Exploring the Opportunities and Challenges of ICT-Mediated Food Sharing in Japan

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Abstract: Information and Communication Technologies (ICT) have been identified as potential enablers for alternative forms of sharing surplus food to prevent food loss and waste. Food sharing platforms can also provide an entry point to the sustainability transition by encouraging its users to confront the systemic causes of unsustainable and inequitable food systems. The paper explores the opportunities and challenges of ICT-mediated food sharing platforms in Japan. A comparative case study of 10 food sharing platforms operating in Japan was drawn from a web content analysis and semi-structured interviews. A consumer-side analysis was conducted, based on a Japan-wide survey of 10,000 respondents, to understand consumers' general attitudes towards ICT-mediated food sharing and identify key challenges and drivers for its expansion. This paper provides initial contributions to understanding the Japanese experience of ICT-mediated food sharing from both the supply and consumption sides. All investigated food sharing platforms embedded food waste reduction and sustainable objectives in their mission. However, a consumer-side survey suggests that participation in food sharing was mainly driven by price consciousness and convenience orientation. Distrust towards the safety of redistributed food and reluctance to engage in a sharing community were some of the main barriers identified to food sharing. Highlighting convergences and divergences between platforms and consumers was key to starting developing intervention designs towards expanding online food sharing and leading consumers' behaviour change.

Keywords: food loss and waste; surplus food redistribution; food sharing; food supply chain

1. Introduction

The Food and Agriculture Organisation (FAO) estimates that one-third of the global food production is wasted annually, amounting to a staggering 1,3 billion tonnes of food loss and waste [1]. This wasted food leads to a significant waste of resources despite the between 702 and 828 million people suffering from hunger worldwide [2]. The large amounts of food wastage reflect the unsustainability of current production and consumption patterns, as well as the general perception of food as a mere commodity, disconnected from its social and environmental impacts. In addition to leading to the overutilisation of water and land use, deforestation, as well as soil and water pollution, food is a major driver of greenhouse gas emissions from its resource-intensive production, manufacturing, distribution across borders, and disposal. It is estimated that food loss and waste (FLW) account for 8–10 per cent of total greenhouse gas emissions [3]. Tackling FLW thereby emerges as a key challenge to mitigate sustainability issues such as the climate crisis, shortages of natural resources, and food insecurity, and presents a key entry point to confronting complex systemic causes of unsustainable and inequitable agri-food systems. The 2015 United Nations Sustainable Development Goals highlight the importance of tackling the issue of FLW by setting the target 12.3 of halving food waste at the retail and consumer levels and reducing food loss along the food value chain by 2030 [4].

Food waste is a particularly critical issue in Japan especially due to its low food self-sufficiency rate and limited available landfill sites for waste disposal [5]. Japan is one of the world's biggest emitters of food waste, generating an average of 17.13 million tons of FLW. In the fiscal year 2020, a total of 5.22 million tons of edible food was discarded in Japan [6]. Within this, 2.75 million tonnes originated from food businesses and 2.47 million tonnes from households. In light of the Food Recycling Act, the Japanese government encourages local governments and business operators to lead food waste reduction efforts and form a food recycling loop [7]. Since 2019, the Act on Promotion of Food Loss and Waste Reduction has promoted nationwide actions to prevent FLW [8]. Nevertheless, Liu et al. argue that while 43% of food waste produced in 2011 was recycled or reduced, another 21.52 million tons could be recycled or reduced with further efforts at the downstream level [5]. While waste recycling was prioritised and promoted at the national level, among the "3Rs" (Reduce, Reuse, Recycle) promoted by the Japanese government, waste reduction and reuse have lagged behind recycling [9].

While the underlying causes of FLW are extensive, a key identified factor is the failure to efficiently redistribute surplus food, or "the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer" [10] (p. 3). This study aims to evidence this current gap in the Japanese food system and to provide an assessment of a potential bridging practice presented by the recent development of online platforms enabling surplus food sharing. Utilising Information and Communication Technologies (ICT) can be a crucial enabler for alternative forms of food redistribution, facilitating the precise and convenient matching of existing surplus food supply and demand beyond traditional distribution channels. ICT-mediated food sharing designates any form of "technologically-augmented collective or collaborative practices around growing, cooking, eating and redistributing food" [11] (p. 1).

