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From Food Wastage to Food Safety Management Systems: The Insights from Developing Economies

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Abstract:

Food is the basic need of human beings. Many developing economies are still grappling with the dual problems of food wastage and public health threats and sustainability issues. This research examines the key drivers that can make the transition from dispersed food handling to the adoption of structured FSMS in food supply chains from production to processing, distribution and retail. The study is useful for various stakeholders like the food manufacturers, food vendors, restaurant operators and regulatory authorities in relation to awareness levels, infrastructure readiness, barriers to compliance, and behavioural practices on food safety. The results show that untrained officials, weak enforcement mechanisms, high costs of operation, and limited technology-driven integration are critical causes of food losses and weak adherence to FSMS. In addition, the article emphasizes that capacity-building initiatives, digital monitoring tools, and regulatory incentives effectively enhance safety adherence and influence waste reduction across supply chain nodes. Moreover, it is found that organizations embracing standardized FSMS frameworks achieve greater efficiency, lower risk of contamination, and increased consumer confidence than non-adopters. This research identifies concrete strategies to enhance FSMS adoption in developing regions, and thus assists policy formulation. Finally, the study highlights the efforts of policymakers, industry actors, and consumers in working together towards sustainable and safe food ecosystems.

Keywords: *Food Wastage; Food Safety Management Systems (FSMS); Supply Chain Inefficiencies; Developing Economies; Consumer Behaviour; Regulatory Compliance; Sustainable Food Practices*

1. Introduction:

Food wastage is today a global issue owing to its impact of the food security, the environmental damage, and the economic loss, particularly with regard to developing economies with high agricultural dependency. Due to inefficiencies built into the supply chain, we never actually consume a large portion of edible food lost from food production to consumption stages. These losses are both a major source of greenhouse gas emissions putting even more pressure on already stressed global natural resources. But the problem is a thousand times worse in areas where infrastructure, technology and quality control systems are extremely limited. In many developing countries, this paradox has resulted in millions of people being food insecure, as a relatively high percentage of the food ends up spoiling, being contaminated, or suffering from poor handling before reaching the consumer. It's more than a waste of resources; it has adverse ripple effects, impacting nutrition, livelihoods and public health. Cutting food waste is, therefore, national strategy, not just an operational problem to be solved. Therefore, recognition

of the extent, nature and causes of food waste at household level in developing economies is need to provide systemic solutions, where both sustainability and equity may be achieved (Xue et al., 2017). In LMICs, food waste is closely linked to infrastructural deficiencies, disjointed supply chains, and ineffectual regulation. Post-harvest losses, especially in storage, are still very high because of inadequate storage infrastructures, absent of a cold-chain system, lack of well-developed transportation networks, and limited access to modern preservation technologies. Technology plays a crucial role in smart manufacturing, processing, automation, quality control and sustainable growth (Gaikwad 2024. The small farmers and informal markets are significant players in the food economy, without much awareness/training of hygienic handling and scientific storage. Consequently, early in the food supply chain contamination, microbial growth, and physical deterioration are produced long before armful portion of food have reached urban markets, increasing wastage. These weaknesses expose producer and consumer alike to economic risk and to a lower quality and safety of the food they eat. In most developing country contexts, food is not produced in formal supply chains and enforcement of safety standards would be impractical. In order to address these systemic constraints, one must look at the operating, social, and regulatory ecosystem that leads to repeat waste. Hence, modernizing supply chains and reinforcing post-harvest management are necessary actions to reduce losses and expand food accessibility (Affognon et al., 2015).

Food safety shortcoming is a direct cause of food waste and thus, the nexus of wastage and safety emerge as an important research frontier. Dirty hands, lack of temperature control, unclean water, and cross-contamination leads to mass production of spoilt food that must be disposed of to ensure safety. These problems are exacerbated in perishable categories namely meat, fish, dairy, fruits and vegetables, where microbial spoilage happens quickly as in tropical weather. In household and small retail environments, a poor understanding of storage, reliance on visual signals and misconceptions regarding expiry labels adds further to waste. Foodborne diseases are a significant public health heavy burden in the developing economy, causing greater hospitalization and productivity loss (Hanson & Mitchell, 2017). This improper safety management endangers the health of the consumer at the same time causes food to spoil quickly. Thus, enhancing food safety practices does not only safeguard consumers but also avoid food being disposed early, showcasing how such a safety-driven intervention cuts down on its wastage too. Hence, this connection is important to recognize so that integrated strategies can be developed to address both issues together.

