Journal of Ecohumanism
2025
Volume: 4, No: 3, pp. 349 – 366
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i3.6649

Development of Model for Effective Waste Management on Community-Based Co-Production: A Case Study of Thailand

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Abstract

This research critically examines the dynamics of community waste management, highlighting both the successes and persistent challenges in Tha Muang District, Kanchanaburi Province, Thailand. It aims to analyze the successes and challenges faced by local communities and administrative bodies in managing community waste, industrial waste, and infectious waste, as well as to develop a waste management model that increases community participation and co-production principles, with potential for adaptation in other areas facing similar contexts. Employing qualitative and area-based research methodologies, fieldwork was conducted from April 25 to October 30, 2022. The findings underscore critical waste management issues, such as budgetary shortfalls, inefficient processes, and a lack of adequate human resources. These challenges have undermined the community's capacity to implement effective waste management solutions. In response, this research proposes a model grounded in the co-production framework, fostering a more symbiotic partnership between local communities and governmental authorities. The proposed model addresses structural deficiencies in budgeting, operational processes, and workforce management. Additionally, it advocates for a transformative approach that mitigates environmental impact and empowers communities to take a proactive role in sustainable waste management. By foregrounding these issues, the study highlights the urgent need for more integrative, community-driven solutions to enhance waste management systems in resource-limited settings.

Keywords: *Waste Management, Co-Production, Area-Based Research, Environmental Conservation, Community-Based Co-Production Model.*

Introduction

The intensifying global waste management crisis presented a severe risk to environmental sustainability, worsened by the increasing rate of urbanization and industrial growth. This expansion resulted in a remarkable surge in waste production, surpassing the capabilities of current waste management infrastructures and methods. The effects of the crisis were far-reaching, encompassing ecological harm, reduction in biodiversity, and additions to climate change from the breakdown of waste and improper waste handling practices.

Empirically, the World Bank emphasized the severity of the situation, with over 2.01 billion tons of waste generated annually, and a significant portion being mishandled. This problem was magnified in regions like Thailand, where waste exceeded 16 million tons yearly, yet less than 20 percent was recycled, falling short of the national reuse target. (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018). The lack of effective waste segregation and inadequate collection services, especially in remote areas, underscored the urgency for innovative waste management solutions.

While there was an increasing shift towards local waste management strategies emphasizing waste reduction, recycling, and community involvement, a substantial gap remained in the research and application of co-

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production models that leveraged community participation. Traditional approaches

This study aimed to bridge this knowledge gap by focusing on Tha Muang District, Kanchanaburi Province, Thailand, a region where the potential for community-driven waste management models had not been fully explored. By developing and suggesting a co-production-based model for community-engaged waste management, this research sought to provide insights and frameworks that were both effective locally and adaptable to similar contexts globally.

By achieving this, the research contributed to the broader discourse on sustainable community waste management, offering a path forward that was both environmentally sustainable and socially inclusive, thereby addressing one of the most pressing environmental challenges of our time.

Research Objectives

To analyze successes and challenges faced by the local communities and administrative bodies in managing community waste, industrial waste, and infectious waste
To develop a model for waste management that increased the principles of community participation and co-production, also with the potential for adaptation in other areas facing similar waste management contexts

Literature Review

The study highlighted the importance of collaborative efforts in tackling the complex facets of waste management, incorporating co-production to provide a multifaceted theoretical foundation. This approach enhanced the research's depth and applicability, contributing significantly to waste management literature by offering nuanced insights into co-production's role in effective waste management and community engagement across various contexts.

Viewing co-production through the lens of ontology, or the study of existence, suggested that the formation of reality and society were not merely interdependent but actively shaped by both tangible and symbolic practices within certain frameworks. This perspective revealed co-production as a fluid process, constantly in flux, adapting, and challenging norms. It drew from a diverse range of disciplines, from economics to environmental studies, involved a broad spectrum of participants from both the public and private sectors to the end-users, and leveraged various platforms, from conferences to models. Co-production operated across different levels, from the global to the local, and embraced a variety of approaches, from conventional hierarchical to participatory methods. These elements intertwined and diverged, influencing its manifestation at any particular time and place through social practices Benton and Craib (2011).

In this light, co-production fostered the collective shaping of realities, reflecting the combined aspirations, needs, and inputs of all participants. These co-created realities were continuously evolving, shaped by constant negotiation and interaction. From an ontological perspective, this highlighted the adaptability and dynamic interaction of roles and identities within co-production, with participants fluidly moving between roles as contributors, learners, facilitators, and users. This challenges traditional notions of expertise, authority, and power.

When applied to waste management, an ontological approach recognized the diverse perceptions and values that community members and other stakeholders hold towards waste. This emphasized the need for waste management strategies that aligned with the specific spatial and temporal contexts of communities, leading to more effective solutions and increased community engagement and participation (Bandola-Gill, Arthur, & Leng, 2022).

Co-production, viewed through epistemology, or the study of knowledge, referred to the framework of co-production, which examined the interplay between science and decision-making as a reflection of social and epistemic orders and their interrelations. It emphasized the significance of non-traditional actors, such

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as non-professionals or laymen alike, in the co-production process, highlighting how co-production transcended mainstream scientific and policy-making horizons to incorporate a wider range of perspectives and forms of knowledge.

In this context, co-production challenged traditional notions of scientific knowledge production and validation. By involving diverse participants, including those outside of scientific communities or experts, co-production practices could lead to the generation of new types of knowledge that were community-grounded and more directly applicable to local policies and community needs. This inclusive approach to knowledge production led to highlighting the value of different types of knowledge, including experiential and contextual including local knowledge, in addressing waste management issues.

