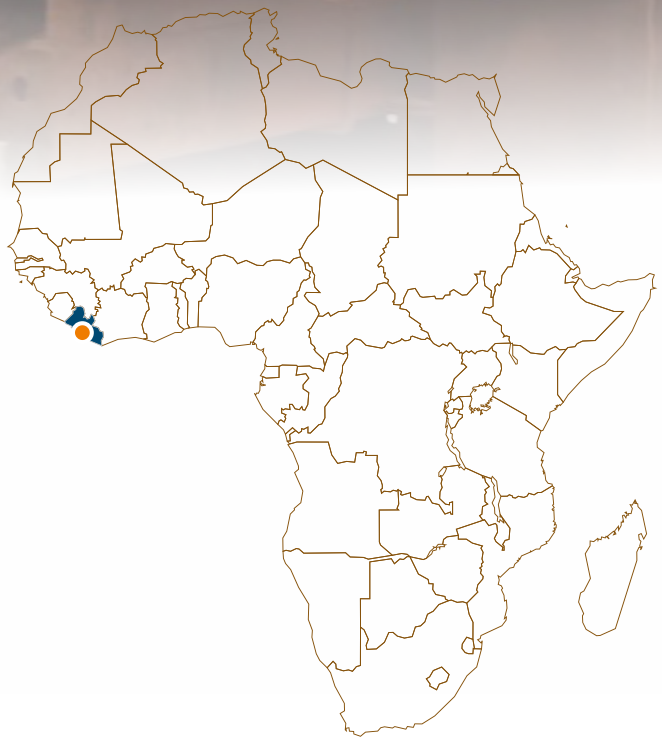
JUNE 2025

CASE STUDY

SUSTAINABLE INSECTICIDE-TREATED NET (ITN) WASTE MANAGEMENT IN LIBERIA: THE EXPERIENCE OF THE 2024 MASS CAMPAIGN

amp | The Alliance for Malaria Prevention
Expanding the ownership and use of mosquito nets

CONTENTS



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BACKGROUND

Liberia, a West African nation with a population of close to six million[1] is divided into 15 counties (see Figure 1). Malaria remains a significant public health concern throughout the country, accounting for 34 per cent of outpatient visits, 48 per cent of hospitalizations, and 23 per cent of inpatient deaths[2].

Figure 1: Map of Liberia showing counties

The National Malaria Control Programme (NMCP) is guided by the National Strategic Plan 2021—2025, which is aligned to technical guidance from the World Health Organization (WHO) and supported by the Government of Liberia and partners such as the Global Fund, the US President's Malaria Initiative (PMI) and the RBM Partnership to End Malaria (RBM), among others.

1. https://www.worldometers.info/world-population/liberia-population/#google_vignette (retrieved 9 June 2025)
2. https://www.severemalaria.org/statistics-facts-by-country/liberia#:~:text=Liberia%20is%20a%20country%20in,and%2023%25%20of%20hospital%20deaths.

The core malaria prevention intervention in Liberia is the distribution and use of insecticide-treated nets (ITNs). ITN distribution is conducted through three channels: routine health services, via antenatal care (ANC) and the Expanded Programme on Immunization (EPI), school-based distribution, and mass campaigns aiming at universal coverage.

The Liberian Ministry of Health, through the NMCP and partners, implemented a national ITN mass distribution campaign in 2024. The campaign targeted the country's total population of over 5.5 million people with dual active ingredient (AI) nets, largely funded by the Global Fund. Based on the mass campaign macro-quantification, a total of 3,093,479 nets (61,870 bales) were procured by the Global Fund. The microplanning workshops at the sub-national level (counties) subsequently identified a gap of over 200,000 nets, which was filled by US PMI - Liberia.

In October 2024, the NMCP and partners concluded the nationwide mass campaign, with 2,983,903 ITNs distributed across the country through fixed distribution points, outreach and mobile distribution sites as well as door-to-door delivery (see Table 1).

