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Six Sigma-DMAIC and Food Waste Hierarchy-Based Framework for Reducing Food Waste in University Canteens in Ethiopia

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A B S T R A C T

The aim of this paper is to propose a Six Sigma-DMAIC and food waste hierarchy-based framework that can be successfully implemented by Ethiopian University canteen managers to reduce food waste in a sustainable way. The importance of this research is twofold. First, the Six Sigma-DMAIC methodology is used to evaluate and improve the process to prevent food surplus and waste in the canteen. Second, other waste hierarchy options will be used to mitigate food waste problem in a sustainable way. This has a positive social, environmental, and economic implications.

Keywords: Six Sigma, DMAIC, Food waste hierarchy, University canteen, Food waste.

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1. Introduction

Food waste problem is attracting increasing attention due to its social, economic, and environmental impact. It is suggested that the first step towards a more sustainable resolution of the food waste issue is to adopt a sustainable production and consumption approach and tackle food surplus and waste throughout the global food supply chain [1]. Although food loss and food waste occur throughout the whole food supply chain, from farm to table, food waste at the consumer stage attracts particular attention because the relatively large amount of consumer food waste means that all resources input at production, processing, storage, and distribution stages was used in vain, and a significant amount of Greenhouse Gas (GHG) emissions occurring at these stages and at waste management is added [2]. Besides, considering the rapid growth of the global population and declining of the per capita availability of resources and energy for food production, food waste also intensifies the global food shortage and malnourishment [3].

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Various authors investigate the issue of food waste in food catering industries such as school canteens. Casimir [4] suggested that the large amount of food waste generated in Sweden was strongly related to children's ignorance of the impact of food waste on the environment and ethical issues associated with it. Silvennoinen et al. [5] performed a study on different Swedish companies operating in the catering sector and provisioning canteen service in schools. This study, in addition to the previously described solutions, suggests to reduce the self-service and buffet solutions and to give a greater attention to the education of schoolchildren towards a healthier diet [5]. Strotmann et al. [6] propose the aim of the study was to reduce food waste in a hospital, a hospital cafeteria, and a residential home by applying a participatory approach in which the employees were integrated into the process of developing and implementing measures. Belè et al. [7] suggested lunch supervision by caretakers, education and increased awareness of both pupils and staff, as well, improved operations, planning and communication to be applied to reduce food waste in school canteen. Ali et al. [8] discuss forecasting as a framework for reducing food waste in University canteen in Ethiopia. Studentt's arrival in the canteen is highly variable during the first two weeks of operation. The moving average and exponential smoothing forecasting methods were used to forecast the student's arrival for the year 2019. Moving average was more accurate forecasting method than exponential smoothing for forecasting student's arrival in the canteen [8]. Papargyropoulou et al. [1] discuss the boundaries between food surplus and food waste, avoidable and unavoidable food waste, and between waste prevention and waste management. This paper proposes a framework to identify and prioritize the most appropriate options for prevention and management of food waste. The proposed framework interprets and applies the waste hierarchy in the context of food waste [1].

This study proposes Six Sigma-DMAIC and food waste hierarchy-based framework to mitigate the issue of food waste problem in WU canteen (Ethiopia) in a sustainable way.

2. Methodology

2.1. Six Sigma-DMAIC

Six Sigma is defined as a systematic and organized techniques to improve the strategic process, new product, and development of service that focus on scientific and statistical methods to make considerable reductions in customer determined defect rates [9]. The initial concept of Six Sigma was basically developed and executed by Motorola in 1987, so that they could aim to achieve a difficult target of 3.4 ppm defects, namely 3.4 defects per million opportunities [10]. Later on, plenty of companies including General Electric, Honeywell, Sony, Caterpillar, and Jonson controls have performed Six Sigma and gained considerable benefits [11]. Not only Six Sigma has been prevalently incorporated into manufacturing and service industries because of the positive effect on quality improvement and cost reduction, but also it has gained extreme popularity and acceptance among academic community [12].

In Six Sigma improvement methodology implementation, generally there are two commonly used frameworks: Define-Measure-Analyze-Improve-Control (DMAIC) and Define-Measure-Analyze-Design-Verify (DMADV). DMAIC is used to improve existing processes, products, and/or services to meet customer needs and DMADV is used to design new processes, products, and/or services to meet customer needs.