Lastly, co-production, when approached from a methodological perspective, underscored its intricate nature and broad applicability across diverse fields. It was conceptualized as a continuum of practices that linked overarching knowledge systems with localized interactions, with the goal of augmenting the utility of knowledge.

This methodological view recognized co-production as an occurrence that spanned multiple levels, from broad socio-political systems to specific institutional contexts, and further into the realm of situated practices. Each level complemented the others, collectively contributing to the dynamic transformation of social and knowledge frameworks. The methodological lens on co-production stressed the necessity for a collaborative approach to knowledge co-creation, involving a wide array of stakeholders. This approach acknowledged the contributions of different scholarly disciplines to the evolution of co-production as a concept.

In practical terms, this perspective on co-production called for well-defined expectations and robust mechanisms for ongoing dialogue, information exchange, and partnership throughout the research lifecycle. By fostering such collaborative environments, co-production as methodological aimed to tackle intricate issues through a unified effort, leveraging the collective skills and insights of all participants.

In Shanghai, Batu City, and Northern Thailand, empirical cases demonstrated the effectiveness of community-based co-production strategies in household waste management. These initiatives re-defined the interaction between human behavior, cultural norms, and systemic frameworks through environmental ontology, emphasizing the interconnectedness and shared responsibilities within the waste management ecosystem. In Shanghai, the government transitioned to a facilitator role, encouraging community engagement and effective waste sorting through collective will and peer pressure (Lu & Sidortsov, 2019). Batu City's Waste Banks Program highlighted the importance of community involvement, with residents actively participating in waste management, thereby fostering a sense of environmental stewardship (Irkham et al., 2019). Similarly, in Northern Thailand, participatory methods facilitated collaboration between communities and local governments, integrating cultural insights into waste management practices, which not only reduced costs but also promoted community ownership and sustainable practices (Chaichakan & Khampeng, 2016). However, these studies also pointed to the need for further exploration of innovative practices, local cultural adaptations, and the complexities of stakeholder dynamics to enhance the long-term success and scalability of co-production in waste management across diverse setting.

In 2015, Gutberlet J. explored participatory waste management in Brazil, highlighting the significant yet often undervalued role of informal waste collectors and recycling cooperatives. This study advocated for their increased involvement in urban waste management, emphasizing the importance of collaborative practices for sustainable and inclusive urban environments. In 2018, the 'Chiang Rai Zero Waste' project in Thailand demonstrated an integrated community-based approach to municipal solid waste management, addressing challenges and infrastructural needs in rural areas. By engaging households in composting and recycling, and assessing impacts in 18 pilot villages, the initiative showcased the effectiveness of community-driven efforts and the combination with social capital as soft-infrastructure in waste management (Manomaivibool et al., 2018). Both studies underscored the potential of participatory approaches and the need for further research to overcome limitations and explore new avenues for enhancing the sustainability

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and inclusivity of waste management practices.

In 2016, Buaban M.'s research in Kanchanaburi Province, Thailand, revealed the significant impact of integrating local knowledge, traditions, and cultural practices into community-led tourism for waste management through the lens of epistemology. This approach not only enhanced the tourism experience but also played a crucial role in protecting the region's natural and cultural heritage. The collaboration between tourists and locals led to tourism that supported environmental conservation and raised collective ecological awareness, thereby bolstering the local environment's resilience. Recognizing and valuing local customs fostered more environmentally conscious behaviors, emphasizing the importance of nature conservation. However, further investigation into the long-term sustainability of such initiatives and their adaptability to other regions could provide deeper insights into the role of innovative tourism in promoting environmental sustainability.

In 2021, Masawat, Rangpan, Thongmak, & Kaewmanee investigated the 'Garbage for Eggs' initiative in Yala Province, Thailand, where eggs were used as incentives to encourage community involvement in waste management. This novel approach led to notable behavioral shifts, reducing waste and boosting recycling efforts. Despite its success, the project faced challenges in maintaining participation and managing environmental impacts, suggesting the need for strategic planning for sustained effectiveness. Similarly, in 2019, Pakdee, Treerat, Yodkhad, & Saengnual examined a local waste management innovation in Ban Pa Koo, Chiang Rai Province, involving small incinerators, compost bins, and charcoal kilns. The initiative significantly reduced waste and produced valuable by-products like compost and charcoal, demonstrating the power of community engagement and local solutions. However, concerns about long-term community involvement and the environmental effects of incineration and charcoal production highlighted the importance of balancing waste reduction with sustainable practices. Both studies underscored the potential and challenges of community-led waste management strategies, emphasizing the need for careful implementation and evaluation to achieve lasting environmental benefits.

These empirical studies highlighted that a co-production strategy was pivotal in establishing symbiotic relationships among communities, governments, waste managers, and key stakeholders. This collaborative approach was in harmony with the growing recognition of co-production as crucial in producing relevant and practical knowledge for complex issues like waste management.

Research Methodology

Research Methods

This study employed a qualitative research design with a participatory action approach to develop an area-based, community-driven model for effective waste management. Model development was grounded in qualitative methods, including focus group discussions, in-depth interviews, observations, and surveys. This methodology was chosen to explore waste management challenges, community needs, and environmental awareness within the Tha Muang District.

