Available online at www.koozakar.com/journals/ajspim

African Journal of Science Policy and Innovation Management

AJSPIM

What More Can We Say About Managing Plastic Pollution? Exploring the Cradle–Culture–Consciousness Model for Transformative Global Action

Koleayo Omoyajowo[1*], Augustus Eli[2], Sunday Amiolemen[3], Kolawole Omoyajowo[4], Victor Sobanke[3], Amos Ogunyebi[1], Morufu Raimi[2], and Adenike Ariyo[2]

[1]University of Lagos, Akoka, Nigeria
[2]Federal University Otuoke, Bayelsa, Nigeria
[3]National Centre for Technology Management, Victoria Island, Nigeria
[4]University of Illinois Urbana-Champaign, IL, United States

[*]Corresponding author
Email: koleyomi@gmail.com

Article information

https://doi.org/10.69798/77221221

ISSN (Online): 3066-3660

Published by Koozakar LLC. Atlanta GA 30350, United States

A Journal of the African Institute for Science Policy and Innovation, AISPI, Obafemi Awolowo University, Ile-Ife.

Edited by: Prof. Olawale Adejuwon

Keywords: Plastic pollution, Sustainability, Cradle–Culture–Consciousness (CCC) Model, Environmental stewardship, Policy interventions

ABSTRACT

Plastic pollution is a global sustainability challenge particularly in developing economies where global production is expected to surpass 400 million tonnes annually and waste generation is projected to rise by 17.4% by 2050. Despite decades of policy interventions, recycling initiatives, and public awareness campaigns, the crisis continues to outpace global mitigation efforts. In an effort to mitigate the menace of plastic pollution, this study develops the Cradle–Culture–Consciousness (CCC) Model integrating education, culture, and awareness. Using an integrative review of 135 sources published between 2015 and 2025, the study finds that behavioral and cultural dimensions are critical complements to policy and technology. The CCC model offers a novel framework for sustainability transitions fostering environmental consciousness, and a heuristic tool for informing future research, policy experimentation, and value-driven approaches to environmental stewardship.

INTRODUCTION

Plastics have become indispensable to modern civilization, underpinning advancements in packaging, healthcare, construction, and consumer goods due to their durability, versatility, and cost-effectiveness (Geyer *et al*., 2017; Omoyajowo *et al*., 2021). However, these same properties have precipitated a rapidly escalating environmental crisis. The most widely produced polymers; Polyethylene Terephthalate (PET), Low-Density Polyethylene (LDPE), Polyvinyl Chloride (PVC), and High-Density Polyethylene (HDPE) are highly resistant to degradation, leading to their persistent accumulation across terrestrial and aquatic ecosystems. As a result, plastics have transitioned from being symbols of industrial progress to pervasive environmental pollutants, posing profound threats to ecological integrity and sustainable development (EPA, 2023).

Globally, plastic production has exceeded 460 million metric tons annually, with approximately 20 million metric tons leaking into the environment each year. This figure is projected to increase significantly by 2040 (UNEP, 2021). This surge has intensified pressure on ecosystems, contributing to biodiversity loss, habitat degradation, and climate change (Ragusa *et al*., 2021; UNEP, 2021). Of particular concern is the proliferation of microplastics and hazardous chemical additives such as bisphenol A (BPA) and phthalates, which disrupt ecological food webs and pose risks to both wildlife and human health (Omoyajowo *et al*., 2022). Empirical evidence from aquatic systems, including the Lagos Lagoon, further demonstrates that plastic contamination adversely affects water quality and aquatic biota, thereby compounding environmental and public health challenges (Isukuru *et al*., 2024; Omoyajowo *et al*., 2022). Additionally, the life cycle of plastic from production to disposal, contributes significantly to greenhouse gas emissions, reinforcing their role in global climate dynamics (UNEP, 2021).

Despite growing awareness and policy attention, existing plastic waste management strategies remain largely inadequate. Current approaches are predominantly anchored in a linear economic model characterized by production, consumption, and disposal, with limited emphasis on material recovery and system regeneration. Although the transition toward a circular economy has gained traction as a sustainable alternative, its implementation remains uneven, particularly in low- and middle-income countries where infrastructural deficiencies, weak regulatory frameworks, and the dominance of informal waste economies constrain effectiveness (Fuss *et al*., 2021; Babaremu *et al*., 2024). Furthermore, recent global disruptions, including the COVID-19 pandemic, have amplified reliance on single-use plastics, exposing the fragility of existing systems and the limitations of technocentric solutions (Omoyajowo *et al*., 2021).

A critical limitation in prevailing discourse is the insufficient integration of human behavioral, cultural, and cognitive dimensions into plastic pollution governance. While technological innovations and policy instruments are essential, they often fail to account for the socio-cultural contexts and value systems that shape consumption patterns and waste practices. This gap underscores the need for a more holistic, human-centered framework that bridges environmental sustainability with social behavior, cultural norms, and consciousness-driven change.

In response, this paper proposes the Cradle–Culture–Consciousness (CCC) Model as an integrative framework for rethinking plastic pollution management. The CCC Model advances beyond conventional circular economy paradigms by embedding environmental responsibility within cultural practices, behavioral change mechanisms, and reflective awareness. It emphasizes the interplay between material life cycles (cradle), socio-cultural systems (culture), and individual and collective cognition (consciousness), thereby offering a systems-oriented approach to sustainable plastic governance.

Accordingly, the aim of this study is to develop and examine the CCC Model as a comprehensive, human-centered framework capable of addressing the multidimensional nature of plastic pollution, particularly within contexts characterized by socio-economic and infrastructural constraints.

