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ORIGINAL RESEARCH ARTICLE

# Institutional stakeholder perceptions of plastic upcycling practices and environmental benefits in Dutse Town, Jigawa State, Nigeria

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## ABSTRACT

This study evaluates institutional stakeholders' perspectives on plastic waste handling, upcycling practices, and their perceived environmental benefits in Dutse Metropolis, Jigawa State. Using a descriptive cross-sectional survey design, structured questionnaires were administered to 113 respondents selected across three institutional stakeholder groups: the Jigawa State Environmental Protection Agency (JISEPA, n = 67, sampled from N = 80 via Yamane's formula), ECO Constructors (n = 32, census), and two private plastic waste handling organizations (n = 14, census). Descriptive statistics, analyzed using SPSS, revealed that Polyethylene Terephthalate (PET) bottles (39.8%) and polythene bags (26.6%) were the most frequently reported types of plastic waste handled by respondents. While general awareness of plastic upcycling was high among stakeholders (85.8%), direct engagement or observation of active upcycling practice was substantially lower (46.0%), highlighting a prominent awareness-implementation gap. Respondents identified general waste reduction (33.6%) and greenhouse gas mitigation (24.8%) as primary general environmental benefits of upcycling. When explicitly contrasted with conventional disposal (open burning and landfilling), respondents designated reduced greenhouse gas emissions (44.2%) and enhanced community participation (24.8%) as comparative advantages. There is a highly statistically significant divergence between stakeholders' awareness of upcycling and their actual reported engagement with or observation of operational upcycling activities in the Dutse metropolis. Overall, institutional stakeholders perceive upcycling as a highly beneficial circular-economy strategy. However, realizing its full potential requires overcoming technological and infrastructural bottlenecks to translate widespread passive awareness into active circular-economy operations.

**Keywords:** Stakeholder Perceptions, Plastic Upcycling, Waste Management, Environmental Benefits, Circular-Economy

# Introduction

## Background and problem statement

The global reliance on synthetic plastics, driven by durability, low production costs and versatility, has created unprecedented environmental challenges (Andrady & Neal, 2009). Global plastic production exceeds 400 million tonnes annually (Geyer *et al.,* 2017), with 4.8 to 12.7 million tonnes entering ocean ecosystems each year (Jambeck *et al.,* 2015). In municipal environments where collection infrastructure is deficient, unmanaged plastic waste causes drainage blockages, leaches chemical additives into soil and groundwater (Rochman *et al.,* 2013) and emits dangerous pollutants during open burning (United Nations Environmental Programme (UNEP), 2020).

In Nigeria, an estimated 2.5 million tonnes of plastic waste are generated annually, making the nation one of Africa's largest producers of unmanaged plastic waste (Akinro *et al.,* 2012). In semi-arid urban centers such as Dutse, the administrative capital of Jigawa State, rapid population growth and widespread consumption of single-use items, such as sachet water packaging and polythene bags, have severely strained municipal waste infrastructure (Jigawa State Government, 2021; Nigerian Meteorological Agency (NIMET), 2022). Drainage channels frequently become clogged with discarded plastics, causing localized seasonal flooding, stagnant water and severe public health risks (NIMET, 2022; UNEP, 2020).

In the traditional system, waste is collected and then disposed of through burning, landfilling or open dumping, resulting in the permanent loss of valuable materials and resources. This linear process follows a "take-use-dispose" model, where products eventually become waste. Upcycling, meaning the transformation of discarded post-consumer waste into secondary products of equal or higher functional or economic value without degrading material quality, represents a promising resource-recovery strategy within a circular economy framework (Braungart & McDonough, 2002; Geissdoerfer *et al.,* 2017). Conceptually, upcycling retains material value above standard recycling and energy recovery processes (Lieder & Rashid, 2016; Wilson *et al.,* 2006).