Scope of the Study Area

The study focused on two main areas:
Tha Muang District, comprising 105 communities across thirteen sub districts, and
Wangsala Subdistrict, recognized as a best-practice model for community waste management. This targeted selection allowed for both an area-wide understanding and a closer examination of waste management community.

Key Informants

The stakeholders in waste management in Tha Muang District can be classified into three groups based on stakeholder analysis or key person analysis: the first group is the public sector, the second is civil society,

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and the third is the private and industrial sector.

Public Sector: In-depth interviews were conducted with key informants from the public sector responsible for local waste management, including members of the District Health Board, mayors of local administrative organizations, and community leaders, to gather insights and perspectives on municipal waste management.

Civil Society: Focus group discussions, alternated with interviews, along with a randomized primary village survey, were conducted with participants, including community leaders, as well as experienced and volunteer representatives from villages and waste management learning centers, to gather insights on community-driven waste handling practices.

Private and Industrial Sector: In-depth interviews were conducted with key informants, including Corporate Social Responsibility representatives from industrial companies (e.g., SCGP and Thai Cane Paper) and other private organizations, to gain insights into the industry's roles and contributions in local waste management and sustainability.

Stakeholder Identification, Engagement, and Co-Production Model Development

The development of the community-based co-production model was primarily achieved by translating the co-production concept itself into practical, actionable steps. This process of operationalizing the concept required a structured approach grounded in local stakeholder engagement, collaborative problem-solving, and adaptive feedback. Through these efforts, the model was constructed in sequential stages.

Stakeholder Identification and Engagement: The community-based co-production model construction began with a stakeholder engagement strategy, ensuring broad representation and alignment with local needs. There were key stakeholders including local government authorities, private and industrial sector representatives, and community members identifying through stakeholder analysis. This process analyzed roles, influences, and vested interests, ensuring each group's perspective was incorporated. A series of consultation meetings followed, during which the ideas and benefits of a community-based co-production model were discussed. The communication channels established at this stage enabled feedback throughout model development, fostering shared ownership.

Problem Identification and Needs Assessment (Co-Initiative): Surveys, interviews, and focus group discussions were conducted to gather insights into existing waste practices, issues, and community priorities. By synthesizing these diverse perspectives, a set of comprehensive problem statements were categorized to reflect the community's specific waste management needs. This phase directly engaged stakeholders in defining core issues, laying a foundation for collaborative problem-solving.

Idea Generation and Solution Conceptualization (Co-Design): In brainstorming sessions moderated by the academic team, stakeholders proposed practical, context-specific solutions through group discussions. This approach fostered creativity while ensuring that solutions were user-friendly and suited to local conditions. Potential solutions were documented for further evaluation, with each idea refined through collaborative feedback.

Consensus Building and Strategy Formation (Co-Decision): The community-based co-production model emphasized inclusive decision-making to effectively prioritize strategies. Model visual solutions conceptualized, synthesized, and mapped by the academic team were presented to stakeholders for feedback, followed by collaborative decision-making exercises to build consensus. The outcomes informed a unified plan detailing resource allocation, roles, and responsibilities across stakeholder groups.

Planning and Implementing Solutions (Co-Delivery): The plan was divided into actionable tasks, assigning responsibilities based on stakeholder expertise, experiences, resources, and capacities. This collaborative approach to implementation allowed each stakeholder group to take ownership of specific

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responsibilities, empowering community involvement.

Establishing Monitoring and Evaluation (Co-Evaluation): A monitoring system was implemented to track both process and progress, while feedback meetings allowed stakeholders to address emerging challenges and refine strategies as necessary. This iterative process ensured that the model remained responsive to evolving community needs and facilitated sustained impact.

Planning for Benefit Sharing and Sustainability (Co-Benefit): Sustainability and benefit sharing were central to the model's long-term success. The achieved benefits were documented and communicated to all stakeholders. Long-term sustainability was addressed by scaling successful practices, securing ongoing support, and embedding waste management within local community cultural norms and practices. This final phase solidified the co-production model as a sustainable, community-driven approach to waste management.

Qualitative Data Analysis

The qualitative data would be analyzed by content analyzing, typology and taxonomy. The data would be grouped for the same contents and comparing data for fulfilling each research objective. Besides, the data would be interpreted and checked for correction by data triangulation.

Contextualizing Tha Muang District and Waste Management

Tha Muang District, situated in the western part of Thailand within Kanchanaburi Province, was characterized by its diverse geography, featuring flat plains conducive to agriculture, bordered by the Tanaosri Range, and bisected by the Kwai Yai River. Tha Muang District presented a vivid texture of geography, demography, and economic activities, interwoven with the challenges and strategies of waste management.

The district's population, numbering around 58,146 to 109,166 residents, showcased a blend of ethnic Thais and various minority groups, including the Karen, Thai Yai, and Mon people, among others. There were also ethnic migrants from Myanmar, Lao and Cambodia, approximately 37,025 people working in the area. Statistical analysis showed that 93 percent of the residents were locals, 75 percent had been living in the district for more than 21 years, and 89 percent owned their homes. Only 3 percent resided in rented accommodations, hinting that these individuals, possibly external workers, might have a lesser engagement with local waste management initiatives. Furthermore, Generation X, those aged between 43 and 58, exhibited a heightened environmental consciousness and were more likely to participate actively in community waste management efforts.

