Causal analysis of factors contributing to food wastage in restaurants of India

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Abstract- **India accounts for 37% of the world's total food-insecure population. Despite this fact, food is still being wasted knowingly or unknowingly. This study identifies the factors contributing to food wastage in restaurants of India. The study is based on the survey analysis which identifies the factors contributing to food wastage in restaurants. A total of 6 factors have been identified through an extensive literature survey. The factors are analyzed to establish a causal relationship using the DEMATEL (Decision-Making Trial and Evaluation Laboratory) approach. The findings reveal that Less Shelf Life (LSL) is the most influencing factor, from the identified ones.**

Keywords: Food wastage, restaurants food waste, DEMATEL, food waste quantification, food sector.

I. INTRODUCTION

Food plays a vital role in keeping people healthy and it can't be underestimated. It is important since it is a need for human survival. It gives humans the sustenance they need for healthy development, physical growth, and effective labor. On one hand, there are a lot of people who sleep without eating two squares of meal due to poverty, on the other hand it has been reported that 1.3 billion tons of food get wasted[1]. There is a need to combat food wastage for social, economic and environmental causes. A lot of people are bothered by food waste as they relate it to a general sense of guilt. Food wastage has impact on environment and due to economic necessity, one should not be able to afford to waste food [2]. There are many factors contributing to food wastage such as improper packaging, insufficient storage, poor quality of food and many more. Basically, in commercial sectors, food services are done in many ways such as in restaurants, cafes, bars, fast foods outlets, and chain outlets[3]. More research on food waste has focused on the consumer level, despite the growing importance of the food service industry. About 30% of global food output is lost or wasted each year, which has a monetary worth of close to $750 billion[4] as per the Food and Agriculture Organization of the United Nations. Wasted food is analogous to a missed chance to provide nourishment for the 17.4 million food insecure families in the United States [5].

According to [6], 45% of participants prefer fast-food restaurants, while 49% participants go occasionally, and reported that the type of food may be an important factor in food wastage that occurs in terms of gender. Around 50% of the food waste from restaurants is noted as plate waste, 30% is kitchen waste and the rest 20% is service waste [4]. Analyzing the factors contributing to food wastage is therefore essential.

This study's contribution is the identification of factors that lead to food wastage. Food wastage is not only the wastage of money, but it also degrades the environment. The study identifies the critical factors and provides the solution to combat food wastage. After understanding the need to examine this issue, the authors try to address the following research question (RQ):

RQ1. What are the factors contributing to food wastage in restaurants?

There is a need to combat food wastage for the sake of our environment. In addition to contributing to climate change, biodiversity loss, and pollution, food waste places an additional strain on waste management systems and impacts food poverty. The results of this research may be used to determine what can be done to reduce food waste in the restaurant industry. The authors identified 6 factors by reviewing and investigating various studies from literature. Mathematical proof calls for quantitative investigation. Additionally, another RQ has been raised.

RQ2. What are the causal relationships between the factors contributing to food wastage?

Previous research was reviewed to help us answer the research question posed above. However, more quantitative and analytical validation and prioritization of these parameters is required. The vast majority of the approaches that the authors discovered in the literature were theoretical or based on surveys. Qualitative research methods, a thorough literature search, and bibliometric evaluation were only a few. These may be useful for spotting the elements, but they won't be of much use in creating the theoretical framework. The authors found the DEMATEL (Decision Making Trial and Evaluation Laboratory) technique useful for tracing causality. A poll with 111 participants was undertaken for this purpose. The authors have used the DEMATEL method to systematically analyze both qualitative and quantitative data.

Reduction in amount of food waste in food sector plays a vital role for taking care of our environment, social and economic sustainability. In recent years, many techniques have been developed to combat food wastage. However, despite this, we continue to face various food wastage

problems. This study identifies the main causes contributing to food wastage and establishes a relationship among the identified factors. This study is sectionalized as follows: Section II comprises of literature review, Section III details the methodology, Section IV presents the result and Section V concludes the study.

