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Food Waste and Loss in the Food Service Industry of Tanzania: Learning from the Value Addition Chain

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Abstract—**Food waste and loss is a current issue of global concern due to its significant effect on the country's food security. Despite the importance of food service industry on the control of food waste, yet the magnitude of waste and food loss in each stage of the value chain is not clear. This study intended to explore the extent of food loss and waste, and dominant factors for the food loss and waste along the value chain. A well-structured questionnaires and interview guide questions were used to collect primary data from customers (*n* = 80), and working staff at restaurants/canteen *n* = 20). Quantitative and qualitative methods of data analysis were employed in the analysis whereby Structural Equation Modeling technique through Confirmatory Factor Analysis was employed to establish the dominant factors for the food loss and waste at each stage in the value chain. The findings revealed that the main kinds of food loss and wastes generated at different stages includes beans, rice, vegetables, food remains e.g., ugali and left outs, meat, fish, bananas and tomato such that rice and beans losses are dominant i.e., rated at 73%. Also, more food loss and waste occur at the production stage mainly during harvesting. The main causes of food loss and waste in the value chain are mostly lack of post-harvest and food preservation technology, customers' and working staff ignorance, poor hygienic storage and preservation facilities. With this positive foundation, the study recommends future research to determine customers' perceptions and behavioral patterns regarding food loss and waste along the value chain.**

Keywords—*Food waste, Value chain, Structural Equation Modeling, preservation technology*

I. Introduction

Over the past several decades, food loss and waste has attracted high research interests in many countries of the world due to severe negative social, economic and environmental impacts. In the world, about one third of food produced for human consumption, equivalent to a total of 1.3 billion tons of food per year is either lost or wasted at different stages of the food supply chain i.e., losses and wastes from initial agricultural production to final stages of consumption [1,2]. Vilariño [3] documented that the annual amount food loss and waste occurring in the world varies in percent depending on the type of crops whereby predictions indicate 30% of losses to be generated from cereals, 40 - 50% from root crops, fruits and vegetables, 20% from the oil seeds, meat and dairy products as well as 35% of losses generated from fish. Usually the quantity of food loss and waste generated are heavily dependent on the geographical condition and the local situation of the specific country/culture.

In the low-income countries particularly of Africa mostly food waste and loss results from a wide range of technical and managerial limitations in the harvesting technologies, storage, processing and cooling facilities, packaging as well as marketing systems. Based on the expected population growth in many developing countries, control of consumer behaviors as well as formulation and/or enforcement of the country specific policies and regulations is critical for effective control of food loss and waste. For example, in a study by Le Mouël & Forslun [4] the world's population is predicted to reach 9.1 billion by 2050 which requires an increase of 70% of the global food availability whereby the significant increase is expected to be from the developing countries of Africa. The steady increase in urban population in the countries have had created a complex and lengthy food supply chains involving many actors presenting challenges in delivery of safe and nutritious food. Hence, establishing strategies for reduction of food loss and waste along the value-added chain is vital for the achievement of sustainable food future. Food losses refer to those losses occurring at the beginning of the value-added chain i.e., production, handling and storage, processing and packaging as well as distribution and marketing, while food waste refers to those losses appearing at the end i.e., consumption stage [30]. According to Yong et al. [5] waste is defined as the residual material which is as a result of human activities that cannot be re-used/recovered as a source, recycled into the production processes.

Also, Hill [6] defines waste as materials which are not prime products i.e., products produced for the market whereby its generator has no more use in terms of its own purpose of production and/or consumption. Wastes therefore, can be characterized in different forms based on their common characteristics such as physical states, physical properties, reusable potentials, biodegradable potentials, source of

production and degree of the environmental impacts [7, 31]. In this regard, there is no single explanation of the food loss and waste because different stakeholders in the global food systems use various definitions and terminologies [8,9]. To date, the contribution and magnitude of food loss and waste in the value chain differs between developed and developing countries of the world. For example, in the developed countries e.g., Europe the largest proportion of food waste comes from the consumption stage, while in developing countries particularly Sub Sahara Africa the largest proportion of food waste is generated from the beginning stages of the value chain i.e., production and processing, among other [10].

