Plastic Leakage Identification and Monitoring for National Action Plan Approach in Myanmar

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Abstract

The growing problem of plastic waste has become a call to ASEAN member states to develop and implement national action plans. In this study, a mechanism for applying national action plans to address plastic waste was applied to plastic leakage monitoring. Focusing on Myanmar's action plans, we developed a comprehensive methodology that focuses on maximizing monitoring to fill gaps in national action plan implementation. This study implemented waste management assessment using the Waste Flow Diagram (WFD) tool, which established the initial framework for monitoring plastic waste status in cities. This assessment was also supported by field surveys using a mobile application (app) for getting an overview of microplastics and consulting stakeholders. We processed the results through Geographic Information System (GIS) analysis to calculate the amount of plastic leaking into the open environment. From our first assessment, we found more than 5,000 tons of plastic waste had possibly leaked from 33 townships in Yangon and, judging from an accumulation survey, that most of the municipal solid waste handled in this city was subjected to open dumping practices. The challenges addressed here emphasize cultivation of different sectors of waste management stakeholders and engagement with informal sectors.

Key words: ASEAN, GIS, national action plans, plastic, waste management

1. Introduction

Plastic waste has emerged as an enormous issue, forcing countries to take active measures. UN Resolution 5/14 established the Intergovernmental Negotiating Committee (INC) to develop an international legally binding instrument for addressing plastic pollution. The second session, INC-2, involved more than 190 nations from around the world in crafting a plastics governance based on the entire life cycle of plastic waste. As a result, numerous approaches have been included among national action plans on plastic that each of the represented countries has embarked on. Their action plans include short-term targets needing concise strategic approaches and practical improvements.

Plastic waste issues has been approached by integrating mapping and modelling to cover wide areas. Plastic waste has been successfully mapped, with different fates of plastic waste identified (Rinasti *et al*., 2022). Studies on plastic waste in rivers imply they are less likely to be found in oceans (van Emmerik *et al*., 2022), and unanswered questions remain about plastics in waterways and prolonged plastic transport. Robust monitoring of plastic waste, which can be automatized, can provide a grasp of plastic transport, and used for fostering strategic actions among stakeholders.

Meanwhile, another approach to plastic pollution has been developed, employing systemic assessment through overall management. Several studies have been conducted and proposals made implementing different applications for addressing hotspot plastic waste in the environment. An approach developed using the Waste Flow Diagram (Cottom *et al.*, 2020), Waste Wise Cities, employs a pollution calculator and encourages plastic hotspot actions and has been developed to its current state. It now focuses on information on plastic waste at the risk of being leaked.

Monitoring systems for plastic waste have involved the use of automation, artificial intelligence and machine learning to grasp the problem of plastic waste. Compliance with monitoring overall is one of the objectives of the application's use in taking action to support treaties on plastics. These monitoring systems have been applied in some cities in Mekong River countries by installing CCTV in canals (Geoinformatics Center, 2023). Solutions for cities overall, however, still need to be developed.

Therefore, an approach was developed integrating the participatory mapping concept with an overall assessment of the whole waste management system. This approach involved technology, employing devices used in daily life like mobile phones. A mobile app used in a previous macro-plastic survey that was well established and had been well known since the CounterMEASURE phase-II project was utilized (Geoinformatics Center, 2023).

As a result, city-level maps were developed that helped build a consensus for national action plans on improving waste management monitoring. The terminology of leakage mapping was introduced via various approaches for tracking down plastic material over its entire lifetime. The automation provides leakage mapping for the calculations in the waste management assessment along with information on actual hotspot areas from the mobile app. This study thereby aimed to address the primary sources of leakage and improve the means of directly addressing the issue, enabling measures to address plastic waste in the environment to be controlled and managed.

2. Methodology

The scope of the study focused on the area covered by the Yangon City Development Committee (YCDC) in Yangon City, Myanmar. The YCDC managed 33 townships, with the boundary assimilated during the study period (August 2022 to December 2022).