Table 1: ITN distribution table by county

County	ITNs required	ITNs distributed
Bomi	93,782	88,676
Bong	275,541	260,510
Gbarpolu	56,579	51,929
Grand Bassa	200,520	188,570
Grand Cape Mount	105,382	91,246
Grand Gedeh	127,716	98,123
Grand Kru	64,445	52,179
Lofa A	259,479	246,164
Margibi	279,732	248,324
Maryland	101,495	80,895
Montserrado	1,117,165	1,007,648
Nimba	419,550	398,322
River Gee	73,470	54,394
Rivercess	53,503	46,453
Sinoe	88,620	70,470
Total	**3,316,979**	**2,983,903**

WASTE MANAGEMENT CONCERNS

Mass ITN distribution campaigns generate large quantities of different kinds of plastic waste which may be contaminated with insecticides, including bale wrappings (polypropylene sheets for bulk ITN transport), individual plastic bags (low density polyethylene - LDPE) sleeves for single ITNs, bale strapping (polyethylene terephthalate - PET), bands for securing bales, and other plastic materials (plastic tags, torn packaging and pallet covers). Given the toxicity risk, sound waste management is essential to prevent environmental contamination.

The ITNs procured for the 2024 campaign were packaged in individual plastic bags, with 50 nets per bale. Recognizing the need for a robust waste management plan, the Liberia NMCP ensured that environmental impact mitigation strategies were included in the campaign's planning and budgeting activities.

ITN WASTE MANAGEMENT STRATEGY

One of the tasks set during the campaign planning was to estimate the volume of plastic waste to be generated to help in planning for the logistics operations and budget, and to ensure tracking and proper documentation of the waste. The estimate for the 2024 ITN mass campaign was over 75,000 kg of plastic waste, as detailed in Table 2. Premier Enviro Solutions had the weights of all IG2 packaging from the 2023 Sierra Leone campaign. Those weights were used to estimate the total weight based on the quantity of all bags, bales, and straps. It was estimated that one bale bag, holding 50 individual packs and straps weighed 1.38 kilograms.

Table 2: ITN waste quantities and types (estimate)

Waste type	Plastic composition	Quantity	Total weight (kg)
Individual bags	Polyethylene (PE) (90%) and polypropylene (PP) (10%)	3,193,479	60,676.10
Bales	PP (woven)	63,870	10,219.13
Straps	Recycled polyethylene terephthalate (PET) (4 per bale)	63,870	4,470.87
Total waste			**75,366.1 kg**

For the earlier 2021 campaign, waste disposal relied on incineration, but due to a lack of incinerators with sufficient capacity or functionality to comply with regulations concerning plastic waste, the waste was burned in open spaces, contrary to WHO recommendations (see Table 3). Based on the lessons from the 2021 campaign, a revised approach for the management of ITN waste was adopted in 2024, prioritizing recycling as a more sustainable alternative.

The 2024 ITN campaign waste management plan had the following objectives:

- To ensure the proper collection and documentation of plastic waste generated from the ITN mass campaign. Distribution point (DP) supervisors were required to verify that the number of waste packets collected matched the number of ITNs distributed. This process was integrated into the supervisory checklist, ensuring that all waste was packed and collected daily at each distribution point.
- To prevent the burning of plastic waste at the community level, ensuring that all waste was collected by the distribution teams and stored in empty bale packs for safe handling.
- To coordinate the reverse logistics and transport of collected waste from the DPs to designated recycling facilities, ensuring environmentally responsible disposal of the plastic waste generated during the ITN mass campaign.

Table 3: Do's and Don'ts of ITN packaging waste management[3]

