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Integrated Review to Combat Food Loss and Waste in Maritime Southeast Asia: A Short Literature

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Abstract
Food loss and waste (FLW) is a global issue with profound implications for food security, environmental sustainability, and economic systems. This problem is particularly acute in Maritime Southeast Asia, where individual contributions to FLW can exceed 150 kilograms per year. Despite its significance, applied research on the underlying causes, management strategies, measurement methodologies, and policy frameworks for FLW mitigation in this densely populated region (over 400 million people) is conspicuously lacking. Our comprehensive literature review identified only 15 articles directly relevant to the topic, offering a limited perspective on the complexities of FLW generation. The methodologies employed in these studies lack the robustness required for wider application within the region or for broader comparative analyses. The review, therefore, requires urgent, expansive research across the entire food supply chain in Maritime Southeast Asia and considers factors such as the social, technological, behavioral, and cultural, further elucidating what the real causes and drivers of FLW are within the region.
Keywords: *food loss, food waste, developing countries, maritime southeast asia, waste management*

Abstrak
Kehilangan dan pemborosan pangan (*Food loss and waste*/ FLW) merupakan masalah global dengan implikasi mendalam bagi ketahanan pangan, keberlanjutan lingkungan, dan sistem ekonomi. Masalah ini tergolong akut ini di Asia Tenggara Maritim, ketika kontribusi individu terhadap FLW dapat melebihi 150 kilogram per tahun. Meskipun signifikan, penelitian terapan tentang penyebab mendasar, strategi pengelolaan, metodologi pengukuran, dan kerangka kebijakan untuk mitigasi FLW di wilayah berpenduduk padat ini (lebih dari 400 juta orang) sangat kurang. Tinjauan pustaka komprehensif kami hanya mengidentifikasi 15 artikel yang secara langsung relevan dengan topik tersebut, yang menawarkan perspektif terbatas tentang kompleksitas pembangkitan FLW. Metodologi yang digunakan dalam penelitian ini tidak memiliki ketahanan yang diperlukan untuk penerapan yang lebih luas di wilayah tersebut atau untuk analisis komparatif yang lebih luas. Oleh karena itu, tinjauan tersebut memerlukan penelitian yang mendesak dan luas di seluruh rantai pasokan pangan di Asia Tenggara Maritim dan mempertimbangkan faktor-faktor seperti sosial, teknologi, perilaku, dan budaya, yang selanjutnya menjelaskan apa penyebab dan pendorong sebenarnya FLW di wilayah tersebut..
Kata Kunci: *kehilangan pangan, limbah pangan, negara berkembang, asia tenggara maritim, pengelolaan limbah*

1. Introduction

The United Nations made quite a loud call in September 2015, capturing in clear terms its ambitious goal of reducing global food wastage by half while considerably reducing global food loss by the year 2030 as outlined in the SDGs agenda [1]. This commitment greatly refocuses the attention of the international community on the reduction of food loss and waste throughout the global value chain of food, both in agriculture and livestock. Food loss and food waste are among the greatest issues ever faced by mankind. As far as has been related to wasted or tossed-out food and more generally to food security, sustainability, and environmental degradation, governments and other non-governmental organizations have begun in recent years to be at frontier positions in the fight. The food loss and food waste issue presents deep ethical dilemmas, more so considering that upwards of 925 million people worldwide continue to suffer from malnutrition, against the backdrop of steadily rising global demand for food [2].

Though there is no broadly accepted definition for food loss and food waste, what is entrenched in scholarship is a distinction between the two. Food loss pertains to the reduction in either the quantity or quality of edible food, a phenomenon observed during production, post-harvest handling, and processing

stages. In contrast, food waste encompasses raw or prepared food of suitable quality found within the value chain, which either remains unconsumed or is discarded, typically occurring at the retail or consumer terminus of the supply chain or production process [1], [3], [4]. Cumulatively, these losses are collectively termed food supply chain losses, encompassing any stage within the chain where a portion of food initially intended for consumption fails to reach its intended consumers [3], [5]–[8]. For the purposes of this paper, we shall employ these two concepts interchangeably, referring to them as FLW (food loss and food waste) throughout the text.

