Solving Food Wastage issues through BYOD application

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ABSTRACT: **Food Wastage is a rising challenge at the global level as 1.4B hectare of land is occupied by wasted food. If annual 1/3rd of wasted food is donated to undernourishment areas, it will result in overcoming food shortage issues. Findings of previous researchers have identified that 49% of food is wasted in households and 20% due to mishandling of best before date. This research fills the gaps by a BYOD (bring your own device) application named ConFood, that can help reduce or eliminate the food wastage by reminding the user about best before date. It also includes a customized alert system, adding family members, BYOD support, recipe suggestions and similar others. The complete framework has been provided to develop the application.**

Keywords: Food Wastage, BYOD app, prevention of food wastage

I. INTRODUCTION

Wastage of Food has becoming one of the issues to be talked and discussed as research topics all over the World. Many techniques, approaches and apps have been developed to control or overcome the wastage of the food. Researchers have adopted many possible ways either using technology or to be done manually. Manual food wastage prevention is with the usage of manual charts of food wastage statistics. A lot of work already exist by using the technologies and currently a lot of research is going on. The technologies exist at Software level as well as hardware level that has been described in this paper. The collective aim is to reduce food wastage and prevent excessive food consumption also. Findings of the research of Food agriculture organization (2019) [1], shows that approximately 1.3B tonnes of food is wased in all over the world, which is one-third of produced food in the world. Most of the food is wasted with the issues of management of best before date. The aims of this research is to discuss the problem of food wastage and propose a solution for that problem. The application of digital technologies would help to reduce food wastage by controlling the purchasing and consuming the food products. Sharing the information with other family members in domestic situation or team members in commercial level.

In the human life, food has a vital role and is a significant necessity in all part of the world. Food Wastage is a rising challenge at the global level as 1.4B hectare of land is occupied by wasted food [2]. A report has been issued in Romania by the Ministry of Agriculture and Rural Development, according to the household food wastage is on the top with (49%), food wastage by the food sector is (37%), by retail sector (7%). In the same way, (5%) and (2%) by public catering, agricultural sector [3],[4][5]. This research has shown that the biggest consumption of food wastage is through households. Another research has shown that the household food wastage is associated with best before date. Another study has been showed that, around 870 million people could be provided with the food that fulfill their daily needs in the world, if we could be saved one-fourth of world food that is produced yearly [6]. If overconsumption of food is avoided, then the issues can be resolved quickly.

WRAP (Waste and Resources Action Programme) registered UK Charity estimates that due to confusion in food date labelling almost 20% of the food is wasted in the UK [7]. Wide understandings about the consumer date marking have been researched. It is deduced that a higher number of issues persist because of a misunderstanding of best before date. From previous research, researchers have discussed some common reasons for wastage of food at home. One of the reasons is overbuying without estimating the need. Another reason is how to use the purchased food and also not being aware of the expiry date for the products placed store area or in the fridge. Such as, 55% of retail food wastage is due to mismanagement of expiry date of food. This expiry date issue results in a higher number of food wastage. If the expiry date is mismanaged on the product then the people tend to rely on it, and they will throw the product as the expiry date has passed.

Many applications have been developed to facilitate users with ease and good shopping experience. To facilitate the users, a solution has been provided to eliminate the direct involvement of the employee's service. They provided this service by Self-service technologies (SSTs) [8]. With the help and implementation of SST solution, many companies have cut down the cost, improved the productivity and improved the service quality. Another example to ease the shopping experience is the use of "Bring Your Own Device (BYOD)" a hand-held device for shopping. *Scandit* and *ShopScanGo* [9],[10] are similar applications to achieve the above goal. These apps are installed on the mobile or other handheld devices. The user simply must scan the product's barcode present on it and then after shopping has to proceed to the self-check-out for payment. In this way user will get rid from standing in long queue in front of counter for payment and checkout without any hassle.