Six Sigma-DMAIC framework was used by academicians and practitioners for solving a variety of problems in different sector. Antony et al. [13] use Six Sigma-DMAIC methodology to reduce engine overheating problem in an automotive industry. Safwat and Ezzat [14] implemented Six Sigma methodology by using DMAIC technique to decrease the junk rate in a plastic injection molding factory [14]. Su and Chou [15] present Six Sigma-DMAIC methodology to study the manufacturing process from a semiconductor by applying this method on inter-metal dielectric and present the efficiency of the Six Sigma technique in decrease defect and waste. Jirasukprasert et al. [16] use the principles of Six Sigma and DMAIC approach to study defects, main causes and get a solution to remove the leaking gloves defects. Hensley and Dobie [17] implemented Six Sigma model in an urban public transit company. The model includes analysis of the transit company's readiness for Six Sigma. The survey analysis was conducted to differentiate in perceptions of service employees and customers.

2.2. Food Waste Hierarchy

The EU directive 2008/98/EC introduces a detailed five step waste hierarchy that must be applied by all state members in order to protect human health and environment from the adverse effect of waste [18]. The waste hierarchy steps, in order of preference, include prevention, reuse, recycling, recovery, and disposal.

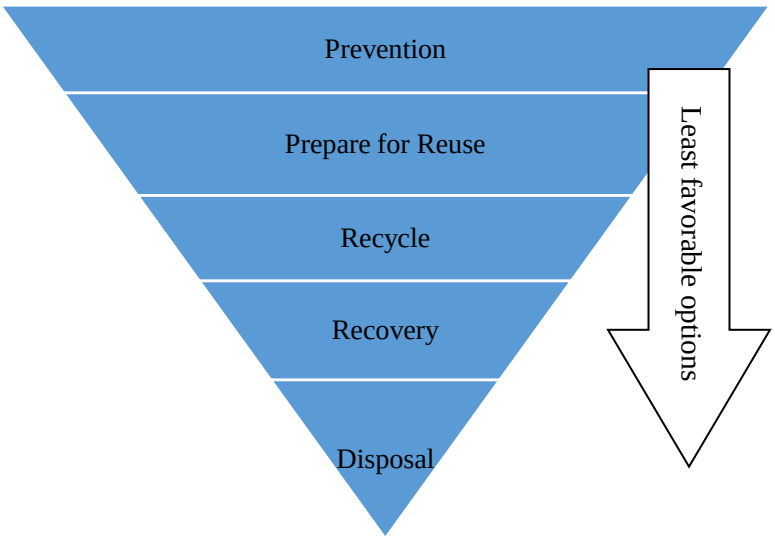

Figure 1. The waste hierarchy.

3. DMAIC and Food Waste Hierarchy-Based Framework

The proposed framework combines the Six Sigma-DMAIC and food waste hierarchy into a single platform to help managers of the University canteens (Ethiopia) to manage food waste problem in their organization easily. In the proposed framework, the Six Sigma-DMAIC principle is used to continuously improve the processes and methods in their canteen to prevent food waste. Then, the unavoidable food wastes can be managed by building redistribution networks for reuse of edible foods which comply with safety standards for human consumption.

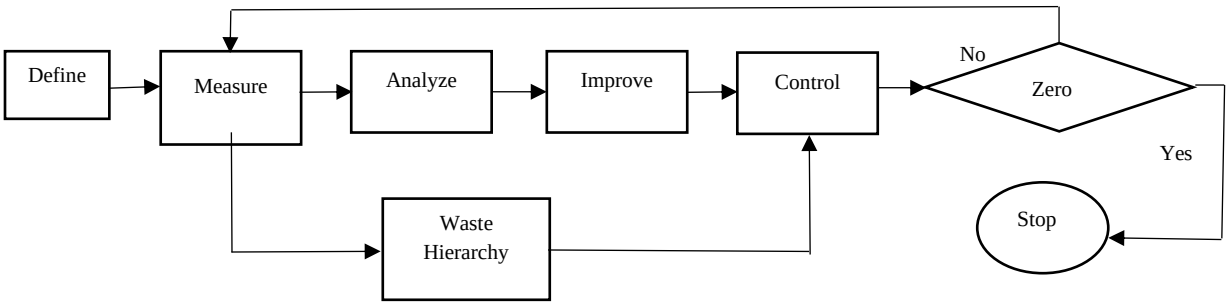

Figure 2. A general DMAIC food waste hierarchy integrated framework for food catering industries.