Approximately 1.3 billion metric tons of edible food, representing one-third of the world's total food production, is discarded annually throughout the supply chain, spanning from production to consumption [3]. This volume of wasted and unused food has the capacity to alleviate malnutrition for roughly one-eighth of the global population [9] and offers a substantial response to the pressing global issue of coping with the projected 50 to 70% increase in food demand by 2050 [10].

The quantity of food wastage varies significantly among countries, influenced by factors such as income levels, degree of industrialization, and the stage of development [11]. In lower-income or developing nations, nearly two-thirds of food loss occurs during the post-harvest and processing phases. This can be mainly attributed to suboptimal agricultural practices, technical limitations, financial and labor constraints, and inadequate infrastructure for storage, processing, and transportation [3]. In contrast, in higher-income or developed countries, which encompass middle to high-income nations, the majority of food waste occurs during the consumption phase. This pattern is primarily driven by consumer values, behaviors, and attitudes [3], [12].

FLW reduces the amount of food that will be available for human consumption, hence posing a quite important problem to nutritional security. Other than that, there are important implications of FLW realized in environmental, economic, use of natural resources, and poverty-reduction sectors [3], [13]. From an environmental standpoint, a substantial portion of discarded food undergoes conversion into methane when deposited in landfills, a greenhouse gas possessing a global warming potential twenty-five times greater than carbon dioxide [14]. Additionally, food waste experiences accelerated decomposition relative to other organic materials in landfills, leading to higher methane emissions and failing to contribute to biogenic sequestration in these locations. As a result, there is an intensified interest in curtailing food waste [15].

In line with Rutten's perspective [16], FLW signifies an unproductive investment in agriculture, giving rise to avoidable greenhouse gas emissions and engendering notable inefficiencies in the utilization of water, energy, land, fertilizer, and labor. On the economic front, initiatives aimed at mitigating FLW often yield adverse consequences for farmers, potentially leading to an expansion of the food supply.

Conversely, reducing FLW offers advantages to food processors, potentially enabling them to distribute larger quantities at more affordable prices. Consumers, too, can reap the benefits, with the possibility of cost savings as food availability becomes more economically accessible [16]. Research also highlights that efforts to combat FLW in developed nations can ultimately lead to reductions in food prices in developing countries, conserving resources that can be redirected towards feeding disadvantaged populations and enhancing efficiency throughout their supply chains [17]. These transformations are expected to improve the availability of nutritious food for vulnerable households [3], [18]. Halving FLW along the supply chain has the potential to meet the nutritional needs of an estimated 63 million individuals suffering from malnutrition in developing and low-income regions [19].

Undoubtedly, the significant annual volumes of lost or discarded food possess the potential to exert a considerable impact on efforts to combat global hunger. Consequently, focused endeavors have been dedicated to devising and implementing an array of innovative strategies to alleviate FLW [20]. Diverse approaches and solutions targeting the reduction of FLW along the supply chain have been explored in various regions worldwide, encompassing pre-consumer stages (e.g., post-harvest, handling, storage, and processing), as well as retail and consumption phases [21]–[24]. Regarding scholarly research, the literature demonstrates a rapid surge in studies addressing FLW, with a pronounced emphasis on the conversion of waste into energy [25]–[27], the extraction of high-value compounds and value-added products like animal feed, organic acids, microbial sap, polysaccharides, amino acids, and enzymes [28], [29], as well as the production of organic compost [30]. While earlier literature reviews predominantly centered on FLW studies in developed nations [15], [31]–[34], comprehensive and systematic assessments of food waste in developing countries remain relatively scarce. Keeping in mind this research gap, we choose to fill some of these voids by consolidating existing knowledge on FLW in developing countries within the Maritime Southeast Asia region. This is particularly interesting because of its socio-economic setting, rapid development, and cultural factors that may affect FLW patterns distinctly from the developed nations. With a large, steadily growing population of 422 million, the MSA region is positioned at the core of finding

solutions that ensure food security regarding sustainability at both regional and global levels. Dealing with the specific challenges and drivers of FLW within this area is not only helpful in designing targeted interventions and policies to reduce food loss and waste but very important in this regard. The reason Singapore will be excluded in the study is because it is a developed country, whereas this study focuses on developing countries.

