains underexplored, with limited understanding of effective strategiesandstakeholderroles.Thisresearchseekstoidentifymajorsourcesofmarinewaste, evaluate circular economy practices, and propose actionable strategies to sustainably reduce ocean plastic pollution, bridging the gap between environmental sustainability and practical implementation.

OBJECTIVES

- Toidentifymajorsourcesofmarinewasteandoceanplasticpollution.
- Toexaminecirculareconomyapproachesusedinmarinewastemanagement.
- Toassessstakeholderrolesinmanagingoceanplasticsustainably.
- Tosuggesteffectivestrategiesforcirculareconomy-basedplasticreduction.

3. REVIEWOFLITERATURE

TamilNadu Fishnet Initiatives (2024) reportedbytheTamilNaduPollutionControlBoard, offers apracticalcirculareconomymodelfor reducingmarineplasticpollution. Theinitiative establishedcollectioncentresforabandonedfishingnets,segregatingandredirectingthemfor recycling, demonstrating stakeholder roles in waste transformation. With about 10,000 kg of nets collected and plans to expand across coastal districts, this project highlights how government action and industry collaboration can turn ocean plastic waste into reusable material, mitigating major pollution sources.

Promoting Circularity in India's Plastic Value Chain (2024) by Bardhan et al. explored theeconomic and environmentalbenefits of transitioning India's plastics industry toward full circularity. The authors estimated significant social and economic gains from recycling and

reuse practices compared to linear waste management. Their findings point to reduced environmental burdens and improved resource efficiency, stressing that circular approaches can mitigate plastic leakage into marine environments. This research contributes to policy discourse on effective strategies for plastic reduction and stakeholder engagement in sustainable waste systems.

Ramesh & Jeyachandran (2025) investigated microplastic pollution in marine ecosystems along the Tamil Nadu coast, focusing on source identification and mitigation. The study adopted a forensic approach to trace microplastic origins and evaluated cost-effective interventions such as pellet-capturing systems and periodic cleanup drives. Their analysis underscored the ecological and economic risks of persistent microplastics and highlighted mitigation strategies that align with sustainable waste management practices. These findings contribute to understanding major pollution sources and potential circular economy solutions in coastal marine environments of India.

Rajetal.(2025)examinedplasticwastemanagementstrategiesunderacircular economylens across India. The review emphasized sustainable solutions, including bio-based plastics, blockchain tracking for waste streams, and enterprise-level valuation of waste resources. It outlined how circular planning can reduce leakages of plastics into marine environments by improving reuse, recycling, and valorisation pathways. The authors argued that integrating responsibleproduction and consumption principles is vital to curb marineplastic sources and enhance stakeholder participation in sustainable practices.

EU-India Resource Efficiency & Circular Economy Project (2025) launched in Chennai illustratesmultistakeholderengagementincircularsolutionsforplastics.Thisinitiativefosters collaboration among government agencies, SMEs, and international partners to improve recycling value chains and promote reuse and alternative materials. Workshops emphasized extendedproducerresponsibility(EPR)andinclusivepracticesthatencouragerecycledcontent adoption. The project thus exemplifies a strategic framework to enhance stakeholder roles in marine litter prevention and sustainable plastic management in Tamil Nadu.

4. RESEARCHMETHODOLOGY

This study adopts a mixed-methods approach to analyze circular economy approaches formarinewasteandocean plasticmanagement.Both primary and secondary dataareused to ensure a comprehensive understanding of marine plastic sources, management practices, and stakeholderroles.Primarydataiscollectedthroughstructuredsurveysandinterviewswithkey stakeholders, including coastal community members, local authorities, NGOs, and representatives from recycling and plastic-related industries. A sample of 200 respondents is selected using stratified random sampling to ensure representation from different stakeholder groups. The study area covers selected coastal regions affected by marine plastic pollution. Secondarydataisgatheredfromresearchjournals,governmentreports,policydocuments,and publications of international organizations such as the UN and World Bank, providing theoretical and global perspectives on circular economy practices. For analysis, quantitative data is examined using statistical tools such as SPSS, applying descriptive and inferential techniques, while qualitative data from interviews is analysed through thematic analysis. Ethicalconsiderations include informed consent, confidentiality of responses, and useof data strictly for academic purposes.

5. ANALYSISANDINTERPRETATION

HypothesesoftheStudy

- H01o:Thereisnosignificantdifferenceamongstakeholdergroupsintheirperception of major sources of marine waste and ocean plastic pollution.
- H02o:Circulareconomypracticesdonothaveasignificantrelationshipwithmarine waste management effectiveness.
- H03o:Stakeholderparticipationdoesnothaveasignificantimpactonsustainable plastic management practices.
- H04o:Circulareconomy–basedplasticreductionstrategiesdonotsignificantlyinfluence the reduction of marine waste and ocean plastic pollution.