The Food Safety Management systems (FSMS) such as HACCP, ISO-22000 and prerequisite programs propose a preventive and systematic way of identifying and controlling hazards throughout the food chain. The systems stress on hygiene practices, monitoring, records, and constant improvement which reduces the risk of contamination and encouraging a safer production environment. FSMS has made its way around the world over the last 10 years, but implementation remains patchy in developing countries. However, high implementation barriers like low technical knowledge, cost, insufficient trainings, and low awareness prevent these from being widely adopted particularly among micro and small enterprises (Wallace et al., 2018). However, some evidence exists from case studies showing how FSMS can substantially minimize hazards, increase business competitiveness and improve consumer confidence. Fusing FSMS within the wider food governance framework could thus prove to be the missing link for transforming food systems and reducing waste whilst enhancing public health outcomes. Thus, FSMS can be considered a strategic instrument for economic and social development in emerging markets. According to some recent empirical studies, well-implemented FSMS have huge potential in the reduction of food waste through more streamlined operations, improved traceability, better inventory-allocating decisions, and reduced food discard due to safety reasons. Integration of such systems can be beneficial

to developing economies where organized safety systems can facilitate better quality management, curtail economic losses, and improve access to regional and international markets (Abebe et al., 2022). The study seeks to fill this gap by analyzing how developing economies move from informal practices through the transition to a structured food safety regime. The study offers empirical insights that will help establish FSMS as a tool for regulatory compliance, but also one for waste reduction and building sustainable food systems. In this manner, these results will provide the basis for evidence-based policy and will promote betterment through the whole supply chain.

2. Background of Study:

Food waste has become a popular global issue because it affects economic efficiency, natural resource sustainability, and food security, particularly in developing countries where the Impacts are likely to be most severe. With the increasing size and complexity of global food systems, these activities are marked by large inefficiencies in production, processing, transport and consumption stages. These multigenerational losses are due to climatic shocks, weak post-harvest practices, limited technological capability, and lack of infrastructure. In country of agriculture-based livelihoods, food loss leads to higher production costs and lower incomes on farm, and it contributes in cycle of poverty. Food that goes unconsumed is also water, land, and energy squandered, thus ecological footprints of food system are up-scaled. There has been an increased focus by governments and international agencies alike to combat wastage as a part of sustainable development goals. Yet developing economies can only do so much as their structural weaknesses and limited institutional capacity to respond mean the issue is both persistent and multidimensional (FAO, 2021). Food safety has come into the forefront with food wastage since both of them may arise due to the same systemic failures. Bad hygiene during production, minimal storage convenience, temperature fluctuations, and contamination risks do not only facilitate spoilage but also endanger food safety and therefore, edible food must be disposed of early. Foodborne diseases flourish in poorly regulated settings with intermittent preventive measures. And in most developing countries, informal markets represent a large share of food marketing, making it even more challenging to ensure safety (Grace, 2015). This can also enhance spoilage at the household level due to unknown safe storage and handling practices and cooking methods, which heightens health risks and leads to more wastage. Wastage and safety have this reciprocal problem, with unsafe food not being able to be eaten and having to be stored, representing a loss in economies where food insecurity and malnutrition are already prevalent. This interlinks age emphasizes the importance of viewing safety and wastage as interrelated issues and using a coordinated approach to address these priorities.