2. Material and Methods

This review was structured in line with the protocols specified by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. We also integrated methodologies based on the framework by Petticrew and Roberts [35] for data collection and analysis, complemented by the qualitative content analysis technique proposed by Hsieh and Shannon [36]. Our research involved a comprehensive examination of relevant literature across six major databases, including the Directory of Open Access Journals, Scopus, Web of Science, PubMed, Semantic Scholar, and Google Scholar. The focus was on identifying research pertaining to food loss and waste within the MSA region

The search strategy was twofold: firstly, the exploration of terms related to FLW, such as "domestic waste," "food loss," "food waste," "kitchen waste," "leftovers," "lost food," "plate waste," and "wasted food.". Secondly, it included specific focus on countries within Maritime Southeast Asia – Brunei, East Timor, Indonesia, Malaysia, and the Philippines. The search, conducted in September 2023, aimed to cover a wide range of scholarly works including journal articles, book chapters, conference papers, and other forms of grey literature available in English, Filipino, Indonesian, Malay, or Portuguese. This extensive search yielded 607 relevant documents.

In addition to database searches, targeted searches on on-going projects and initiatives related to FLW reduction within the MSA region were conducted. The websites of corresponding government agencies, NGOs, and international organizations were searched using keywords such as "food waste reduction," "food banks," and "food rescue." We also reviewed the news articles and reports on FLW initiatives in the region. Projects that met the following criteria were considered: (1) the project or initiative must be actively operating in at least one MSA country; (2) the primary objective of the project has to be food waste reduction or raising awareness about FLW issues; (3) there must be adequate information concerning the project in the public domain enabling the provision of an elementary description and analysis.

To be considered for inclusion in our review, each document had to meet certain criteria. Primarily, the focus of the document had to be on food loss or waste within the MSA region. Additionally, the document types included were journal articles, review articles, conference papers, book chapters, or grey literature. Materials such as abstracts, editorial content, and letters to the editor were excluded from consideration. After removing duplicates, we narrowed down the list to 263 publications. A detailed evaluation of titles and abstracts further reduced this number, leaving 26 papers for full-text examination. Finally, 15 relevant papers were selected for in-depth analysis, comprising 12 journal articles and 3 conference papers. The process and criteria for selection are documented in Figure 1.