TableNo5.1StatisticalToolsUsedforAnalysis.

S.No	Statistical Tool	Purpose
1	PercentageAnalysis	Toanalyze respondentprofile
2	Mean&StandardDeviation	Tomeasureperception levels
3	ANOVA	Totestdifferencesamongstakeholdergroups
4	CorrelationAnalysis	Toexaminerelationshipsbetweenvariables
5	RegressionAnalysis	Toassessimpactofcirculareconomystrategies

Table5.2Stakeholder-wiseClassificationofRespondents(n=200) Profile of Respondents (Sample Distribution)

Stakeholder Group	Stakeholder Group	Stakeholder Group
CoastalCommunity Members	80	40.0
Local Authorities	40	20.0
NGOs	40	20.0
Recycling&Plastic Industries	40	20.0
Total	**200**	**100.0**

Inference

Table 5.2 shows that out of 200 respondents, the largest share comprises Coastal CommunityMembers(40%),reflectingtheirdirectinvolvementandexposuretomarinewaste and ocean plastic issues. Local Authorities, NGOs, and Recycling & Plastic Industries each account for an equal proportion of 20%. This balanced representation of institutional, civil society, and industrial stakeholders ensures a comprehensive understanding of circular economy practices and stakeholder roles in marine waste management.

TableNo5.3MeanScoreonMajorSourcesofMarinePlasticPollution Sources of Marine Waste and Ocean Plastic Pollution.

Source of Marine Waste	Mean	Std. Deviation	Rank
Single-useplastics	4.45	0.62	I
Fishinggearwaste	4.12	0.71	II
Urbansewage& runoff	3.98	0.76	III
Industrialplasticwaste	3.74	0.81	IV
Tourism-related litter	3.56	0.84	V

Inference

The table reveals that single-use plastics are perceived as the major source of marine plastic pollution, securing the highest mean score (4.45) and first rank, indicating strong agreementamongrespondents.Fishinggearwastefollowsclosely,highlightingthesignificant role of fishing activities in marine pollution. Urban sewage and runoff and industrial plastic wasteoccupythemiddleranks,suggestingmoderate influence. Tourism-relatedlitter, though still relevant, is ranked lowest, indicating comparatively lesser contribution.

Table5.4ANOVA–StakeholderGroupvsPerceptionofMarineWasteSources Stakeholder-wise Difference in Perception of Marine Waste Sources.

Source of Variation	Sum of Squares	Df	Mean Square	F-value	Sig.
Between Groups	18.42	18.42	18.42	18.42	18.42
Within Groups	245.36	245.36	245.36		
Total	**263.78**	**263.78**			

Inference

TheANOVAresultsrevealastatisticallysignificantdifferenceinperceptionsofmarine waste sources among different stakeholder groups, as indicated by the F-value of 4.87 and a significance level of 0.003. Since the p-value is less than 0.05, the null hypothesis is rejected. This confirms that stakeholder groups such as policymakers, industries, communities, and NGOsdiffermeaningfullyinhowtheyperceivethesourcesofmarinewasteandoceanplastic pollution.

Table 5.5 Mean Score of Circular Economy Approaches Circular Economy Practices in Marine Waste Management.

Circular Economy Practice	Mean	Std. Deviation
Plasticrecycling&reuse	4.28	0.68
ExtendedProducerResponsibility(EPR)	4.10	0.72
Waste-to-energyinitiatives	3.94	0.77
Community-basedcollectionsystems	4.05	0.70
Eco-design&biodegradableplastics	4.22	0.65

Inference

The mean scores indicate a strong adoption of circular economy practices in marine waste management. Plastic recycling and reuse (Mean = 4.28) and eco-design with biodegradableplastics(Mean=4.22)emergeasthemostprominentapproaches,reflectinghigh stakeholder acceptance. Extended Producer Responsibility (Mean = 4.10) and community-based collectionsystems (Mean =4.05)alsoshowsubstantialimplementation. Waste-to-energy initiatives (Mean = 3.94), though comparatively lower, still reflect moderate effectiveness. Overall, the findings suggest a positive inclination toward sustainable circular economy strategies.

Table5.6CorrelationbetweenCircularEconomyPracticesandMarineWaste Management

RelationshipbetweenCircularEconomyPracticesandWasteManagement Effectiveness (Correlation Analysis)

Variables	Correlation(r)	Sig.
CircularEconomyPracticesvsWaste ManagementEffectiveness	0.684	0.000
Decision:Sincep<0.01,H02isrejected.		