II. Literature Review

One-third of the food produced annually for human use is lost or wasted, according to the Food and Agriculture Organization (FAO) [7]. Apart from financial loss, throwing away edible food increases emissions of greenhouse gases, which in turn affects the amount of water and energy needed to sustain human life [8]. This section presents the literature findings and identifies the factors contributing to food wastage.

A group of researchers conducted a survey on food wastage, they concluded that the large quantities of waste are due to undesirable food quality, wrong portion sizes, insufficient storage etc. [9], [30]. The main reasons of food wastage given by Belgium researchers are due to buying food in bulk, the unpredictability of children and inappropriate packaging sizes [10], [11]. Reducing, reusing, and recycling food waste is heavily influenced by one's awareness of the repercussions of their actions, as well as by one's habits, expected feelings of guilt, and financial concerns. [12], [13]. The important factors that can be used for evaluating waste are limited time of food service, food experience and customer characteristics [6], [14], [15]. According to the research conducted for the food wastage Swiss food services, poor quality of food results in massive food wastage. Low priced food was pointed out as the cause of food wastage [16], [17]. Sometimes the food is not properly packed which seems less attractive and people avoid eating it [18], [19]. In retail sector, the food wastage is mainly due to the overstocking which leads to the expiry of food having less shelf life and spoilage due to change in temperature [20], [21]. People don't follow the exact details mentioned on products like keeping food away from sunlight, maintaining accurate temperature, shelf-life details etc. and it results in spoilage of food [22], [23].

There is a great role of serving size, unit size and self-servicing in food wastage, if the unit sizes and serving sizes aren't appropriate then it leads to massive food waste. [24]. Plate waste is most important factor leading to good wastage. As a matter of fact, most of the plate waste is avoidable food waste [25], [26]. People who get less time to eat their meal or having busy schedule are the food wasters [27], [2]. If the food is visually imperfect, have packaging defects or approaching to the expiry date then, it is considered as no longer edible and hence it is wasted [19], [21].

More time, money, and thought must be put into studying and developing technology that can quantify food waste in order to solve problems like these. Artificial intelligence (AI) is one such technological advancement [28]. Several initiatives have been implemented in Saudi Arabia to cut down on food waste, including smaller portion sizes, the collection of leftovers from restaurants, the imposition of fees for the careless disposal of food, and the provision of complimentary meals in proportion to the quantity of leftovers collected [29]. Overeating and food waste may be reduced significantly by simply decreasing serving sizes. In order to keep customers happy while decreasing food waste, businesses should provide customers smaller portions that they may serve themselves. [24]. Habit and the predicted sense of guilt both have a role in promoting waste-reduction strategies related to food [13]. According to research on Swiss-German restaurant managers' perspectives on reducing food loss, educating the public is crucial to implementing an effective plan to reduce food waste [21].

The identified factor contributing to food wastage are listed in Table 1.

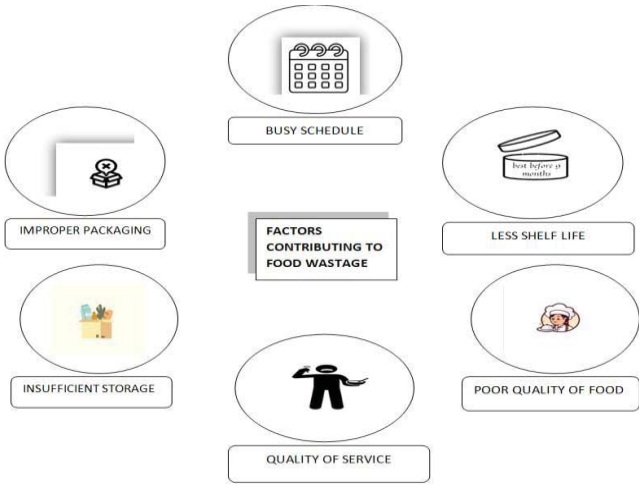

Fig. 1. Factors contributing to food wastage.