II. LITERATURE REVIEW

Economy of any system has negative impact because of the Food wastage in worldwide. The large amount which is consumed on production, retail and supply chain goes waste sometimes. A high waste management cost is also required include operational cost, transportation cost and sometimes separation costs. 55 million metric tons of food, which is (29%) of the annual production cost in the United States is wasted per year [11], [12]. Moreover, due to improper management of the food, a large amount of food gets wasted. Such as in India, due to lack of cold-storage facility, 30% of food gets wasted annually [13]. In China alone, an annual 70% of the food is wasted. If this amount is used for the reconversion of food, it will cost additionally. Thus, a large amount of food is wasted economically at a global level.

To reduce economically loss, a vast number of research have been presented to investigate the behaviour of food wastage and what is its social impact on food wastage [14-16]. Along with the increment of food wastage, the hunger rate has also increased worldwide. Though several calories of food are wasted per year, but, in some under-developed countries, including Africa, India, Nigeria, and other similar countries people hurt from under-nourishment issues. Such as under-nourishment rate of 23.2% was observed in 2014–16 [17]. Asia faced 11.7% of undernourishment rate in 2016 [17]. Apart from under-developing countries, the economic imbalance has also been estimated in developed countries such as in United State, 14% of food insecurity was estimated [17]. This imbalance in economics leads to increment in hunger rate. If the annual 1/3rd of food which is wasted is donated to the under-nourished people, then imbalance in the food can be maintained globally.

Food wastage and loss shares approximately 8.2% share of global greenhouse emission [18]. Most of the wasted food decomposes, and during this process, it emits gases such as carbon dioxide, methane, hydrochlorofluorocarbons, chlorofluorocarbons and similar other gases [19]. According to the US, EPA [20], methane gas is 28% more potent as compared to carbon dioxide. Thus, a large amount of energy is absorbed in the environment. Thus, these gases are deploying the ozone layer, which results in increasing environmental issues.

According to [2], around 1.4 billion hectares of land is occupied by the wasted food. Which is one-third of the global area, more than the land used to produce food. In Pakistan, 40% of total food consumption is wasted, which is 36million tons of produced food [6]. Many storage issues also lead to food wastage at the retailer side. Such as in India, due to lack of cold-storage facility, 30% of food gets wasted annually [13]. Moreover, 1.5 billion hectares of land is occupied by wasted food; this land volume is more massive than India and Canada combine [21]. Circular economy (CE) and behavior reasoning theory (BRT) plays vital role to minimize waste through optimal resource utilization [22]. The researchers in [23] studied the wastage of food among consumer with respect to regulation, reduction and prevention in the role of emotions. As the food is contaminated, the resources used to produce food, which is not eaten also gets wasted. According to [24], 1,211,000 tons of food is wasted in Sweden. In Sweden, 224,000 ton of liquid is wasted as the drainage, that includes tea, beer, semi-solid wastage from pasta, rice, grain, etc. and other fluid items [25]. 55 million metric tons of food, which is (29%) of the annual production cost in the United States is wasted per year. In China alone, the annual 70% of the food is wasted. If this amount is used for the reconversion of food, it will cost additionally [26]. The above statistics show that a large number of foods is wasted around the globe, which results in greenhouse emission and release of many gases.

A. Previous Solutions

Many applications are introduced as BYOD devices, such as *Scandit* and *ShopScanGo*. User can get save the data of product by scanning the barcode on the product. But no application has been designed to control food wastage with the integration of BYOD and food wastage alerts etc. In Sweden, an app introduced by ICA superstore. The app has the feature of self-scanning along with other features. On purchasing of the food products by app, the users of app get promotional discounts from food companies.

User can scan the application and save their data. This application has Barcode scan function.