In contrast, the circular economy approach emphasizes the collection and sorting of waste materials, followed by upcycling and resource recovery processes that transform discarded materials into high-value products. Rather than being disposed of, materials are retained within the economy through reuse, recycling and remanufacturing, thereby preserving their value, reducing environmental pollution, conserving natural resources and promoting sustainable development. The circular system creates a continuous loop in which materials remain productive for as long as possible, minimizing waste generation and maximizing economic and environmental benefits.

Although upcycling is gaining traction in southern Nigerian urban centers such as Lagos and Ibadan (Ndubuisi & Sorunke, 2025), empirical studies addressing stakeholder perspectives and upcycling practices in northern, semi-arid urban contexts like Dutse remain scarce. Dutse metropolis faces environmental management challenges associated with urban expansion, inadequate waste-disposal facilities and flooding. Kazaure (2016) reported variations in household waste-disposal practices across selected neighbourhoods, with only 24% of respondents in Yadi using government-designated disposal sites, compared with

100% in Dan Masara. The study also recorded differences in reported flooding, with Yadi having the highest proportion of respondents reporting flooding (84%), compared with 36% in Dan Masara. Similarly, Kura *et al.*, (2023) identified approximately 25% of the assessed area as highly vulnerable to flooding and 53% as moderately vulnerable. Furthermore, Umar *et al.*, (2025) reported that Dutse's built-up area increased from 41.93 $km^2$ in 2015 to 66.91 $km^2$ in 2025, suggesting increasing pressure on urban infrastructure and waste management systems.

Despite these documented environmental challenges, reliable Dutse-specific information on plastic waste generation, composition, seasonal variation, collection, recovery and disposal remains limited. In particular, the quantities and recovery potential of commonly discarded plastic materials, especially polyethylene terephthalate (PET) bottles and low-density polyethylene (LDPE) films, have not been sufficiently established. This lack of baseline information limits the development of evidence-based interventions for plastic waste management and resource recovery. Moreover, although flooding vulnerability has been documented in Dutse, the extent to which improperly discarded plastics contribute to drainage obstruction and related environmental problems remains insufficiently investigated.

Against this background, it becomes necessary to characterize plastic waste generated in the Dutse metropolis, identify the primary types of plastic waste commonly handled/reported by major institutional stakeholders, assess the level of stakeholder awareness and reported engagement/observation regarding plastic upcycling practices, and evaluate stakeholder perceptions of the environmental benefits of plastic upcycling relative to conventional disposal methods. The study is expected to provide baseline data for informed waste-management planning, demonstrate practical opportunities for plastic upcycling, and promote resource recovery as an alternative to indiscriminate disposal. Ultimately, its findings could contribute to improved environmental management, reduced plastic pollution, employment and income-generating opportunities, and the advancement of circular-economy practices in Dutse metropolis.

## Alignment with regulatory frameworks

At the national level, Nigeria's Extended Producer Responsibility (EPR) operational guidelines administered by the National Environmental Standards and Regulations Enforcement Agency (NESREA, 2018) and the newly gazetted National Environmental (Plastic Waste Control) Regulations (NESREA, 2026) assign statutory obligations across the plastics value chain. However, state-level operationalization in Jigawa State faces institutional and technological constraints (NESREA, 2018). Addressing these challenges requires integrating stakeholder insights with modern digital platforms, such as GIS-based municipal waste mapping, digital waste exchange hubs and technology-driven public awareness platforms, to accelerate SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

## Scope and objectives

Because empirical waste characterization studies require physical waste sampling, this study explicitly investigates institutional stakeholder perceptions and reported practices

regarding plastic waste upcycling in Dutse Metropolis. The study aims to i) identify the primary types of plastic waste commonly handled/reported by major institutional stakeholders in Dutse; ii) assess the level of stakeholder awareness and reported engagement/observation regarding plastic upcycling practices; and iii) evaluate stakeholder perceptions of the environmental benefits of plastic upcycling relative to conventional disposal methods (open burning and landfilling).