The paper explores the opportunities and challenges of ICT-mediated food sharing platforms in Japan to reduce the amount of uneaten food and address related sustainability challenges. The paper aims to answer the following research questions:

- What are the specificities of food sharing platforms operating in Japan?
- What are the main challenges to the expansion of food sharing in Japan?
- What is the general attitude and behaviour toward surplus food and its redistribution through ICT-mediated food sharing platforms?

We identified 10 food sharing platforms operating in Japan and compiled information about their specificities in a typology to integrate the Japanese food sharing experiences into comparative frameworks developed in the extant literature. A consumer-side analysis was conducted, based on a Japan-wide survey of 10,000 respondents, to understand consumers' general attitudes towards food sharing and identify key barriers to the expansion of ICT-mediated food sharing in Japan. Conditions for consumers' engagement in food sharing practices were compared with the obstacles and opportunities experienced by food sharing platforms owners in order to develop a user-side approach to ICT-mediated food sharing. The results allowed to explore approaches to expand online food sharing in Japan and lead consumers' behaviour change.

2. Literature Review

2.1. Food Loss and Waste Prevention through Redistribution

Before it reaches the state of waste, surplus food is still fit for human consumption and can be redistributed along the supply chain to fill unmet needs while minimising environmental impacts and maximising social and economic benefits [12,13]. Surplus food can be a valuable resource to be reused for human consumption through a dedicated redistribution initiative by collecting surplus food from traditional food suppliers and redistributing it to food banks or other food redistribution networks [14–16]. The benefits of redistributing surplus food are multiple. Surplus food redistribution can help tackle food insecurity by being redistributed to households with insufficient food. In France since 2016, retail stores larger than 400 m^2 are legally obligated to redistribute their surplus food to charities [16].

In addition to reducing food waste, food redistributors can benefit from reduced waste management costs and improved public image [17,18]. Countries such as Australia and Italy actively encourage redistribution through a tax rebate system [19,20]. Environmentally, preventing FLW across the food value chain would significantly reduce greenhouse gas emissions and energy consumption, bringing down the amount of land dedicated to food production, eutrophication and water consumption [3].

Even with efficient food waste prevention systems in place, surplus food might not be able to be redistributed in time [21,22]. The highest degree of recoverability is found at the manufacturing and retail stages, which can also offer larger donations, while the lowest recoverability is found at the household consumption stage where surplus food redistributions are limited to small amounts of food [10]. Findings show that FLW reduction measures should prioritise efforts targeting the food service, food processing, and household levels, where most environmental impacts can be averted [23]. However, Reynolds et al. evidence a gap in the academic literature considering the effectiveness of interventions aimed at preventing food waste in the consumption stages of the food value chain [24].

2.2. ICT-Mediated Food Sharing

The development of information technology and the advent of digitalisation provided new opportunities for traditional food sharing and redistribution channels. ICT offers the logistical and technological means to systematically map edible surplus food along with identifying people's needs, thereby optimising the redistribution of surplus food within its narrow edible window [15]. Furthermore, the use of digital technologies in matching food surplus and needs offers ways to build trust within the sharing community through increased traceability, reputation building, and fraud prevention mechanisms [25,26]. Applying the sharing approach to food distribution and consumption may positively impact all three dimensions of sustainable development through increased social relations and financial savings as well as a decreased environmental footprint [22]. While food sharing platforms articulate a wide array of sustainable benefits, research points to the lack of empirical data on the efficiency of ICT-mediated sharing in achieving more sustainable production and consumption, especially in the food domain [27]. This limitation is largely echoed in the IPCC Working Group 3 report highlighting the lack of evidence on the impacts of the sharing economy and digitalisation to enable sustainable consumption [11,28].