Many applications have been designed to overcome food wastage issue, but some gaps have been identified in the applications that are mandatory to be covered. *LeftoverSwap app* is useful to help to donate surplus food to the needy person [27]. It provides efficient services for the prevention of food wastage. Still, there is a need for improvement by providing alert because the user cannot find updates of the inventory until the application is opened. *Zmartfri* is also an efficient solution for food monitoring in the refrigerator [28]. An alert through email is sent to the user for every item. Some users reported issues related to multiple email notifications. *FridgeCam* is a technical approach to reduce food wastage [29]. Fridge cam doesn't remind the user for Best Before date as there are increased chances of food wastage. *Food waste diary* was developed by looking at the economic issues caused by food wastage. A user can get information about the total food wastage and it can lead him to decide reduction of food wastage, but there are no proper measures by application providers to reduce or eliminate food wastage. *LFHW (Love Food Hate Waste)* provides works based on recipe ingredients [30]. There is no priority or alert based on best before date. Also, the application doesn't support the alert-based System. Overall, many technical solutions have been proposed, but these solutions are unable to provide accurate information or alert-based system which lacks some features. Moreover, these applications lack one or more features due to which a necessity arises to propose a new solution that can bring maximum user satisfaction.

III. METHODOLOGY

Initially, the customer survey was done to analyze the requirements of the customers about the data. As an essential step, a design named as an interaction life cycle was used before the designing of a paper prototype. The app features were developed according to the user requirements for the 8-9 participants were dedicated from where the requirements were collected. A paper prototype was asked to be developed and then evaluated with the participants. The highlighted user's requirements were used to develop a paper prototype and then paper prototype was evaluated along with the dedicated participants. The user functional requirements were established along with the app design. To achieve the final prototype for development, the above process was done many times until a final paper prototype was ready. This final prototype was interpreted to check the final interface designing of the application. Results of the user survey have been attached in Appendix. Various important

features have been added in the application interface to provide the evaluation about the best before date and reminder about the application. Also, many BYOD features have been introduced to ease shopping experience.

A. Proposed Solution
Suggested Features:
Following features are required in the application:
1. Users would be able to enjoy features, such as, creating a user account and adding the family member for accessing a centralized system for managing the product scanned or added in to "Your Cart "option. During the shopping, the BYOD application would be able to transform the information from the family members and synchronize the information, such as, best before date, user name and type. This information would be automatically synchronized with the family member's account.
2. The main feature of this app is the custom reminder, which will remind the users about the expiry date of products best before use which they had purchased. User can get the reminder based on customized ringtone and alert-based system.
3. Another feature exists in recipe search by using google created custom search engine, this feature helps the user to search for recipes. The user would be able to search the recipe with existing ingredients.

IV. IMPLEMENTATION

This section presents a comprehensive analysis of implementation of the Confood application.

A. Data Matrix
ConFood app aims to provide information to the user about the best before date of purchased products. Name of the item and its type would also be stored in the application. For demo and prototype purpose, data matrix would be used. All the information would be stored automatically once the user scans the data matrix. The best before date will be stored in the application-based interface with the custom feature on pop only and a popup with manual selection of the limited tones available. Data matrix will be used as it fulfils the requirements of the 3 attributes required by the app, Name, type and best before date. If the GS1 database is used, it can extract the required information (Product Name, Product type and expiration date and much more) and can store in the user end which can later add in more attributes if required at retailers' end. A GS1 data bar can be used that can store at least 20 attributes. If GS1 data bar is used with the combination of user and retailer attributes, such as manufacturing/production date,

batch no, best before date, item type, etc. then this would be beneficial for developers and app like ConFood can be re-designed in such a way that it only extracts the information required by the app that can remind users for the best date about the purchased item. The GS1 Data bar is introduced in Pakistan in food services but not very commonly used by the CGP/Grocery sector. Soon, the food industry might also use GS1 Data bar for effective data retrieval and usage. For this app, GS1 Data bar could not be used because of legal limitations of GS1. As the data matrix doesn't require legal permissions, and is, therefore used for prototype demo purpose. At a professional level, if this application is developed, then a native application (i.e. compatible with GS1 data bar) in combination can provide efficient and effective data retrieval.