Studies to evaluate amount of food waste along the value-added chain in German and Switzerland revealed that losses from food service industry is the second highest source of food wastage while ranked third largest source of food wastage in Switzerland [11,12]. Zeinstra et al. [13] documented that the total food waste from university canteen in German from the value-added chain is about 9.65%. Moreover, the calculated figures from the food service industry in Switzerland indicated 7.41 tons of food waste per annum [11]. In Europe, a study conducted by Tonini et al. [14] revealed that food waste is estimated to amount 88 metric tons equivalent to ca. 173Kg per capita such that in the economic terms, it incurs a loss of 143 billion Euro per annum. While the magnitude of food loss and waste is documented in developed countries, yet little is known about food loss or wastes in developing countries of Sub Sahara Africa particularly the Tanzanian food service industry. Therefore, the main aim of this study was to provide general information about food loss in the food service industry, and to assess the level of waste, reasons for its accumulation and waste composition in the value chain.

This study had two main research questions as follows: RQ1 What are the main causes of food loss/waste at each stage in the value-added chain? and RQ2: What are the dominant factors for waste accumulation and its composition at each stage in the value-added chain? To date, the food service industry is currently ever-increasing in many countries of the world due to changes in consumers' behavior of eating food away from home i.e., restaurants, cafeteria, hotel or pubs [15]. Despite the social and economic gains obtained from the increase, yet waste reduction from the food value added chain is a challenge. In Tanzania, about 70 - 80% of the urban solid wastes are of organic origin whereby kitchen wastes are dominant i.e., 62.5% by composition [16,17]. Considering the global food hunger, food loss and waste has created a social dilemma whereby food waste at the consumer level in many industrialized countries is more than 222 million tons which is equivalent to the total net food production in the Sub Saharan African countries i.e., 230 million tons [18,19]. In addition, the post-harvest losses experienced in majority SSA countries including Tanzania threatens food security, family income, health as well as the livelihoods of normal citizens. For example, the domestic food production in Tanzania is barely sufficient to meet national food needs such that many household's experiences protracted periods of food shortage whereby over 200 million USD is spent to import food per year [20]. Hence, the control of the losses may contribute significantly to offset food shortage in the country. Apart from reduction in the profit margin of the food service providers, a significant amount of money is spent by the government for the food waste control and management, transportation, treatment as well as disposal. The reduction of the food waste could also compensate the amount of food required to feed the expected population growth in the country as well as resource saving and contribute significantly to the environmental conservation.

Tonini et al. [14] documented that food waste incurs huge resources and thus causes significant environmental impacts that results from the multiple processes involved in its entire life cycle. The study added that, environmental impacts of food waste can be categorized into ten (10) clusters ranging from the Global warming to water depletion which includes indirect land use change impacts due to demand for land. This study has quantified the Global warming impacts of avoidable food waste to about 3600KgCO2eq.t-1. Considering the drawbacks of food wastes generated from the industry, understanding the determinants of food waste and strategies for reduction at each stage in the value-added chain is critical.

A. Theoretical framework

This study was guided by the theory of planned behavior which has been extensively applied in understanding of various human behaviors [21]. The theory suggests that the proximal determinants of behavior are intention to engage in that behavior and perceptions of control over that behavior. In this case, intention refers to a person's motivation in the sense of his/her conscious plan to exert effort to perform the behavior, while perceived behavioral control is a person's expectancy that performance of the behavior is within the control. The theory assumes that human behaviors on reduction of food waste are highly affected by his/her intention and perception on that act which requires changes in the attitudes and beliefs of the value chain actors i.e., consumers and food service providers.

II. MATERIAL AND METHODS

A. Study area

This study was conducted in Mvomero district which is one of the six (6) districts forming Morogoro region in Tanzania. The district is located at latitudes 6°17'60.0" South of equator and longitudes 37°27'00.0" East of Greenwich Meridian. Mvomero district covers an area of 6,632.9 Sq. Kms and a population of 312,109 with the household size of 4.3 [22]. This study is proposed to be conducted in Mvomero districts' university (i.e., Mzumbe University) canteen and restaurants due to fact that many families in the district experiences shortage of foodstuffs whereby food saving from restaurants and canteens would be used to feed those families.