Leakage mapping was integrated with modelling, as shown in Fig. 1. The data were mainly collected from city-level assessments, validated through the mobile app survey, and compiled to produce a plastic leakage map for Yangon City.

2.1 Waste Flow Diagram

Waste Flow Diagram (WFD) is a concise tool for mapping the flows of macro waste in a municipal solid waste management system at the city level, including quantifying the sources and fate of plastic leakage. This tool features a prominent workflow that includes overall assessment of plastic leakage (Giang *et al.*, 2023; Rinasti *et al.*, 2022).

WFD provides a rapid assessment methodology to identify macro-waste flows in the municipal solid waste system at the city level (Cottom *et al.*, 2020). The assessment methodology includes quantifying the sources and fates of plastic pollution. In this study, we utilized the features of WFD by incorporating the different fates as part of plastic waste leakage identification in the open environment.

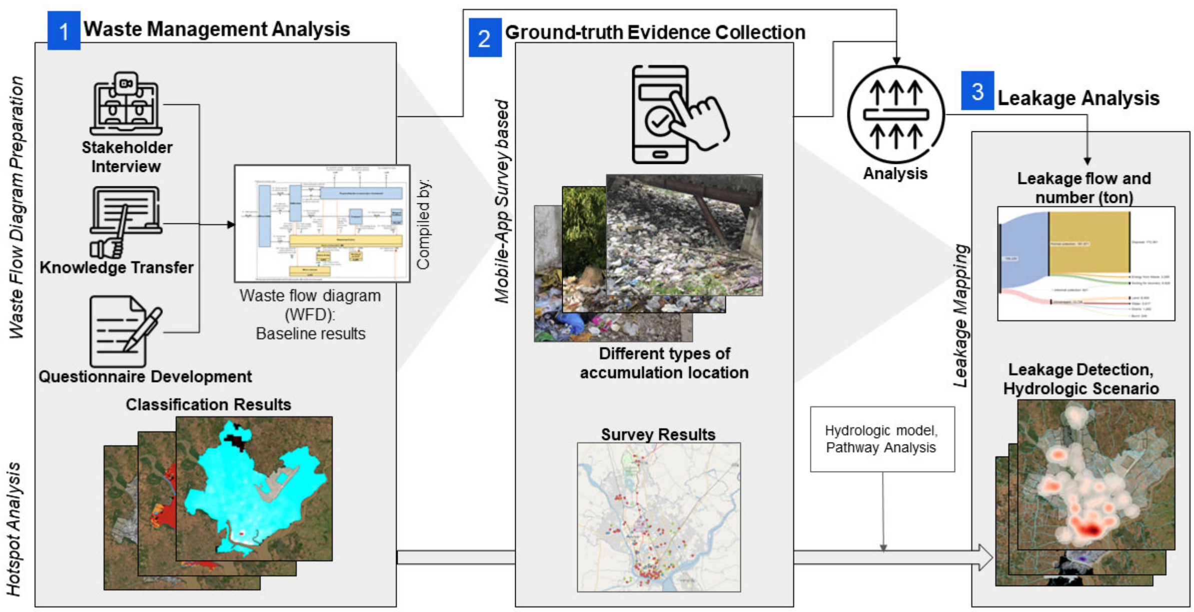

Fig. 1 Graphical methodology for plastic waste identification and monitoring.

WFD is structured according to material flow analysis, representing mass flows. For example, uncollected waste includes all waste generated that does not undergo processing. It quantifies uncollected waste using a mass balance approach, subtracting the quantities received by recovery and disposal facilities from the total MSW generated.

The data compiled by the WFD tool include a general assessment of the city's waste management program. The essential step in developing the WFD assessment was setting the data boundaries based on the different townships in Yangon City. This step in WFD included gathering basic information, such as the composition of the MSW, population information and MSW generation per capita.

The information in the township's waste-management working structure included both formal and informal sectors working on waste treatment and disposal. Based on the WFD User Manual (Cottom *et al*., 2020), the data required at this stage included:

- Waste diverted from disposal for recovery,
- Formal and informal collection of recyclables,
- Service and value chain for informally sorted materials,
- Items rejected from formal and informal sorting,
- Amount of waste going to disposal facilities,
- Composition of disposed waste,
- Materials extracted from disposal facilities and
- Level of control of sorting and disposal facilities.