# Materials and methods

## Study area

Dutse is the administrative capital of Jigawa State, situated in North-Western Nigeria (latitude 11°45'N, longitude 9°20'E), covering approximately 1,326 km$^2$ (Jigawa State Government, 2021). (Fig. 1). The city has an estimated population exceeding 150,000 (National Population Commission, 2022) and functions as an administrative, commercial and transportation hub linking Jigawa to Kano, Bauchi and Yobe States. Located in the Sudano-Sahelian zone, the city experiences a short wet season (June - September) and a long dry season marked by harmattan winds (NIMET, 2022). Rapid expansion and commercial activities have led to the accumulation of heavy plastic in municipal surface drains (Jigawa State Government, 2021; NIMET, 2022).

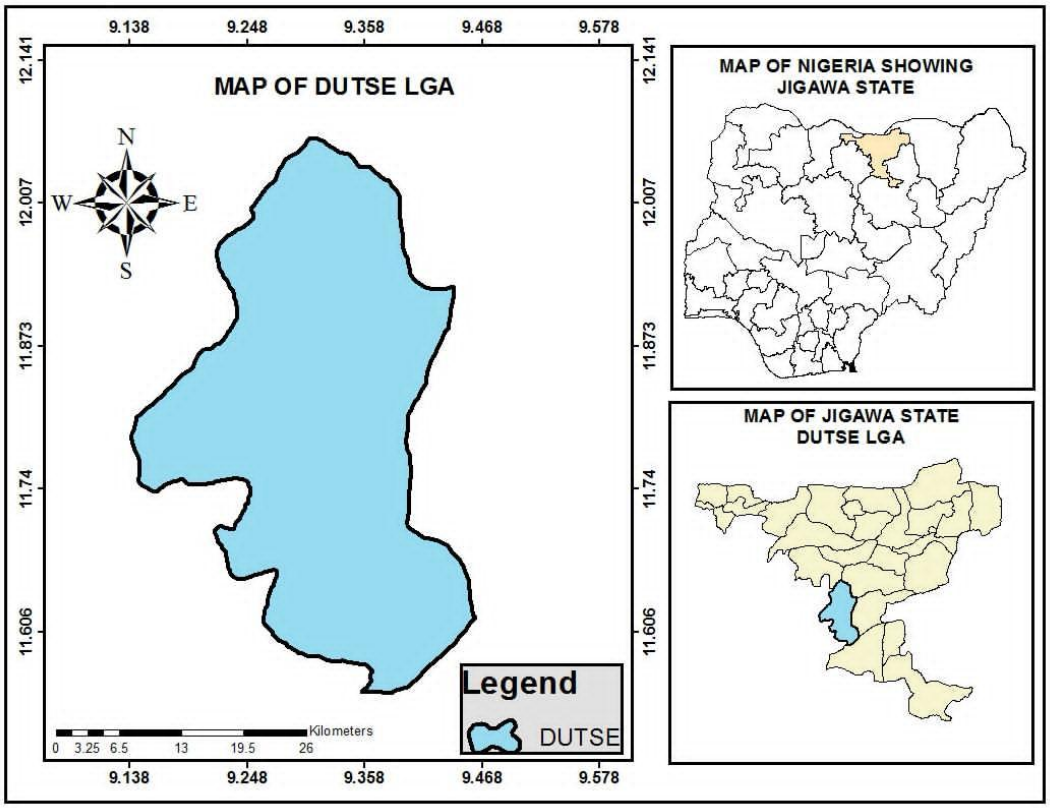



**Figure 1.** Location of the Study Area Source: Laboratory work, 2026

## Research design and population

A descriptive cross-sectional survey design was deployed to systematically capture institutional perceptions and waste management practices at a single point in time (Creswell

& Creswell, 2018; Kothari, 2004). The target population consisted of 126 institutional personnel across the three primary formal entities responsible for waste administration, handling and upcycling in Dutse. 80 staff were from the Jigawa State Environmental Protection Agency (JISEPA), 32 personnel from ECO Constructors, and 14 private waste handlers (Adamu Yelwawa and Abdullahi and Co., Rafin Sanyi). Although the overall target population is modest and heavily skewed toward JISEPA (63.5%), this distribution accurately mirrors the centralized institutional structure of formal municipal waste governance in Dutse. Restricting the population to institutional stakeholders was justified because these actors directly oversee regulatory enforcement, collection logistics and technical upcycling operations, thereby possessing the specialized operational knowledge required to evaluate system-level practices and benefits.