To achieve this aim, the study intends to

a) critically examine the limitations of current plastic pollution management approaches in global sustainability practice;

b) analyze the behavioral, cultural, and governance determinants that shape plastic consumption, disposal, and pollution management outcomes;
c) synthesize evidence on how environmental education, social norms, and reflective awareness influence plastic-related behaviors and sustainable waste practices;
d) conceptualize the Cradle–Culture–Consciousness (CCC) Model as a systems-based framework for understanding and improving plastic pollution mitigation; and
e) propose an integrated CCC-informed strategy for policymakers, educators, and community stakeholders involved in sustainable plastic governance.

LITERATURE REVIEW

Plastic pollution is a complex, systemic challenge driven by the interaction of behavioral, infrastructural, economic, and governance dynamics. Rather than a purely technical problem, it reflects deeply embedded production–consumption systems and socio-cultural practices. Accordingly, this review adopts a thematic and critical approach, synthesizing existing knowledge while identifying key gaps that justify the development of the Cradle–Culture–Consciousness (CCC) Model.

Drivers of Plastic Pollution

Overreliance on single-use plastics

The dominance of single-use plastics represents one of the most significant contributors to global plastic pollution. Items such as packaging materials, bottles, and carrier bags account for a substantial proportion of the over 460 million metric tons of plastics produced annually, with a large share discarded after a single use (Geyer *et al*., 2017; UNEP, 2021). Their low cost, convenience, and durability have entrenched a "disposable culture," resulting in widespread environmental leakage, particularly in regions with weak waste governance systems.

While existing interventions, including bans and circular economy strategies have attempted to curb this trend, the literature reveals a critical limitation: an overemphasis on material substitution and regulatory control at the expense of behavioral and cultural transformation. Consumption patterns are not solely economically driven but are also shaped by social norms, identity, and habitual practices. However, these psychosocial dimensions remain under-theorized in dominant policy and technological approaches. This gap highlights the need for integrative frameworks such as the CCC Model, which situate plastic consumption within broader cultural and consciousness-driven contexts.

Ineffective waste management systems

Waste management systems globally remain largely linear, characterized by collection and disposal rather than recovery and regeneration. Even in high-income countries, landfilling and incineration dominate, reflecting structural inefficiencies in achieving circularity (EPA, 2023). In low- and middle-income countries, these challenges are compounded by inadequate infrastructure, weak institutional capacity, and fragmented governance systems (Fuss *et al*., 2021). Importantly, informal waste economies play a significant yet under-recognized role in material recovery, often operating without policy integration or social protection. Existing studies largely focus on technical and institutional deficiencies but insufficiently engage with the role of community norms, local knowledge systems, and collective stewardship practices. This oversight limits the effectiveness of interventions, particularly in culturally diverse contexts. Embedding socio-cultural dynamics into waste governance as proposed in the CCC Model offers a pathway for more inclusive and context-sensitive solutions.

Low recycling rates and market constraints

Despite global commitments to circular economy principles, recycling rates remain critically low, with only about 9% of plastics ever produced being recycled (Geyer *et al*., 2017). Structural disruptions, such as China's 2018 "National Sword" policy, exposed the fragility of global recycling markets and the overdependence on transboundary waste trade (Brooks *et al*., 2018). Key barriers include contamination, insufficient sorting infrastructure, and weak economic incentives. However, beyond these technical constraints, the literature pays limited attention to the role of values, perceptions, and behavioral motivations in shaping recycling participation and material valuation. Recycling systems ultimately depend on human compliance and engagement, yet

this human dimension is often treated as secondary. The CCC Model addresses this gap by introducing a consciousness-oriented perspective, emphasizing reflective awareness and ethical responsibility as drivers of sustainable material practices.

Behavioral and awareness deficits

Behavioral factors remain a central yet inadequately addressed driver of plastic pollution. Studies highlight persistent issues such as "wish cycling," poor understanding of recycling systems, and convenience-driven consumption patterns, all of which contribute to inefficiencies and contamination in waste streams (EPA, 2023; Thomas *et al*., 2024). While awareness campaigns are increasingly common, their impact is often limited by a lack of integration with cultural contexts and long-term value systems. Much of the literature treats behavioral change as an outcome of information provision rather than a socially embedded and culturally mediated process. Consequently, there is limited exploration of how early education, social identity, and ethical reflection interact to produce sustained behavioral change. This reinforces the relevance of the CCC Model, which integrates behavioral transformation across life stages (cradle), socio-cultural systems (culture), and reflective cognition (consciousness).

Policy, Education, Infrastructure, and Innovation: Towards an integrated approach

Policy and regulation

Policy interventions play a critical role in shaping plastic production and consumption patterns. Measures such as single-use plastic ban and Extended Producer Responsibility (EPR) schemes have demonstrated potential in reducing waste and promoting eco-design (OECD, 2021; IUCN, 2024). However, the effectiveness of these policies vary significantly across contexts, often constrained by enforcement challenges and limited public buy-in. Emerging research suggests that policy success is strongly influenced by public perceptions of risk, efficacy, and fairness (Tyllianakis *et al*., 2025). Yet, regulatory frameworks rarely incorporate mechanisms for building environmental consciousness or aligning with cultural values, which are essential for long-term compliance and legitimacy. This gap indicates the need for policy designs that move beyond enforcement toward normative and consciousness-based engagement, as advanced in the CCC Model.