B. Sources of data and data collection

A participatory approach was used to collect primary data from employees in the university canteen or restaurants, and consumers. The multistage sampling technique was applied in the selection of representative employees and customers to be

consulted. A well-structured questionnaire, interviews and focus group discussion were employed to collect primary data from randomly selected employees and customers during lunch or dinner in a sample size *(n)* of 100 respondents i.e., 80 customers and 20 employees) from Mzumbe University canteens/restaurants in Mvomero district. Moreover, the qualitative data were collected using notebooks, and then transcribed, coded and translated into English.

C. Methods for data analysis

Descriptive method of data analysis was used to establish the demographic profile of respondents, as well as the dominant factors for food loss or waste at each stage in the value-added chain. The preliminary analysis has had involved coding, cleaning and screening of data prior analysis. The Statistical Package for Social Sciences (SPSS) software was employed in the analysis of the quantitative data which were coded in a five-point Likert scale. The descriptive analysis was used to compute frequencies, mean, standard deviations and percentages based on the employee and food customer responses. Thereafter, the Structural Equation Modeling (SEM) technique using Confirmatory Factor Analysis was applied to establish the relationships between the observed measures and the latent variables, and within the constructs (i.e., food waste during; storage, preparation, serving and plate (i.e., food remains after eating)) whereby the accumulation and dominant factors for the food loss or wastes at each stage in the value chain were determined.

SEM has several benefits including precise estimation of the indirect of the exogenous variables on all the endogenous variables. Besides, SEM is useful when the study has multiple constructs such that each construct is presented by multiple measuring variables [23]. Similarly, Jihne [29] documented that SEM is useful in the analysis of the latent variables and their relationships, which offers opportunity for analyzing the dependencies of psychological constructs without measurement error. Prior the confirmatory factor analysis, several assumptions were made and tested such that they all found to meet the conditions. The first assumption was requirement of large number of sample size, ranging from 100 to 400 (whereby this study has used sample size of $n = 100$), the correlation level of $r = 0.3$ or greater than, and the Bartlett's test for sphericity should be statistically significant at $p<0.05$ and Keiser Meyer Olkin *(KMO)* of 0.6 or above. Based on the assumptions above, the analyzed data were found to have Cronbach's alpha of 0.83 and Bartlett's with a $P_{value}<0.05$ which indicates the data collection instrument was reliable and guarantees the analysis. In addition, a qualitative method of data analysis was used to examine the main causes of food loss or waste at each stage in the value chain which was analyzed by using Atlas_ti software. These data were presented in a form of summary narratives, and verbatim illustrative quotes which substantiates the explored findings on the causes of food loss and waste in each stage of the value-added chain.

III. Results

A. Respondents demographic profile

Table 1. presents the demographic profile of respondents which revealed that out of 100 respondents, the majority were female 59(59%) with male forming 41(41%) of the total respondents. The obtained differences in gender might have been caused by nature of works in restaurants and canteens in many developing countries which favors more female than male. Most of the respondents possess or undertakes a diploma 47(47%) or degree 32(32%) levels of education, while few possess a primary 9(9%), secondary 8(8%) or certificate 4(4%) education respectively. The researcher found that out of the 20-working staff at restaurants and canteens, 6(6%) respondents have a working experience of 1 month – 1 year, 7(7%) have working experience of 1 – 3 years, 4(4%) working experience of 3 – 5years and 3(3%) respondents with working experience of more than 5 years. The results revealed that staff retention at canteens/restaurants is a challenge following many staff change jobs in search for green pasture or more pay jobs.

TABLE I. Respondents profile

Demographic profile	Item	N (%)
Gender	Male	41(41%)
(N = 100)	Female	59(59%)
Education	Primary	9(9%)
(N = 100)	Secondary	8(8%)
	Certificate	4(4%)
	Diploma	47(47%)
	Degree	32(32%)
Work experience *(N = 20)*	1 month – 1 year	6(6%)
	1 year – 3 years	7(7%)
	3 years – 5 years	4(4%)
	5 years and above	3(3%)

Frequency; Percent (%)

B. Food waste in the value-added chain

This study also wanted to bring the understanding of the extent and causes of food loss or waste at each stage of the value-added chain of restaurants and canteens at Mzumbe University such that the results are as follows: Production i.e., during or immediately after harvesting on the farm. At this stage respondent opinion indicates that losses are mainly due to poor harvesting technology, farmers' ignorance on proper harvesting techniques and their benefits, carelessness in production and low production technology. In the interview one respondent admitted to experience high rice losses at farm due to lack of modern harvesting method such that majority crops are left in farm. Handling and storage i.e., crops, vegetables or fruits produce leaves the farm for handling, storage, transport and use. At this stage, the results showed that food losses are mainly caused by lack of proper storage facilities, dirty storage premises, ignorance of the actors in the value chain, poor handling and storage facilities, poor hygienic storage and preservation facilities, improper preservation methods, as well as careless during storage and preparation.