After that, the numbers obtained on plastic waste composition continued to be quantified for plastic leakage by determining fates. The fates of plastic leakage were considered in four areas: burnt, on land (retained on land but not managed), in storm drains and in water systems. Using a decision-making tree process, the quantification was determined in tons based on one-year data input and observations.

The WFD study in Yangon (Fig. 2) found plastic waste generation of 196,229 tons/year. This amount of waste is equated to a population of 5,515,000 people, 0.5 kg/person of municipal solid waste (MSW) per capita, and plastic composition in MSW. Plastic waste was the second most generated waste (19.5%) behind organic waste (59%), followed by "other types" (11%), paper (5%), glass (3%) and metals (3%).

2.2 Data Collection and GIS Mapping

Plastic leakage monitoring has been improved by including GIS (Geographic Information System) processing. The leakage mapping concept was enhanced by correlating it with a plastic value-chain analysis and spatial context assessment (Tran-Thanh *et al*., 2022). This study incorporated the GIS concept's utility by developing data collection methods and replicable analysis.

A mobile app was developed to improve the data collection experience. The mobile app was introduced to process observations of plastic waste accumulating in the open environment. This study focused on macroplastics (plastic items with a dimension > 5 mm) since the data collection was determined based on visual assessment. The mobile app compiled data based on geolocation