Education and awareness

Education is widely recognized as a foundational pillar of sustainable plastic management. Studies consistently show that environmental literacy, risk perception, and self-efficacy significantly influence pro-environmental behavior (UNESCO, 2021; Omoyajowo *et al*., 2022). Behavioral frameworks such as the capability–opportunity–motivation model further highlight the importance of reflective motivation and identity in shaping sustainable practices (Lee *et al*., 2025). However, existing approaches often emphasize short-term awareness campaigns rather than long-term value formation and cultural embedding. There is growing recognition that effective education must extend beyond information dissemination to include experiential learning, community participation, and culturally relevant narratives. The CCC Model builds on this by emphasizing early-life interventions and continuous consciousness development as drivers of enduring behavioral change.

Recycling systems and infrastructure

The literature underscores the importance of robust recycling infrastructure, including source segregation, advanced sorting technologies, and formalized collection systems (Wilson *et al*., 2006). Integrating informal waste workers into formal systems has been shown to improve efficiency, equity, and sustainability, particularly in developing contexts (IUCN, 2024). Nevertheless, infrastructural improvements alone are insufficient without corresponding behavioral and cultural alignment. Participation in recycling systems is highly dependent on public cooperation, trust, and social norms. Yet, these social dimensions remain underexplored in infrastructure-focused studies. This suggests the need for people-centered infrastructure systems, where technology is complemented by education, community engagement, and shared responsibility frameworks, an approach central to the CCC Model.

Innovation and sustainable alternatives

Technological innovation offers promising pathways for reducing plastic pollution, including bio-based materials, advanced recycling technologies, and circular design strategies (Hopewell *et al*., 2009; Korley *et al*., 2021). Emerging solutions such as chemical recycling, additive manufacturing, and intelligent sorting

systems have enhanced the efficiency and value recovery potential of plastic waste streams. However, the adoption and scalability of these innovations depend heavily on user acceptance, behavioral adaptation, and socio-cultural compatibility. The literature increasingly acknowledges that technological solutions are most effective when embedded within supportive social and cultural systems. This reinforces the need for integrative frameworks like the CCC Model, which align technological innovation with human behavior and cultural context.

Sustainable Alternatives: Business models for reuse systems

Transitioning from single-use plastics to reuse systems requires business models that are not only economically viable but also socially and culturally embedded. Models such as refill systems, deposit-return schemes, subscription services, and pooled packaging platforms demonstrate significant potential for reducing waste (Willis *et al*., 2019; Rhein & Sträter, 2021; Patreau *et al*., 2023). A critical insight from the literature is that the success of these models depends less on technological feasibility and more on user behavior, trust, and social norms. Reuse systems require consistent participation, habit formation, and community acceptance. However, many studies treat these behavioral elements as secondary considerations rather than central design components. Integrating education, cultural alignment, and consciousness-building as proposed in the CCC Model can enhance the scalability and sustainability of reuse-based systems.

Theoretical Foundations for Behavioral and Environmental Action

Understanding plastic pollution requires a strong theoretical grounding in behavioral and social sciences. Social Learning Theory (Bandura, 1977) emphasizes that behaviors are acquired through observation and reinforcement, highlighting the importance of early-life exposure to sustainable practices. The Theory of Planned Behavior (Ajzen, 1991) identifies attitudes, subjective norms, and perceived control as key determinants of behavioral intention, underscoring the role of social influence and cultural expectations.

Similarly, the Value–Belief–Norm (VBN) Theory (Stern, 2000) explains how environmental values and moral obligations drive pro-environmental action. Together, these frameworks demonstrate that sustainable behavior is shaped by interactions between individual cognition, social context, and moral consciousness.

However, existing applications of these theories in plastic pollution studies are often fragmented, lacking integration into a unified systems framework. The CCC Model advances this discourse by synthesizing these theoretical insights into a cohesive structure that connects early learning (cradle), socio-cultural systems (culture), and reflective awareness (consciousness). In doing so, it provides a more holistic and actionable framework for addressing plastic pollution in diverse socio-economic contexts.

Synthesis and Research Gap

The reviewed literature demonstrates substantial progress in understanding the technological, economic, and policy dimensions of plastic pollution. However, three critical gaps persist:

a) Fragmentation of approaches, with limited integration of behavioral, cultural, and structural dimensions.
b) Underrepresentation of socio-cultural and consciousness-based factors in mainstream plastic governance frameworks.
c) Lack of a unified, systems-oriented model that connects early education, cultural norms, and reflective awareness with material lifecycle management.

Addressing these gaps necessitates a paradigm shift toward more holistic, human-centered frameworks. The proposed Cradle–Culture–Consciousness (CCC) Model responds to this need by integrating behavioral science, cultural systems, and environmental management into a coherent approach for sustainable plastic governance.

METHODOLOGY

Research Design and Analytical Orientation

This study adopts a theory-building, conceptual research design, consistent with innovation management scholarship that advances new frameworks and integrative perspectives. Specifically, the study employs an integrative review methodology combined with interpretive thematic synthesis to develop the Cradle–Culture–

Consciousness (CCC) Model as a holistic framework for plastic pollution governance.
Unlike empirical or hypothesis-testing studies, this research is non-inferential and explanatory in orientation, focusing on the systematic integration of interdisciplinary knowledge rather than statistical generalization. The design is appropriate given the fragmented nature of existing plastic pollution literature, which spans environmental science, policy studies, behavioral research, and sustainability transitions.

Accordingly, the methodological approach pursues two interrelated objectives:

a) to critically synthesize and integrate existing evidence on the drivers and management of plastic pollution across multiple domains; and
b) to conceptualize and position the CCC Model within these domains as a systems-based, human-centered framework.

This approach aligns with established guidance on conceptual and theory-building research, where rigor is ensured through transparency, systematic literature integration, and coherent theoretical development rather than empirical measurement.