## Sampling strategy and sample size

Using Yamane's (1967) sample size determination formula $n = N / (1 + N(e)^2)$ at a 5% margin of error (e = 0.05), a representative sample of 67 JISEPA staff was randomly selected, while a full census approach was applied to all 32 ECO Constructors personnel and 14 private waste handlers due to their smaller group sizes, resulting in a total sample of 113 respondents (Table 1). However, limiting the sampling frame to formal institutional actors constitutes a methodological limitation, as it excludes informal waste pickers and residential households whose grassroots recovery

**Table 1:** Target Population and Sample Size Distribution

| Category | Target Population (N) | Sampling Technique | Sample Size (n) |
|---|---|---|---|
| JISEPA Staff | 80 | Yamane Formula | 67 |
| ECO Constructors | 32 | Full Census | 32 |
| Private Handlers | 14 | Full Census | 14 |
| **Total** | **126** | | **113** |

activities and waste-generation behaviors also influence the broader waste management ecosystem; future studies should integrate these gaps for a more comprehensive assessment.

## Instrument, validity and reliability

Data were collected using a structured questionnaire developed into four sections: (A) Demographic Characteristics containing respondents' sex and age, (B) Plastic Waste Types Handled, which asks, 'What type of plastic waste do you generate most often?' (C) Awareness and Engagement in Upcycling, with such questions as "Have you heard of the term plastic upcycling?" and (D) Perceived Environmental Benefits, carrying such questions as, "Do you think plastic upcycling helps reduce environmental pollution in Dutse Metropolis?" The instrument underwent expert validation by three senior environmental management academics to establish content and construct validity.

To validate the data collection instruments before full-scale deployment across Dutse Metropolis, a pilot study was conducted with a representative sample of 20 respondents (comprising 10 JISEPA staff, 6 ECO Constructors personnel and 4 private waste handlers). Internal consistency reliability for the multi-item Likert-scale constructs was evaluated using Cronbach's Alpha (α), while categorical socio-demographic and waste-flow items were

verified via Test-Retest Reliability (Cohen's Kappa, κ) over a two-week interval. All instrument sections exceeded the standard psychometric threshold of $\alpha \geq 0.70$, confirming strong internal consistency and structural clarity for field deployment. Standard administrative retrieval procedures were executed to ensure a 100% completion rate across all 113 targeted participants.

### Data analysis and methodological clarification

Quantitative data were processed using IBM SPSS (Version 26) and summarized using descriptive statistics (frequencies and percentages). Inferential causal claims such as "upcycling reduced emissions by X%" were avoided; therefore, the data reflect stakeholder-reported perceptions and observations rather than direct physical or chemical measurements.

### Ethical clearance

Ethical approval was obtained from the Health Research Ethics Committee of the Jigawa State Ministry of Health. Permission to conduct the study was also obtained from the Jigawa State Environmental Protection Agency (JISEPA), Dutse. Participation in questionnaires was voluntary, based on informed consent and participants' identities and responses were treated confidentially. Field activities were conducted in accordance with relevant environmental, occupational health and safety regulations to minimize risks to participants, researchers and the environment.

## Results

### Socio-demographic characteristics

Male respondents represent the majority at 57.5% (n = 65) compared to female respondents at 42.5% (n = 48) (Table 2). This reflects a balanced yet male-leaning participation rate across waste management, collection and institutional stakeholder roles, reinforcing the relevance of targeted capacity building for youth and women enterprise operators. The age distribution remains heavily concentrated among young adults and the economically active workforce. Respondents aged 21 – 30 years (39.8%, n = 45) and 31 – 40 years (26.6%, n = 30) together account for 66.4% (n = 75) of all participants. Including youth under 20 years (17.7%, n = 20), individuals aged 40 years and below represent 84.1% (n = 95) of the sample. The consolidated > 40 years age bracket accounts for 15.9% (n = 18) of the sample. This provides a statistically robust comparative group representing senior institutional officials and established scrap aggregators against the younger operational workforce.