B. Implementation of API (Application Based Interface)

There are three major parts of the proposed System; one is its front-end technology, using which application interfaces are designed; the second is the backend technology or framework; the third is the APIs which are used for implementing the features within the application. There is a fourth side also which is the Online Database, the Firebase Online Realtime Database would be used for online instant queries for centralized data architecture. Using this feature, authentication using Signup and Login system, the Your Cart and family member features can be implemented. The detailed explanation is as follows.

1) *Angular JS:* Starting with the Angular Js; it is a frontend design framework that would be used in designing the interfaces of the mobile application. It is a tag-based framework which resembles with the HTML language. The Angular Js is a part of the Ionic Cross-Platform Mobile Application development technology. Ionic currently requires AngularJS to work at its full potential. It also consists of some major modules for data representation from backend to frontend to make it dynamic. Angular Js is used in conjunction with SAAS based styling pre-processor, to define some basic and also advanced level styling of design objects or components.

2) *Typescript (TS):* Typescript is very similar to the JavaScript, but with slight changes and simpler syntax for cross-platform programming. The Typescript works as a backend development technology in the Ionic framework. All the APIs and interchange of online data through the online database is done with Typescript. Typescript consists of all

major modules to be used for barcodes, firebase, REST APIs & other major features.

3) *Ionic Framework:* The framework or set of technologies which are used in Ionic 3 Framework. The ionic framework facilitates the user to write just one single piece of code to create mobile applications for both Android & iOS. Therefore, the ionic framework is called as cross-platform Hybrid Mobile Application development framework. The app developed using this framework is called a hybrid application. The hybrid app makes use of web application concept and runs itself on inbuilt apache Android or iOS server using the Webkit of the Operating System it's running on.

4) *Apache Cordova:* The major hybrid application is based on this framework. The Apache Cordova framework enables the user to write the Mobile Application by using the Website Design Concepts and web technologies. It makes use of HTML, CSS & JS to develop mobile app. Apache Cordova plugins were used to utilize them, as features within the cross-platform mobile application. The Apache Cordova is based on Apache Webkit Engine.

C. Major Application Programing Interfaces (APIs)

1) *Firebase API:* The firebase is provided by Google APIs which is an online Realtime database. The firebase is a secure way and also a centralized database system for inter-communicating the data in form of JSON. The user authentication and sign up in mobile app ConFood system would be implemented. In the form of API call, Firebase API key & authentication token is forwarded to our Firebase Database. The data of a given user is retrieved from the online firebase database in the JSON format whenever, the user logins and processed in the code.

2) *QR Code API:* In the app, scanning the QR Codes feature would also embed for the product QR codes scanning. Data Matrix is one of the QR Code types that is used for this app. By scanning the QR Code of product, the app will add that product into Your Cart module. Data Matrix plugin or Code scanning API which is a third-party product would be used for the Ionic framework for utilizing this feature. This feature will help to develop an interface to scan the pictorial data (QR Code) into the textual data for user's product.

3) *Google Custom Search Engine:* To implement the recipe searching feature, Google Custom Search Engine API would be used that is provided by google. To derive the results, Google custom search engine carry some of the main website

sources. As the user enters keyword, that keyword is sent to google custom search engine that convert it into JSON format to envision it inside the app. As a result, quick overview of recipe, the images and its rating are shown. therefore, on selection of any recipe by user, the recipes result will be displayed In-App browser of the ConFood app. In this way, all the things are displayed in one single screen to facilitate the user.

V. SYSTEM ARCHITECTURE

The user signup & login on the System by using the Mobile App. The data of a given user is retrieved in the JSON format from online database named as firebase. Data from the Firebase Realtime Database by means of the Firebase API verifies the information and the user proceed for next step. How to search a recipe in mobile application? a search module is shown in the Figure 1. To forward the data in the direction of
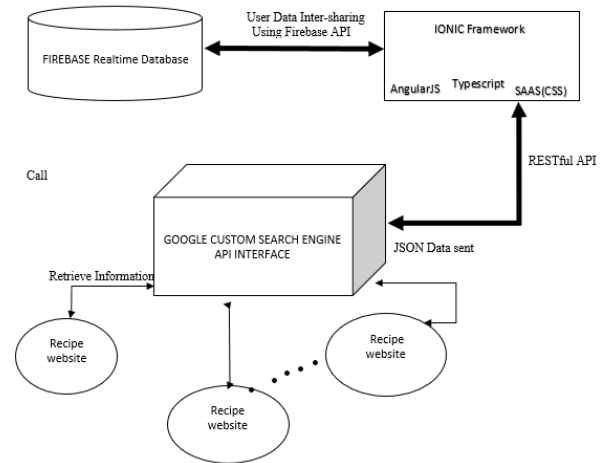