Tha Muang District's economy was predominantly agricultural, with over 90% of the population engaged in farming activities such as rice, sugarcane, and fruit cultivation, leveraging the district's fertile lands and ample water supply. The district also encompassed a variety of industrial activities. The district reported a total of 169 factories, among which there were 3 large industries and 2 medium-sized industries. The industrial sector, which included wood, paper, packaging, food processing, mineral processing, and liquor distillation, played a crucial role in the economic landscape of the district. While the industrial presence contributed positively to the economy, the district was now facing with increasing industrial waste management problems, which were organic waste from food processing, craft production residues, chemical by-products, and packaging materials. Besides, problems were found with lax regulations, wastewater discharge, and the smuggling of toxic waste and scraps into the area. All these could pose environmental and health risks if not properly managed. Despite these challenges, only 2 large industries actively supported community waste reduction initiatives, such as waste sorting, composting, green cone, waste education campaigns and mentor, through their corporate social responsibility programs.

Household waste management in Tha Muang District mirrored the urban-rural divide, with urban areas generating more solid waste, while rural locales generated primarily garbage and agricultural waste.

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Approximately there were 1-2 kilograms a day per household. The management of infectious waste, particularly during the COVID-19 pandemic, became critically important, necessitating stringent disposal and treatment measures to protect public health. The locals handled infectious waste as if it were ordinary household trash. The Pollution Control Department reported that Tha Muang District had three waste management sites; one was a proper garbage disposal facility, while the other two were improperly managed and lacked both a leachate treatment plant and groundwater monitoring wells. The community faced waste management challenges, such as inadequate garbage disposal facilities, an influx of garbage from outside the area, and budgetary constraints.

Nonetheless, the district implemented a variety of waste management approaches, combining conventional techniques such as landfilling and open dumping with more eco-friendly practices, including composting, sorting, awareness campaigns, zero-waste village role modeling, and community-led recycling efforts. Despite these efforts, the district continued to encounter substantial waste management hurdles, such as insufficient infrastructure, limited public awareness, and challenges in the segregation and treatment of diverse waste types. Nevertheless, a collaborative effort among village leaders, public and civil sectors, the private sectors, and governmental sectors including academia was underway to address these issues.

Research Finding

This research identified that the challenges and barriers to waste management, both in community settings and within industrial contexts, could be divided into three main aspects. The details were as follows.

Budget constraints aspect: The budget for waste management was restricted and not much, so hiring labors for waste management and waste keeping was inadequate, especially, waste keeping officers and public health officers in local administrative organizations. The officers would be directly responsible for waste management and environmental preservation in the district. This might be a cause of ineffective waste management in the areas. Besides, the lack of budgets for garbage truck procurement was also a cause of ineffective waste management. There was not a garbage truck in any local administrative organization which could contain waste to a landfill. It caused the amount of waste increased rapidly in community. In addition, there was not a proper landfill for industrial waste in community and beyond.

Waste management process aspect: In the area, although there was a cooperation from organizations such local administrative organization, industrial sectors, community hospitals and civil societies that participate in waste management by distributing bags for waste sorting and educating people how to deal with household waste but there was any activity supported people and community to run for waste management by themselves. Moreover, another problem of waste management was insufficient landfill for general waste and industrial waste that was not standardized. Therefore, the cooperation from the industrial sectors was very important to manage the waste appropriately and correctly and the people had to be educated and embedded the environmental care consciousness. These would bring about the environment preservation sustainably.

Personnel and manpower aspect: Public health volunteers played the major roles in community waste management but they had not worked for that continuously such campaigning for waste sorting, educating people. Besides, the public health volunteers were inadequate to work, they had to work for other functions in public health such vaccine distribution, home visiting, elderly care giving, etc. Furthermore, the number of scavengers from local administrative organizations was inadequate and the local administrative would not have a vivid plan for waste management. These would need people's participation in waste management for more effectiveness. Due to the higher cost of industrial waste management, the industries would not seriously manage the waste and pollutions from their productions as good as possible. The local government officers should take part in the serious waste management and pollution check and the industries should be fined and punished if they did not follow the laws of pollution control.

In addition, problems and obstacles of infectious waste management in the situation of Covid-19 pandemic composed of 3 aspects also. Details as following.

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Budget constraints aspect: the problem was the same to waste management in community and industrial waste management. Those were not sorting kinds of waste, transporting waste to the landfills, etc. But the important problem was that people did not separate the infectious waste from other kind of waste. This was the cause of danger in waste management. The scavengers infected Covid-19 from waste. Fortunately, district hospital had a good management of infectious waste and community could also transport the infectious waste to the garbage bins of the hospital. Due to the pandemic situation and people worked from home, the amount of infectious waste became spontaneously increasing so the management of infectious was not well designed before and lack of budget for the increasing waste. It might be a cause of pandemic in the community also. The budget of local government was spent more for serving food for the infected and detained people not for the infectious waste.

Infectious waste management process aspect: the people in community were not aware of the danger as much as they should do. The infectious waste management was run inappropriately by community and local administrative organizations. The process of waste sorting was not designed for management. All kinds of waste were collected in the same garbage bins and transportation. Although, some household could sort out the infectious waste but finally it was combined in the same bin and transportation to the landfill. The local administrative organizations should clearly announce the measurement of infectious waste management and have well planned and budget to mobilize it. According to the widely educating people and campaigning about the infectious management, the people's participation in management was at low level. The late measurement and management in the situation of Covid-19 pandemic also caused any loss and damage in community.

Personal and manpower aspect: public health volunteers and community staff did not have much knowledge and skill to manage the infectious waste in communities. The manpower in community waste management was also insufficient and the communication to people in community for disseminate the correct way to sort the infectious waste such ATK, surgical masks, etc. was inefficient, most people did not know how to deal with it. If the people understood, infectious waste management should be more efficient and effective.