4. Implementation

4.1. Define

In the define phase, the project was defined with all the possible details including project title, objective, scope, project team, risk involvement, expected benefits, schedule for the project in terms of the customer requirements, and identification of the process delivering these requirements [19].

4.2. Measure

The food waste generated in the canteen will be collected by using visual estimation, weighing the waste by each category, and so on.

4.3. Analyze

The data is analyzed by using Pareto chart to prioritize the food types which results in higher waste in the canteen as indicated by [20]. And Couse and effect diagram is used to point out the reasons for wastage of the identified food items as shown in figure below.

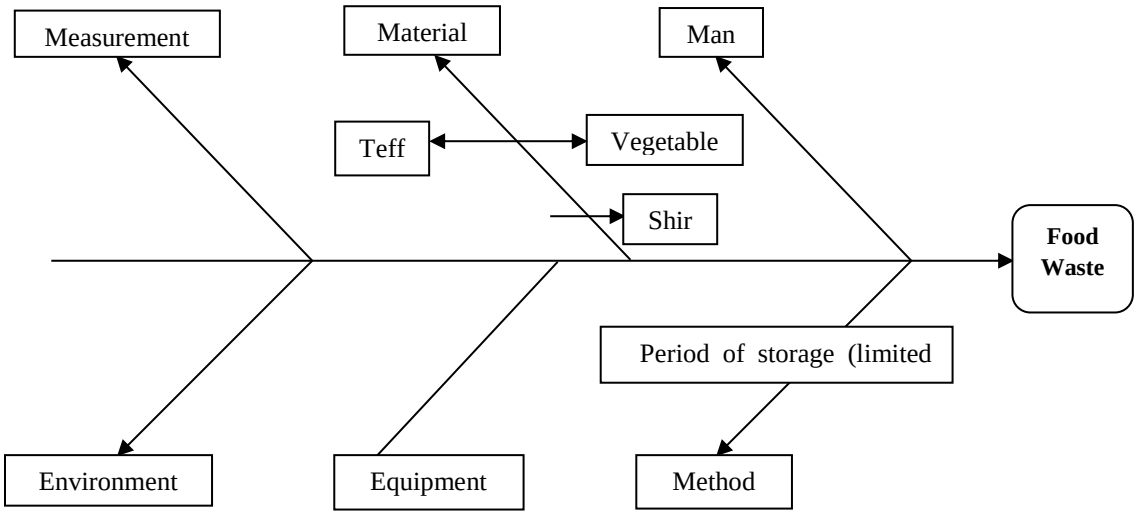

Figure 3. Couse and effect diagram.

4.4. Improve

According to [1], at the consumption stage, the food surplus prevention includes the supply of only what is required, correct portion sizes, and addressing unsustainable consumption patterns. For the surplus food that has not been consumed, the option is redistributing it for groups affected by food poverty; assuming food safety can be ensured.

4.5. Control

The purpose of this step is to sustain the gains, monitor the improvements to ensure continued and sustainable success, create a control plan, and update documents, business process, and training records as required. In control phase, tools are put in place to ensure that the key variables remain within acceptable ranges over time so that process improvement is maintained. A control chart can be useful during the control stage to assess the stability of the improvements over time by serving as a guide to continue monitoring the process and provide a response plan for each of the measures being monitored in case the process becomes unstable [21].

4.6. Reuse

The management of the canteen can build the redistribution networks to deal with the food surplus that cannot be prevented. Other waste hierarchy options such as recycling of food waste for animal feed can be considered to manage unavoidable food waste.

5. Conclusion

This paper presented the use of Six Sigma-DMAIC framework for reducing food waste in food catering industries such as University canteens. Pareto chart and fishbone diagram are used to prioritize the food items that contribute to higher food waste generation and to find out the main causes of food waste generation in the canteen. For future work, various food waste management hierarchy options such as prevention, use for human nutrition, conversion for human nutrition, use for animal use, etc. that can be developed into the proposed framework and evaluated based on the multiple objectives.

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