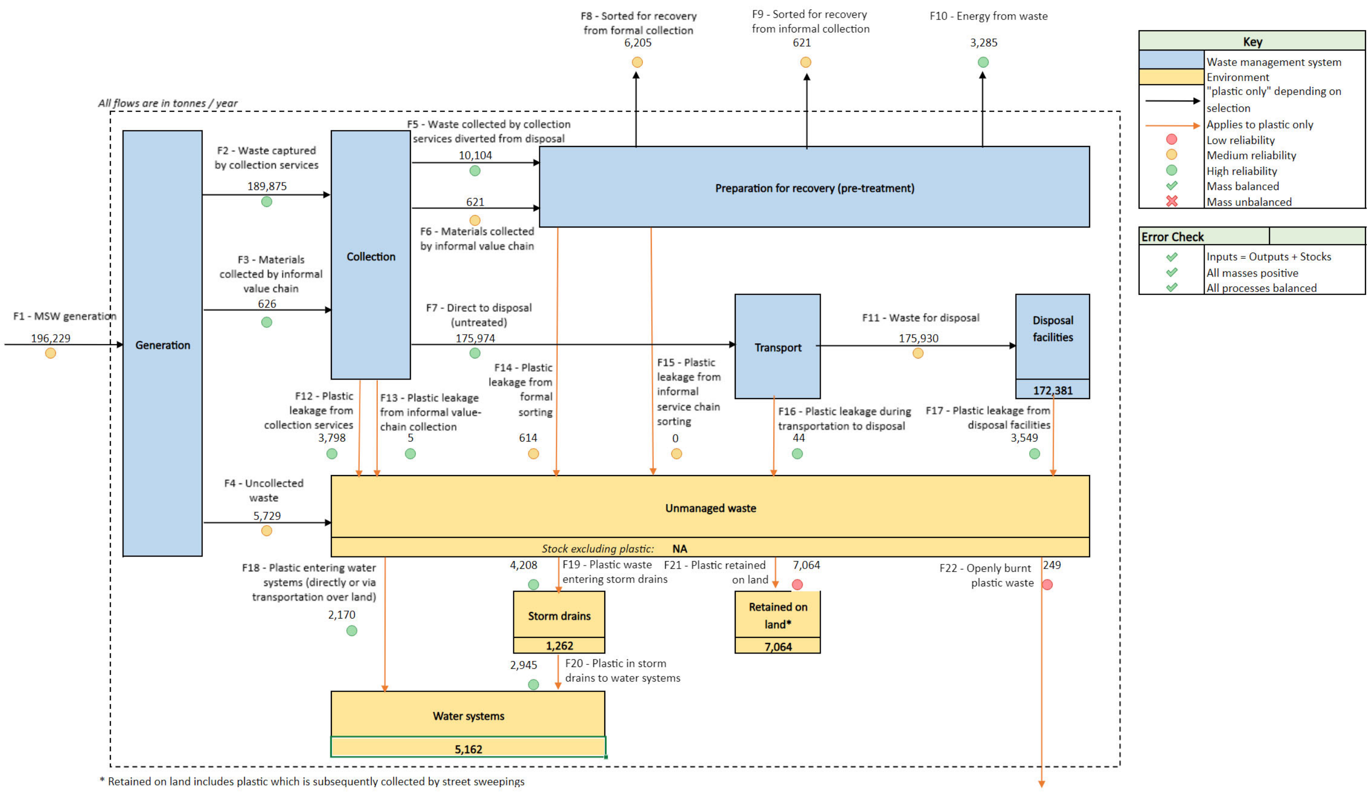

Fig. 2 Plastic waste flow diagram over a one-year period.

(recorded using Global Positioning System (GPS] location), photos of the sites and some basic information about the area where plastics were accumulating.

Through the data collection method, we planned for the team to survey different areas based on township coverage. The team was assigned to collect data on the overall types of plastic accumulation prominently found in the open environment. In this survey, we generalized and categorized it into three kinds of accumulation:

- Artificial Barrier
  An artificial structure in a river or riverbank that captures or blocks plastic debris from entering rivers.
- Littering Site
  A location where many people dispose of or carelessly strew their waste or garbage improperly, creating environmental pollution and visual blight.
- Uncontrolled Dumpsite
  An unauthorized location where waste is dumped without proper management. Commonly, such areas do not reach a level that would be considered open dumping.

Later, the team considered conditions of plastic accumulation, such as whether cleaning was carried out in the area, the approximate sizes of the accumulated plastics, the dominant types of plastic waste seen, and the presence of COVID-19-related waste (i.e., medical waste).

The accumulated and recorded location results were used as data input for analyzing plastic leakage and its trajectory. The analysis concluded with the use of GIS methodology to define the hotspot area.

2.3 Survey Strategies

The key to plastic leakage monitoring at the local level is implementation of educational and capacity-building initiatives for policymakers, township staff and waste management experts.

The survey areas were deliberately chosen based on the Yangon City map to cover all townships and districts of the Yangon City area. Yangon City has four districts, which comprise 33 townships. The survey team, including the Yangon City Development Committee (YCDC), Environmental Conservation Department (ECD), Yangon and the Environmental Quality Management (EQM) consultant team, conducted the plastic surveys in each township, coordinating with the working level staff of each local township development committee, who would be more experienced with the existing waste disposal situation along the roads and streets within their respective township, such as where and how the local community were habitually releasing their waste, and how this had changed over time.

Furthermore, a comprehensive approach was developed to achieve this, utilizing a waste flow diagram and survey tool, which were subsequently shared with stakeholders in the city's waste management authority.

Before the tools were applied for data collection, a series of focus group discussions and training workshops were organized at the YCDC. These events welcomed relevant personnel from various organizations, including the ECD, YCDC, townships and local partners, to familiarise them with the tools and their application.

During the survey phase, additional internal meetings and discussion sessions took place for reviewing the collected data and gaining insights from applying the tools on the ground. After the data collection phase was completed and the data had been analyzed, another series of meetings and discussions were convened to validate the data and results with the key stakeholders.

3. Results and Discussion

3.1 Waste Flow Diagram Results

Figure 2 illustrates a detailed analysis of the plastic waste flow, revealing that most plastic waste leakages stayed in situ on land, amounting to 7,064 tons per year (equivalent to 51% of mismanaged plastic waste). At the same time, 249 tons/year accumulated in the atmosphere, 1,262 tons/year were retained in storm drains, and 5,163 tons/year infiltrated into water systems, resulting in a cumulative mismanaged plastic waste volume of 13,738 tons/year in Yangon. Accordingly, the average individual contributes approximately 0.9 kg per year to marine plastic debris.

