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Addressing Plastic Waste in Bali, Indonesia: Learning from Global Non-Governmental Organization (NGO) Initiatives and Government Policies

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Abstract: Global plastic production has surpassed 400 million tons annually, causing significant environmental harm, particularly in freshwater and marine ecosystems. Bali, a leading tourist destination, suffers from severe plastic pollution due to high tourist influx and inadequate waste management infrastructure. Drawing from a comprehensive review of literature, policies, and case studies, this study emphasizes the importance of adopting successful non-governmental organization (NGO) models, technological innovations, and comprehensive policies at regional, national, and union levels. It is critical to address the entire plastic lifecycle—production, consumption, and post-consumption—while advancing recycling technologies and improving formal waste processing systems. A circular economy approach, supported by active engagement from all stakeholders, is vital for enhancing Bali's plastic waste management framework. Effective strategies are essential not only for environmental preservation but also for the long-term sustainability of Bali's tourism industry, which plays a key role in the island's economic future.

Keywords: Plastic pollution, Stakeholders, Circular Economy, Bali, Sustainable tourism

1 INTRODUCTION

Plastic pollution has become a critical environmental challenge worldwide, causing significant harm to marine and terrestrial ecosystems, wildlife, and human health (Nava et al. 2023; Pinheiro et al. 2023). Millions of tons of plastic waste are generated every year, with a large proportion ending up in the environment, particularly in the oceans. Indonesia ranks as the second-largest global contributor to mismanaged plastic waste, contributing an estimated 0.48–1.29 million metric tons (MMT) of plastic debris to the ocean annually (Jambeck et al. 2015). Bali, one of Indonesia's most popular tourist destinations, is

especially vulnerable to plastic pollution due to its geographic proximity to the sea and the massive influx of tourists, which significantly exacerbates plastic waste generation (Hendrawan et al. 2023).

Recent studies estimate that Bali alone contributes approximately 89 tons of plastic waste into the ocean daily, with plastic debris densities reaching up to 7.15 pieces per square meter along its coastline (Hendrawan et al. 2023). This escalating pollution threatens marine life, disrupts local livelihoods, particularly those reliant on tourism and fishing (Purba et al. 2019), and diminishes Bali's environmental sustainability.

To address this crisis, the Indonesian government has pledged to reduce marine plastic litter entering its seas by 70% by 2025 (Arifin et al. 2023). This ambitious national policy emphasizes an active role of local government, the improvement of the waste management system, and the establishment of marine plastic research. Indonesia can draw lessons from countries like Rwanda, which has demonstrated how stringent policies on single-use plastics can reduce plastic pollution (Ogutu et al. 2023). However, previous studies indicate that policy implementation alone is insufficient. Local-level interventions (Van Calcar and Van Emmerik 2019) and strong stakeholder engagement (Schnurr et al. 2018; Van Emmerik and Schwarz 2020) are essential to bridge the gap between national goals and practical outcomes.

While existing studies have examined the effectiveness of policy-driven approaches to plastic waste management, there is limited exploration of how localized initiatives, particularly those led by NGOs, can complement national strategies. Multi-stakeholder collaborations are crucial for reducing plastic emissions into aquatic environments (Schmaltz et al. 2020). Additionally, past research often focuses on environmental and regulatory dimensions, neglecting critical social aspects such as local wisdom, community perceptions, resistance to policies, and the broader socio-economic impacts of interventions. Organizations like Everwave (Everwave 2024) and Sungai Watch (Sungai Watch 2024) have demonstrated innovative models for intercepting plastic waste and engaging local communities. However, challenges persist in Bali, including inadequate waste management infrastructure, mismanaged landfills, and the need for better integration of community-based solutions, technological innovations, and policy enforcement.

This paper aims to explore successful approaches from global NGO initiatives and government policies while addressing gaps in current strategies. It offers insights and recommendations for a comprehensive plastic waste management strategy in Bali. Furthermore, we emphasize the importance of addressing plastic waste management across all stages—production, consumption, and post-consumption—by adopting a clear framework such as the circular economy pathway.