**Table 2:** Demographic Characteristics of Respondents (N = 113)

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Sex | Male | 65 | 57.5 |
| | Female | 48 | 42.5 |
| **Sex Total** | | **113** | **100** |
| Age Group | <20 years | 20 | 17.7 |
| | 21 – 30 years | 45 | 39.8 |
| | 31 – 40 years | 30 | 26.6 |
| | >40 years | 18 | 15.9 |
| **Age Total** | | **113** | **100** |

## Common types of plastic waste handled

PET Bottles (beverage and water bottles) represent the single largest category identified, accounting for 39.8% (n = 45) of all responses. This highlights high consumption rates of bottled drinks and identifies polyethylene terephthalate (PET) as the primary rigid polymer stream available for systematic collection and shredding (Table 3). Polythene Bags (shopping and carrier bags) constitute the second-largest category at 26.6% (n = 30), followed by Sachet Water Bags (drinking water nylons) at 15.9% (n = 18). Combined, these flexible low-density polyethylene (LDPE) film plastics represent 42.5% (n = 48) of the reported waste stream. Because flexible films are lightweight and easily wind-blown, they are the primary drivers of urban drainage blockages during the rainy season.

Food Packaging (rigid containers and wrappers) accounts for 17.7% (n = 20) of the distribution, reflecting widespread reliance on single-use takeaway containers and commercial snack wrappers. Together, PET bottles (39.8%) and polythene/sachet bags (42.5%) comprise 82.3% (n = 93) of all identified plastic waste. This confirms that local upcycling technologies, such as thermal-compression molding, should be specifically calibrated to blend PET and LDPE feedstocks with mineral aggregates to capture the vast majority of the municipal plastic waste stream.

**Table 3:** Plastic Waste Types Handled/Reported by Stakeholders

| Plastic Waste Category | Primary Source Items | Frequency (n) | Percentage (%) |
|---|---|---|---|
| PET Bottles | Beverage & water bottles | 45 | 39.8 |
| Polythene Bags | Shopping/carrier bags | 30 | 26.6 |
| Food Packaging | Rigid containers & wrappers | 20 | 17.7 |
| Sachet Water Bags | Drinking water nylons | 18 | 15.9 |
| **Total** | | **113** | **100** |

## Stakeholder awareness versus engagement in upcycling

It was observed that awareness is overwhelmingly high (85.8%, n = 97), indicating that institutional and community stakeholders are well-informed about plastic upcycling concepts (Table 4). Practical Engagement lags significantly behind (46.0%, n = 52), with less than half of the stakeholders actively participating in or observing upcycling operations. Negative or uncertain responses rise from just 14.2% for awareness to 54.0% for actual engagement/observation. This, by implication, shows that high awareness does not automatically translate into operational practice in Dutse metropolis.

**Table 4:** Stakeholder Awareness versus Engagement in Upcycling (N = 113)

| Metric | Yes (%) | No (%) | Not Sure (%) | Total |
|---|---|---|---|---|
| Awareness of upcycling | 85.8 (97) | 13.3 (15) | 0.9 (1) | 100% |
| Reported Engagement/ Observation | 46.0 (52) | 40.7 (46) | 13.3 (15) | 100% |

To test whether there is a statistically significant association between stakeholders' awareness of upcycling and their reported engagement/observation, the data in Table 4 were subjected to a Pearson's Chi-Square ($\chi^2$) test, which was conducted on the hypothesis that there is no association between stakeholder awareness levels and engagement levels in plastic upcycling in Jigawa State and the result is presented in Table 5.