For example, a respondent who is also engaged in fruits and vegetables horticulture confessed that many kilograms of fruits and vegetables are lost due to lack of hygienic preservation methods that could extent shelf life of the products without affecting its nutritional value and food taste.

Processing and packaging i.e., during industrial or domestic processing and/ or packaging. The study revealed that losses at this stage are mostly caused by poor technology during processing, poor processing and packaging technology, careless during storage and packaging as well as unawareness on proper processing and packing benefits/costs. One of the canteen owners admitted to have experience more food losses due to poor packaging of food products used as raw materials. Also added that many food products manufactured locally do not have labels like expiry dates, composition of ingredients, among others such that it's hard to tell exactly when it will not be fit for processing just end up with throwing them away.

At the stage of distribution and market i.e., during distribution to markets, including losses at restaurant/canteen, the study results indicated the key caused to be from poor quality of crops mainly maize, beans and rice, ignorance of the actors in the value chain and lack of modern food preservation methods that are embedded in the food transport and distribution systems. At last food waste at consumption stage i.e. wastes in the restaurants or canteens. The respondents' opinion indicates that food wastes are mainly caused in great extent by bad preparation of food i.e., not cooked well, poor quality food i.e., no value for money, too much served for the customer as well as ignorance in food preparation and serving.

C. Dominant factors for food loss/waste accumulation in the value chain

The five constructs were formulated based on the study by Kenny & Editor [24]. The variables falling under each construct i.e., production, handling and storage, process and packaging, distribution and marketing and consumption were employed to examine the dominant factors for food loss and waste in the value-added chain (Table 4.2). The Confirmatory Factor Analysis (CFA) results revealed that all factors are significant at $P_{value} < 0.05$.

TABLE II.   DOMINANT FACTORS FOR FOOD LOSS AND WASTE

Construct	Measure variable	P_{value}	Loading (λ)
Production (PD)	Fruits/vegetables damaged during picking		0.52
	Crops sorted out for not meeting quality standards	***	0.53
	Crops left behind in fields due to poor harvesting	***	0.46

Construct	Measure variable	P_{value}	Loading ( )
	Crops left behind in fields due to sharp drops in prices	***	0.54
	Fish/meat discarded during fishing/slaughtering operations	***	0.58
Handling & Storage (HS)	Edible food eaten by pests		0.47
	Edible produce degraded by fungus or disease	.003	0.52
	Livestock death during transport to slaughter or not accepted for slaughter	.002	0.46
	Fish/meat that are spilled or degraded after landing	.003	0.41
Processing & Packaging (PP)	Milk spilled during pasteurization and processing		0.44
	Edible fruit/ vegat. or grains sorted out as not suitable for processing	***	0.40
	Livestock trimming during slaughtering and industrial processing	.002	0.45
	Fish/meat spilled or damaged during canning/smoking	***	0.60
Distribution and market (DM)	Edible produce sorted out due to quality		0.67
	Edible products expired before being purchased	.003	0.73
	Edible products damaged in market	.003	0.36
Consumption (CONS)	Edible products sorted out due to quality		0.39
	Food loss when serving	.003	0.23
	Food loss at plate	.003	0.51
	Food not cooked well	.050	0.51
	Too much for me	.010	0.43