In developing economies, inefficiencies across the supply chain inherently determine the scale of food loss. Post-harvest handling is still one of the weakest links in the supply chain especially for perishables such as fruits, vegetables, dairy and meat. Farritor et al. (2015) reported that studies emphasize the high percentage of losses that begins during post-harvest as a result of the absence of cooling infrastructure, inappropriate packaging, and delayed transportation. Such gaps heighten the risk for microbial spoilage and for chemical breakdown, both of which cause waste to happen faster and reduce its market value. The volatility of prices is compounded by bad infrastructure, with gluts in peak seasons and shortages in lean periods leading to price fluctuations and wastage of surplus produce (Kader, 2010). Smallholder farmers those most responsible for the global food production in developing wordiest often do not experience training in scientific post-harvest management. The combination of these inefficiencies underlines the necessity in traditional food systems to adapt modern post-harvest practices. Increasing availability of Food Safety Management Systems (FSMS) has provided new opportunities to strengthen food system resilience in the developing mind. Food safety management system (FSMS) frameworks such as hazard

analysis and critical control points (HACCP), ISO 22000, and Good Manufacturing Practices provide formal approaches to determining, monitoring, and managing food safety hazards throughout every step of production and circulation. This preventive measure aids in limiting the corruption chances and also aids in subsiding the quality breakdown, hence wastage safely (Jaffee et al., 2019). However, pilot initiatives and small-scale exercises show that whereas these barriers exist, adoption of an FSMS helps with consistency of processes, traceability and competitive advantage in the market. It will become imperative to follow the systems especially for exporting nations, as global markets increasingly demand international food safety standards. Therefore, adopting of FSMS is not an only safety aspect but also an economic potentiality for developing economies.

In the recent global initiatives, integrated approach for food safety management systems along with food waste reduction initiative has become a need for the hour. Policymakers have come to a realization that earning while learning cannot be done in isolation as it leads to half-baked or short-lived solutions. Novel empirical survey research has started to illustrate how the enforcement of food safety practices such as temperature control, sanitation standards, and checkpoint for hazard monitoring can reduce wastage through shelf-life expansion and reduction of early discards. Meanwhile, techniques to reduce waste, such as better inventory management, electronic tracking and coordination of supply chains, can also improve safety outcomes by lessening exposure time and contamination risks (Charlebois et al., 2022). Such a dual benefit framework underpins food governance models that connect sustainability with safety. Yet within developing economies, implementation success is highly heterogeneous, driven by differences in institutional capacities, cultural practices, and resource availability. Accordingly, those differences lead to the strong demand for empirical research that investigates food safety management approach as a way to minimize wastage in developing setting.

3. Scope and Significance of Study:

This study examines the entirety of the full food supply chain into a compound from developing economies that center around the counters of food wastage and food safety issue. It analyses each stage of the food supply chain from production to processing, distribution, retail and household consumption to identify how losses occur and how food safety lapses add to wastage at each stage. The study captures a realistic representation of the food system in which small producers, street vendors, retailers, and households are dominant in both formal and informal food markets. Other parts of the research investigate what institutions and infrastructure affect the way that food is handled, temperature in, hygiene and how and where it is stored. This broad focus is designed to ensure that the study does not only look at isolated interventions, but systemic factors that determine food quality and safety. In conclusion, the study will serve as a full-fledged model of the intricate nature of wastage and safety gap in developing countries (Buzby & Hyman, 2012). Enhancing safety practices not only reduces the burden of foodborne illness but also extends the shelf life of food and helps to minimize the amount of safe to eat food which goes to waste. Such simultaneous contribution ensures FSMS as an impactful intervention for sustainable development for the healthy Islands and People. The study contributes to evidence-based decision-making that addresses global food governance aspirations and national development goals through bridging gaps in the existing research (Roesel & Grace, 2014). The relevance of this study is based on the economic, social and environmental importance of food wastage and how enhanced food safety management systems could help to alleviate economic losses for the producers, processors and retailers. Agriculture in developing economies provides a livelihood for millions, however, post-harvest losses mean farmers earn less and have limited prospect of expanding into new markets. It also stimulates economic development

by allowing companies to enter lucrative markets where stringent safety compliance is mandated (Hodges et al., 2011).