**Table 5:** Test of Association between Stakeholder Awareness and Engagement in Upcycling

| Metric | Yes | No | Not Sure | Total |
|---|---|---|---|---|
| Awareness (Observed) | 97 | 15 | 1 | 113 |
| Awareness (Expected) | 74.5 | 30.5 | 8.0 | 113 |
| Engagement (Observed) | 52 | 46 | 15 | 113 |
| Engagement (Expected) | 74.5 | 30.5 | 8.0 | 113 |
| **Total** | **149** | **61** | **16** | **226** |

Statistical Significance ($p<0.001$)

The significant gap highlights structural barriers, such as inadequate local processing infrastructure, poor coordination between informal collectors and processors, and limited access to affordable technology, rather than a lack of educational outreach. As such, the null hypothesis ($H_0$) of no association between awareness and engagement levels is rejected. Therefore, there is a highly statistically significant divergence between stakeholders' awareness of upcycling and their actual reported engagement with or observation of operational upcycling activities in the Dutse metropolis.

## Perceived environmental benefits

Respondents evaluated general environmental benefits and specific comparative advantages of upcycling compared to traditional open burning and landfilling (Table 6). On the general perceived environmental benefits, overall environmental waste reduction (primary driver) ranked highest (n = 38, 33.6%, mean rank = 2.67), indicating that approximately one-third of respondents view direct volume reduction of solid waste as the most immediate environmental advantage. The remaining three benefits (balanced secondary priorities) show a relatively even distribution across the sample. Reduction in greenhouse gas emissions ranked second (n = 28, 24.8%, Mean Rank = 2.50),

**Table 6:** Perceived Environmental Benefits by Frequency and Percentage

| Environmental Benefit Category | Specific Perceived Benefit | Frequency (n) | Percentage (%) | Mean Rank* |
|---|---|---|---|---|
| **General Benefits** | Overall environmental waste reduction | 38 | 33.6 | 2.67 |
| | Reduction in greenhouse gas emissions | 28 | 24.8 | 2.50 |
| | Natural resource conservation | 24 | 21.2 | 2.42 |
| | Prevention of drainage blockage and flooding | 23 | 20.4 | 2.41 |
| | **Total** | **113** | **100.0** | — |
| **Comparative Benefits** (Burning vs. Landfill) | Reduced greenhouse gas emissions | 50 | 44.2 | 2.88 |
| | Enhanced community participation/awareness | 28 | 24.8 | 2.50 |
| | Decreased soil & water contamination | 20 | 17.7 | 2.35 |
| | Conservation of municipal landfill space | 15 | 13.3 | 2.27 |
| | **Total** | **113** | **100.0** | — |

* Higher values indicate higher priority.

followed closely by natural resource conservation in third (n = 24, 21.2%, Mean Rank = 2.42) and prevention of drainage blockage and flooding in fourth (n = 23, 20.4%, Mean Rank = 2.41). The narrow spread in mean ranks (2.41 to 2.67) suggests that respondents recognize multiple interconnected environmental benefits rather than a single dominant factor.

Concerning comparative benefits (burning vs. landfill), a dominant climate priority was observed upon comparing waste management alternatives; reduced greenhouse gas emissions emerged strongly in the first place (n = 50, 44.2%, mean rank = 2.88), accounting for nearly half of all responses. Respondents associate alternative waste management practices primarily with mitigating air pollution and emissions compared to open burning or landfilling. Social versus physical infrastructure benefits of enhanced community participation and awareness, ranked second (n = 28, 24.8%, Mean Rank = 2.50), outranking direct physical containment benefits such as decreased soil and water contamination (n = 20, 17.7%, Mean Rank = 2.35, 3rd) and conservation of municipal landfill space (n = 15, 13.3%, Mean Rank = 2.27, 4th). This wider dispersion in mean ranks (2.27 to 2.88) demonstrates a clearer consensus around emissions reduction and community engagement over long-term landfill capacity preservation.

# Discussion

## Dominant plastic streams and recovery potential

The reported predominance of PET bottles (39.8%) and polythene bags (26.6%) aligns with urban plastic consumption patterns documented across regional Nigerian studies (Akinro *et al.,* 2012). In Dutse, the reliance on bottled beverages and packaged water products creates a continuous, high-volume waste stream. Because PET and high-density polythene possess high technical recoverability, prioritizing collection and technological conversion for these specific polymers represents the most viable pathway for regional circular-economy interventions (Geissdoerfer *et al.,* 2017; Ndubuisi & Sorunke, 2025).