In addition, the SEM results (Fig.1) indicated strong correlation of many variables within and between constructs i.e., production, handling and storage, packaging and processing, distribution and marketing as well as consumption stages in the value chain.
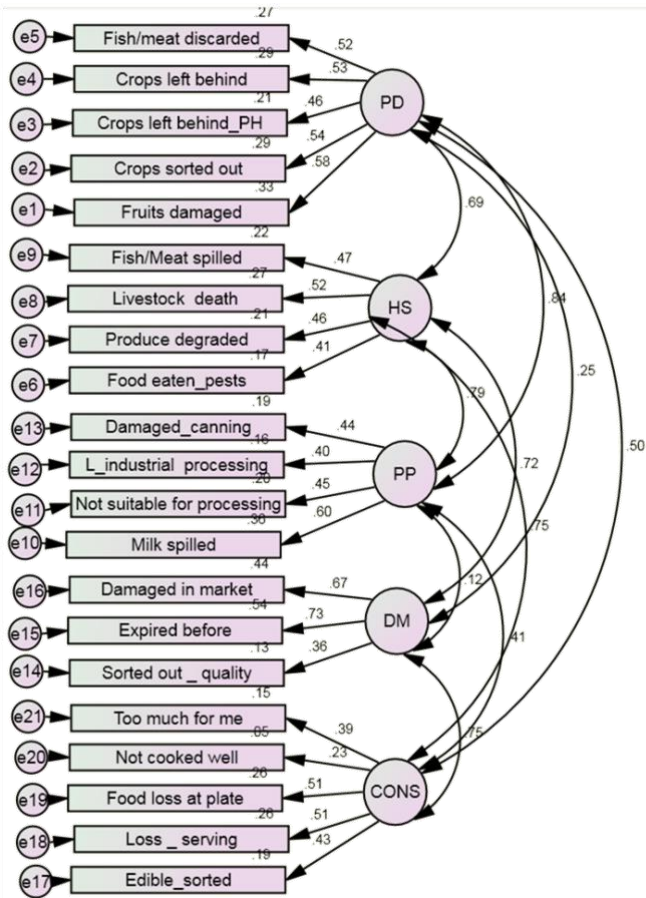

Fig. 1. SEM for the dominant factors for food loss or waste (PD=Production, HS=Handling and storage, PP=Packaging and processing, DM=Distribution and marketing, CONS=Consumption)

The SEM results showed strong correlation of production versus handling and storage (λ =0.69), handling and storage versus processing and packaging (λ =0.79), distribution and marketing versus consumption (λ =0.75), production versus consumption (λ =0.50). While weak correlation was obtained when comparing the constructs processing and packaging versus distribution and marketing (λ =0.12) which may disqualify some of the factors in explaining the constructs' characteristics. When tested at loading factor (λ = 0.69) for correlation between production (PD) and handling & storage (HS) constructs; fruits/vegetables damaged during picking (λ = 0.52), crops sorted out for not meeting quality standards (λ = 0.53), crops left behind in fields due to poor harvesting (λ = 0.46), crops left behind in fields due to sharp drops in prices (λ = 0.54) and fish/meat discarded during fishing/slaughtering

operations (λ = 0.8) are confirmed to be dominant factors for food loss during production stage.

When tested at loading factor (λ = 0.72) for correlation between distribution and marketing (DM), and handling & storage (HS) constructs; edible food eaten by pests (λ = 0.47), edible produce degraded by fungus or disease (λ = 0.52), livestock death during transport to slaughter or not accepted for slaughter (λ = 0.41) and fish/meat that are spilled or degraded after landing (λ = 0.41) are confirmed to be dominant factors for food loss during handling and storage stage in the value chain. The testing results at the loading factor (0.79) for the correlation between handling & storage (HS), and processing & packaging (PP) constructs; milk spilled during pasteurization and processing (e.g., cheese) (λ = 0.44, edible fruits/ vegetable or grains sorted out as not suitable for processing (λ = 0.40, Livestock trimming during slaughtering and industrial processing (λ = 0.45 as well as fish/meat spilled or damaged during canning/smoking (λ = 0.60) are confirmed to be dominant factors for the food loss during processing and packaging stage in the value chain.

Using the loading factor (λ = 0.72) using a correlation between handling & storage (HS) and distribution & marketing (DM) constructs; edible produce sorted out due to quality (λ = 0.67, edible products expired before being purchased (λ = 0.73), and edible products damaged in market (λ = 0.36), are confirmed to be the dominant factors for the food loss and waste during distribution and marketing stage in the value chain. When tested at a loading factor (λ = 0.75) for correlation between distribution & marketing and consumption constructs; edible products sorted out due to quality (λ = 0.43), food loss when serving (λ = 0.51), food loss at plate (λ = 0.51), food not cooked well (λ = 0.23), too much for me (λ = 0.39) are confirmed to be the dominant factors for food waste in the value chain.