The primary contributors to this mismanaged plastic waste were the accumulation of uncollected waste, responsible for 41.7% of the total, followed by challenges within the collection services, contributing 27.6%. Although collection container capacities were generally sufficient, approximately 32% of the area experienced lower collection frequencies, falling below the required frequency of one to three times a week (Vásquez, 2022). Consequently, dumping of waste around the containers occurred occasionally.

The third contributor to mismanagement was problems with disposal facilities (25.8%), primarily due to the persistence of open dumping practices in the region. Additional issues revolved around the disposal facilities, encompassing improper waste handling and a lack of fence maintenance. Approximately 68% of the facilities engaged in waste compaction, while 56% covered the waste each day. Waste was also often noted to be piled above ground, exposing it to wind, rain and surface runoff across all disposal facilities. Furthermore, only 29% of disposal facilities used a fencing system encompassing the entire perimeter.

The Waste Flow Diagram (WFD) data collected for Yangon were obtained during November and December 2022, incorporating survey questionnaires and inquiries directed to the Yangon CDC. Nevertheless, the study encountered specific challenges due to data limitations, primarily in the informal waste management sector. These issues were exacerbated by a lack of engagement with

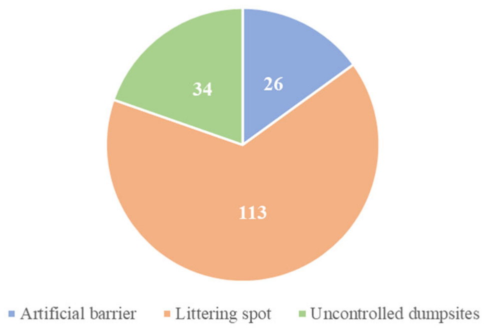

Fig. 3 Composition of plastic types found accumulating in Yangon.

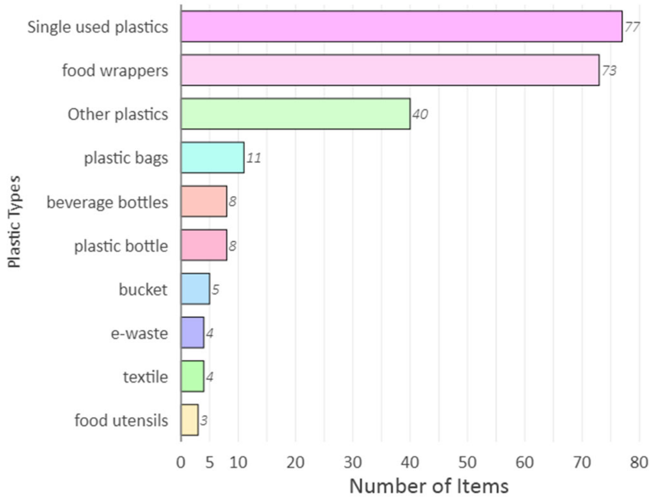

Fig. 4 List of dominant plastic types.

informal sector stakeholders, which hindered the sharing of essential data.

3.2 Mobile App Survey Results

The key results of the overall survey data using the mobile app in the city were marked with their locations, comprising 173 points of sample locations, covering the whole city. The findings included 26 artificial barriers and ports (accounted for 15% of total sampling points in Yangon), 113 littering sites (65%), and 34 uncontrolled dumpsites (20%), as shown in Fig. 3.

The average volume of solid waste that had accumulated at 26 artificial barriers was 220.4 L (estimated volume in a unit of 20 L plastic bottle), the average volume of waste that had accumulated at 113 littering sites was 1.27 m^3, and the average volume of waste that had accumulated at 34 uncontrolled dumpsites was 35.5 m^3.