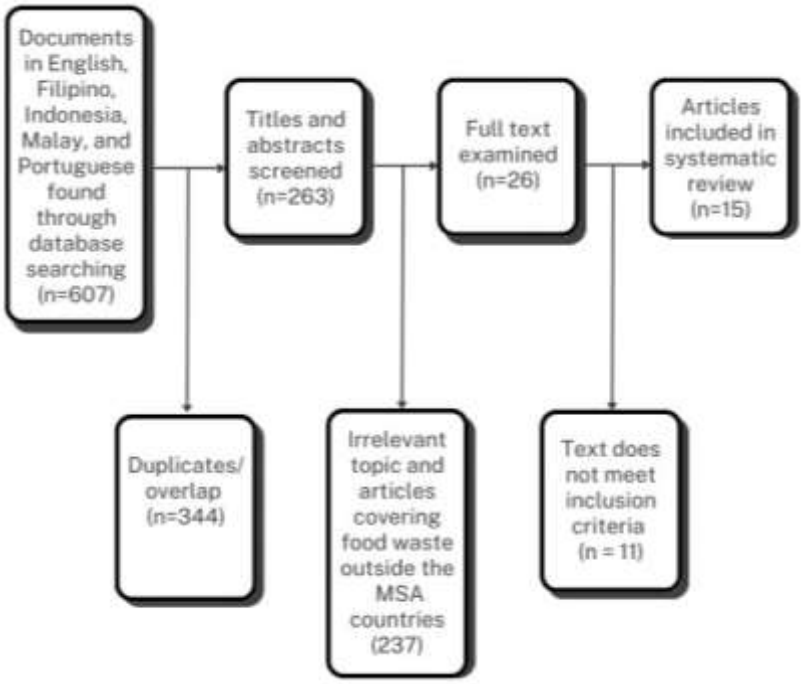

Figure 1. Flowchart depicting the search and screening procedure for studies concerning food loss and food waste within MSA countries

3. Results and Discussion

The interest in research on Food Loss and Waste (FLW) has experienced a significant and rapid global upsurge, evident by a remarkable 300% increase over the past decade, as illustrated in Figure 2. FLW research within the Maritime Southeast Asia (MSA) region is also on an upward trajectory. However, the productivity and publication rates exhibit annual fluctuations and consistently represent a small fraction of the world's overall research output, consistently remaining below 1%. The limited research productivity concerning FLW in MSA countries can be attributed to various interconnected factors. These factors include a lack of enthusiasm for the subject among local scientists, a limited pool of local scientists specializing in FLW, inadequate government funding and support, and the inherent challenges associated with conducting such research in developing nations, stemming from cultural and religious barriers.

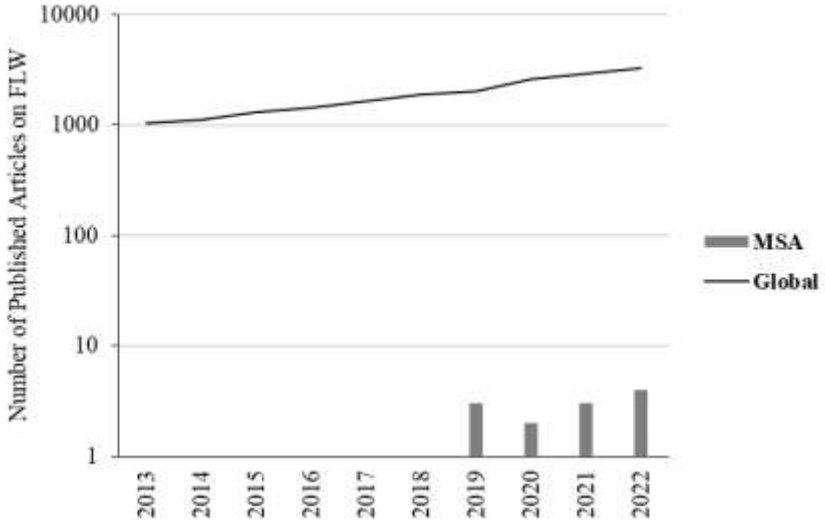

Figure 2. Chart showing the number of publications per year during 2013 – 2022 on food loss and food waste globally and in MSA countries. The number of articles from 2013 to 2015 is zero, and from 2016 to 2018 is one.

A significant revelation from our literature search is the scarcity or complete absence of FLW data in most MSA countries, as depicted in Figure 3. Among these five countries, East Timor, being a relatively young and economically disadvantaged nation, logically presents a lower percentage of research publications. Within the MSA, Malaysia emerges as the most prolific contributor. Some articles have focused on household waste and its composition [37]–[40], with others exploring FLW in other segments of the food supply value chain, including the retail and hospitality sectors within the MSA [41]–[44]. It is noteworthy that limited attention has been given to other facets of the supply chain, such as agricultural production, transportation, storage, and processing. The majority of the identified studies have delved into the causes of food waste or various aspects of consumer attitudes and behaviors related to food waste generation [45]–[51].