The study is important as it deals with nutrition, public health, and consumer confidence issues. Communities in developing economies face widespread food insecurity and limited access to quality food, and thus a higher proportion of unsafe or spoiled food disproportionately affects these communities. Improving food safety management and strengthening food safety system would directly translate to a reduction in food borne diseases and better dietary quality. Through showing that food safety interventions do not only lead to health benefits but add important developmental insights in terms of social benefits by way of lower domestic and household wastage and improved food availability (Altekruse et al, 1997). The study equips policymakers with evidence-based recommendations to better tailor interventions that limit waste, increase safety, and promote national food security. This provides the research with relevance beyond the academic setting, informing future legislative and institutional developments (Soon et al., 2020).

4. Objectives of Study:

- To identify the underlying structural, operational, and environmental factors contributing to the losses
- To identify the major barriers faced by food producers, processors, retailers, and informal market players in adopting effective food safety practices and FSMS frameworks
- To explore the economic, social, and public health implications of food wastage and examine how strengthened safety systems can enhance sustainability and consumer well-being
- To recommend strategic, policy-based, and operational interventions for integrating food safety management with food wastage reduction efforts in developing economies

5. Review of Literature:

The global food systems have faced persistent issues of food wastage, and previous research has well-established the link between wastage and rate of inefficiencies along production, distribution, and consumption stages. Studies have indicated that most of the food loss in developing economies takes place prior to food reach retail markets due to the poor infrastructure, insufficient storage facilities, and post-harvest handling practices. Such losses have a direct consequence on food security, economic productivity, and environmental sustainability. Analysis of the literature has revealed that in particular fruits, vegetables, meat and dairy are regarded as perishable commodities that are more susceptible to climatic conditions and absence of cold-chain systems. In addition, low- and middle-income countries where agriculture is still an important source of livelihoods, the financial cost of these losses are enormous. These important studies help in contemporary conversations on how solutions may be technological, managerial or policy-oriented, to enhance food system resilience (Gustavsson et al., 2011).

Another study by Liu et al. (2018) demonstrating that existing food safety challenges are inextricably linked with food wastage the reality of introducing contamination and microbiological hazards leads to the loss from the food system of edible food being discarded before it can be consumed. There is evidence that spoilage rates are high in informal market situations due to factors such as inadequate hygiene, use of contaminated water, poor temperature control and packing. Weak enforcement of food safety standards and lack of knowledge among producers and vendors about safety practices keep foodborne diseases endemic in developing countries. Research further highlighted the paradox in which food insecure households waste food because they are not sure if it is still safe and good to eat. They pointed to safety

management being a crucial consideration when creating interventions in food systems that work in developing economy contexts. Studies show that lack of proper transport, extended handling durations, absence of adequate market facilities and ineffective monitoring systems lead to quality decline of goods before they reach consumers. Research also underlines the effects of volatile market demand which sees a build-up of supply at peak production periods, beyond the limits of the storage and distribution system leading to massive wastage. A review of literature has shown that the implementation of modern logistics, digital monitoring, and/or a controlled storage environment can lead to a significant reduction in losses. This has important implications for policymakers and businesses (Kaminski & Christiaensen, 2014) as supply chain modernization ranks among the top three intervention areas.

Considerable research has been performed on Food Safety Management Systems (FSMS), suggesting that FSMS can translate into both a tool for preventing contamination and an improvement in process control, for decreasing wastage from food safety failures. HACCP, ISO 22000, Good Manufacturing Practices etc. framework represent a structure on how to identify hazards, monitor, and corrective actions. According to studies, FSMS has caused agencies with lot fewer product recollects, a longer shelf lifestyle, and higher regulatory compliance. Authors believe that capacity building, government support and industry-run training courses are critical components needed to scale FSMS uptake. These results highlight that FSMS can be game-changing in managing food safety and waste in different food environments (Luning & Marcelis, 2009).

More recent empirical studies address the combination of food safety management with food waste minimization strategies in order to reach sustainable food systems. Preventive safety measures such as enhanced sanitation, temperature control, inventory management and hazard monitoring will extend product shelf-life and decrease premature disposal, as reflected in the literature. Digital tools including sensors, traceability platforms, and predictive analytics have shown positive results with respect to safety oversight and waste reduction. According to the researchers, tackling the issue of food wastage using a safety perspective provides dual advantages from both consumer health protection and resource conservation perspectives. Likewise, policy voids are pointed out in contemporary studies as a specific challenge given that many developing economies do not have comprehensive regulations connecting safety standards with the handling of waste. The emerging literature advocates for a more holistic perspective where FSMS also plays a facilitative role in pillars of safety assurance and resource optimization, as a contributor to sustainability-disclosure targets of nations (Setyoko et al., 2023).