2 METHODS

This review employs a comprehensive literature search, combining qualitative and quantitative data sources to provide a thorough understanding of plastic waste management initiatives and policies. The primary sources include literature review of scholarly articles, reports, and case studies on plastic waste management, NGO initiatives, and government policies published in the last decade (2014-2024). Five global NGO initiatives, namely Everwave, Sungai Watch, The Ocean Cleanup, Plastic Bank, and Parley, were chosen based on their significant contributions to accelerating plastic waste management, recycling, and upcycling for the circular economy. Their technologies or strategies, outcomes, and potential applicability in Bali were discussed in this study.

Rwanda, European Union, India, and Chile were chosen as benchmarks of government policies fighting plastic waste representing main global regions, namely Africa, Europe, Asia, and America, respectively. Government reports, policy documents, and international guidelines were analyzed to understand the implementation, impact of these policies, and its applicability in Indonesia, particularly in the local government of Bali.

3 DISCUSSIONS

3.1 NGO Initiatives on Plastic Waste Management

The challenge of plastic waste pollution is a global environmental crisis, with more than 1000 rivers acting as major conduits for 80% of plastic emissions entering the oceans (Meijer et al. 2021). Addressing this crisis requires innovative solutions and collaborative efforts from various organizations. This section reviews the initiatives and strategies of five leading NGOs—Sungai Watch, Everwave, The Ocean Cleanup, Plastic Bank, and Parley—and critically evaluates their outcomes. By examining these approaches, the study aims to highlight lessons learned and assess their potential applicability to Bali's unique context. These NGOs adopt diverse methods to intercept, remove, and recycle plastic waste, while actively engaging local communities and

influencing policy frameworks to foster sustainable change.

Among these organizations, Sungai Watch stands out as it has already established a strong foothold in Bali with its plastic waste management initiatives. As a locally driven NGO, Sungai Watch has implemented innovative yet practical solutions, such as floating barriers in rivers, while fostering community participation through clean-up campaigns and educational programs. Given its presence in Bali, Sungai Watch serves as a crucial example and baseline for this study, allowing a comparative analysis of its methods against the strategies employed by other leading NGOs to provide actionable recommendations for enhanced waste management in Bali.

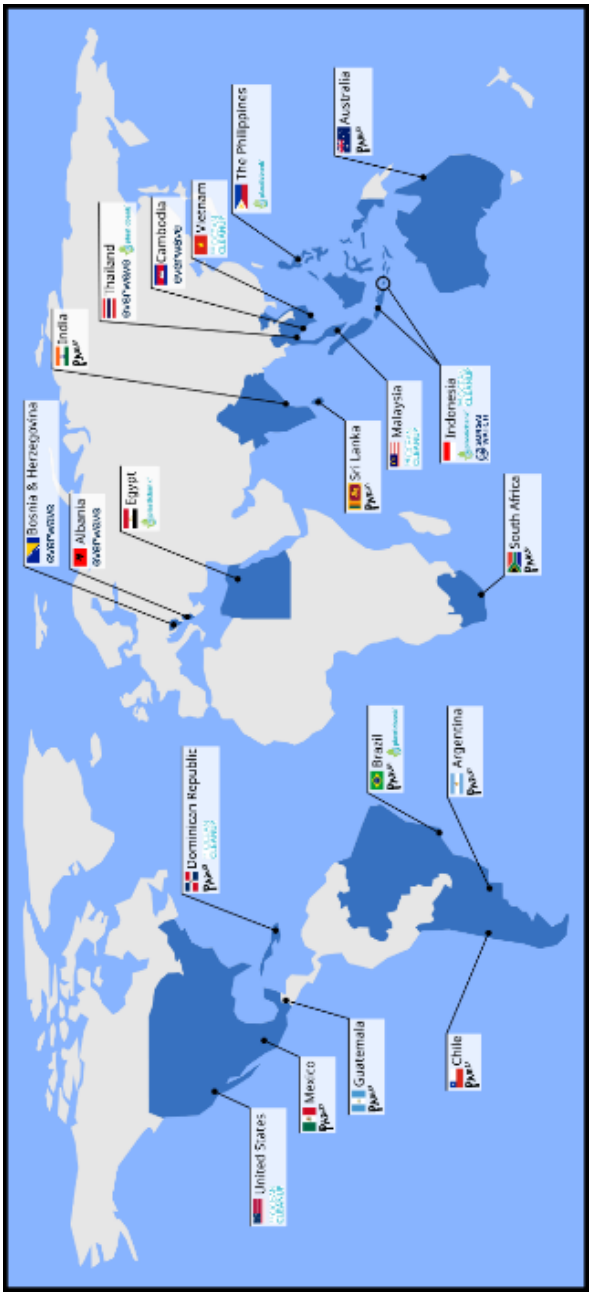

Figure 1. Global Distribution of Leading NGO Initiatives for Plastic Waste Management