Many of the studies on food sharing mechanisms map the various food sharing ICT initiatives operating globally or in specific countries or regions and develop typologies to categorise and compare them [15,22,27,29–31]. This variety of comparative analyses offers a much-needed basis of empirical data on ICT-based food sharing initiatives and develops a comprehensive approach to categorising the collected data. In the database of 492 urban food sharing initiatives in 27 countries compiled by Davies and Legg, a high concentration of food sharing initiatives was especially observed in leader cities such as London, Vancouver, and Toronto [27]. The authors recognise the need to conduct more in-depth research in native languages to identify food sharing activities in South America, Asia, and Africa. Huang et al. highlight current gaps in the Taiwanese food supply system and put forward the potential bridging solution presented by a food sharing information platform for the food industry and people in need [32]. Among others, the Japanese experience in developing food sharing initiatives and its impacts were largely underreported in the literature. It is thus critical to explore and evaluate the potential of food sharing efforts in Japan, as one of the biggest reported food waste emitters per capita.

2.3. Consumers' Attitudes and Behaviour towards (ICT-Mediated) Food Sharing

Consumers' attitudes and behaviours towards food practices are complex and multifaceted. Hebrok and Boks illustrate the complexity of food practices which are deeply entangled with socio-cultural and material factors to an extent that consumers might not be aware of themselves [33,34]. Thus, unsustainable practices such as wasting food would be largely predetermined by the value attributed to food and a large array of decisions

and actions taking place long before. Bava et al. argue that food provisioning practices are shaped by a process of trade-off between preferred practices and the constraints operating at a given point of time, resulting in practices which demand convenience in food provisioning to minimise time and cognitive effort [35]. Consumers' reluctance to consume surplus food as a way to prevent food waste may be a result of its perception as substandard or unsafe [36].

Previous studies identified the main motivations to participate in food sharing. Instrumental, ideological, and identification motivations such as anti-consumerism convictions and strong awareness on food waste were drivers for food sharing [37]. Morone et al. highlight in their experimental study that the alleged causal relationship between food sharing and food waste reduction is dependent on variables such as environmentally friendly behaviour, economic awareness, or collaborative behaviour [38]. Mazzucchelli et al. uncovered a strong link between consumers' perception of responsibility toward sustainability issues and their behavioural response toward engaging in ICT-mediated food sharing [39]. Social drivers such as the sense of belonging to a community are also the main motivations for consumers to partake in food sharing [30,40]. An online food sharing community can empower individuals to form a local action-based community from their shared awareness of the global food paradox [41]. Nevertheless, Morrow recognises that the use of ICT is not the sole factor in facilitating food sharing, and ultimately a successful match between available food resources and a community will rely on offline interactions of actively engaged members of the food sharing community [42]. Inversely, Harvey et al. explored the extent to which digitally mediated sharing and gift giving influence consumers' behaviour, evidencing that repeated engagement helps normalise new patterns of collaborative consumption [40]. In line with this, Weymes and Davies argue that the heightened awareness around food wastage resulting from the rising popularity of food sharing initiatives might translate into behaviour change [15]. Potential barriers limiting the effectiveness of a food sharing application depend on the trust and comfort felt when giving or taking shared food [29,43].

Food sharing has traditionally been part of the Japanese culture and has fostered resilience against natural disasters and socio-economic challenges [44]. It was evidenced that consumption of shared food resources is greater in inland and coastal rural communities than in semi-urban ones [45]. As such, this suggests that urbanisation has weakened traditional sharing mechanisms and its associated social connections. Furthermore, levels of food sharing activities were shown to have decreased in Japan during the COVID-19 pandemic, suggesting limitations due to voluntary self-isolation [45]. Compared with their Western counterparts, Japanese customers were found to place more emphasis on the food quality and price fairness [46]. Thus, investigating Japanese consumers' perception of surplus food redistribution fills a gap in the extant research by identifying key cultural differences in approaches towards food sharing.