### The Awareness–Implementation gap

The primary finding of this study is the marked disparity between high stakeholder awareness (85.8%) and modest reported practice/observation (46.0%). This suggests the presence of operational barriers in Dutse, primarily not driven by information deficit. Instead, regional literature suggests that the shortfall is likely attributable to structural limitations such as inadequate technical equipment, absence of formal financial incentives, weak enforcement of NESREA EPR guidelines at the state level (NESREA, 2018) and underdeveloped market demand for upcycled goods.

### Perceived sustainability and social co-benefits

Stakeholders overwhelmingly perceived upcycling as superior to open burning and landfilling, highlighting reduced greenhouse gas emissions (44.2%) and soil/water protection (17.7%). These perceptions align with established circular-economy models (Geissdoerfer *et al.,* 2017; Lieder & Rashid, 2016; Wilson *et al.,* 2006). Notably, 24.8% of respondents emphasized “enhanced community participation” as a major comparative advantage. This demonstrates that upcycling is perceived not merely as an environmental control mechanism but as a socio-economic strategy capable of fostering civic engagement, local skills development and community-level enterprise creation (Ndubuisi & Sorunke, 2025).

## Conclusion

This study provides empirical insights into institutional stakeholder perspectives regarding plastic upcycling in Dutse, Jigawa State. Institutional stakeholders recognize PET bottles and polythene bags as the primary waste streams needing management. While stakeholder awareness of upcycling principles is high, active operational engagement remains underdeveloped. Stakeholders perceive upcycling as offering significant environmental and social co-benefits over open burning and open dumping. There is a highly statistically significant divergence between stakeholders' awareness of upcycling and their actual reported engagement with or observation of operational upcycling activities in the Dutse metropolis. Overall, environmental benefits are primarily through immediate waste volume reduction and climate mitigation, whilst general benefits, such as resource conservation and drainage protection, are recognized at comparable levels across Dutse metropolis.

However, because the study sample is predominantly composed of institutional stakeholders rather than a fully representative cross-section of all waste-management actors, caution must be exercised when generalizing these findings across the entire Dutse metropolis. Institutional perspectives may not fully reflect the lived realities, economic constraints and operational barriers faced by informal waste pickers, itinerant scrap buyers, private recycling enterprises and household waste generators. Consequently, while these findings offer a robust baseline for policy and institutional planning, broader empirical validation across both formal and informal waste-management sectors is essential to guide comprehensive, city-wide circular economy interventions.

# Recommendations and policy implications

Based on the findings of this work, it was recommended that;

1. The Jigawa State Environmental Protection Agency (JISEPA) should formally integrate plastic upcycling targets into municipal waste frameworks, aligning local enforcement with the gazetted National Environmental (Plastic Waste Control) Regulations (NESREA, 2026.
2. Sustainable waste management initiatives and public sensitization programs are most likely to resonate with stakeholders when anchored in tangible waste reduction and cleaner air outcomes. Consequently, interventions should focus on bridging the technological and infrastructural bottlenecks to turn widespread passive awareness into active circular economy operations.
3. To overcome the institutional bias of existing assessments and ensure city-wide adoption, municipal waste agencies should formally integrate informal waste pickers, itinerant scrap buyers, and youth/women groups into the recovery chain through structured training in waste sorting and pre-treatment.
4. Future studies in Dutse and surrounding urban centers should move beyond institutional perception surveys to conduct physical waste characterization, material flow analysis, and socio-economic assessments targeting households, informal collectors and private scrap enterprises to ensure comprehensive, city-wide policy scalability.

## Declarations

**Author contributions (CRediT):** *Not applicable*

**Funding:** *Not applicable*

**Conflict of interest:** *Not applicable*

**Ethics approval and consent (where applicable):** *Not applicable*

**Data availability:** *Not applicable*

**Use of AI tools (where applicable):** *Not applicable*

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