Sungai Watch

As one of global pioneers in plastic waste management in Indonesia, Sungai Watch, with its slogan "Protecting rivers starting in Indonesia," is a locally engaged NGO focused on cleaning rivers and preventing plastic waste from reaching the oceans by employing innovative trash barriers installed in rivers to intercept plastic waste. This organization also conducts regular cleanup activities and actively engages local communities in waste management. Based on their impact report in 2023, the NGO had cumulatively installed 268 trash barriers across rivers and 385 cleanup activities in Bali and East Java, successfully collecting over 844,936 kg of non-organic waste in 2023 alone (Sungai Watch 2023).

Their comprehensive workflow—comprising cleaning, sorting, brand audits, and recycling preparation—forms the backbone of their operations. A unique aspect of their strategy is the brand audit process, which analyzes collected plastic waste to identify the top polluting companies and single-use items. This data-driven approach equips Sungai Watch to engage stakeholders more effectively, fostering accountability and driving corporate responsibility. For instance, audits conducted in 2023 identified the top 10 polluters across categories such as single-use cups, PET bottles, sachets, hard plastics, and Tetra Paks.

Everwave

In initial phase, Everwave collaborated with several institutes from Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen University, Germany to conduct thermochemical treatment processes of plastic waste, namely pyrolysis, gasification, and incineration. The pyrolysis condensate has a potential for biotechnological upcycling (Hee et al. 2020). Furthermore, this NGO focuses on preventing plastic waste from reaching the oceans by intercepting it in rivers. They collaborate with the German Institute for Artificial Intelligence to detect plastic waste in water. Cleanup boats are their prominent technologies, often supplemented with floating barriers, used to collect plastic waste from waterways. With this technology, they have been successfully collecting garbage from more than 1,600 metric tons of water. Afterwards, they undergo a recycling process by working with local recycling and inspire local communities to protect water bodies and the environment from plastic waste through educational programs and volunteer activities (Everwave 2024).

Everwave has successfully removed thousands of tons of plastic waste from rivers

across Europe and Asia. Through their educational programs, they have raised awareness about plastic pollution and inspired local actions in countries such as Bosnia and Herzegovina, Cambodia, and Thailand. With appropriate customization to local conditions, Everwave's technology and operational model can be effectively adapted and implemented in regions like Bali.

The Ocean Cleanup

The Ocean Cleanup develops and deploys advanced systems to remove plastic from oceans and rivers. Their technology includes large-scale cleanup devices designed to capture and remove plastic waste efficiently. The organization's approach involves deploying floating systems to intercept and remove plastic waste from water bodies. They also conduct extensive research and data collection to improve their technology and strategies covered in their publication reports, including the distribution, composition, and movement of plastic waste in the ocean (Cózar et al. 2024; Royer et al. 2024). The studies on the density and types of plastics in different regions help also in refining their technology and understanding the scope of the problem (Calvert et al. 2024). The Ocean Cleanup has worked with various partners, including academic institutions and research organizations, to enhance their technology and broaden their impact. These collaborations help in validating their methods, optimizing their systems, and ensuring the effectiveness of their cleanup operations (The Ocean Cleanup 2024).

The Ocean Cleanup has successfully deployed systems in major river systems and parts of the Great Pacific Garbage Patch, removing significant amounts of plastic waste. Their continuous innovation aims to increase efficiency and scalability. The technology and strategies used by The Ocean Cleanup can be applied to various water bodies worldwide, including those in Bali, with necessary adaptations to local conditions.

Plastic Bank

Plastic Bank creates a platform providing economic incentives for collecting and recycling plastic waste in developing countries. Their model transforms plastic waste into a currency that can be exchanged for goods and services. The organization sets up recycling centers where local residents can bring collected plastic waste. The waste is then processed and sold to manufacturers for reuse. Plastic Bank also provides education and training programs to support community involvement (Katz 2019). Through the transformative idea of 'plastic as money,' they have successfully collected more than 130,000 metric tons of plastic waste.