Based on the data analyzed, the researcher was able to categorize the factors influencing waste management into two main groups: success factors and obstacle factors. The specifics of these factors were outlined in the table below.

Table 1. Success and Obstacle Factors of Waste Management

Success Factors of Waste Management	Obstacle Factors of Waste Management
- participation of people in communities for waste management. - communities' leaders sacrifice for leading people to manage the waste problems. - supports form private sectors in the area. - support from local administrative organizations - rules and regulations in wasted management that created and agreed on by people in communities. - linking the outcomes of waste management to socio-economic for people and communities.	- lack of environmental and sorting waste consciousness. sorting waste should commence firstly from households. - non register people in the areas that cause the increasing waste a lot. In contrast, the budget from government was restricted and granted per head of the register people in the areas. - urban expansion and new housing development increasing cause the amount of waste. - smuggling waste transportation from outside

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Success Factors of Waste Management	Obstacle Factors of Waste Management
- environmental consciousness learning for children and students in communities that bring about understanding and preservative minds for them and their parents. - communities meeting and all stakeholders in waste management joining the meeting - social capital in communities and their own potentialities.	the area to dump in. - rubbish incinerator construction plan in communities was terminated and unaccepted - scavenger of local administrative organizations infected Covid-19 that caused the inadequate staff to collect the garbage in communities. - organization structure of local administrative organizations affected the waste management.

This co-production model was developed through brainstorming sessions involving community leaders, industrial partners, local government officials, and academics, aiming to reconceptualize sustainable waste management in the community. The focus was on improving infrastructure, encouraging active public engagement, and adapting to local specifics. Tailored specifically for the district, the model includes six essential components.

- Co-Initiative: This foundational stage involved community members collectively recognizing and articulating the waste management challenges within the district, setting the stage for collaborative problem-solving.
- Co-Design: Stakeholders, including residents and various social partners, collaboratively developed solutions based on a thorough analysis of the root causes of waste issues in the area.
- Co-Decision: Together, the involved parties committed to addressing the waste management problem, agreeing on the strategies and methods to be employed.
- Co-Delivery: All participants shared the responsibility for implementing the agreed-upon waste management services, ensuring collective action.
- Co-Evaluation: The effectiveness of the waste management efforts was jointly monitored and assessed by all stakeholders. A community was chosen to represent the district in the Zero Waste Award project, an initiative by the Ministry of Interior, highlighting exemplary waste management practices.
- Co-Benefit: The collaborative waste management efforts yielded multifaceted benefits, not only enhancing public health but also generating economic gains and welfare through the sale of recyclables. Additionally, the private sector was encouraged to contribute to these efforts through corporate social responsibility (CSR) initiatives.

Each component of this model was driven by co-producers, with success factors and mechanisms that interconnected and reinforced one another, as detailed in the accompanying table.

Table 2. Community-based Co-production Model

Co-production	Co-producers	Key Success Factors	Mechanisms

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Co-Initiative	1. District chief officer and committee of District health board	1. Participating in a competition and receiving an award from the Department of Environmental Quality Promotion, Ministry of Natural Resources and Environment.	1. Investment Laws for public company limited (CSR: Corporate social responsibility)
(identify the waste problem in the district by the people in communities together.)	2. Community leaders	2. Support from both the public and private sectors for resource development. (Local administrative organizations, District office, SCGP factory)	2. Policy of Ministry of Public Health (committee of District health board / Policy of Provincial clean).
	3. Support team of community leaders	3. Community areas where volunteers could serve as a model for solving waste issues (Ban Hua Pong).	3. The policy mechanisms of the Ministry of Education that enabled schools to conduct environmental activities and address waste issues, such as waste bank initiatives.
	4. Industrial sector (SCGP factory)	4. Collaboration of various sectors in the area.	4. The religious belief in merit-making by donating waste.
	5. Local administrative organizations (such Wangsala municipal)		5. The mechanism of District health board.
	6. Home-Temple-School (H-T-S)		
Co-design	1. Industrial sector (SCGP factory)	1. The selection of model areas for addressing waste management issues in accordance with the clean province policy.	1. The volunteer spirit of the community
(people and other social partners design the solutions form root cause analysis in the area.)	2. Community leaders	2. The community's needs in addressing waste management issues.	2. Innovations from the private sector that existed and were applied in households, such as world-saving container innovations (waste decomposer).
	3. Support team of community leaders	3. Collaboration of various sectors in the area.	3. The use of local wisdom in designing waste management solutions in the area.
	4. District chief officer and committee of District health board	4. Continuous provision of knowledge on waste management issues in the area, including hazardous waste,	4. Guidelines for waste management known as 'Zero Waste,' which is an environmental conservation.