GUIDANCE	
PRACTICES TO BE AVOIDED **DO NOT**	**ACCEPTABLE PRACTICES** **DO**
✖ Encourage the reuse of ITN bags for any other purpose to avoid the risk of pesticide poisoning. ✖ Dispose of ITN bags and contaminated baling material as ordinary waste or in improper sanitary landfills. ✖ Burn ITN bags and baling material in the open air as there is a risk of emission of harmful substances that mainly pollute the air, surface water, soil, and food.	✔ Where possible, and with no reduction in the public health benefit, distribute ITNs without leaving any packaging with the intended ITN recipient. ✔ Recycle ITN packaging. Recyclers processing used ITN bags and baling material should apply proper controls of their materials and processes to ensure the bags are only recycled into appropriate products, which have "limited potential for human contact and are not likely to be recycled again". ✔ Ensure proper personal protective equipment is used and control measures are strictly followed by workers involved in all stages of waste management operations for the collection, sorting, recycling, and disposal of ITN bags and baling material. ✔ Incinerate ITN bags and baling material ONLY if specified high temperature incineration conditions for pesticide-tainted plastic can be assured, following the Basel Convention Technical Guidelines[4] and in accordance with national regulations and requirements. ✔ Store used ITN packaging awaiting future safe recycling, disposal, or other processes in dry, well-ventilated, and secure facilities. ✔ If recycling or incineration is not possible and if the ITN manufacturer provides directions on methods for safe disposal, follow the manufacturer's recommendation. Alternatively, landfilling of bags and baling material in a properly engineered landfill is an option, as detailed in the FAO/WHO Guidelines on Management Options for Empty Pesticide Containers. ✔ National pesticide registration authority to make mandatory that manufacturers provide recommendations on the safe disposal and/or recycling of ITN packaging. This will include information on the labels of ITN bags regarding the material used in the production of such bags. ✔ Ensure that the disposal of ITN packaging is included as a condition in the procurement of ITNs. ✔ Develop national ITN packaging management protocols for these wastes and ensure that all stakeholders are aware of proper packaging disposal procedures that are aligned with national regulations and requirements. ✔ Integrate good practice recommendations on the sound management of ITN packaging into the existing national malaria strategy and related frameworks and ensure that recommendations are aligned with national regulations concerning the safe handling and disposal of chemical waste (or pesticide-tainted waste).

3. WHO, 2011 *Recommendations on the Sound Management of Packaging for Long-Lasting Insecticidal Nets.* https://continuousdistribution.org/wp-content/uploads/2022/03/WHO-Recommendations-LLIN-Packaging.pdf
4. https://www.basel.int/Implementation/TechnicalMatters/DevelopmentofTechnicalGuidelines/TechnicalGuidelines

As an initial step during macroplanning, the NMCP and partners, through the National Public Health Institute of Liberia (NPHIL), assessed incineration capacities across the 15 counties, considering their operational temperatures and suitability for ITN waste. This assessment revealed that most health facilities lacked incinerators capable of meeting WHO standards for ITN packaging disposal (i.e. 850°C–1100°C for hydrocarbon wastes and 1100°C–1200°C for halogenated wastes). Furthermore, existing incinerators often failed to completely combust medical waste, leaving a thick, melted plastic residue. Consequently, given the specific plastic composition of the campaign materials, NPHIL strongly advised against using these county-level incinerators, as the ITN waste would likely cause further damage and incomplete combustion.

Consequently, efforts were focused on identifying local recycling options with more environmentally friendly and sustainable options, including reusing some plastics in local/regional industries, for example, for making construction materials.

IDENTIFICATION AND ASSESSMENT OF PRIVATE SECTOR WASTE RECYCLING OPTIONS

The NMCP, with technical assistance from International Public Health Advisors (IPHA), initiated a search for a registered private recycling company within the country capable of managing the volume of plastic waste produced from the ITN mass campaign. The selected company was required to comply with environmental, health, and safety guidelines in managing ITN-associated plastic waste, aligning with WHO recommendations to ensure that the waste was recycled into appropriate non-consumable products.

The assessment team, composed of staff from BASF West Africa, International Public Health Advisors (IPHA), and Premier Enviro Solutions with experience in waste management and recycling, reviewed all aspects of the waste management needs, including budgets, gaps, compliance guidelines, and lessons learned from an ITN waste management project that took place in Sierra Leone in 2023 to assess local companies with the following requirements:

- Use of mobile crushers to reduce the volume of waste at the county level.
- Moving of plastic waste (already crushed) directly from the county warehouses/ stores to the capital, Monrovia.
- Capacity to handle the estimated quantity of waste.