Literature Search Strategy and Source Selection
A systematic and replicable Boolean search strategy was employed to ensure transparency, consistency, and comprehensive coverage of relevant literature. Searches were conducted across Scopus, Web of Science, Google Scholar, and PubMed, with queries adapted slightly to fit database-specific syntax requirements. 420 studies were identified with 135 studies retained based on an integrative literature review conducted.

The core search string was constructed using clearly defined Boolean operators (AND, OR) and thematic keyword clusters as follows:

("plastic pollution" OR "plastic waste" OR "mismanaged plastic*" OR "marine plastic debris" OR "plastic leakage")
AND
("circular economy" OR "extended producer responsibility" OR "waste management" OR "waste governance" OR "recycling systems")
AND
("behavioral change" OR "consumer behavior" OR "social norms" OR "environmental awareness" OR "environmental education" OR "sustainability behavior")

To enhance precision and reduce irrelevant results, the following search restrictions were applied where database functionality allowed:

a) **Field limitations:** Title, Abstract, and Keywords (TITLE-ABS-KEY in Scopus; TS in Web of Science)
b) **Language:** English
c) **Document type:** Peer-reviewed journal articles, reviews, and institutional reports
d) **Timeframe:** 2015–2025

Where necessary (e.g., in Google Scholar), simplified versions of the query were used while maintaining the same logical structure. Truncation symbols (e.g., *plastic* or *plastic***) were applied to capture variations such as *plastics* and *plasticity* where appropriate.

Screening and selection process
The search results were subjected to a two-stage screening process to ensure relevance and quality:

a) **Title and Abstract Screening:**
Articles were initially screened for thematic relevance to plastic pollution drivers, governance, behavioral factors, and sustainability transitions.
b) **Full-Text Review:**
Selected articles were further evaluated for conceptual depth, methodological rigor, and relevance to the study objectives.

To improve robustness, backward and forward snowballing techniques were also applied:

a) **Backward snowballing:** Reviewing references of key articles
b) **Forward snowballing:** Identifying newer studies citing selected core papers

Data Extraction and Thematic Synthesis
Selected studies were subjected to a structured thematic analysis, enabling systematic identification, comparison, and integration of key concepts across the literature. The process followed three iterative stages:

a) Open Coding:
Key themes were inductively identified from the literature, including drivers of plastic pollution, behavioral determinants,

governance mechanisms, and sustainability interventions.

b) Axial Coding:
Related concepts were grouped into higher-order categories, linking behavioral, cultural, and structural dimensions of plastic pollution.

c) Selective Coding and Integration:
Core themes were synthesized into a coherent conceptual structure, forming the basis of the CCC Model.

This iterative and interpretive synthesis approach ensures analytical depth while maintaining flexibility to integrate diverse disciplinary insights. Importantly, the method moves beyond descriptive summarization toward critical comparison, identification of inconsistencies, and gap analysis, thereby strengthening theoretical contribution**.**

Use of Contextual Demographic Evidence

To situate the conceptual framework within real-world dynamics, the study incorporates secondary demographic data from globally recognized sources, including World Population Review, OECD, and World Bank datasets.

These data are used descriptively and illustratively, providing contextual grounding for understanding the scale and distribution of plastic consumption and waste generation pressures. Consistent with the study's conceptual orientation:

a) Demographic variables are not operationalized for statistical testing or causal inference;
b) No predictive modeling or econometric analysis is performed; and
c) Data serve solely as contextual anchors to reinforce the argument that plastic pollution is embedded within broader socio-demographic systems

This approach enhances the external relevance and practical interpretability of the CCC Model without compromising methodological coherence.

Conceptual Integration and Model Development

The development of the CCC Model followed a theory synthesis approach, integrating insights from environmental education theory, behavioral science frameworks, sociocultural systems analysis, sustainability governance literature. Key constructs such as early environmental socialization, social norms, risk perception, identity formation, and moral responsibility were systematically mapped and organized into three interdependent domains: **Cradle** (early-life learning and environmental socialization), **Culture** (shared norms, practices, and institutional influences), **Consciousness** (reflective awareness, values, and ethical responsibility).

Rather than aggregating data quantitatively, the analysis emphasizes relational and systemic interactions among these domains. The resulting model illustrates how behavioral, cultural, and cognitive dimensions jointly influence plastic consumption patterns and policy effectiveness.

The CCC Model is therefore positioned as a heuristic and integrative framework, designed to advance theoretical understanding of plastic pollution governance, bridge fragmented disciplinary insights, inform policy design, educational strategies, and community-based interventions, and provide a foundation for future empirical validation.

Methodological Rigor and Limitations

Rigor in this study is ensured through transparent and replicable literature search procedures, explicit inclusion and exclusion criteria, systematic thematic synthesis and theory integration, and use of high-quality and authoritative sources.

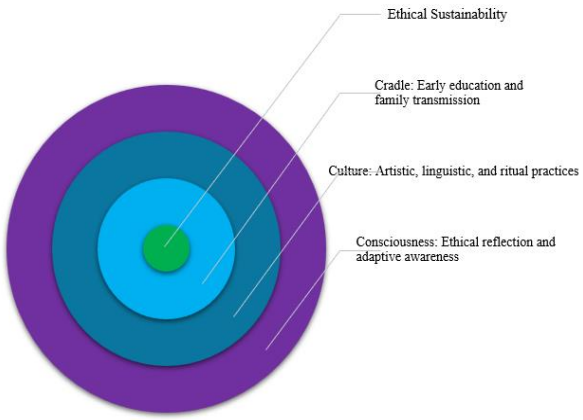

Figure 1: The Cradle–Culture–Consciousness (CCC) Model and the dynamic interrelationships among its core components
Source: Authors' conceptualization

However, consistent with conceptual research designs, the study does not provide empirical

validation or statistical generalizability. The CCC Model (as presented in Fig. 1) should therefore be interpreted as a propositional framework, requiring future empirical testing across different socio-cultural and geographic contexts.