The survey results showed that the top five dominant plastic waste types found at artificial barriers were “all kinds of plastics,” food wrappers and sachets, takeaway containers, beverage bottles, and plastic bags. The top five dominant plastic waste types found at littering spots were takeaway containers, “all kinds of plastics”, food wrappers and sachets, beverage bottles, and plastic bags. The top five dominant plastic waste types found at uncontrolled dumpsites were “all kinds of plastics,” food wrappers and sachets, takeaway containers, beverage bottles, and plastic bags. The types of plastic leakage found in Yangon City overall are shown in Fig. 4.

“All kinds of plastics” were also identified as “single-use plastics” (SUPs), which were contaminated. They were categorized among general plastics found in the open environment. Figure 4 depicts the more prevalent plastic types, representing the city’s most used plastics.

Visual interpretations of the macroplastic survey of different types of accumulated plastics were the source of the various findings. Below, multiple data taken at artificial barriers (Fig. 5), littering sites (Fig. 6) and uncontrolled dumpsites (Fig. 7) are presented.

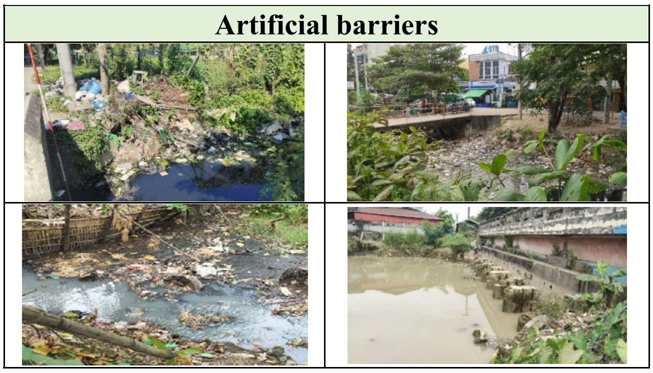

Fig. 5 Examples of visual interpretation of artificial barriers.

Fig. 6 Examples of visual interpretation of littering sites.

Fig. 7 Examples of visual interpretation of uncontrolled dumpsites.

3.3 Plastic Leakage Hotspots

The area of the city under consideration is almost 598.75 km^2, making the YCDC's area of jurisdiction distributive yet comprehensive. Figure 8 below shows the level of plastic leakage in the city. The plastic waste hotspots are primarily detected in areas of intense human activity, typically in the city's centre. Hotspot areas are more concentrated near the junction of the Hlaing and Yangon Rivers (the main rivers flowing through the western part of the city) than around the Bago River (the main river in the eastern part).

As the map in Fig. 8 indicates, four different types of hotspot areas must be monitored. There are accumulation points, well-managed areas, suburban locations and the banks of the main rivers. The accumulation points are shown on the map (Fig. 8) at their identified locations indicated by points (uncontrolled dumpsites, littering sites and artificial barriers), which were also found utilizing the mobile app in the city. As seen from the distribution of buildings and road networks, these accumulation points were identified mainly in the settled areas, surrounding the locations of the buildings. This finding indicates the proportion of the waste collection coverage and people's habits in the settlements in those areas.

Another finding worth noting is identification of well-managed areas. Well-managed areas are identified by high density of building distribution and settled population, with no accumulation points being found. Well-managed areas are also indicated by zero tons of plastic at risk of being leaked into the environment.

Suburban and outskirt areas have less attentive actions, and some leakage is found from accumulation points mainly in the northern part of the city. Some cases have also been seen that were attributable to long distances to the official dumping sites, resulting in a growing number of locations of uncontrolled dumpsites.