3. Methodology

3.1. Case Study of Ten ICT-Mediated Food-Sharing Platforms

A representative sample of online food sharing initiatives operating in Japan was identified (Table 1). The selection process was conducted through a desktop survey in search engines and the App Store with the relevant keywords "food sharing", "food loss", "food waste", or "food waste reduction" in both English and Japanese. The sample selection methodology was inspired by previous studies on the same topic [30,31]. The scope was strictly limited to online-based initiatives enabling the redistribution of available surplus food for human consumption in Japan. The process resulted in identifying and selecting ten platforms operating in Japan. A website content analysis and semi-structured interviews were conducted with platform representatives between December 2019 and March 2020 (updated in November 2022) to collect relevant information about each initiative's business model, activities, and impacts. The collected information was compiled in a typology to categorise the different platforms. The typology of online food sharing initia-

tives developed by Michelini et al. was applied [30]. It proposes a detailed classification model of surplus food redistribution initiatives. It includes criteria on sustainability impacts, types of donors, and delivery models (Appendix A). The typology table was adapted and used to compare the food sharing initiatives available in Japan with initiatives available overseas. Interviews investigated the personal background, motivations to start the food sharing initiative, and challenges encountered. The semi-structured format allowed conversation-like interviews with relevant follow-up questions to gain an in-depth understanding of participants' perceptions and opinions.

Table 1. Sample of ten ICT-mediated food sharing networks operating in Japan.

Food Sharing Platform	Website	Description
FuriFuru	https://sustainable.furifuru.com/ (accessed on 1 February 2023)	Furifuru (launched in 2017) relies on advertising revenues to buy smallholder farmers' fruits and vegetables failing to meet market standards and redistribute them for free to their supporters.
Kuradashi	https://kuradashi.jp/ (accessed on 1 February 2023)	Kuradashi (launched in 2016) sells surplus manufacturing products at a discounted price (up to 97%) to their members. A portion of the benefits is donated to charities such as food banks or environmental and animal protection organisations.
Loss Zero	https://www.losszero.jp/ (accessed on 1 February 2023)	Loss Zero (launched in 2017) is an e-commerce website that connects surplus food stocks from manufacturers and wholesalers to consumers to reduce food waste emissions. A surplus food rescuing subscription service was launched in November 2021. The platform donates a portion of its proceeds to charities.
Olio	https://olioex.com/ (accessed on 1 February 2023)	Olio (launched in 2016) is a British platform that connects neighbours and local businesses to redistribute surplus food and other goods, instead of throwing them away. While the concept of OLIO relies on a neighbour-to-neighbour food sharing system, businesses can subscribe to their Food Waste Heroes programme to redistribute larger amounts of surplus food.
Otameshi	https://otame4.jp/ (accessed on 1 February 2023)	Otameshi (launched in 2017) describes itself as a "social e-commerce" website contributing to solving social issues by purchasing surplus food and products about to be discarded from their manufacturer and selling them at a discounted price on its online platform.
Rebake	https://rebake.me/ (accessed on 1 February 2023)	Rebake (launched in 2018) is an online shopping platform initially centred on redistributing surplus bread from bakeries in Japan. The service has since expanded to include non-surplus bread but continues to hold a dedicated section for surplus bread.
Shareshima	https://shareshima.com/ (accessed on 1 February 2023)	Shareshima (launched in 2019) is an exclusively B2B food sharing platform connecting food manufacturers with food surplus to other manufacturers in demand of the same ingredient. The service takes on the responsibility of traceability and evaluating food safety to facilitate the transfer of surplus food.
Tabekifu	https://tabekifu.com/ (accessed on 1 February 2023)	Tabekifu (launched in 2019) is a platform that aims to reduce food waste and help the world's underprivileged. Restaurants and food retailers provide customers with discounted prices and discounts on cancelled and over-prepared meals. A part of the proceeds is donated to charities.
Tabeloop	https://tabeloop.me/ (accessed on 1 February 2023)	Tabeloop (launched in 2018) is a platform connecting food manufacturers and retailers with sub-standard food products, due to defects in packaging, irregular shape, scratches, or nearing expiration date, which are about to be discarded with potential buyers (businesses or consumers).
Tabete	https://tabete.me/ (accessed on 1 February 2023)	Tabete (launched in 2018) is a food sharing platform that connects users to food retailers and restaurants to easily rescue freshly cooked meals about to be wasted.