DISCUSSION

This study advances a human-centered and systems-oriented interpretation of plastic pollution, integrating contextual demographic insights with behavioral theory and governance analysis through the Cradle–Culture–Consciousness (CCC) Model. Rather than treating plastic pollution as a purely technical or regulatory challenge, the discussion synthesizes evidence to demonstrate how demographic pressures, socio-cultural practices, behavioral dynamics, and institutional capacity interact to shape global plastic waste patterns and management outcomes.

Demographic Scale and Global Patterns of Plastic Waste

Contextual global assessments indicate that plastic waste generation is projected to increase substantially from approximately 436 million tonnes in 2025 to over 500 million tonnes by 2050 largely driven by population growth and urban expansion under existing consumption patterns. Countries such as India, China, the United States, Pakistan, Nigeria, and Indonesia already contribute significantly to global plastic waste volumes due to their demographic scale.

These patterns are illustrated in **Figure 2**, which presents estimated rankings of the top plastic waste-generating countries globally.

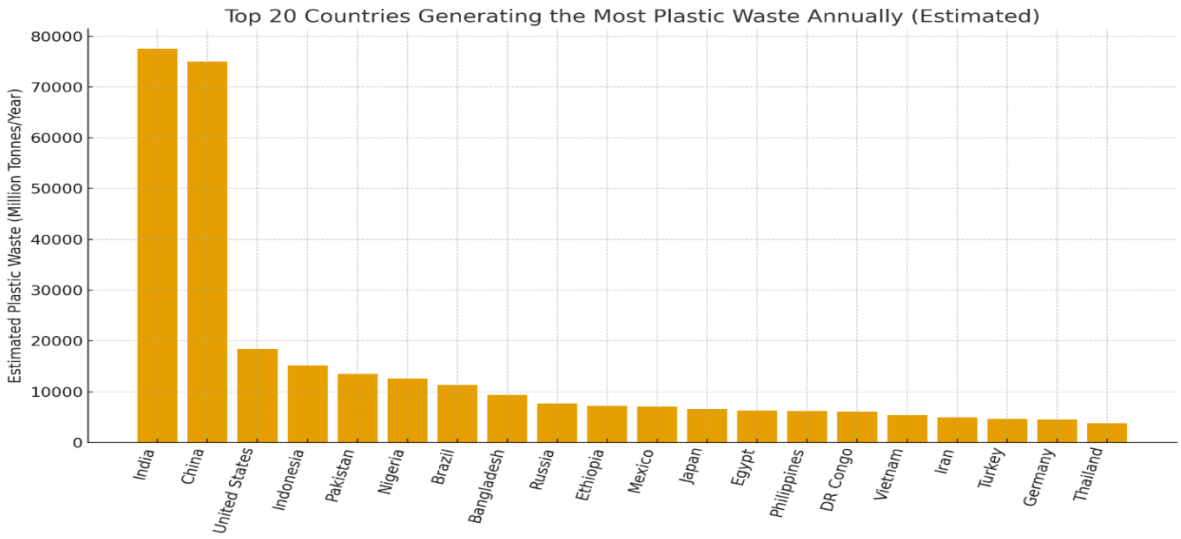

Figure 2: Top 20 Countries Generating the Most Plastic Waste Annually (Estimated)
Source: Adapted from World Population Review (2025)

This highlights that aggregate plastic waste generation is strongly associated with population size, rather than purely per-capita consumption. This reinforces the importance of incorporating demographic context into plastic pollution analysis and policy design.

Uneven Distribution and Structural Context

Beyond aggregate volumes, plastic waste generation exhibits a markedly uneven global distribution, reflecting differences in population density, economic development, and consumption systems. Regions in South and East Asia dominate global waste generation due to their scale and industrial activity, while many low-income regions contribute smaller absolute quantities.

This uneven distribution is visualized in **Figure 3**, which maps estimated annual plastic waste generation across countries.
Importantly, Figure 3 illustrates that waste burden and waste management capacity are not evenly aligned.

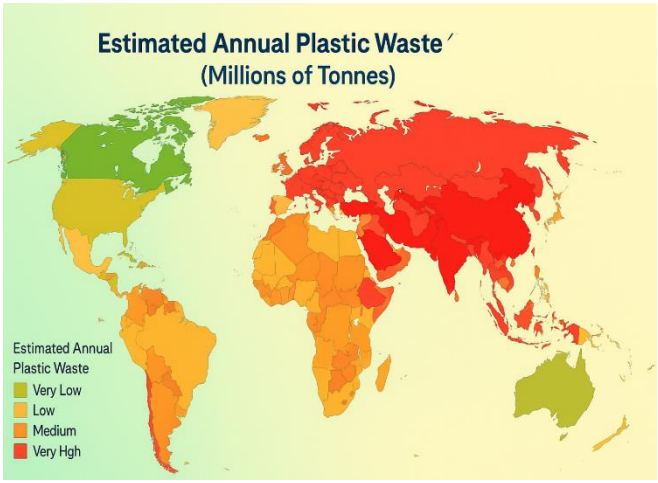

Figure 3: Estimated Annual Plastic Waste Generation by Country (Millions of Tonnes)
Source: Adapted from World Population Review (2025)

Regions with lower absolute waste volumes often face disproportionately severe environmental impacts due to infrastructural deficits and governance limitations. This distinction underscores the need to move beyond aggregate metrics toward context-sensitive interpretations of plastic pollution.