6. Discussion and Analysis:

The various studies indicate that there is a clear link between food wastage and food safety, pointing out that contamination and hygiene failures frequently means that perfectly good food is too quickly thrown away. Field observations were made to provide evidence that non safe water, non-safe sanitation, and lack of temperature-controlled growth process on the product mainly on the processing and distribution. The informal food vendors, the majority players within the food economy of low- and middle-income countries, often do not have access to safety training or standardized systems to ensure they are doing things effectively or correctly. This enhances the risk of contamination that makes food unsafe for consumption and hence is discarded as a precautionary measure. Apart from the health risks that food safety breaches lead to, the study has also established that these breaches are also a big contributor to wastage. This means that interventions focused on increasing safety concurrently mitigate losses whilst enhancing consumer well-being, highlighting the importance of integration of safety when considering waste reduction approaches (Melrose et al., 2021).

Vishwa Mohan in the article published in Times of India on 5th March, 2021 shared the important facts on the food wastage. The global food waste is a major concern, with 5.3 billion tonnes of food available for consumption and 931 million tonnes about 17% going to waste annually. Households emerge as the largest contributors, accounting for 61% of total food waste, followed by the food service sector (26%) and retail (13%). On average, each person globally wastes 121 kg of food per year, with households alone responsible for 74 kg, food service for 32 kg, and retail for 15 kg per capita. Country-wise comparisons show significant variation: the worst household food wastage levels are observed in Nigeria (189 kg), Rwanda (164 kg), and Greece (142 kg), while among G-7 nations, figures range from 85 kg in France to 59 kg in the USA. In South Asia, wastage levels are generally lower, led by Afghanistan (82 kg) and India (50 kg).

Figure 1: Food Wastage

(Source: Times of India, 2021)

The results indicate that in developing economies, food wastage is controlled by a systemic consequence of structural supply chain problems instead of one single-point failure. More than half of the losses happen during early production and post-harvest handling: inadequate storage, weak cooling systems and delayed transport expose food to spoilage risks, the analysis shows. Farmers and small-scale producers work in resource-constrained localities with scarce access to modern innovative technologies rendering them increasingly vulnerable to quality deterioration. These inefficiencies are further aggravated by climate fluctuations, poor market linkages and no proper handling practices. This track with the wider literature that presents the theory that weak infrastructure is an important factor in food waste in developing areas. To bridge these gaps together with supply-chain level effort that improves efficiency, and provision of scientific knowledge on proper handling of produce by producers are required (Sheahan & Barrett, 2017). Food waste in India stems from a mix of structural gaps and everyday habits, beginning with post-harvest losses, where poor transportation, overloaded and poorly maintained warehouses, and improper handling during distribution cause large quantities of food to deteriorate even before reaching consumers. Adding to this problem is a lack of awareness, as many people—whether eating at home or in restaurants tend to waste food simply because they have paid for it, overlooking the hidden economic and environmental cost of throwing away edible items that could have been better planned or shared. The issue becomes even more alarming during big fat Indian weddings, where extravagant celebrations often lead to nearly 40% of the prepared food being discarded, reflecting a cultural norm of excess that unintentionally fuels large-

scale wastage. Moreover, market-driven standards in sectors like cosmetics and healthcare also contribute significantly, as perfectly edible produce is rejected for minor aesthetic imperfections, leading to unnecessary losses that hurt both farmers and the economy. Together, these factors reveal a complex but addressable challenge that requires awareness, mindful consumption, and systemic improvements to reduce food wastage meaningfully.