Plastic Bank has established an approach in several countries, significantly reducing plastic waste and providing economic benefits to local communities. Their model promotes sustainable waste management and social entrepreneurship. The Plastic Bank model can be replicated in other regions, including Bali, to address plastic pollution and support local economies.

Parley

Parley's Global Cleanup Network operates on a global scale, actively combating marine plastic pollution by implementing education initiatives and developing upcycling infrastructure. Collaboration is the main value of this NGO by involving numerous individuals, organizations, and communities dedicated to protecting the oceans and driving change at local, national, and global levels. Parley's strategy is to Avoid, Intercept, and Redesign plastic waste by promoting recycling initiatives, and collaborating with brands to create products from recycled ocean plastic. They also run educational and advocacy campaigns to influence public policy and consumer behavior (Parley 2024).

Parley has engaged millions of people worldwide in cleanup efforts and has successfully collaborated with brands to create products from recycled plastic, raising awareness and driving change. Their advocacy efforts have influenced policies and consumer practices. Parley's collaborative and multifaceted approach can be adapted and scaled to various regions, including Bali, to tackle plastic pollution effectively.

3.2 Government Actions Against Single-Use Plastics

The previous chapter highlighted the critical role of NGOs in tackling plastic waste pollution, showcasing initiatives by Sungai Watch, Everwave, The Ocean Cleanup, Plastic Bank, and Parley. Building on the insights from these global NGO initiatives, this chapter examines how government policies can complement these efforts and drive sustainable change. Various regions have adopted different strategies to combat this issue, providing valuable lessons for others. This discussion focuses on five case studies of successful plastic waste management policies and their potential applicability to Bali. The initiatives examined include Rwanda's ban on single-use plastics, the European Union's Single-Use Plastics Directive, Chile's plastic bag ban, India's Plastic Waste Management Rules, and insights from a

comprehensive review of these policies. By analyzing these diverse approaches, Bali can develop and implement effective strategies to address its plastic pollution challenges.

Rwanda's Ban on Single-Use Plastics

Rwanda implemented a nationwide ban on plastic bags in 2008, followed by a broader ban on single-use plastics in 2019. The government introduced alternatives, such as paper bags and reusable products, to replace plastic items. The ban is enforced through strict regulations, fines, and public awareness campaigns. Inspections and penalties for non-compliance ensure adherence to the policy (Ogutu et al. 2023).

Rwanda's ban has led to a significant reduction in plastic waste, cleaner urban and rural areas, and increased awareness about environmental conservation. The success of the policy is attributed to strong government commitment, effective enforcement, and community participation. Rwanda's model demonstrates that stringent policies, coupled with public engagement, can effectively reduce plastic pollution. Bali can learn from Rwanda's experience to develop and implement its own policies against single-use plastics.

European Union's Single-Use Plastics Directive

In 2019, the European Union (EU) adopted a directive to reduce the impact of certain plastic products on the environment, focusing on banning single-use plastics such as straws, cutlery, and plates by 2021 (Kiessling et al. 2023). The directive also includes measures to reduce consumption and increase recycling. EU member states are required to transpose the directive into national law and ensure compliance through regulations, incentives, and public education (Kasznik and Łapniewska 2023).

The directive has led to significant reductions in single-use plastic products across the EU, increased recycling rates, and greater public awareness of plastic pollution. The EU's comprehensive approach to reducing single-use plastics, including legislation, incentives, and public education, can inform Bali's efforts to develop and implement effective policies.

Chile's Plastic Bag Ban

Chile became the first country in the Americas to ban plastic bags nationwide in 2018. The ban applies to all businesses, including large supermarkets and small shops. The ban is enforced through fines and penalties for businesses that violate the regulations. Public awareness campaigns and the promotion of reusable bags support the enforcement efforts (Amenábar Cristi et al. 2020; Frey and Cifuentes 2024).

The ban has successfully reduced the use of plastic bags, leading to cleaner environments and increased use of sustainable alternatives. Chile's approach has been praised for its effectiveness and public support. Chile's successful nationwide ban on plastic bags provides a model for Bali to implement similar regulations and promote sustainable alternatives.