Shifting Geography of Plastic Waste Pressure

Emerging evidence points to a significant reconfiguration in the global geography of plastic waste generation, with increasing concentration in rapidly urbanizing regions of the Global South. Projections suggest that by mid-century, countries such as Nigeria, Pakistan, Ethiopia, the Democratic Republic of Congo, Brazil, and Bangladesh will account for a growing share of global plastic waste.

Crucially, this shift is driven less by high per-capita consumption and more by population growth, accelerated urbanization, and expanding material demand associated with economic transition. As a result, plastic pollution challenges are increasingly likely to manifest in contexts characterized by limited waste management infrastructure; weak institutional and regulatory capacity; high reliance on informal waste systems; and complex socio-cultural dynamics influencing consumption and disposal. These conditions increase the probability that rising waste volumes will translate into higher levels of mismanaged plastics, environmental leakage, and associated ecological and public health risks.

Beyond structural constraints, the literature highlights the importance of behavioral norms, cultural practices, and governance complexity in shaping waste outcomes. In many contexts, disposal practices and material use are embedded within everyday social systems, making purely technocratic or policy-driven interventions insufficient.

This geographic shift therefore reinforces the need to reframe plastic pollution as a socio-technical and culturally embedded challenge. The CCC Model provides a critical contribution in this regard by integrating early environmental socialization and education (Cradle), shared norms and community practices (Culture), and reflective awareness and ethical responsibility (Consciousness). By aligning these dimensions, the CCC framework offers a context-sensitive and systems-oriented lens capable of addressing the complexities of emerging waste geographies and supporting more sustainable, locally grounded interventions.

Behavioral and Cultural Determinants of Plastic Use

While demographic dynamics define the scale of plastic pollution, behavioral and socio-cultural factors determine its expression. Evidence shows that plastic consumption and disposal practices are shaped by convenience, perceived utility, social norms, and risk awareness.

In many high-growth regions, plastic-intensive behaviors are normalized, while environmental consequences remain abstract or temporally distant. This explains the limited effectiveness of interventions that rely solely on information dissemination. The CCC Model addresses this limitation through Cradle – promoting early formation of pro-environmental values; Culture – reshaping collective norms and practices; and Consciousness – strengthening moral engagement, awareness, and perceived agency. This integrated approach highlights that sustainable behavior change requires alignment between knowledge, social expectations, and enabling systems, rather than isolated awareness campaigns (UNEP, 2024).

Governance and Infrastructure Constraints

The regions experiencing the fastest growth in plastic waste are often those with the least developed waste management systems. Common

challenges include inadequate waste collection coverage, weak enforcement of environmental regulations, limited recycling infrastructure, and dependence on informal waste handling systems. These constraints increase the likelihood that rising waste volumes will result in mismanaged plastics and environmental degradation.

Policy tools such as Extended Producer Responsibility (EPR), plastic ban, and circular economy initiatives remain important but are often difficult to implement effectively without contextual adaptation. The CCC Model enhances these approaches by embedding cultural relevance, community participation, and behavioral alignment, thereby improving policy uptake and sustainability.

Integrated Pathways for Sustainable Plastic Management

This study demonstrates that isolated interventions are insufficient to address plastic pollution at scale. Instead, effective solutions require integration across behavioral, institutional, and technological domains since environmental gains are often constrained where innovation is not supported by credible institutions, enabling infrastructure, and learning systems (Omoyajowo, 2026). The CCC Model provides a structured pathway: Cradle – long-term behavioral formation through education, Culture – transformation of social norms and practices, Consciousness – reinforcement of ethical responsibility and awareness.

Technological innovations, including artificial intelligence, can support these efforts by improving sorting systems, enhancing recycling efficiency, and enabling real-time behavioral feedback. Zhu *et al*. (2025) show that combining near-infrared spectroscopy with machine-learning models, enables high-accuracy identification of polypropylene across different aging stages, improving recycling outcomes and material quality. When embedded within supportive governance and education systems, such technologies can function not merely as technical fixes but as enablers of environmental consciousness and collective responsibility. However, their effectiveness depends on human adoption, institutional support, and cultural alignment, reinforcing the need for integrated approaches.

CONCLUSION AND IMPLICATIONS

Conclusion

Plastic pollution remains a complex, transboundary sustainability challenge that extends beyond material inefficiencies and regulatory shortcomings. This study demonstrates that the persistence of plastic leakage into terrestrial and aquatic systems is fundamentally shaped by the interaction of demographic pressures, socio-cultural practices, behavioral dynamics, and institutional capacity. As such, approaches that rely solely on technological innovation or policy enforcement are unlikely to produce sustained or globally equitable outcomes.

In response to these limitations, this study advances the Cradle–Culture–Consciousness (CCC) Model as a novel, human-centered conceptual framework for understanding and addressing plastic pollution. By integrating early environmental socialization (cradle), culturally embedded norms and practices (culture), and reflective awareness and ethical agency (consciousness), the model provides a systems-oriented lens that complements existing circular economy and governance approaches.

The findings further highlight that demographic expansion and urbanization act as structural amplifiers of plastic waste generation, particularly in rapidly growing regions of the Global South. In these contexts, the convergence of population growth, limited infrastructure, and informal waste systems increases the risk of environmental leakage and associated public health impacts. However, these outcomes are not predetermined; they are mediated by behavioral patterns, cultural norms, and governance effectiveness.

Overall, this study reframes plastic pollution as a socio-technical and human-centered challenge, emphasizing that sustainable solutions must align technical capacity with behavioral transformation and cultural adaptation. The CCC Model contributes to this discourse by offering a coherent integrative framework capable of explaining variation in plastic governance outcomes across diverse contexts.