While sustainability claims through references to the SDGs and the reduction of food waste were numerous, there was a lack of empirical data to support these claims in most initiatives' online communication. As such, assessing initiatives' sustainability impacts from online data proved itself challenging with many initiatives not communicating their number of suppliers and users, the amount of food redistributed through their initiatives, or the resulting reduction in GHG emissions and other socio-environmental impacts.

3.2. Consumer-Side Survey

A large-scale survey of 10,000 individuals capturing a representative sample of Japan's sociodemographic and geographic characteristics was conducted online. A third-party survey provider was contracted to select survey participants from a nation-wide and representative pool of individuals. Responses were collected in two sets. The first set gathered 6000 responses from 23 prefectures in November 2019 and the second set surveyed the remaining 4000 individuals from the other 24 prefectures. The respondents' age profile ranged from 15 to 99 years old, with the mean age being 50.6 years old (Table 2). The aim was to acquire an understanding of the user-side attitude towards food sharing practices. A questionnaire made up of closed questions was built upon previous studies on attitudes and behaviours towards food waste prevention and food sharing [34,37,47,48] (Appendix B). The study takes into consideration the limitations of this format to gain a comprehensive understanding of consumer level perception of surplus food sharing. Nevertheless, the systematic approach of the sampling as well as the large scale of the survey provided a solid overview of the problem and allowed a comparison with the extant literature and platforms' specificities to evidence gaps and opportunities of available services. While this survey approach lacked an in-depth aspect, it provides a first understanding of some of the trends and perceptions of Japanese customers, thereby providing necessary information for a better food sharing platform design.

Table 2. Socio-demographic profile of respondents (*n* = 10,000).

Gender	Female	52%
	Male	48%
	15–29 years old	17%
	30–39 years old	14%
	40–49 years old	17%
Age	50–59 years old	14%
	60–69 years old	17%
	70–99 years old	22%
	More than 200,000 inhabitants	62%
Population size of the municipality where respondents reside	More than 50,000 but less than 200,000	27%
	Less than 50,000	10%
	Invalid answers	1%
	One-person household	19%
	Two-person household	35%
Household size	Three-person household	23%
	Four-person household	16%
	Five-person household or more	7%

As a novel food provisioning system, food sharing platforms challenge traditional food-related behaviours. However, as pointed out by McCarthy et al., innovative food provisioning models might be confronted with a general reluctance or hesitation from most consumers [36]. As such, it is critical to assess consumers' readiness and willingness to engage in ICT-mediated food sharing. This willingness might differ according to a variety of variables including age, gender, household size, geographic location, or general attitudes towards food waste prevention. It is thus crucial to appropriately segment and target consumer groups that are most likely to engage in ICT-mediated food sharing to identify their drivers of behavioural change. Inversely, determining barriers to food sharing on the user's side will help platforms overcome them.

A test for association was performed to develop the average socio-demographic profile of current and prospective consumers. It was hypothesised that common users' profiles would be women in their thirties with children, according to the targeted user profile described by food sharing platforms oriented towards consumers (Appendix C).

The cluster analysis aimed to evaluate users' attitudes towards FLW issues and their motivations to consume redistributed surplus food. It was hypothesised that consumers already actively preventing food waste would respond positively to the opportunity to take part in initiatives aiming to prevent FLW across the food supply chain. Respondents were allowed to submit up to two responses to determine which factors most influenced their attitudes and behaviours around food waste prevention and food sharing. Nevertheless, we acknowledge that the survey carried limitations in its design as scholars have shown a weak link between attitude and behaviour [33].

4. Results

4.1. Case Study: Models and Barriers of ICT-Mediated Food Sharing Experiences in Japan

4.1.1. Models of ICT-Mediated Food Sharing Experiences in Japan

Compiling the information collected on ICT-mediated platforms operating in Japan in a typology highlights the ways in which ICT mediation is shaping alternative food distribution systems in Japan (Table 3). Identified platforms covered a wide range of stages within the food value chain, from the agricultural stage to the consumer stage.