IV. DISCUSSION

This study has explored the extent and causes of food loss and waste at each stage in the value chain namely production, handling and storage, processing and packaging as well as distribution and market. The results indicated that food loss and waste occur at the production stage due to many factors including poor harvesting technology, farmers' ignorance on proper harvesting techniques, carelessness in production and low production technologies used. The results agree with the World Bank [25] study which documented that the post-harvest grain losses in Sub Saharan Africa (SSA) is valued at USD 4 billion each year whereby the magnitude of grain losses exceeds the value of total food aid received in SSA over the last decade whereby control of food loss is an important strategy for food security.

At Handling and storage stage, food loss and waste are mainly caused by lack of proper storage facilities, poor handling and storage facilities, poor hygienic storage and

preservation facilities, and improper preservation methods. The results also showed that many kilograms of fruits and vegetables are lost due to lack of hygienic preservation methods that could extend shelf life of the agriculture produce without affecting its nutritional value and food taste. Similar results were also found by Ezekoye et al.[26] who emphasized on the use of technologies by smallholder farmers that increases shelf life of perishable items like fruits, vegetables and vegetable related products. This study added that a number of rural areas in Eastern Africa suffer substantial post-harvest losses of vital agricultural products in which the region losses about 20 to 60% of their agricultural harvest per year due to spoilage, insufficient post-harvest management as well as fungal and microbial degradation of fruits and vegetables.

At the Processing and packaging this study revealed that losses are caused by poor technology during processing, poor processing and packaging technology, and unawareness on proper processing and packing benefits or costs. The results are in-lined with the study by Wohner et al. [27] which documented that a significant amount of food loss and waste are contributed with the packaging materials and processing methods whereas some packages do not show composition of ingredients, expiry dates, and important information which guarantee users about quality performance.

At the stage of distribution and market, the results indicated the key causes to be from poor quality of crops, ignorance of the actors in the value chain and lack of modern food preservation methods that are embedded in the food transport and distribution systems. Also, food waste at consumption stage the results indicated that food wastes are caused by bad preparation of food, poor quality food, too much served for the customer and ignorance in food preparation and serving. Mabaso & Hewson [28] found similar results to this study such that poor food quality, too much served for the customers, and bad preparation were the main reasons for food waste by many restaurants.

The SEM results for the five constructs i.e., production, handling and storage, process and packaging, distribution and marketing, and consumption were employed to explore the dominant factors for food loss and waste in the value-added chain following the study by Kenny & Editor [24].

V. Reflection on Food Loss and Waste Accumulation in The Value Chain

This study also wanted to understand the kinds of food losses and wastes generated at restaurants or canteens. It was revealed that the main kinds of food losses and wastes are beans, rice, vegetables, food remains e.g., ugali and left outs, meat, fish, bananas and tomato such that rice and beans losses are dominant i.e., rated at 73%. In terms of accumulated wastes at different stages in the value chain, responses from the customers and some working staff at the canteen/restaurants who have experience in farming activities admitted more losses to greatly occur at farm i.e., post-harvest losses. In terms of losses at the canteen/restaurants more food wastes seem to mostly occur during handling and storage, processing and

packaging as well as during consumption such that waste generation during consumption are dominant. Now looking at the food waste generation along the value chain it shows that the perceptions of both customers and food service providers have significant contribution to the amount of food wastes generated whose understanding is critical.

VI. Conclusion

This study has established the main causes of food loss and waste at each stage of the value-added chain of the restaurants and canteens in Mvomero district. Also, the dominant factors for the loss/wastes, and reflections about its accumulation in the value-added chain was explored. The study found that food loss and waste at food service industries have been significantly caused by several factors ranging from management, technical and financial such that lack of harvesting and food preservation technologies, poor food packaging and transportation infrastructures, ignorance and perception of customers, among others. In terms of the extent of food loss and waste in the value chain, the study found that more losses occur at the production stage i.e., during harvesting whereby more attention should be paid by farmers at this stage. The present study was limited to understanding the dominant factors for food loss and waste in Tanzania food service industry at all stages in the value-added chain. Future research can be conducted to determine customers' perceptions and behavioral patterns regarding food loss and waste along the value chain. In addition, the present study can be scaled up to cover a wide geographical area i.e., at national level so as to see the real impact of food loss and waste control on food security in the country.

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