Fig. 2: Architecture suggestion for ConFood development
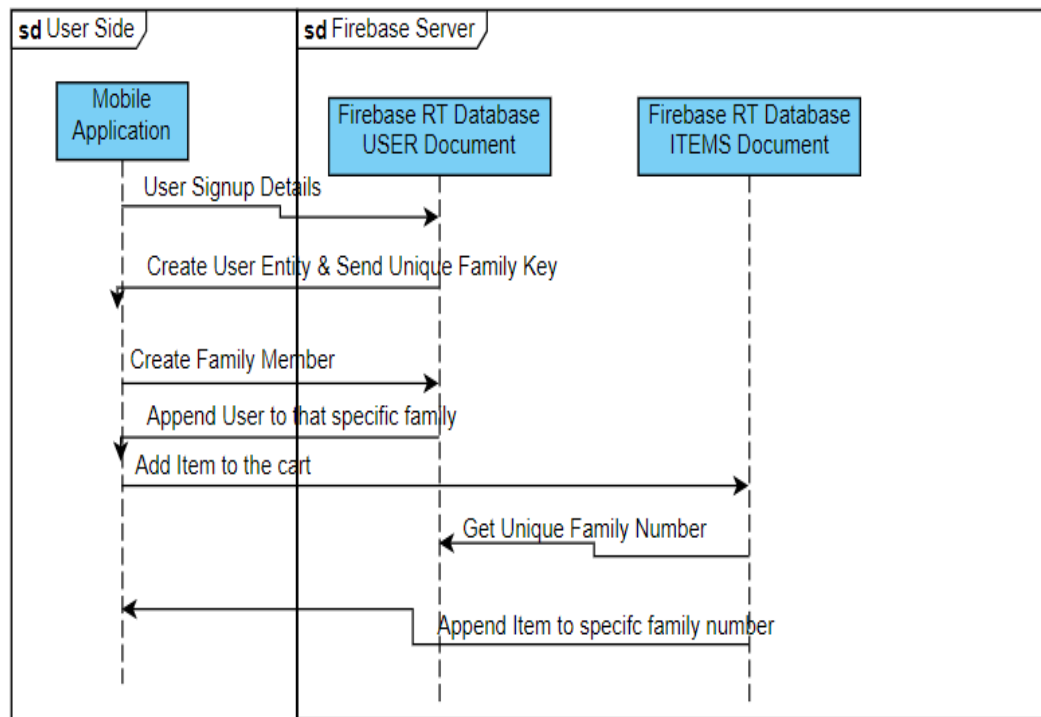

Fig. 1: Family structure sequence diagram

online Google custom search engine, the RESTful API is used as client in ConFood mobile application. As the search keywords enter by user Google CSE receives these search keyword and get results from predefined and connected recipe from Pakistani recipes websites. This project already defines the data format as JSON format and meta-data. After collection of data in JSON format it is transformed into an array. The collected results are already managed and parse the JSON which is presented on display of smartphone as a client-side or front-end.

A. Family Tree & Your Cart Features

The Figure 2 represents application's main two features: 1) Family Tree and 2) Your Cart. Here specific family member can view and add the selected product items. These two features involve querying architecture of Firebase database. In Firebase, this app based on two Documents; named as Items and the Users. To avoid the duplication of product items purchased from different members belong the same family i-e hassle-free family shopping experience. For each family a unique family number is created and

against each family member one single family cart is created. When any family member added the product items that will be visible for all family members. In the same, if any family member discard product item it will be visible for all family members. Your Cart feature is dependent and interconnected on the family feature. Whenever any family member added an item, its value is affixed to the item array according to the unique family number therefore it become visible to all family members. In the same, when an item is discarded then its value is removed from the cart and become visible for all family members.