TABLE I. FACTORS CONTRIBUTING TO FOOD WASTAGE

Factors contributing tofood wastage	Description	References
Busy Schedule(BS)	People who have more time tend to finish their meal whereas people with less time waste their food.	Deliberador etal.(2021)
Qualityof service (QoS)	Due to improper management of serving time, people might leave the restaurant which again leads to food wastage.	Deliberador etal.(2021)
Poor Quality of Food (PQoF)	Food with poor quality result in greater amounts of waste.	Deliberador etal.(2021), cerrah&yigitoglu.(2022)
Improper Packaging (IP)	Packaging has significant impact on the amount of damage occurring during transport.	Cooreman-algoed et al.(2021), Karwowska etal.(2021)
Less Shelf Life(LSL)	The shelf life ofmeat and meat products is relatively short and has impact on wastage.	Karwowska et al.,(2021)
Insufficient Storage (IS)	It leads to formation of pest, bacterial and fungi growth	Deliberador etal.(2021)

III. Methodology

The purpose of this research is to determine the primary causes of food waste. Firstly, factors that contribute towards food waste have been drawn from extensive literature reviews. DEMATEL technique is used to visualize the structure of complicated casual relationships through matrices or diagraphs. The DEMATEL approach groups "cause" and "effect" factors together to find out which one influences food waste the most. A survey was carried out to gather responses

in order to assess the interplay of the different components. The poll was sent through Google Forms, an internet tool. Facebook, WhatsApp, and LinkedIn were all used to get in touch with the participants. A total of 111 replies were obtained for the questionnaire's 28 questions. Excel was used to conduct the DEMATEL-based pairwise comparison matrix analysis. A detailed procedure of DEMATEL has been discussed step by step in this section.

Step-01 Initiation of Direct-relation Matrix.

First, the decision-maker determines which criteria have the most direct impact by analyzing the correlation between the various sets of paired criteria. The grading system is as follows:

0 - No influence
1 – Low influence
2 – Medium influence
3 – High influence
4 – Very high influence

$$A=\begin{bmatrix} 0 & a_{12} & \dots & a_{1j} & \dots & a_{1n} \\ a_{21} & 0 & \dots & a_{2j} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{i1} & a_{i2} & \dots & a_{ij} & \dots & a_{in} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nj} & \dots & 0 \end{bmatrix} \quad (1)$$

Step-02 Normalization of direct-relation matrix

$$Y = k.A \quad (2)$$

Where,

$$k = \frac{1}{\underset{1 \le i \le n}{max} \left(\sum_{j=1}^{n} aij\right)} (i, j = 1,2, \dots\dots, n)$$

Step-03 Estimation of the total relation Matrix

- In this case, the identity matrix is used to estimate the whole relation matrix.
- The entire connection between each pair of criteria is represented by the matrix T.

$$T = Y(I - Y) - 1 \quad (3)$$

Step -04 Evaluate the sums of rows and columns in T matrix.

$$Ri = \left[\sum_{j=1}^{n} t_{ij}\right] n \times 1 = [t_i] n \times 1, i = 1, 2, \dots\dots, n \quad (4)$$

$$Cj = \left[\sum_{i=1}^{n} t_{ij}\right] 1 \times n = [t_j] n \times 1, j = 1,2, \dots\dots, n \quad (5)$$

Step-05 Defining the threshold value (α)

- Average of the elements in total Matrix T.

$$\alpha = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [t_{ij}]}{N} \quad (6)$$

Step-06 Formation of the casual diagram

Based on the attribute type and impact level, it offers information to identify the most relevant criteria, allowing one to determine the driving factors of the examined problem in a complex system and to develop suitable ways to take care of the concerns accordingly. This diagraph will show us the that which is the most important factor, and which is not influential factor based upon the study. The steps for DEMATEL approach have been listed in Fig.2.