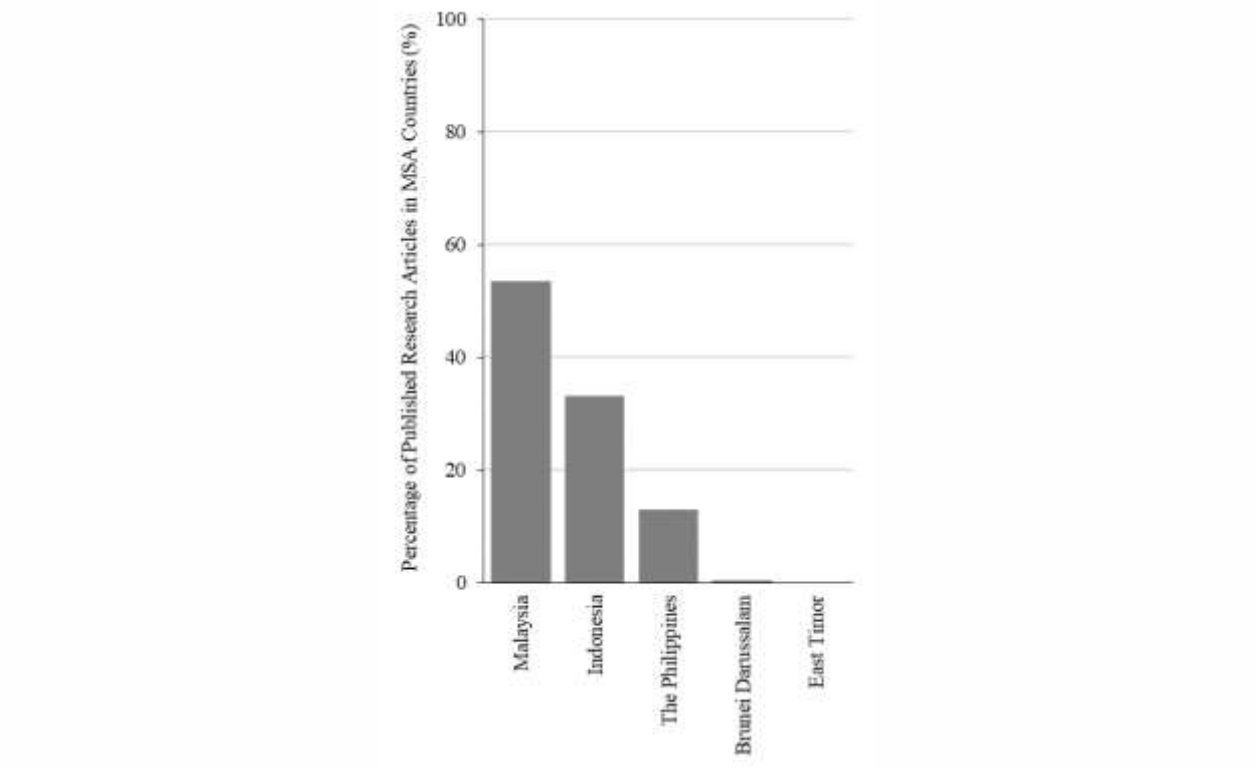

Figure 3. Published scientific research distributed across the MSA countries in 2013 – 2023.

Our investigation has unveiled noteworthy patterns in food waste trends while also shedding light on areas that merit further investigation. For instance, within Malaysia, a nation considered stable in the MSA region, there is a conspicuous increase in waste generation during social and religious gatherings, notably during the fasting month of Ramadan [48]. Food waste during this sacred month surges by approximately 20% to 30% compared to typical months, a similar pattern observed in Indonesia, where the increase stands at 20% [52]. The upswing in food waste during Ramadan can be attributed to excessive food preparation that far exceeds the needs of individual families, leading to the disposal of leftover food. It's noteworthy that this practice contradicts Islamic teachings, which encourage Muslims to share surplus food with those in need. Despite Islam's explicit prohibition of wastefulness in all aspects of life, including time, energy, and food [Quran 6:141; Quran 5:87], the teachings of other Abrahamic religions, such as Christianity and Judaism, also align with Islam in considering food waste a sin [Proverbs 23:20–21]. Nevertheless, there exists a scarcity of data within the MSA region regarding the quantity of food wasted during religious events like Christmas or other Christian holiday celebrations.