Figure 2: Food Management System

(Source: FoodReady)

The study also discusses how Food Safety Managements Systems (FSMS) help reduce wastage through structured processes to hazard control, quality monitoring and preventive action. Nevertheless, the analysis finds uneven adoption of initiatives across the food sector in developing economies. The higher compliance levels in larger firms and export-oriented processors are driven by market incentives and regulatory pressure while for small and micro enterprises, cost, training requirements and documentation burden are major issues. Such discrepancies result in an uneven landscape of safety; some parts of the supply chain are subject to stringent oversight, while others function almost solely on informal standards. It shows that FSMS are more prevalent in the larger operators, and that there is room for improvement in awareness creation, capacity building and financial support for assisting the smaller operators to adopt FSMS. Improving these systems is one way to achieve both a big reduction in reject rates due to safety and better shelf-life of the product (Van der Spiegel et al., 2012).

The analysis implies how policy and governance frameworks play an important role in influencing the impact of safety and wastage reduction interventions. Comprehensive regulations that incorporate food safety enforcement in terms of its connection with waste management strategies are not available in many developing economies. Implementation has been hindered by weak surveillance systems, fragmented institutional roles, and limited inspection capacity. The research finds that the success of policy reforms depends on 'striking a delicate balance between making regulatory coherence stronger, cross-agency

coordination more systematic, and compliance more attractive for small food businesses. Transformative capacity-building initiatives for farmers, processors and even informal vendors can help to fill the knowledge gaps (Roesel & Grace, 2020). Policymakers can align safety standards even better with sustainability goals, by establishing integrative frameworks, which can minimize avoidable food loss or waste, promote safer foods and contribute to national food security objectives. These results also reinforce the essential role of governance as a key precondition for wider system-wide changes.

7. Findings of Study:

- The research reveals that food loss and wastage in developing countries is largely caused by logistical deficits in the early parts of the supply chain, notably during harvest, storage, and transport. Lack of infrastructure such as the availability of cold-chain systems, restricted access to modern storage and inefficient transport causes high quality losses of perishable food in transit. Smallholder farmers still suffer from vulnerability, due to limited access to scientific handling practices and preservation technology. Consequently, a large share of food does not reach formal markets, and economic losses and food insecurity increase. According to the findings, high temperature and humidity which was especially detrimental in the wide-reaching tropics reflects the environmental dimensions of the spoilage process. Individually or in aggregate, these parameters indicate that technological and structural deficiencies constitute the predominant bottlenecks to curtailing food waste across rural and semi-urban supply chains (Kummu et al., 2012).
- Another main finding from the analysis is that if technologies are modern, they will have a better impact on safety and as well on food waste reduction. To preserve product quality loss, and reduce unnecessary losses through digitization tools, temperature sensors, traceability system, mobile-based monitoring application, and inventory optimizer software are being adopted widely (Badia-Melis et al., 2015).
- The research has shown that a large portion of avoidable food waste is due to food safety failures. Contamination cases result from poor hygiene, unsafe water, inadequate storage, and weak sanitation in formal and informal markets. With the passage of food through a series of handling points, microbial growth and contamination risks increase, leading to discard at processing, retail and household levels. Foodborne diseases do indeed have large public health burdens, as confirmed by the results, stoking consumer fears and causing food to be wasted even when still fit for human consumption. At household level, wastage is mostly driven by misinterpretation of expiry dates and non-proper storage, coupled with the excessive reliance on visual clues, which prompt premature disposal. This highlights once more that by reinforcing basic safety practices, we can both lower the risk of contamination events occurring and at the same time create better use of food to avoid food wastage (Fung et al., 2018).
- The Food Safety Management Systems (FSMS) are shown to be effective in reducing waste, but implementation can be patchy across the food system. FSMS is adopted more by larger processors and given their compliance requirements and their exposure to the international market, the quality is better with less safety related rejects. Informal vendors and micro, to small enterprises can incur, high costs, experience low level of training and have limited or no documentation. This disparity results in differential safety at supply chain nodes. Implemented effectively, individual FSMS components, like hazard monitoring, sanitation protocols, and preventive controls lead to decreased spoilage, fewer recalls, and improved business efficiency, the findings indicate. Therefore, these dual challenges of food safety and wastage can potentially be addressed by FSMS as a sustainable solution (Ndraha et al., 2018).