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		organic waste, and recyclable waste.	
	5. Public health volunteers and subdistrict health promotion		
Co-decision	1. District chief officer and committee of District health board	1. Participation of people in communities.	1. Collaborative decision-making in each step of waste management processes in the area.
(People decided to solve the waste problem and set up the way they should do.)	2. Community leaders		
	3. Support team of community leaders		
	4. Industrial sector (SCGP factory)		
	5. Local administrative organizations (such Wangsala municipal)		
	6. Home-Temple-School (H-T-S)		
Co-delivery	1. District chief officer and committee of District health board	1. Participation of people in communities and shophouse entrepreneur	1. Roles and functions of subdistrict administrative organizations.
(People were responsible their duties in delivering the public services in waste management.)	2. Community leaders	2. Readiness of resources to support the public services in waste management such as waste bin, garbage truck, garbage bags, budget, etc.	2. Resource supports from private sector, not only budget and resources but also knowledge and innovative idea.
	3. Support team of community leaders	3. Public policy and private support continuity in waste management in the areas	
	4. Industrial sector (SCGP factory)		
	5. Local administrative organizations (such Wangsala municipal)		
	6. Home-Temple-School (H-T-S)		
	7. People in communities		

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DOI: https://doi.org/10.62754/joe.v4i3.6649

	8. Shophouse entrepreneurs		
	9. Public health volunteers and subdistrict health promotion		
	10. shop purchase garbage (Wongpanich)		
Co-evaluation	1. Department of Climate Change and Environment, Ministry of Natural Resource and Environment. (National Level)	1. Extracting lessons from the community in developing a waste-free community model.	National-level competition for a waste-free community model that will foster community pride and ownership.
(People monitored and evaluation the results of waste management together.)	2. Office of Natural Resource and Environment, Kanchanaburi (Provincial Level)	2. Creating collaborative learning among community members in waste management problem-solving.	
	3. Communities		
Co-benefit	1. District chief officer and committee of District health board	1. Quality of life enhancement for people in communities.	1. Recognizing the shared benefits among each sector in the community and being prepared to support collaborative waste management initiatives for sustainable development.
(People all got the benefits from waste management.)	2. Community leaders	2. Utilizing social capital for waste management, where communities effectively manage waste and generate income from community waste management activities. Furthermore, serving as a model for other communities to study and emulate.	
	3. Support team of community leaders	4. Addressing the mission of the industrial sector in line with environmental industry approaches (eco-town), where industry coexists with the community in a mutually satisfying manner.	
	4. Industrial sector (SCGP factory)	5. Reducing waste issues in the area, improving the quality of life for people, and decreasing the burden on subdistrict administrative organizations can be achieved under the framework of self-governance.	

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	5. Local administrative organizations (such Wangsala municipal)	6. Promoting unity among households, temples, and schools while also fostering community income. Additionally, promoting good health by addressing waste and various pollution issues in the community.	
	6. Home-Temple-School (H-T-S)	8. Reducing the cost of using plastic bags.	
	7. People in communities	9. Simplifying waste management for the community by making it easier to address waste issues. This was achieved through the implementation of waste burial and the establishment of waste separation guidelines from the source.	
	8. Shophouse entrepreneurs	10. Purchasing old items and waste from the community, supporting people in the community to generate income from waste management, particularly benefiting the elderly and children who dedicate their free time to sorting waste. This initiative also includes community businesses that can reduce costs by avoiding the use of plastic bags.	
	9. Public health volunteers and subdistrict health promotion		
	10. shop purchase garbage (Wongpanich)		

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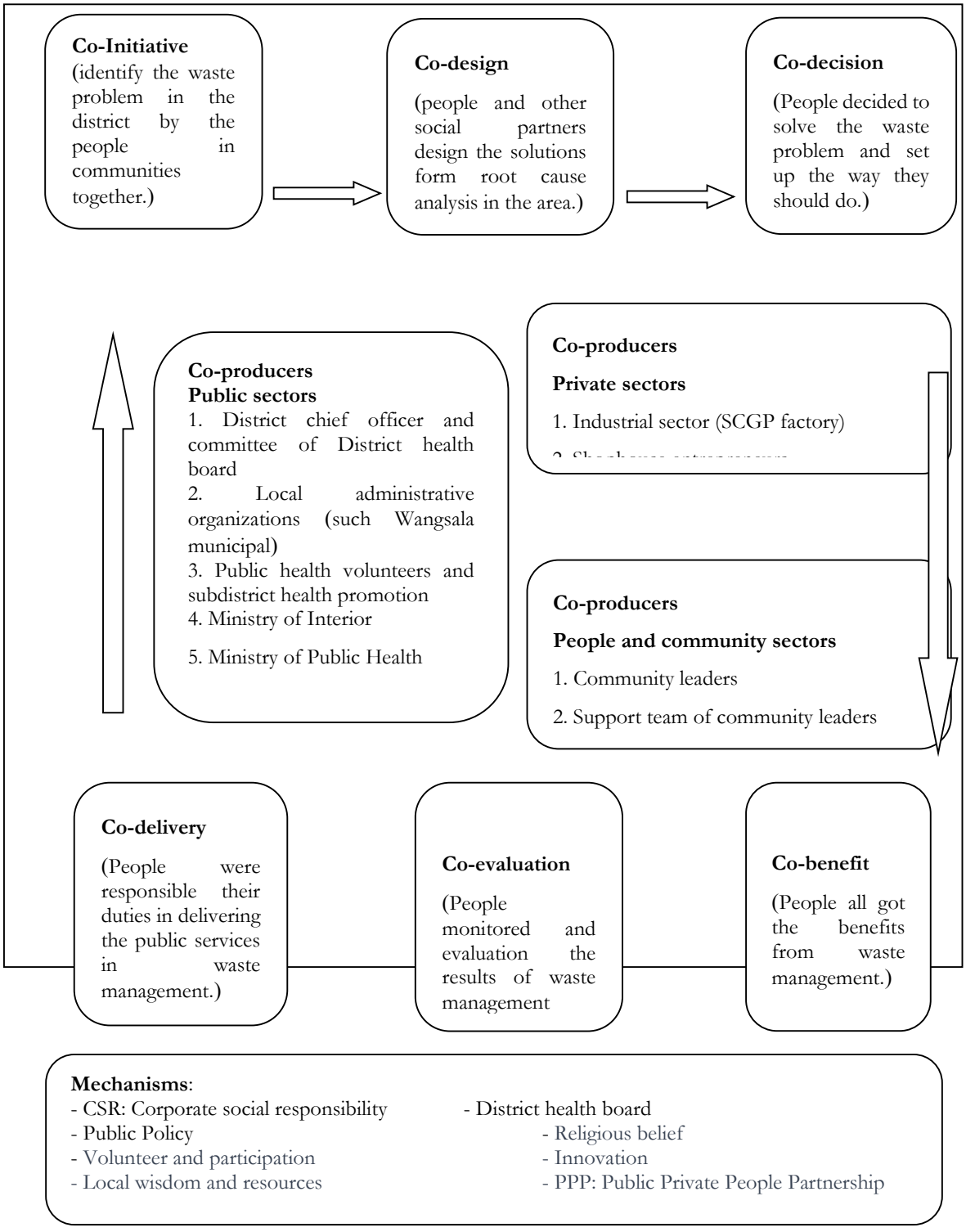