India's Plastic Waste Management Rules

India's Plastic Waste Management Rules, introduced in 2016 and amended in 2018, aim to address plastic waste through extended producer responsibility (EPR), banning certain single-use plastics, and promoting recycling. The rules require manufacturers and brand owners to take responsibility for the plastic waste generated by their products. Enforcement includes fines and penalties for non-compliance, as well as support for recycling initiatives (Chauhan et al. 2022).

The rules have led to increased recycling efforts, greater producer accountability, and reduced plastic waste. Public awareness campaigns and community participation have also contributed to the policy's success. India's EPR model and comprehensive waste management rules offer a framework for Bali to enhance producer responsibility and promote recycling initiatives.

Indonesia's Fight Against Plastic Pollution: Current Actions and Critical Improvements

As a central government of Bali, Indonesia has implemented a plastic pricing mechanism on single use plastic bags for combating plastic pollution in 2016. Such a strategy is popular and has been applied in many countries as a fast action to mitigate the elevation of plastic waste in the environment (Knoblauch and Mederake 2021). Indonesia plans to ban single-use plastic by the end of 2029.

The national policies should move the focus beyond simple polymer, such as single use plastic bags and bottles towards more complex items or composites used in food packaging and textile industries (Nielsen et al. 2020; Knoblauch and Mederake 2021). In fact, the current emphasis of plastic waste management remains heavily on the consumption phase, with less attention given to the production and post-consumption phases.

In the production phase, policies and research should prioritize creating products that are simpler and easier to recycle, rather than focusing on complex or composite materials (Ragaert et al. 2020; Knoblauch and Mederake 2021). In the post-consumption phase, the improvement of recycling

technology should be the priority of formal sectors to tackle the emerging waste of composite or complex plastic. In contrast, the recycling process in Southeast Asian developing countries like Indonesia is often carried out conventionally by informal sectors, such as households and scavengers (Apriadi et al. 2024). Therefore, the policies including decisions on national budget and investment should be also prioritized on this recycling technology mainly by the formal sector to promote a circular economy (Chenavaz and Dimitrov 2024).

3.3 Challenges and Opportunities for Bali

Bali's waste management system, already overburdened by the local population, is overwhelmed by the additional waste from tourists. This lack of awareness leads to careless disposal, further complicating the situation (Ain et al. 2021; Hendrawan et al. 2023). Consequently, much of this plastic waste ends up polluting Bali's rivers, beaches, and ultimately the ocean, which not only damages the island's reputation, but also poses a serious threat to its fragile ecosystem (Astawa 2022).

If left unaddressed, the plastic pollution crisis could lead to long-term damage to Bali's environment, which would have severe repercussions for its tourism industry and overall economy. Thus, the complexity of Bali's plastic pollution problem lies not just in the volume of waste but in the intersection of environmental, economic, and social factors driven by its status as a world-renowned tourist destination (Hendrawan et al. 2023).

The implications of this crisis are far-reaching, as Bali's unique position—bordering the densely populated island of Java (figure 2A) and home to popular tourist areas like Denpasar and Kuta (figure 2B)—exacerbates the threat of plastic pollution. Bali also has several conserved areas for marine life located in the West Bali National Park (TNBB) and in the Nusa Penida marine protected area (NPMPA) (figure 2C). As a consequence, the flow of plastic waste from Java Island and tourist areas in south Bali could threaten the TNBB and NPMPA, respectively (Suteja et al. 2021; Hendrawan et al. 2023).

Furthermore, studies have shown that the southern part of Indonesia, mainly Java and Bali, are a significant source of ocean plastic waste that washes up on Australian shores. This transboundary movement of plastic waste is a major environmental concern, as it affects marine life and ecosystems in both countries (Galaiduk et al. 2020).

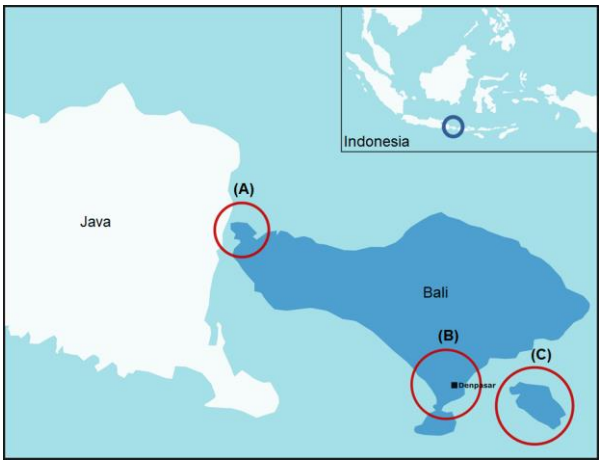

Figure 2. The vulnerable areas towards plastic debris in Bali province, Indonesia, namely (A) West Bali, close to the border with Java Island, (B) South Bali including capital city Denpasar and tourism central area, Kuta, and (C) Nusa Penida Island.