The findings of the assessment indicated that no recycler had the mobile diesel crushers required to reduce volume, since the crushers in Liberia are all fixed-site. Machines for compressing bales were also not available. However, the assessment showed that one local company, DuraPlast, which specializes in plastic manufacturing and recycling, could receive the individual crushed bags, with an estimated weight of approximately 61 tonnes. In addition, DuraPlast could transport the crushed ITN waste from crusher points in Monrovia (Montserrado) and Gbarnga (Bong) to their recycling site at no cost to the NMCP. The assessment found no recyclers in Liberia that could recycle the crushed bales and uncrushed straps.

PUBLIC-PRIVATE SECTOR PARTNERSHIP

Following the extensive assessment, a public-private partnership was established with DuraPlast to handle the 2024 ITN mass distribution of plastic waste. It was agreed with DuraPlast to recycle (re-process) the waste into conduits (pipes used in the construction industry)[5]. DuraPlast also produces steel (iron) rods from scrap metal for construction and manufactures various kinds of household and industrial plastic pipes using both virgin and recycled plastic.

The subsequent operational plan determined the roles and responsibilities of different stakeholders involved in the management of the waste.

DuraPlast was responsible for the following:

- Segregation, bagging, and weighing
- Loading and transporting of waste from county seats to their warehouses in Monrovia[6]
- Storage at their warehouses and crushing Recycling crushed waste (packaging)[7] into building materials such as conduit pipes.

Plan Liberia, the campaign implementer, was responsible for the following:

- Transport of the waste from source (pre-positioning and distribution points) to the county seats
- Consolidation of the waste at central sites in the county seats
- Official handover of waste to DuraPlast

The process included:

1. **Collection and segregation** – Sorting waste by plastic type into categories (individual packs, bales, straps) and storing in empty bale sacks.
2. **Transport and consolidation** – Transporting waste from distribution points to county warehouses for consolidation and later moving to Monrovia for crushing before recycling.
3. **Crushing and recycling** – Processing the waste into construction materials.

5. Jessica Rockwood, *Liberia Waste Management Assessment Findings, Budget and Recommendations*, May 2024.
6. Due to some logistical and weather-related challenges, crushing was done in Monrovia and not at county seats.
7. As bales and straps could not be recycled by DuraPlast, another company, Premier Enviro Solutions, was tasked to manage cross-country logistics for bales and straps and collect and transport the balance of the waste (estimated 14.6 tonnes).

IMPLEMENTATION OF THE WASTE MANAGEMENT PROCESS

The campaign management team decided that the waste should be stored at a decentralized level and go through the following process:

- During distribution, teams removed ITNs from their plastic packaging before delivering nets to households, ensuring no plastic waste was left with recipients.
- Each type of waste was collected and packed separately (i.e., individual packs in one large pack, empty bales in one bag, and straps in a different bag).
- Teams packed collected waste in empty bale sacks daily throughout the distribution period.
- Vehicles used for monitoring visits in the field were used to transport the waste back to the district warehouse.
- After the completion of the distribution, the ITN campaign implementing partners transported the waste generated during the campaign from the district warehouses to the county seat.
- The recycling company collected the waste from the county seat (or other locations where bad roads did not allow them to reach the county seat) to their factory in Monrovia for recycling[8].

Crushed plastic ready to be transported

8. A longer than usual rainy season and impassable roads and bridges resulted in not being able to crush the plastic bags and bales at the county level.

RESULTS

Table 4 gives a summary of the waste actually collected by county.

County	Waste generated (total)	Individual plastic bag	Bale	Strap	Total
Bomi	1,866	1,234	203	93	1,530
Bong	6,503	5,000	542	115	5,657
Gbarpolu	1,311	1,009.5	128.5	45	1,183
Grand Bassa	4,096	2,769	445	215	3,429
Grand Cape Mount	2,487	1,954.5	270.5	34	2,259
Grand Gedeh	2,315	1,830	255	33	2,118
Grand Kru	1,315	981	90	32	1,103
Lofa A	5,130	3,701	551.5	234.5	4,487
Margibi	5,863	4,620	403	166	5,189
Maryland	1,863	1,467	201	83	1,751
Montserrado	26,712	21,487	3232.5	833.5	25,553
Nimba	8,675	5,887	542	315	6,744
River Gee	1,287	926	116	55	1,097
Rivercess	1,075	843	109	18	970
Sinoe	1,643	1,116.5	152	51.5	1,320
Total	**72,141**	**54,825.5**	**7,241**	**2,323.5**	**64,390**

Table 4: Summary of weight (kilograms) of waste collected by county

Figure 2 below shows graphically the very extensive operation that the recycling company undertook to ensure that 89 per cent of the total waste was recycled.