Diagram 1. Model of Co-production in Waste Management in Tha Muang District, Kanchanaburi

The diagram illustrated the co-production model, which offered a comprehensive and collaborative approach to waste management, addressing key challenges through enhanced community empowerment, budgetary efficiency, process optimization, and the promotion of sustainable practices. This model was expected to improve the waste management outcomes and foster a sense of community stewardship and environmental responsibility.

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Discussion

In the domain of waste management, ontology previously explored the essence of waste alongside the realities and societal dynamics surrounding waste management practices. The introduction of the co-production model was grounded in its network effects. The model posited that the reality was co-produced out of various stakeholders such as individuals, organizations, communities and technologies. This model re-imagined waste management, shifting from viewing waste solely as material for disposal or a logistical issue, to seeing it as a valuable resource that could be woven into the socio-economic fabric of the community. In Tha Muang District, the implication of such co-production model showcased significant network effects, where collaboration across different sectors led to amplified benefits, including improved waste management efficiency, increased community participation, and stronger industrial support. This collective approach underlined the potential for sustainable environmental practices and innovations, driven by the reinforcing network effects within community waste management.

In examining waste management through the lens of epistemology, and embedding it within community waste management contexts, it became apparent that waste management had transcended scientific or technical realms, flourishing instead through the amalgamation of local insights and experiences with scientific knowledge. This approach, which opened up shared spaces to value both local experiences, community-led innovation, and government authority, led to more nuanced and effective waste management strategies. It encouraged a shift away from exclusive reliance on authorities towards a more participatory, knowledge-sharing framework. In Tha Muang District, the adoption of a community-based co-production model implied the significance of community involvement in waste management. This model, valuing contributions from community members, authorities, and professionals, aimed not only to promote a knowledge-sharing framework but also to empower the local communities, thus challenging the conventional reliance on public service delivery in waste management.

Focusing on the co-production model and methodologies utilized in the research conducted in Tha Muang District, this account delved into the innovative approach towards community-based waste management. This methodological stance emphasized that effective waste management solutions emerged from collaborative inquiry and action, fostering a synergistic relationship between local communities and governmental entities to improve the efficiency and sustainability of waste management practices. Contrary to traditional top-down approaches, the co-production model emphasized mutual engagement and shared responsibility among all stakeholders, including local residents, community leaders, the private sector, government bodies, and academia. This model underlined the notion that effective waste management solutions were co-created, leveraging the unique insights, experiences, and resources of each participant. The model's success hinged on its inclusive nature, ensuring that strategies were not only environmentally sound but also culturally appropriate and socially accepted within the community context. This research presented a compelling case for the adoption of co-production in waste management, offering valuable insights and practical frameworks that could be adapted to similar contexts globally, driving sustainable environmental solutions grounded in community participation and collaboration.

By examining the study through the lenses of ontology, epistemology and methodology, the co-production model for waste management in Tha Muang District represented a holistic and participatory approach. It challenged conventional perceptions of waste, embraced a broad spectrum of knowledge sources, and employed diverse research methods to understand and address waste management challenges in a comprehensive manner. This discussion revealed the theoretical underpinnings that informed and shaped the study's approach to tackling the complex issue of waste management through community-based co-production. The conceptualized and proposed model emphasized a symbiotic partnership between local communities, private sectors and governmental bodies including academia, implying to overcome common challenges in Tha Muang District such as budgetary constraints, process inefficiencies, and limitations in human resources. By fostering this collaborative approach, the model could possibly lead to more efficient and sustainable waste management practices, tailored to the context-specific needs and resources of the local community. It encouraged the integration of innovative waste management solutions such as recycling,

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composting, modeling, and the conversion of waste into resources like energy and money through waste bank, potentially transforming the local waste management system into more efficient and sustainable operations.

The effectiveness of these all-inclusive co-production operations in waste management had been confirmed by empirical studies, with cited examples from Shanghai (Lu & Sidortsov, 2019), Batu City (Irkham et al., 2019), and Northern Thailand (Chaichakan & Khampeng, 2016), demonstrating the positive outcomes of community-based co-production strategies. However, a critical examination might have raised a question about the (re)scalability of this approach due to the differences in the cultural, economic, and political landscapes such as the unique social fabric, communal values, and individualistic society presented in Northern Thailand as much as that of Tha Muang District. This research suggested that the proposed co-production model was more than just a theoretical concept; it demonstrated significant adaptability to diverse situations and settings, bridging the gap between theory and practice. In other words, the application of co-production could take various forms, such as the one in Tha Muang District, indicating active and engaged participation from the local community.