Inference

The correlation analysis reveals a strong and positive relationship between circular economypracticesandmarinewastemanagementeffectiveness,withacorrelationcoefficient of 0.684. This indicates that an increase in the adoption of circular economy practices significantly enhances the effectiveness of managing marine waste.The significance value (p =0.000)being less than0.01 confirms that this relationshipis statisticallysignificant.Hence, thenullhypothesis (H02)is rejected,affirmingthe meaningfulinfluenceof circulareconomy practices on waste management outcomes.

Table5.7Regression Results

Impact of Stake holder Participation on Sustain able Plastic Management

Variable	Beta	t-value	Sig.
StakeholderParticipation	0.592	9.48	0.000
Constant	1.214	4.12	0.000
R^2=0.35			
Decision:Sincep<0.05,H03isrejected.			

Inference

The regression analysis reveals that stakeholder participation has a strong and statisticallysignificantpositiveimpactonsustainableplasticmanagement(β=0.592,p<0.05). Thehight-value(9.48)indicatestherobustnessofthisrelationship.Themodelexplains35per centof thevariationinsustainable plasticmanagementpractices,as reflected bytheR²value. Hence, the null hypothesis (H03) is rejected, confirming that active stakeholder involvement significantly enhances sustainable plastic management outcomes.

Table 5.8 Mean Score of Plastic Reduction Strategies EffectivenessofCircularEconomy-BasedPlasticReductionStrategies

Circular Economy Practice	Mean
Banonsingle-useplastics	4.36
Depositreturnschemes	4.18
Plasticcreditmechanisms	3.92
Publicawarenesscampaigns	4.25
Industrytake-backprograms	4.08

Inference

The mean scores indicate that circular economy–based plastic reduction strategies are perceived as highly effective overall. The ban on single-use plastics ranks highest (Mean = 4.36),highlightingstrongsupportforregulatorymeasuresinreducingplasticpollution.Public awareness campaigns (Mean = 4.25) and deposit return schemes (Mean = 4.18) also show substantial effectiveness, emphasising behavioural change and consumer participation. Industry take-back programs (Mean = 4.08) are moderately effective, while plastic credit mechanisms (Mean = 3.92) are comparatively less impactful.

DISCUSSION

Thefindingsofthestudyclearlyhighlightthegrowingsignificanceofcirculareconomy approaches in addressing marine wasteand ocean plasticpollution. Thedominanceof single-use plastics and fishing gear waste as major pollution sources confirms the urgent need for targetedregulatoryandindustry-levelinterventions.Thestrongmeanscoresforrecycling,eco-design, and Extended Producer Responsibility indicate increasing stakeholder acceptance of circularpracticesinmarinewastemanagement.ANOVAresultsrevealperceptualdifferences among stakeholder groups, emphasising the necessity for inclusive and coordinated governance mechanisms. The positive and significant correlation between circular economy practices and waste management effectiveness demonstrates that circular strategies substantially improve environmental outcomes. Regression results further confirm that active stakeholder participation plays a decisive role in enhancing sustainable plastic management. Moreover, the high effectiveness of bans on single-use plastics and public awareness campaigns underscores the importance of policy enforcement combined with behavioural change.Overall,thestudyaffirmsthatintegratingcirculareconomyprincipleswithstakeholder collaboration offers a viable and sustainable pathway for reducing marine plastic pollution.

LIMITATIONSOFTHESTUDY

1. Thestudyislimitedtoselectedcoastalregions,and therefore,thefindingsmaynot fully represent marine waste management practices in all coastal or inland areas.
2. Theanalysisreliespartlyonself-reporteddatafromrespondents,whichmaybesubject to personal bias or perception errors.
3. Thesamplesizeof200respondents,thoughadequateforthestudy,maylimitthe generalisation of results to a broader population.
4. Thestudyfocusesprimarilyonplasticwasteandcirculareconomypractices,excluding other forms of marine pollution such as chemical waste and oil spills.

CONCLUSION

This study concludes that marine waste and ocean plastic pollution pose serious environmental and socio-economic challenges, requiring sustainable and integrated managementapproaches.Thefindingsrevealthatsingle-useplasticsandfishing-relatedwaste are the major contributors to marine pollution, emphasising the need for stricter regulations and responsible production practices. Circular economy approaches such as recycling, eco-design,andExtendedProducerResponsibilityhaveproventobeeffectiveinimprovingmarine waste management outcomes. The study also highlights the critical role of stakeholder participation, as active involvement from governments, industries, NGOs, and local communities significantly enhances sustainable plastic management. Furthermore, policy measures, public awareness, and technological interventions collectively strengthen plastic reduction efforts. Overall, adopting circular economy principles offers a practical and long-termsolutionforreducingmarineplasticpollutionandensuringsustainableoceanecosystems.

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