However, there are significant opportunities to address plastic waste management issues. By adopting successful NGO models, enforcing comprehensive regulations on plastic lifecycle, engaging local communities in waste management, and developing a circular economy, Bali can move towards a more sustainable waste management solution (Ain et al. 2021).

The synthesis of NGO initiatives and government policies provides a multifaceted approach to tackling plastic waste in Bali. The analysis reveals several key factors that are critical to the success of plastic waste management efforts.

a. Innovative technologies

Adopting innovative technologies for waste interception and recycling is essential. Several technologies have been explained in the previous section 3.1 NGO Initiatives on Plastic Waste Management. Sungai Watch is well known for their trash barriers. Everwave collects and separates plastic waste with their cleanup boat and its integrating facility. Ocean Cleanup extends research on plastic waste mitigation to capture plastic waste from rivers before it reaches the ocean. A laboratory study was conducted to identify the effect of size, density, and shape on the wave-induced transport of floating marine litter (Calvert et al. 2024). As a proof of concept, a new sensor has been established to monitor marine litter from space (Cózar et al. 2024). Furthermore, a computer vision segmentation model- deep learning has been designed, offering an efficient, more robust, standardized, highly replicable, and less labor-intensive alternative to particle counting (Royer et al. 2024). Plastic Bank has established a

socio-economic platform to reduce plastic waste as well as to help the local economy. Parley's project relies on collaboration with current focus on future material replacing synthetic plastic and upcycling of plastic waste. These technologies can be customized and scaled to fit the specific needs of Bali, considering its geographic and socio-economic context. Collaborating with local governments and private sectors to develop centralized waste processing hubs equipped with research and development laboratories could streamline recycling and upcycling. By reducing dependency on manual interventions like river barriers, such systems could ensure efficient handling of waste and recycling at a larger scale. These hubs could also integrate educational spaces to demonstrate sustainable practices, promoting transparency and accountability.

b. Community engagement and educational programs

A study revealed that personal responsibility and knowledge significantly impact every stage of sustainable plastic consumption behavior—purchase, use, and disposal—and also serve as key factors in distinguishing different consumer profiles (Van Oosterhout et al. 2023). Engaging local communities in waste management efforts is crucial for achieving sustainability. NGOs like Sungai Watch have demonstrated that involving residents in waste collection and recycling not only helps mitigate plastic pollution but also fosters a deeper sense of ownership and accountability (Sungai Watch 2024).

However, Sungai Watch still faces significant challenges, including the identification of over 350 illegal landfills in Bali, which highlights the urgent need for better community engagement and waste management

While learning from successful models is valuable, it is essential to tailor approaches to the local context. Bali's unique challenges and opportunities must be considered in developing and implementing waste management strategies. This includes understanding local waste generation patterns, cultural practices, and economic activities to design effective and sustainable solutions (Nayanathara Thathsarani Pilapitiya and Ratnayake 2024).

Traditional Balinese values of *Tri Hita Karana*—harmony with nature, humans, and the divine—can play a pivotal role in environmental campaigns. Partnering with local leaders and cultural organizations to embed these principles into waste management practices can strengthen emotional and cultural ties to environmental stewardship. For instance, community ceremonies or festivals celebrating clean rivers and nature could integrate messages about sustainability, reinforcing both cultural and environmental goals.

While cleanup activities and awareness campaigns are essential, encouraging community participation through reward programs could foster consistent involvement in waste management. Initiatives such as waste-for-cash schemes or discounts on utilities for active participants can serve as tangible motivators, making environmental stewardship more accessible and rewarding. These programs could be tailored to include village-based competitions to stimulate local pride and engagement.