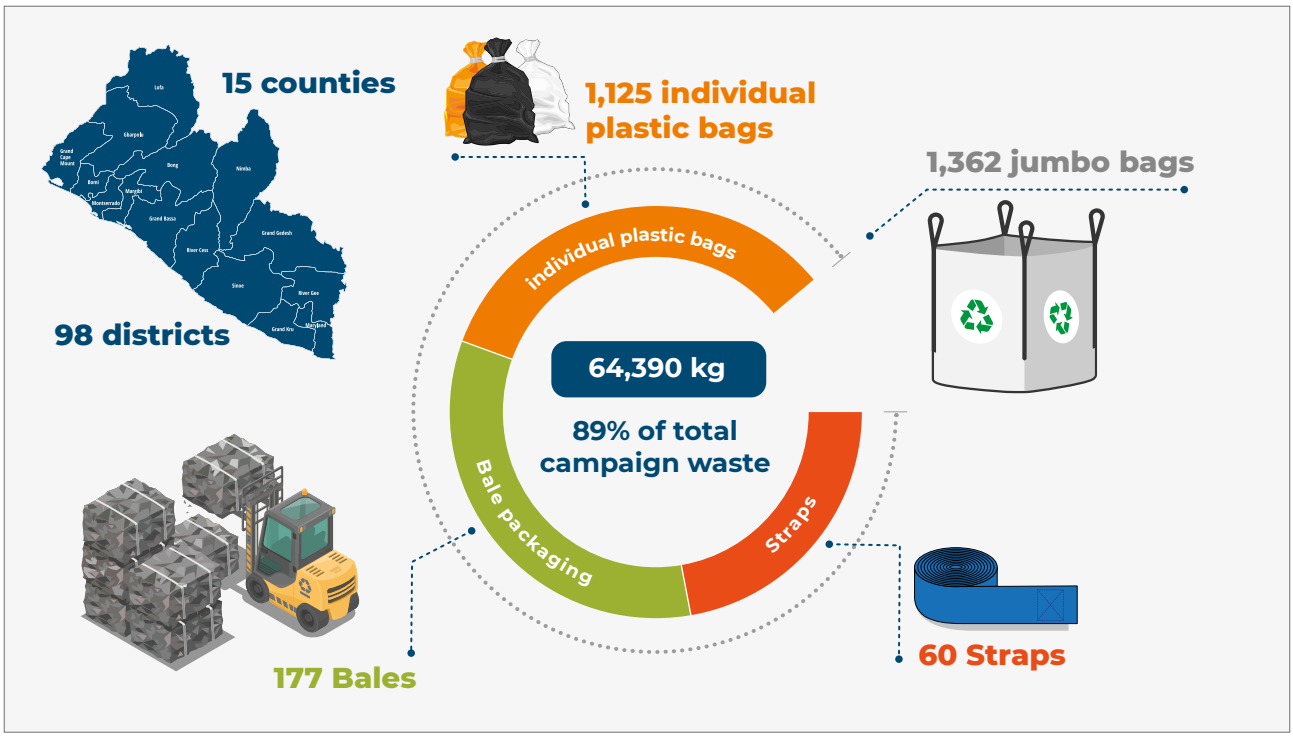
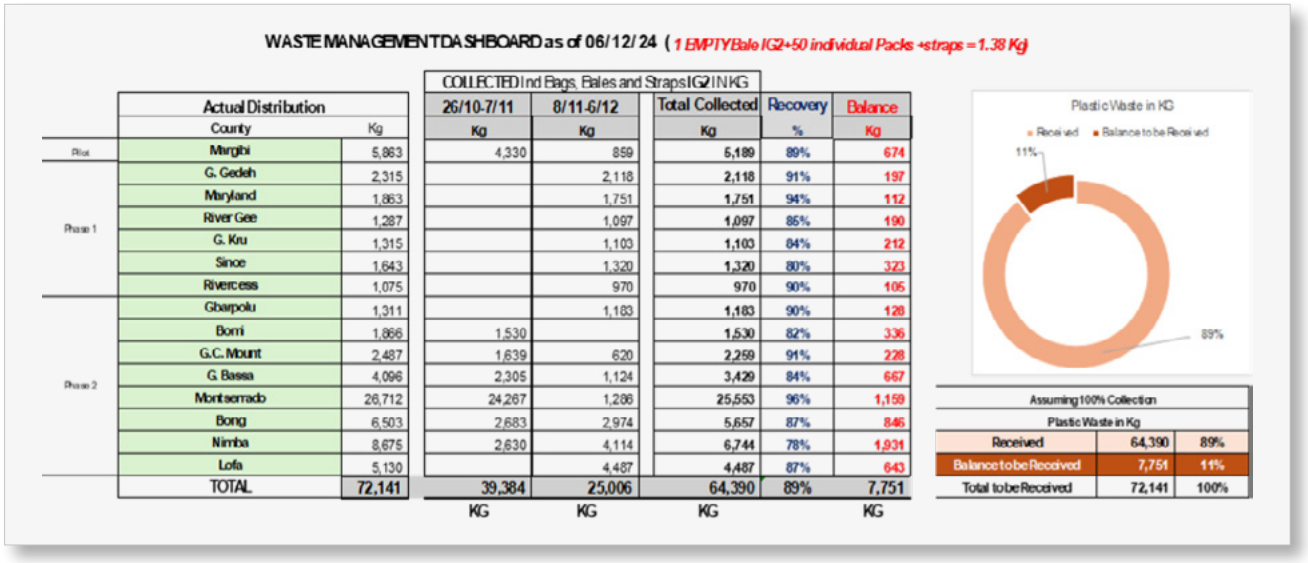