VI. CONCLUSION

This research provides a solution to rising food wastage issues in Pakistan as well as other countries. It initiates with the food wastage and statistics of food wastage in different Asian countries. It also included some European countries data to analyze the severity of food wastage issues around the globe. In the second part, the researcher has compared different solutions proposed solutions and applications to control food wastage. It also identified gaps and lack of previously proposed solutions. The methodology has been defined in the next section. A comprehensive solution with the mobile application has been proposed that can store best before the date and remind the users about the expiry date of food with the custom alert approach. The application will consist of a BYOD device also that will analyze the bar codes and store the information related to best before date, name, type and similar other attributes in the application. An alert message would be generated based on best before date. Various API, Framework and data matrix have been suggested. Overall, this application would help in overcoming Food Wastage by custom alert method.

Conflict of interest

The author(s) declared no potential conflicts of

interest with respect to the research, authorship,

and/or publication of this article.

REFERENCES

[1] FWF, "Food wastage footprint & Climate Change," (2019). [Online]. Available: http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/FWF_and_climate_change.pdf. [Accessed 2022].

[2] Mendoza, T. C., "Food security implications of biofuel production," Annals of Tropical Research, 2009, 31(1), 1-33.

[3] S. Romani, S. Grappi, R. P. Bagozzi, and A. M. Barone, "Domestic food practices: A study of food management behaviors and the role of food preparation planning in reducing waste," Appetite, 2018, vol. 121, no. 2, pp. 215-227. doi: 10.1016/j.appet.2017.11.093

[4] K. Abeliotis, C. Chroni, and K. Lasaridi, "Consumers' behavior regarding food waste prevention," in Encyclopedia of Food Security and Sustainability, 2018, vol. 2, no. 1, pp. 510-514

[5] L. Przezbórska-Skobiej, and P. L. Wiza, "Food waste in households in Poland—Attitudes of young and older consumers towards the phenomenon of food waste as demonstrated by students and lecturers of PULS," Sustainability, 2021, 13(7), 3601.

[6] F.H.Mughal. "Food waste and its consequences," Retrieved from Daw, 2018. https://www.dawn.com/news/1394618

[7] L. J. Mallinson, J. M. Russell, and M. E. Barker, "Attitudes and behaviour towards convenience food and food waste in the United Kingdom," Appetite, 2016, vol. 103, no. 2, pp. 17-28

doi: 10.1016/j.appet.2016.03.017

[8] X. Guan, L. Xie, W.G. Shen, and T.C. Huan, "Are you a tech-savvy person? Exploring factors influencing customers using self-service technology," Technology in Society, 2021, 65, 101564.

[9] V. Taneja, S. Mishra, and A. Saxena, "A Systematic Approach to mHealth in COVID-19: Patient Generated Health Data on Opportunities and Barriers for Transforming Healthcare," In Proceedings of Data Analytics and Management, 2022, pp. 193-210. Springer, Singapore

[10] N. Shekokar, A. Kasat, S. Jain, P. Naringrekar, and M. Shah, "Shop and Go: An innovative approach towards shopping using Deep Learning and Computer Vision," In 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), 2020, pp. 1201-1206. IEEE.

[11] S. Nassauer, " Leftovers: Tasty or Trash?," The Wall Street Journal, 2012

https://www.wsj.com/articles/SB100014240
52702304724404577293620871384492

[12] K. Venkat, "The climate change and economic impacts of food waste in the United States," International Journal on Food System Dynamics, 2011, 2(4), 431-446.