Furthermore, education must go beyond these efforts to empower communities with knowledge about the circular economy, waste segregation, and upcycling (Ain et al. 2021). Programs targeting schools, youth groups, and community organizations should emphasize the broader impacts of plastic pollution and equip participants with practical skills for waste management. Collaborating with local artisans to upcycle waste into marketable products could also provide economic incentives, aligning sustainability with economic growth.

c. Policy implementation

According to the United Nations Environment Assembly (UNEA) resolution to end plastic pollution, there are five key focus areas: (1) implementing regulations to address plastic waste, (2) promoting collective responsibility for reducing plastic use, (3) improving waste management and collection practices, (4) enhancing collection efforts through public education, and (5) leveraging technology to eliminate plastic pollution (Islam et al. 2023).

Policies such as the EPR scheme in India are instrumental in holding manufacturers accountable for the lifecycle of their products, including the production and post-consumer phases (Amin, Strik, and Van Leeuwen 2022). This policy framework is designed to encourage producers to design more sustainable packaging and increase recycling rates.

At the regional level, Banyumas Regency in Central Java, Indonesia, serves as a model for effective waste management through its robust regulatory framework. Banyumas Regional Regulation No. 9 of 2020 has introduced stricter penalties for waste management violations, strengthened community involvement, and promoted source-based waste management. Additionally, it encourages the integration of technology into waste management practices. These measures have improved compliance and

enhanced the efficiency of waste reduction efforts (PERDA Kabupaten Banyumas 2020).

In addition, Banyumas Regent Regulation No. 24 of 2023 has provided clear instructions for implementing waste management programs. By formalizing processes such as waste segregation, recycling, and community engagement, this regulation has streamlined operations and fostered collaboration between local governments, communities, and private sector stakeholders (PERBUP Kabupaten Banyumas 2023).

Integrating similar regulatory frameworks into Bali's waste management strategy could bolster efforts to combat plastic pollution. Emulating Banyumas' success, Bali could benefit from developing stricter penalties for waste management violations, promoting source-based waste segregation and community-led initiatives, and enhancing transparency and efficiency through technology.

These localized regulations, when combined with global policy frameworks like EPR, can create a cohesive and actionable plan to address plastic pollution in Bali and beyond.

d. Collaborative efforts

Collaboration between the government, policymakers, NGOs, scientists, industry, and local communities is key to achieving a plastic-free Bali. Multi-stakeholder partnerships can leverage resources, expertise, and networks to address plastic pollution comprehensively. Joint initiatives and coordinated efforts can enhance the impact and sustainability of waste management programs (Lampitt et al. 2023).

Insights from Banyumas highlight the importance of inclusive collaboration. In Banyumas, the government provides infrastructure, technology, and funding, while the private sector invests in waste processing facilities and creates job opportunities. Innovations such as the Salinmas (Sampah Online Banyumas) and Jeknyong (Ojeke Enyong) apps enable residents to sort and sell their waste efficiently. The establishment of community-based organizations (CBOs) further strengthens local participation and accountability.

For Bali, adopting similar multi-stakeholder models can provide a framework for success. Existing initiatives like SIDARLING (government-led), Buangin, Sangkara Waste Management, and ecoBali Recycling can be integrated into a unified platform to amplify their impact. Actively engaging all stakeholders—community members, businesses, and civil society—will ensure a comprehensive and inclusive waste management approach.

3.4 Pathways to a Circular Economy in Bali

The implementation of a circular economy in Bali requires a collaborative effort rather than relying on individual actions (Lampitt et al. 2023). Key stakeholders—including industries, local communities, startups, NGO initiatives supported by scientists, and government policies—should focus on sustainable production, consumption, recycling, and upcycling of plastic.

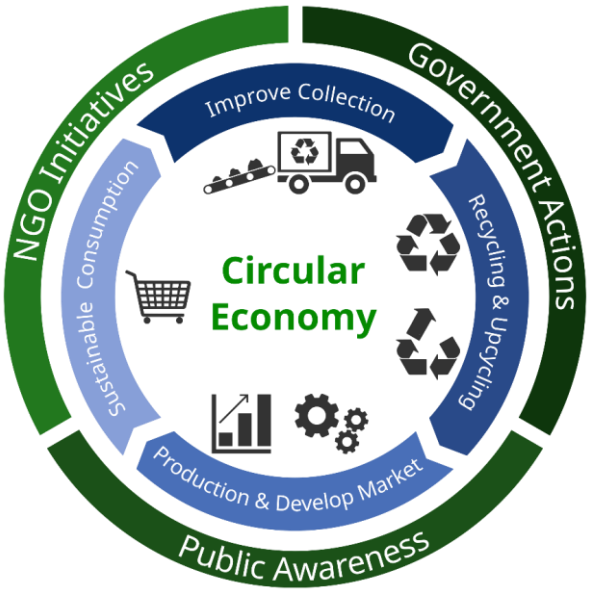

Figure 3. Suggested pathway of circular economy in Bali to improve plastic waste management.