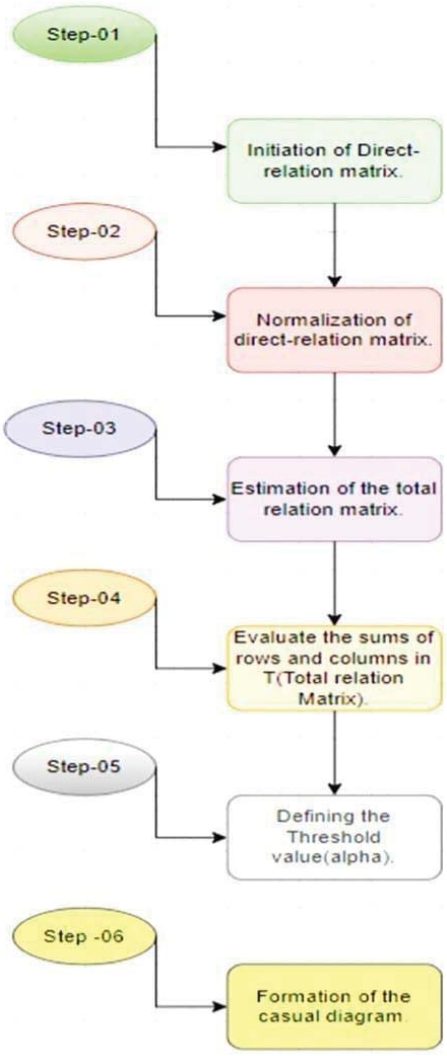

Fig. 2. Steps of DEMATEL approach

IV. Result

This section highlights the DEMATEL technique's findings, in which the primary causes of food waste have been categorized according to their effects on one another. The direct relation matrix is formulated in Table II. Table III shows the result of formulating the Average relation matrix. The decision matrix has been normalized and is shown in Table IV. At last, the authors determined the set of primary factor columns and rows in the T matrix and labeled them R (effective) and C (influential), respectively which is shown in Table V. Degrees of both factor interaction (R+C) and factor relationship (R-C) were calculated. Tables VI and VII illustrate that causes with a positive R-C are effective, whereas effects with a negative R-C are influential. As shown by the results of this study, in this model, busy schedule, poor quality of food, and insufficient storage are the causes, and quality of service, improper packaging, and less shelf life are the effects. The interconnected nature of these causes of food waste is graphically shown in Fig.2. The causal relationship graph is shown in Fig.3.

TABLE II. DIRECT RELATION MATRIX

Factors contributing to food wastage	BS	QoS	PQoF	IP	LSL	IS	SUM
BS	0	3	4	3	3	3	16
QoS	3	0	1	3	4	3	14
PQoF	3	3	0	3	3	3	15
IP	3	2	3	0	3	2	13
LSL	2	3	3	2	0	3	13
LS	3	3	3	3	3	0	15

TABLE III. AVERAGE DIRECT RELATION MATRIX

Factors contributing to food wastage	BS	QoS	PQoF	IP	LSL	LS
BS	0	0.1875	0.25	0.1875	0.1875	0.1875
QoS	0.1875	0	0.0625	0.1875	0.25	0.1875
PQoF	0.1875	0.1875	0	0.1875	0.1875	0.1875
IP	0.1875	0.125	0.1875	0	0.1875	0.125
LSL	0.125	0.1875	0.1875	0.125	0	0.1875
LS	0.1875	0.1875	0.1875	0.1875	0.1875	0

TABLE IV. NORMALIZED DIRECT RELATION MATRIX

Factors contributing to food wastage	BS	QoS	PQoF	IP	LSL	LS
BS	0	0.1875	0.25	0.1875	0.1875	0.1875
QoS	0.1875	0	0.0625	0.1875	0.25	0.1875
PQoF	0.1875	0.1875	0	0.1875	0.1875	0.1875
IP	0.1875	0.125	0.1875	0	0.1875	0.125
LSL	0.125	0.1875	0.1875	0.125	0	0.1875
LS	0.1875	0.1875	0.1875	0.1875	0.1875	0

TABLE V. TOTAL RELATION MATRIX (T)