Figure 2: Proportion of waste recycled

Figure 3 below shows the dashboard summary of results.



WASTE MANAGEMENT DASHBOARD as of 06/12/24 (1 EMPTY Bale IG2+50 individual Packs +straps = 1.38 Kg)

	Actual Distribution		COLLECTED Ind Bags, Bales and Straps IG2 IN KG				
	County	Kg	26/10-7/11	8/11-6/12	Total Collected	Recovery	Balance
			Kg	Kg	Kg	%	Kg
Pilot	Margibi	5,863	4,330	859	5,189	89%	674
Phase 1	G. Gedeh	2,315		2,118	2,118	91%	197
	Maryland	1,863		1,751	1,751	94%	112
	River Gee	1,287		1,097	1,097	85%	190
	G. Kru	1,315		1,103	1,103	84%	212
	Sinoe	1,643		1,320	1,320	80%	323
	Rivercess	1,075		970	970	90%	105
Phase 2	Gbarpolu	1,311		1,183	1,183	90%	128
	Bomi	1,866	1,530		1,530	82%	336
	G.C. Mount	2,487	1,639	620	2,259	91%	228
	G. Bassa	4,096	2,305	1,124	3,429	84%	667
	Montserrado	26,712	24,267	1,286	25,553	96%	1,159
	Bong	6,503	2,683	2,974	5,657	87%	846
	Nimba	8,675	2,630	4,114	6,744	78%	1,931
	Lofa	5,130		4,487	4,487	87%	643
	TOTAL	72,141	39,384	25,006	64,390	89%	7,751
			KG	KG	KG		KG

Assuming 100% Collection		
Plastic Waste in Kg		
Received	64,390	89%
Balance to be Received	7,751	11%
Total to be Received	72,141	100%

Figure 3: Waste management summary

DuraPlast has recycled 64,390 kg of plastic waste into cable conduit pipes. The recycling process involved extruding ITN bags into pellets, blending them with colourants, and moulding them into conduit pipes—a time-intensive procedure.