The successful recycling and upcycling play an important role to get optimum benefit of circular economy, which is explained in detail, as follows:

a. Transition to a Circular Economy by Integrating Recycling and Upcycling Processes

The transition to a circular economy in Bali involves fundamentally rethinking how plastic waste is managed through new technologies (Sánchez-García et al. 2024). Recycling facilities should be developed and upgraded to be capable of handling various types of plastic waste to new raw materials or products in an efficient way (Naderi Kalali et al. 2023). Collaborating with NGOs like Everwave and Sungai Watch, which have demonstrated successful models for intercepting plastic waste in rivers and coastal areas, can help Bali leverage existing expertise and resources to implement effective recycling programs.

Unlike recycling, upcycling projects will turn plastic waste into valuable products. This can include pyrolysis, gasification, photo reforming, and mechanical reprocessing to generate high-value products, such as liquid fuel, hydrogen, nanomaterial, and monomer (Zhao et al. 2022).

Furthermore, providing funding and support for startups and small businesses focused on upcycling would create a favorable environment for these enterprises, which can foster innovation and drive the local circular economy.

b. Benefits of a Circular Economy

Transitioning to a circular economy offers numerous benefits that can help Bali address its plastic pollution problem while promoting sustainable development. By recycling and upcycling plastic waste, the amount of plastic entering the environment is significantly reduced. This helps preserve Bali's natural beauty and protect marine and terrestrial ecosystems from the harmful effects of plastic pollution. A circular economy reduces the reliance on landfills by diverting plastic waste into recycling and upcycling processes (Zhao et al. 2022; Naderi Kalali et al. 2023). This extends the lifespan of existing landfill sites and minimizes the environmental hazards associated with landfill waste.

A circular economy ensures that plastic materials are used efficiently and remain in circulation for as long as possible. This reduces the need for virgin plastic production, conserving natural resources and reducing the carbon footprint associated with plastic manufacturing. Recycling and upcycling enable the recovery of valuable materials from plastic waste, turning what was once considered trash into a resource. This aligns with sustainable resource management principles and promotes a more resilient and sustainable economy (Vidal et al. 2024).

The development of recycling and upcycling industries creates new job opportunities in waste collection, processing, and product manufacturing. This can help boost local economies and provide livelihoods for residents. A circular economy encourages entrepreneurship and innovation in waste management (Kandpal et al. 2024). By supporting startups and small businesses in the recycling and upcycling sectors, Bali can become a hub for sustainable business practices and technological advancements.

Promoting a clean and sustainable environment enhances Bali's reputation as a tourist destination. Tourists are increasingly seeking eco-friendly travel options, and a commitment to reducing plastic waste can attract environmentally conscious visitors, boosting the local tourism industry.

4 CONCLUSION

Bali, renowned for its breathtaking natural beauty and rich cultural heritage, has the potential to be a leading ecotourism destination. However, overcoming the pervasive issue of plastic waste requires a comprehensive strategy that involves coordinated action from all stakeholders. Addressing gaps in waste management infrastructure, incentivizing sustainable behaviors, leveraging Balinese cultural values, and strengthening regional policies can help manage the entire plastic lifecycle—production, consumption, and post-consumption. A circular economy approach is crucial to achieving effective and sustainable waste processing in Bali. By integrating recycling technologies and enhancing formal waste management systems, Bali can reduce its plastic footprint and promote environmental sustainability. Effective waste management practices can significantly enhance the island's reputation as an eco-conscious destination, preserving its pristine beaches, lush forests, and clear waters. Moreover, upcycling plastic waste into value-added products offers the opportunity to boost the local economy and create employment, further contributing to sustainable development and eco-tourism.

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