Facto rs contri buting to food wastage	BS	QoS	PQoF	IP	LSL	LS
BS	1.382652	1.549582	1.592952	1.540547	1.71222	1.549582
QoS	1.376252	1.228898	1.297041	1.376252	1.576538	1.386793
PQoF	1.463519	1.472103	1.313305	1.463519	1.626609	1.472103
IP	1.314058	1.277313	1.325503	1.156163	1.458023	1.277313
LSL	1.268956	1.323319	1.317597	1.268956	1.309186	1.323319
LS	1.463519	1.472103	1.311199	1.463519	1.626609	1.314208

TABLE VI. CAUSAL RELATIONSHIP BETWEEN FACTORS CONTRIBUTING TO FOOD WASTAGE

	Ri	Ci	Ri+Ci	Ri-Ci
BS	9.327536	8.268956	17.59649	1.05858
QoS	8.241774	8.323319	16.56509	- 0.08155
PQo F	8.811159	8.317597	17.12876	0.493562
IP	7.808373	8.268956	16.07733	- 0.46058
LSL	7.804006	9.30186	17.10587	- 1.49785
LS	8.811159	8.323319	17.13448	0.48784

TABLE VII. CLASSIFICATION OF CAUSE-AND-EFFECT GROUPS

	Ri+Ci	Ri-Ci	IDENTITY
BS	17.59649	1.05858	CAUSE
QoS	16.56509	-0.08155	EFFECT
PQoF	17.12876	0.493562	CAUSE
IP	16.07733	-0.46058	EFFECT
LSL	17.10587	-1.49785	EFFECT
LS	17.13448	0.48784	CAUSE

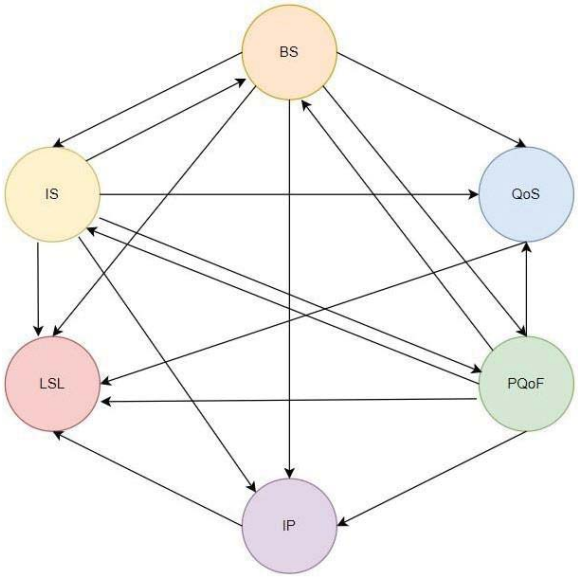

Fig. 3. Casual relationship representation

V. CONCLUSION AND FUTURE WORK PLANS

In conclusion, this study aimed to identify the factors contributing to food wastage in restaurants in India, and using the DEMATEL technique, establish a causal relationship among these factors. The study found that Busy Schedule, Poor Quality of Food, and Insufficient Storage are the main factors that contribute to food wastage, while Quality of Service, Improper Packaging, and Less Shelf Life are the factors that appear under the effect group. These findings highlight the importance of addressing these factors to reduce food waste in restaurants. Restaurant owners and managers can use this information to implement strategies to minimize food waste, such as improving the quality of food, ensuring proper storage, and enhancing the packaging of food items. The findings of this research have the potential to improve the restaurant business in terms of both environmental and economic sustainability. Several directions might be taken to further explore this topic in the future. Researching the efficacy of targeted strategies to curb restaurant food waste might be a significant field of inquiry. For example, future studies could examine the impact of implementing food waste reduction initiatives, such as food donation programs or composting systems, on reducing the overall amount of food waste generated by restaurants. Additionally, the research could be conducted to investigate the attitudes and behaviors of consumers toward food waste in restaurants and to identify effective methods for promoting sustainable consumption practices. Overall, more study is needed to identify causes of food waste in restaurants and devise solutions that will help bring about more sustainable practices across the food business.

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