During social events such as weddings, births, and funerals, a longstanding tradition involves the preparation of lavish meals that often serve as symbols of wealth and social status. To illustrate, the quantity of food discarded at a wedding ceremony in Malaysia in 2020 would have been more than sufficient to provide nourishment for approximately 90 individuals in need [53]. In contrast, estimates from 2019 suggest that in Indonesia, this figure is approximately ten times higher than in Malaysia. Unfortunately, comprehensive data on the extent of food waste generated during such events across the entire MSA region remains conspicuously absent.

Our calculations, based on existing data, highlight the substantial variation in household-level food

waste generation across MSA countries: 83 kilograms per person per year in the Philippines, 134 kilograms per person per year in Brunei, and a range of 115–184 kilograms per person per year in Indonesia. In Malaysia, the figure stands at a significant 190 kilograms per person per year. Evaluations of FLW in public hospitals in Indonesia have revealed that food waste constitutes an average of 27.6% of the portions served [54], while a survey conducted in university canteens in the Philiipines [55] approximated rice waste at 0.028 kilograms per person per meal, equivalent to 8.9% of the total food waste produced per person. An overview of the 15 studies published within the MSA region is presented in **Table 1**, providing insights into the study location, scope, as well as the data collection methodology, encompassing details such as the timeline, duration, sample type, and size.

Table 1. Summary of the research studies in MSA countries meeting inclusion criteria of the systematic review.

Location of study	Scope	Year data collected	Data collected method	Reference
Ilocos Norte, The Philippines	The knowledge, attitudes, and practices on food waste of households	2019	Structured questionnaire from 100 respondents	[46]
Klang Valley, Malaysia	The elements that impact an individual's choices regarding food wastage and examine how these elements influence food waste actions	2022	Structured questionnaire from 431 respondents	[40]
Malaysia	The patterns and causes of food waste generation in the hospitality and food service sector	2019	Comparative analysis of five case studies from the hospitality and food service	[42]
Malaysia	The factors that affect the behavioral intention to reduce food waste	2020	Structured questionnaire from 352 respondents	[48]
Malaysia	The level of awareness related to food waste behavior and the component responsible for food waste decomposition.	2021	Structured questionnaire from 400 respondents	[49]
Padang, Indonesia	Food industries waste generation, characteristics, and composition	2022	35 industries waste samples collected and analyzed in field study over a period of 8 days	[43]
Palu, Indonesia	The factors influencing commercial food waste decisions and study the effect of these factors on food waste behavior	2019	Structured questionnaire	[41]
Sabah, Malaysia	Household and commercial waste generation, and composition	2021	60 households and 20 commercials waste samples collected over a period of 14 days	[38]
Sarawak, Malaysia	The awareness of food waste behavior	2022	Face-to-face survey of 2,059 respondents	[44]
Selangor and Terengganu, Malaysia	Identify the factors influencing the individual’s food waste decisions, as well as study the effect of these factors on food waste behavior	2017	Structured questionnaire from 333 respondents	[39]
Semarang, Indonesia	The awareness on food waste problems and behavior	2020	Structured questionnaire from 100 respondents	[47]
Serdang and Cheras, Malaysia	Household waste generation	2017	Structured questionnaire from 333 respondents	[37]
The Philippines	The factors that help accelerate the reduction of food loss and waste in agriculture	2015	Not reported	[45]

Location of study	Scope	Year data collected	Data collected method	Reference
The Philippines	The factors influencing household food waste.	2021	Structured questionnaire from 303 respondents	[50]
Yogyakarta, Indonesia	Household waste generation (fruits and vegetables) and awareness of food waste behavior	2022	150 respondents waste samples collected and analyzed in addition to face-to-face survey of households in field study over a period of 7 days	[51]

There is growing worldwide recognition of the sustainability challenges facing our food supply. This heightened awareness has led to the initiation of various initiatives and actions by non-governmental organizations, including awareness campaigns and food banks. Their primary objective is to reduce food waste by collecting surplus, unused food and distributing it to individuals facing food scarcity [56]. In **Table 2**, we offer an overview of ongoing initiatives and projects within MSA countries that primarily focus on reducing food waste or preventing the disposal of edible food in landfills. The collected data underscores that all these regional initiatives are relatively recent, commencing their operations in the year 2013.