Theoretical Implications

This study makes several important contributions to the literature on sustainability transitions and environmental governance.

First, it addresses the fragmentation in existing plastic pollution research by integrating insights from environmental science, behavioral theory, and socio-cultural analysis into a unified conceptual model. In doing so, it advances a systems-based perspective that moves beyond dominant technocentric and policy-centric paradigms.

Second, the CCC Model extends existing theoretical frameworks—such as behavioral change models and circular economy approaches—by explicitly incorporating early-life socialization, cultural context, and consciousness-driven action as central determinants of environmental outcomes. This contributes to a growing body of literature emphasizing the role of human agency, identity, and moral responsibility in sustainability transitions.

Third, the study introduces a multi-level analytical lens linking micro-level behavior (individual awareness and action), meso-level dynamics (community norms and cultural practices), and macro-level structures (policy and infrastructure). This integrative perspective enhances theoretical understanding of how plastic pollution emerges and persists across different socio-economic and geographic contexts.

Policy Implications

The findings of this study have significant implications for policymakers, practitioners, and sustainability stakeholders. The findings highlight the need to move beyond isolated policy instruments toward integrated behavioral–institutional strategies. While regulatory tools such as Extended Producer Responsibility (EPR), plastic ban, and circular economy initiatives remain essential, their effectiveness depends on public acceptance, cultural alignment, and behavioral compliance, as sustainability outcomes often vary according to the strength of supporting institutional and social conditions (Omoyajowo, 2026).

In addition, the CCC Model underscores the importance of early and continuous environmental education as a long-term strategy for shaping sustainable consumption patterns. Embedding sustainability principles within educational systems can influence values and behaviors across generations, particularly in rapidly growing populations.

Similarly, culturally grounded interventions are critical for ensuring policy relevance and effectiveness. Programs that align with local norms, community practices, and social identities are more likely to achieve sustained behavioral change than externally imposed or purely technocratic solutions (Omoyajowo *et al.*, 2023). Furthermore, consciousness-oriented approaches including awareness campaigns, participatory engagement, and value-based communication can strengthen risk perception, efficacy beliefs, and moral responsibility, thereby enhancing individual and collective action.

Finally, technological innovations, including artificial intelligence–enabled waste sorting and decision-support systems, can serve as important enablers of sustainable plastic management. However, their impact depends on institutional support, accessibility, and user engagement, reinforcing the need for alignment between technological solutions and human systems (Omoyajowo, 2026).

Implications for Research and Future Directions

As a conceptual study, this research does not empirically validate the CCC Model, but it provides a foundation for future empirical and interdisciplinary inquiry. Future research should focus on:

a) Empirical testing and validation of the CCC Model across diverse cultural and socio-economic contexts
b) Integration of behavioral, cultural, and demographic data into plastic pollution analysis
c) Examination of how educational systems, social norms, and governance structures interact to influence plastic consumption and waste management outcomes
d) Evaluation of CCC-informed interventions in real-world policy and community settings
e) Exploration of pathways for decoupling demographic growth from plastic waste generation

Such research will enhance the operational relevance of the model and contribute to the development of adaptive, context-sensitive, and scalable solutions.

Acknowledgements

The authors gratefully acknowledge the anonymous reviewers of AJSPIM for their thoughtful and constructive feedback. We also thank Koozakar Curiosity Lab (USA) for its collegial support and intellectual encouragement throughout the development of this conceptual study. Their support helped strengthen the clarity, relevance, and direction of a work intended to speak to wider global sustainability and environmental policy discussions, including those of relevance to UNEP.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Babaremu, K., Adediji, A., Olumba, N., Okoya, S., Akinlabi, E., & Oyinlola, M. (2024). Technological advances in mechanical recycling innovations and corresponding impacts on the circular economy of plastics. *Environments*, *11*(3), 38. https://doi.org/10.3390/environments11030038

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall. 247pp.

Brooks, A. L., Wang, S., & Jambeck, J. R. (2018). The Chinese import ban and its impact on global plastic waste trade. *Science Advances*, *4*(6), eaat0131. https://doi.org/10.1126/sciadv.aat0131

Chen, X., Wang, Y., & Zhang, L. (2021). Recent progress in the chemical upcycling of plastic wastes. *ChemSusChem*, *14*(19), 4137–4151. https://doi.org/10.1002/cssc.202100868

EPA. (2023). *Advancing sustainable materials management: Facts and figures report*. United States Environmental Protection Agency. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management United States Environmental Protection Agency, pp.25

Fuss, M., Barros, R. T., & Poganietz, W. R. (2021). The role of a socio-integrated recycling system in implementing a circular economy: The case of Belo Horizonte, Brazil. *Waste Management*, *121*, 215–225. https://doi.org/10.1016/j.wasman.2020.12.006

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, *3*(7), e1700782. https://doi.org/10.1126/sciadv.1700782

Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: Challenges and opportunities. *Philosophical Transactions of the Royal Society B*, *364*(1526), 2115–2126.