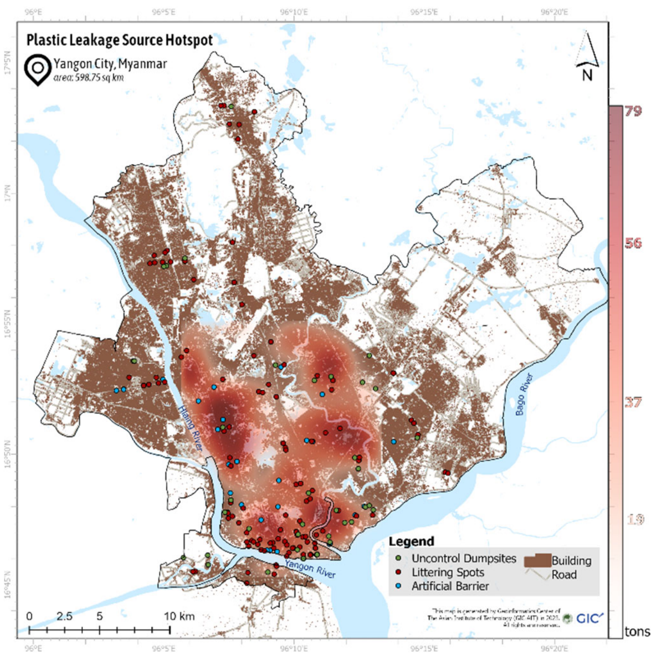

Fig. 8 Map of plastic leakage hotspots in Yangon.

The hotspots depicted in Fig. 8 were allocated different levels with colours, from 0 to 79 tons per year, in the open environment. Some areas of concern arise when the hotspots are located on riverbanks, which are prone to marine debris contribution.

4. Conclusions

National action plans have been implemented with the aim of achieving plastic waste management by applying a holistic 3R approach (reduce, reuse and recycle) to minimize the environmental damage from plastic pollution by 2030, and also to help build the capacity of the accelerators among the stakeholders and authorities to use evidence-based decision-making, reporting and monitoring. The tools applied in this study, including WFD and leakage monitoring, have contributed to significant improvements in participation and data reliability.

4.1 Impact

The framework identifies the most problematic stages in municipal solid waste management by pointing out the locations having issues, including plastic waste pollution and hotspots. Our research findings outlined recommendations that could significantly impact national action plans in the management of wastes that are mainly plastic. For instance, the results of plastic waste flows and GIS analysis integration helped to establish a robust tracking and monitoring mechanism, providing a tool for evaluating the effectiveness of national action plans and sound policymaking at the local level.

The study's incorporation of field surveys and consultations adds a practical dimension to the research, connecting stakeholders and updating data for informed decision-making. By identifying and addressing challenges within the waste management landscape, this study also emphasizes the need for collaboration among different sectors and the engagement of informal waste management mechanisms.

In conclusion, this research elucidates the specific challenges and opportunities in plastic waste management within Myanmar. It offers a valuable approach to formulating, implementing, monitoring and improving national action plans effectively.

4.2 Recommendations

Based on our overall methodology, we encourage the integration of plastic leakage monitoring measures into the decision-making process. Utilizing our study's findings, we recommend the development of waste management in Yangon by taking the following measures:

- Implementing plastic reduction programs, such as behaviour-change initiatives and regulations targeting producers, to decrease the proportion of plastic in

MSW by 8–10%. Currently, the content of Yangon City's MSW is 20% plastic.

- Enhancing collection and recycling efforts by promoting extended producer responsibility (EPR), which involves improving product design, facilitating take-back mechanisms and promoting waste segregation.
- Addressing the problem of uncollected waste by increasing collection frequency to three times a week throughout Yangon.
- Transitioning from open dumping to proper sanitary landfilling to improve waste disposal practices, given the prevalent reliance on open dumping.
- Establishing a national-level data management system to monitor progress in the national action plans, integrating local governments and informal sectors into the monitoring framework.

These recommended actions might be followed up by continuous monitoring and assessment. That way, the frameworks under national action plans can be elaborated.

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Aprilia is a researcher with a B.Sc in Geodesy and Geomatics; she pursued her waste management expertise and obtained her Master's in Marine Plastics Abatement (M.MPA) at the Asian Institute of Technology (AIT), Thailand. Her expertise concerns plastic waste management and focuses on spatial analysis in location-based methods. She has also developed some prominent modelling methods for calculating plastic leakage, as well as a monitoring framework, and has served on one of the steering committees in the Scientist Coalition for an Effective Plastic Treaty. She is also part of the Women+ in Geospatial (WIG+) community, endeavouring through the scientific-based community approach.

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