The literature review further confirmed the pivotal role that active community engagement had played in waste management, with examples from Brazil (Gutberlet J., 2015) and Chiang Rai Province, Thailand (Manomaivibool et al., 2018), while also raising questions about its sustainability. The proposed co-production model was illustrated as a comprehensive process of civic engagement that spanned from upstream to downstream activities, marked by the involvement of key stakeholders including community leaders, local government entities, private sector companies, and academic institutions. The active participation and continued commitment of these groups had indicated a trend towards the institutionalization of the co-production approach in waste management. This highlighted the success factors like community leader involvement, support from private sectors, and governmental support as key drivers of successful waste management.

Achieving community participation presented challenges due to various human factors that acted as agents of change in community waste management, such as apathy, lack of awareness, or competing priorities among community members. Additionally, socio-economic barriers restricted participation from certain groups, leading to constrained waste management outcomes. In Tha Muang District, the number of trans-local migrants further limited the effectiveness of these community-led waste management efforts.

Nonetheless, the co-production model must not have been exaggerated due to the fact that it encompassed context-specific knowledge like local wisdom and socio-cultural capitals in enhancing waste management strategies. The case of Kanchanaburi Province had integrated local knowledge, traditions, and cultural practices into tourism while ensuring environmental preservation (Buaban, M., 2016). The co-production strategies needed to have balanced between situated practice embedded with local knowledge and established scientific knowledge. The co-production model suggested its effectiveness in democratic settings where power was shared among participants. Consequently, in Tha Muang District, stakeholders engaged in mediation, oscillated between positions, and negotiated within open spaces. Furthermore, democratic environments paved the way for the emergence of new ideas and innovations in community waste management.

Yala Province (Masawat, Rangpan, Thongmak, & Kaewmanee, 2021) and Baan Pa Koo, Chiang Rai (Pakdee, Treerat, Yodkhad, & Saengnual, 2019), Thailand had demonstrated community-led incentives and local innovation. However, the projects encountered issues with strategic planning and the problematic application of local technology. This proposed co-production model served as a reminder that the co-production approach was most effective when it originated from local initiatives, rather than being totally imposed by external parties or treated as a social lab experiment, thereby fostering a sense of insider ownership and ensuring sustainability. Its success also hinged on evaluation, closely aligned with the community's values and practices.

In a final analysis, the scalability of the waste management model beyond Tha Muang District to a certain

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extent could possibly pose challenges due to varied cultural, economic, and political contexts, necessitating flexibly-designed adaptations. A balanced approach was crucial, blending situated practice embedded with local knowledge with the scientific forefront and best practices to avoid over-dependence on conventional methods. Achieving extensive community engagement required overcoming apathy, enhancing awareness, and tackling socio-economic barriers for inclusive participation. The model's sustainability depended on ongoing community and government support, bolstered by sustainable funding and policies. Strategic planning and community empowerment, aligned with scientific best practices and local insights, were key to the model's successful deployment and enduring effectiveness, culminating in a sustainable and inclusive waste management system.

Conclusion

The research conducted on the dynamics of community waste management in Tha Muang District, Kanchanaburi Province, Thailand, presented an innovative approach to tackling the complexities of waste management through a co-production framework. This study aimed to formulate a model that emphasized collaborative efforts between local communities and government entities, addressing various challenges such as financial constraints, inefficiencies in waste management processes, and the scarcity of human resources. The essence of this model lay in its integrative strategy, which not only focused on mitigating environmental issues but also played a pivotal role in empowering communities and fostering a sense of stewardship towards waste management.

Central to the study's findings was the principle of community engagement and empowerment, which advocated for the active participation of local residents in the waste management process. This participatory approach nurtured a sense of collective responsibility and ownership, paving the way for more effective and enduring waste management practices. Furthermore, the model underscored the importance of symbiotic partnerships between the community and governmental institutions, facilitating a shared pool of resources, knowledge, and expertise, thus enhancing the efficacy of waste management efforts.

The model proposed indicative solutions to address budgetary and resource limitations by leveraging the combined strengths of community members and governmental bodies. It also advocated for the optimization of waste management processes through the adoption of localized, innovative practices such as recycling, composting, and waste-to-resource initiatives, which enhanced the efficiency and effectiveness of waste management systems.

An essential component of the model was the emphasis on fostering environmental responsibility among community members. The model aimed to cultivate a culture of environmental stewardship, encouraging practices that contributed to sustainable waste management. The flexibility and adaptability of the model ensured that waste management strategies were not only environmentally viable but also culturally relevant and widely accepted within the community.

In summary, the development of a community-based co-production model for waste management in Tha Muang District marked an advancement in tackling both local and global waste management challenges. By fostering collaborative efforts, enhancing waste management processes, and empowering communities at a local level, this model illuminated a path towards sustainability that resonated globally. It not only advocated for local action but also highlighted the potential for these localized efforts to contribute to broader, global environmental preservation goals. In synthesizing these elements, the study formulated a comprehensive framework that not only catered to the specific needs of Tha Muang District but also bridged localized initiatives with a glo-locally inspired approach to environmental preservation and sustainable waste management practices worldwide.

Acknowledgement: This research was funded by Mahidol University Mini-research Cluster (MU-MiniRC), 2022

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