The recycled product – conduit pipes for the construction industry

CHALLENGES

Contracting delays: A lengthy procurement process for the waste management service provider hindered timely waste management implementation. Late decisions were made over the waste management strategy due to a long tendering process involving evaluation and negotiations due to the complexity of the job, as well as needing to consider the size of vehicle required, distances to cover and road conditions.

Logistical hurdles: Heavy rains and poor road conditions disrupted transport which had an impact on the waste collection timeframe. There were delays in consolidating waste at county warehouses (e.g. Nimba, Lofa). Not all waste was brought to the county warehouses and DuraPlast Liberia Inc. had to dispatch trucks to other locations within the county, resulting in increased cost to the company.

Limited recycling capacity: Only one recycler could process individual bags; bales and PET straps were processed separately. A slow pelletization process delayed final recycling: individual plastic bags must be turned into pellets by extrusion and then blended with colouring to produce the cable conduit pipes.

Inefficient consolidation and tracking process before crushing: Plastic waste transported back to county seat warehouses was not counted or weighed. The estimated weight relied on the ITNs distributed figure multiplied by the average weight per pack of waste (1.38kg). At the county seat warehouses, the collected plastic was just offloaded and stored with other waste from other locations within the county. The probability of tracking errors was very high, with difficulty in detecting where the discrepancies may have occurred.

RECOMMENDATIONS

a. **Early planning:** Integrate waste management into campaign design and budgeting from the onset, i.e. at the time of ITN procurement, when it has been confirmed that ITNs will have individual bags.

b. **Stakeholder engagement:** Partner with recyclers early to assess capacity, negotiate costs, and invest in local recycling infrastructure. This stage involves working first with national ministries or departments that are responsible for waste.

c. **Training and regulatory compliance:** Train campaign personnel on proper waste segregation and documentation.

d. **Technology integration:** Use barcoded packaging to track waste recovery rates and improve accountability.

e. **Unlock private sector investment:** The government, through the Ministry of Environment, to engage with the private sector and advocate for their support in ensuring sustainable waste management.

f. **Cost considerations:** A key consideration for replicating this successful waste management model is its cost. The direct contractual cost paid to DuraPlast for the crushing, transport and recycling of 64,390 kg of plastic waste was USD 46,741. It is important to note that this figure does not represent the total cost of the end-to-end waste management process. Additional costs were embedded within the broader campaign budget, including those associated with the work of implementing partners to transport and consolidate waste at the county seats. Furthermore, significant in-kind technical assistance was provided by the assessment team during the planning and partnership development phase. While disaggregating these embedded costs is challenging, the USD 46,741 serves as a clear benchmark for the direct private sector engagement required for a recycling initiative of this scale in Liberia

CONCLUSION

The Liberia 2024 ITN campaign demonstrated that sustainable plastic waste management in mass campaigns is achievable. Through partnerships with recyclers and innovative waste management strategies, 89 per cent of campaign waste was collected and recycled.

Glossary

Individual plastic bags	Polyethylene (PE) sleeves used to package single ITNs
Bales	Woven polypropylene (PP) sheets used for bulk ITN transport
Straps	Recycled polyethylene terephthalate (PET) bands used to secure ITN bales
Non-recyclable waste	Materials like PET straps require specialized disposal (e.g. transport to Sierra Leone for construction blocks)
Incineration	Burning in a state-of-the art industrial facility. This involves burning waste at high temperatures to eliminate toxins. This approach is discouraged by WHO unless compliant with safety guidelines.
Recycling	Recycling plastic waste into new products (e.g. conduit pipes for the construction industry)
Segregation	Separating waste into categories (e.g., individual bags, bales, straps) for efficient processing
Crushing	Reducing plastic volume using mobile or fixed-site machines to prepare waste for recycling
Pelletization	Extruding crushed plastic made into pellets for manufacturing new products

AMP CONTACTS

To join the weekly AMP conference call each Wednesday at 10:00 AM Eastern time (16.00 PM CET) use the following Zoom meeting line:
https://us06web.zoom.us/j/2367777867?pwd=a1lhZk9KQmcxMXNaWnRaN1JCUTQ3dz09

You can find your local number to join the weekly call:
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