Isukuru, E. J., Opha, J. O., Isaiah, O. W., Orovwighose, B., & Emmanuel, S. S. (2024). Nigeria's water crisis: Abundant water, polluted reality. *Cleaner Water*, *2*, 100026. https://doi.org/10.1016/j.clwat.2024.100026

International Union for Conservation of Nature and Natural Resources (IUCN). (2024). *Plastic pollution: Issues brief (May 2024 update)*. https://iucn.org/sites/default/files/2024-05/plastic-pollution-issues-brief-may-2024-update.pdf

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: A global snapshot of solid waste management to 2050*. World Bank. https://openknowledge.worldbank.org/handle/10986/30317

Korley, L. T., Epps III, T. H., Helms, B. A., & Ryan, A. J. (2021). Toward polymer upcycling: Adding value and tackling circularity. *Science*, *373*(6550), 66–69. https://doi.org/10.1126/science.abg4503

Lee, D., Wan, C., Isbanner, S., Rundle-Thiele, S., & Fung, Y.-N. (2025). Driving voluntary reduction of single-use plastic consumption: Capability, opportunity, and motivation. *Sustainable Futures*, *10*, 101020. https://doi.org/10.1016/j.sftr.2025.101020

Ocean Conservancy. (2022). *Trash Free Seas program report*. Retrieved November 7, 2025, from https://oceanconservancy.org/trash-free-seas/

Organisation for Economic Co-operation and Development. (2016). *Extended producer responsibility: Updated guidance for efficient waste management* (292 pp.). OECD Publishing. https://doi.org/10.1787/9789264256385-en

Organisation for Economic Co-operation and Development. (2022). *Global plastics outlook: Economic drivers, environmental impacts and policy options* (201 pp.). OECD Publishing. https://doi.org/10.1787/de747aef-en

Omoyajowo, K., Amiolemen, S., Makengo, B. M., & Ogunyebi, A. (2021). Impact of COVID-19 pandemic on single- use plastics in some American firms: Policy insights. *Ecological Safety and Balanced Use of Resources*, *2*(24), 7–12. https://doi.org/10.31471/2415-3184-2021-2(24)7-12

Omoyajowo, K., Raimi, M., Waleola, T., Odipe, O., & Ogunyebi, A. (2022). Public awareness, knowledge, attitude and perception on microplastics pollution around Lagos Lagoon. *Ecological Safety and Balanced Use of Resources*, *2*(24), 35–46.

Omoyajowo, K., Danjin, M., Omoyajowo, K., Odipe, O., Mwadi, B., May, A., Ogunyebi, A., & Rabie, M. (2023). Exploring the interplay of environmental conservation within spirituality and multicultural perspective: Insights from a cross-sectional study. *Environ Dev Sustain* 26, 16957–16985

Omoyajowo, K. (2026). The scarcity paradox in eco-innovation: Mechanisms, boundary conditions, and environmental outcomes. *Nature and Trends in Science & Technology, 2(1)*, 24–38. https://doi.org/10.69798/98999912

Patreau, V., Bernard, S., Leroux, J., Bellemare, M., & Morissette, J. (2023). Consumer interest and willingness to pay for in-bulk products with reusable packaging options. *Frontiers in Sustainability*, *4*, 1228917. https://doi.org/10.3389/frsus.2023.1228917

Ragusa, A., Svelato, A., Santacroce, C., Catalano, P., Notarstefano, V., Carnevali, O., & Giorgini, E. (2021). Plasticenta: First evidence of microplastics in human placenta. *Environment International*, *146*, 106274. https://doi.org/10.1016/j.envint.2020.106274

Rhein, S., & Sträter, K. F. (2021). Intended and unintended effects of statutory deposit return schemes for single-use plastic bottles: Lessons learned from the German experience. *GAIA*, *30*(4), 250–256. https://doi.org/10.14512/gaia.30.4.8

Stern, P. C. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social*

Issues, 56(3), 407–424. https://doi.org/10.1111/0022-4537.00175

Thomas, D. S., Kneifel, J. D., & Butry, D. T. (2024). *The U.S. plastics recycling economy: Current state, challenges, and opportunities*. National Institute of Standards and Technology. https://doi.org/10.6028/NIST.AMS.100-64

Tyllianakis, E., Kolade, O., Ambituuni, A., Ogunde, O., Oyinlola, M., & Abolfathi, S. (2025). A behavioural risk perspective to plastic waste management: Insights from Nigerian SMEs. *Journal of Cleaner Production*, *534*, 147086. https://doi.org/10.1016/j.jclepro.2025.147086

United Nations Educational, Scientific and Cultural Organization. (2020). *Education for sustainable development: A roadmap* (66 pp.). UNESCO. https://doi.org/10.54675/YFRE1448

United Nations Environment Programme. (2021). *Drowning in plastics: Marine litter and plastic waste vital graphics* (77 pp.). United Nations Environment Programme, Secretariat of the Basel, Rotterdam and Stockholm Conventions, & GRID-Arendal. https://www.unep.org/resources/report/drowning-plastics-marine-litter-and- plastic-waste-vital-graphics

Wang, M., Bauer, F., Syberg, K., & Gammage, T. (2023). Finance plastics reuse, redesign, and reduction. *Science*, *382*(6670), 526. https://doi.org/10.1126/science.adl4491

Willis, K., Hardesty, B. D., Vince, J., & Wilcox, C. (2019). The success of water refill stations reducing single-use plastic bottle litter. *Sustainability*, *11*(19), 5232. https://doi.org/10.3390/su11195232

Wilson, D. C., Velis, C., & Cheeseman, C. (2006). Role of the informal sector in waste management. *Habitat International*, *30*(4), 797–808.

World Population Review. (2025). *Plastic pollution by country: Mismanaged waste index*. Retrieved November 7, 2025, from https://worldpopulationreview.com/country-rankings/plastic-pollution-by-country

Zhu, K., Wu, D., Yang, S., Cao, C., Zhou, W., Qian, Q., & Chen, Q. (2025). Identification of aged polypropylene with machine learning and near-infrared spectroscopy for improved recycling. *Polymers*, *17*(5), 700. https://doi.org/10.3390/polym17050700