[13] P. Mukherji, "New Delhi Starts Drive to Root Out Hunger.," The Wall Street Journal., 2011 https://www.wsj.com/articles/SB100014240 52702304259304576372813010336844

[14] M.Prášilová and P.Varvazovska, "Food Wastage in The Czech Households as An Economic, Social and Environmental Issue," Journal of Selcuk University Natural and Applied Science, 2014, vol. , no. , pp. 1038-1048

[15] J. N. Narendrababu CR and B. Prakash GC, "A New Approach to Reduce Food Wastage using Ubiquitous Technique,"J. Food Process. Technol., 2015, vol. 6, no. 10, pp. 1-4. doi: 10.4172/2157-7110.1000496

[16] H. Yildirim, R. Capone, A. Karanlik, F. Bottalico, P. Debs, and H. El Bilali, "Food Wastage in Turkey: An Exploratory Survey on Household Food Waste," J. Food Nutr. Res., 2016, vol. 4, no. 8, pp. 483-489. doi: 10.12691/jfnr-4-8-1.

[17] FAO , "Food and Agriculture Organization, International Fund for Agricultural Development, UNICEF, World Food Programme, & WHO. (2017). The state of food security and nutrition in the world 2017: Building resilience for peace and food security.," [Online]. Available: http://www.fao.org/3/a-i7695e.pdf. [Accessed 2022].

[18] C. Hanson, "What's Food Loss and Waste Got to Do with Climate Change? A Lot, Actually.," (2012). [Online]. Available: https://www.wri.org/blog/2015/12/whats-food-loss-and-waste-got-do-climate-change-lot-actually. [Accessed 2022].

[19] Fao, "SAVE FOOD: Global Initiative on Food Loss and Waste Reduction," Retrieved from Food and Agriculture Organization of the United Nations:, 2019

http://www.fao.org/save-food/resources/keyfindings/en/

[20] US EPA, [Online]. Available: https://www.epa.gov/. 2019. [Accessed 2021].

[21] Grandhi, "What a waste! A study of food wastage behavior in Singapore," Journal of Food Products Marketing, 2016, 471-485.

[22] R. Sharma, A. Shishodia, T. Tewary, and R. Sharma, "Can CE Reduce Food Wastage? A Proposed Framework," in Environmental Footprints and Eco-Design of Products and Processes, 2021. (pp. 119-132). Springer, Singapore.

[23] M. Srivastava and S. K. Srivastava, "Examining the relevance of emotions for regulation of food wastage behaviour: A research agenda," Soc. Bus., 2020, 10(2), 151-171. doi: 10.1362/204440820x15813359568327

[24] J. Carl, " Swedish EPA," [Online]. Available: http://www.naturvardsverket.se/Documents/ publikationer6400/978-91-620-8695-4.pdf. 2012. [Accessed 2021].

[25] A.-K. Nyström, "Swedish waste statistics," [Online]. Available: https://unstats.un.org/unsd/environment/FD ES/EGES3/6Sweden_Swedish%20waste%2 0statistics.pdf. 2012.[Accessed 2022].

[26] ICF, "Market study on date marking and other information provided on food labels and food wastage prevention," WRAP, 2018, 45-55.

[27] A. C. Anyigor-Ogah, and E.I. Egba, "Usage of Information Technology in Technical and Vocational Trades for Effective Waste Management," Title/Author 2017, Page, 29, 183.

[28] M. Hebrok, and N. Heidenstrøm, "Contextualising food waste prevention-Decisive moments within everyday practices," Journal of Cleaner Production, 2019, 210, 1435-1448.

[29] H. Nasir, W. B. W. Aziz, F. Ali, K. Kadir, and S. Khan, "The implementation of IoT based smart refrigerator system," In 2018 2nd International Conference on Smart Sensors

and Application (ICSSA), 2018, pp. 48-52. IEEE.

[30] H. Yamakawa, I. Williams, P. Shaw, and K. Watanabe, "Food waste prevention: Lessons from the Love Food, Hate Waste campaign in the UK," In Proceedings of the 16th International Waste Management and Landfill Symposium, S. Margherita di Pula, Sardinia, Italy, 2017, pp. 2-6.

Appendix

1. Survey Conducted for Interface