Table 2. Summary of ongoing projects and initiatives in MSA countries related to FLW reduction and increasing public awareness.

Ongoing project/Initiative	Goal	Country	Year of implementation
Food Aid Foundation (NGO)	Food banks, for individuals in need, food banks gather excess food donated by manufacturers, distributors, wholesalers, retailers, companies, or members of the public.	Malaysia	2013 [57]
SAVE FOOD	Global initiative on food losses and waste reduction	Brunei, East Timor, Indonesia, Malaysia, The Philippines	2015 [58]
Food Bank	• Raise awareness about food waste. • Collect and distribute unserved foods from hotels, restaurants and catering services. • Fight hunger and food waste by managing food losses and waste	Indonesia Malaysia Brunei Filipina	2015 [59] 2018 [60] 2020 [61] 2021
The Lost Food Project (NGO)	"Rescue" undamaged food from markets and producers that would otherwise be thrown into landfills and directly distribute it to needy residents and charities.	Malaysia	2016 [62]
Green Hero (NGO)	Distribution of unsold and still edible food that would otherwise be wasted.		2017 [57]
GRASP 2030 (Gotong Royong Overcome Food Loss & Waste 2030)	Encourages businesses to collaborate with other stakeholders throughout the food system chain in developing solutions to reduce food loss and waste.	Indonesia	2021
The Sustainable Food Tourism Program	Reducing the level of food waste at the hotel and tourism level.	Indonesia	2023

4. Conclusions

The extensive impact of FLW on the economy and environment, especially in regions dependent on food imports and with limited local food production capacity, is undeniable. The lack of comprehensive research and reliable data on FLW, particularly in understanding its extent, causes, and effective management strategies, is a significant concern in MSA countries. Addressing FLW is crucial for sustaining food systems and ensuring regional food security.

Identifying the causes of FLW and developing effective solutions is of utmost importance. Quantifying FLW within MSA countries is essential to formulate effective measures to reduce it. Recognizing the significance of FLW and its impacts can motivate communities to engage in efforts to reduce food loss and waste.

Most MSA countries have published at least one research article on FLW, yet there is a clear need for more research and knowledge sharing to understand food disposal practices, the nature and extent of waste, and strategies for prevention and reduction.

On a second level, and arising from the above, the results of the review emphasized the need for more case studies on FLW in Maritime Southeast Asia. Firstly, the needs that have emerged through previous studies are as follows:

1. Determination of why there has been so much food waste in developing MSA countries, including what drivers, such as the cultural and social lifestyles that have existed for centuries, and economic factors that determine why such high amounts of what otherwise could be nutritious food are placed into the FLW stream.
2. Examining both environmental and economic impacts from FLW in the region. This includes quantification of greenhouse gas emissions, water usage, and land degradation from FLW; and economic costs of FLW to producers, retailers, and consumers.
3. Evaluate the effectiveness of existing policy measures and strategies for FLW reduction in MSA on the policy levels—ranging from food waste bans, composting programs, to consumer education campaigns.
4. Investigate the drivers of FLW along the supply chain—packaging, labeling, marketing, and distribution systems—considering consumer influential and impact.
5. Assess the impact of food loss and waste on food security and nutrition in the region, including how food loss and waste affect availability and affordability of food for the most food insecure and those mired in poverty.

In addition, effective collaboration between academic institutions, public and private sectors across the region is necessary. Such partnerships are vital for developing policy instruments and tools to reduce FLW across all stages of the food supply chain, alongside platforms for knowledge sharing, policy implementation, and capacity building for FLW reduction efforts.

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