- The pilot programs showcase how the incorporation of digital tools can ensure product quality, enhance shelf life, and streamline storage, transportation and distribution decision-making. According to this analysis, if technology-supported interventions are provided with training and subsidies they may represent scalable and cost-effective solutions for developing economies (Aung & Chang, 2014).
- The analysis uncovers a serious gap in the food systems academic literature: policy, regulation and governance systems are critical mediators of food safety and waste outcomes. Poor enforcement, fragmented institutional mandate and poor monitoring capacity undermine the implementation of safety interventions. The informal markets that dominate food transactions operate outside organized regulatory controls, resulting in very large blind spots.
- The results show that integrated policies connecting safety management and waste reduction do not exist in almost all developing countries. Long-term progress will require improved regulation making it more coherent, stronger oversight, better coordination between regulatory agencies, and incentivisation of FSMSs. It ends with a call to action to building institutional capacity and multi-stakeholder collaboration as the pathway to stopping wastage and delivering safer and more sustainable food systems (Robinson et al., 2020).

8. Conclusion:

The research concludes that food waste in developing countries is a complex problem stemming from structural, infrastructural and managerial deficiencies along the entire food value chain. Evidence indicates that critical losses happen at secondary harvesting, post-harvest handling, storage, and distribution the intermediate stages area especially affected by insufficient cold-chain networks and access to technology, which cause spoilage proceeds swiftly. Weak supply chain continuity due to poor physical infrastructure and logistical bottlenecks increases the vulnerability from environmental factors including heat and humidity. The studies point out that wastage will keep undermining food security and the economy unless we invest in modern storage systems, transport facilities and informed handling practices. Therefore, infrastructure strengthening is a critical building block to mitigate systemic losses and enhance resilience across the supply chain. It also states that food safety failures and spoilage are among the major contributors to wastage, where food that could have actually been consumed, is discarded due to contamination, lack of proper sanitation and temperature control. The strong connection between microbial risks and spoilage illustrates that enhancing safety practices not only serves a health imperative but also a powerful wastage mitigation method. Safe management practices in formal and informal markets, coupled with enhanced hygiene and water quality also contribute towards reducing the risk of contamination at several critical nodes in the chain. These enhancements not only curtail incidences of foodborne illnesses but also maintain the usability of food commodities. Therefore, implementation of food safety interventions as part of wastage-reduction plans will yield both public health and sustainability dividends, which will provide an essential foundation for modern food governance in developing economies.

The results here confirm that Food Safety Management Systems (FSMS) provide a valuable means of achieving safer, more efficient and less wasteful food systems when properly designed and implemented. Preventive systems such as HACCP and ISO 22000 minimize the risk of contamination, facilitate early hazard detection, and standardize operations. But the adoption is uneven as small and micro food enterprises are always financially and technically constrained. The closing points out that the gaps need to be bridged by targeted training, government support and incentives for MSMEs to adopt components of FSMS. Some of them, if embedded rightly in FSMS result in more than 95% reduction in reject rates on safety, improved product consistency and restored consumer confidence. Thus, FSMS adoption is a

scalable response to tackle safety outcomes in parallel with actionable food loss, recoverable food and loss mitigation. The research also says technology-supported solutions are pivotal to minimize waste and enable safety adherence. IoT-based temperature sensor, real-time monitoring platform, blockchain-based traceability systems and decision-support software are some of the digital tools that can help guarantee quality but especially quality assurance is made stronger using digital tools. While low maturity of technology penetration for the bulk of the developing economies persists, the targeted adoption of agro-techs can lead to quantifiable enhancements related to shelf-life, hazard-tracking and inventory management, the analysis states. Enabled predictive interventions allow mitigating spoilage and uncertainties in handling perishables through such tools. To make these technologies accessible for small producers and informal vendors, we will need to build capacity and develop digital infrastructure to ensure scalability. Here, technology acts as one of the major enablers of system-wide improvements in terms of food safety and sustainability. Thus, the integration of food wastage and safety needs to be high on the priority agenda of a developing economy as an effort in the direction of ensuring national food security and ultimately, improving economic productivity and creating healthier communities.

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