Table 3. Typology of food sharing platforms operating in Japan adapted from Michelini et al. [30] (Appendix A). Business to business (B2B), business to consumer (B2C), and consumer to consumer (C2C). Information on both the sustainability claims and measured impacts made by the food sharing platforms were compiled and categorised under "waste reduction" and "social contribution". Limiting the geographic area data input to "local" or "national" enables highlighting the proximity of the transaction, which might be linked with an increased sense of community. The total count of initiatives for each category included all initiatives filling the scope of the category.

Platform	Organisation Profile	Technology	Delivery Model	Type of Donor	Type of Beneficiary	Type of Transaction	Sustainable Impacts	Geographic Area
Furifuru	For-profit	Website and app	B2C	Farmer	Consumer	Free (delivery cost)	Waste reduction and Social contribution	National (delivery)
Kuradashi	For-profit	Website	B2C	Manufacturer	Consumer	Discount	Waste reduction and Social contribution	National (delivery)
Loss zero	For-profit	Website	B2C	Manufacturer	Consumer	Discount	Waste reduction and Social contribution	National (delivery)
Olio	For-profit	App	B2C and C2C	Consumers, Retailer, Food Service	Consumer	Free	Waste reduction and Social contribution	Local (pick up from sharers)
Otameshi	For-profit	Website	B2C	Manufacturer	Consumer	Discount	Waste reduction and Social contribution	National (delivery)
Rebake	For-profit	Website	B2C	Retailer (bakery)	Consumer	Discount	Waste reduction	National (delivery)
Shareshima	For-profit	Website	B2B	Manufacturer	Manufacturer	Discount	Waste reduction	National (delivery)
Tabekifu	For-profit	App	B2C	Retailer	Consumer	Discount	Waste reduction and Social contribution	Local (pick up from participating restaurants)
Tabeloop	For-profit	Website	B2B and B2C	Farmer, Manufacturer, Retailer (wholesaler)	Retailer, Food service and Consumer	Discount	Waste reduction	National (delivery)
Tabete	For-profit	App	B2C	Food Service	Consumer	Discount	Waste reduction	Local (pick up from participating restaurants)
Total	For-profit: 10	App: 4 Website: 7	B2C: 9 B2B: 2 C2C: 1	Farmer: 2 Manufacturer: 5 Food retailer: 4 Food Service: 2	Consumer: 9 Manufacturer: 1	Discount: 8 Free: 2	Waste reduction: 10 Social contribution: 6	National (delivery): 7 Local (pick up): 3

Source: Authors.

The various sustainability impact claims were gathered from both interviews and web content analysis. The data compilation evidenced the variety of social, environmental, and

economic goals pursued by surplus food redistribution initiatives in Japan with outcomes often extending further from food waste reduction.

All initiatives claimed to have environmental benefits in terms of leading to food waste reduction. As such, many of the platforms claimed to have a positive impact on the resulting resource efficiency and reduction of CO_2 emissions. Several of them also claimed to financially contribute to environmental organisations. Social benefits were claimed by six platforms. Such social benefits were in the form of financial contributions to charities or the development of enhanced community networks and associated well-being. It was also found that all platforms claimed some form of economic benefit from their service. Such economic benefits could be made through more affordable/free provision of food products through the platform for users. Households struggling with food insecurity could thus potentially provide themselves with food. Nevertheless, only one of the platforms actively targeted lower income users by calling for the participation of single parents. Many platforms also highlighted the additional income generated by participating food suppliers. Products which were meant to be discarded could be revalued through the platform, generating new income along with avoiding the cost of a waste management fee incurred by food waste disposal.

Before highlighting any forms of sustainability impacts, most initiatives highlighted their provision of tasty, new, or healthy food. In ten out of twelve initiatives, the main selling point to attract users was access to tasty, new, or fresh food. As such, generally speaking, contribution to sustainability impacts was not seen as a main point of attraction to most users. This observation was further confirmed by interviews which revealed that environmental and social contributions could not be seen as inviting selling arguments for Japanese consumers.

The visualisation of the typology classifies the ten platforms according to two key defining patterns (Figure 1):

- type of supplier: farmer, manufacturer, retailer (supermarket, bakery, etc.), food service (restaurant, caterer, etc.), and consumer.
- delivery model: business to business (B2B), business to consumer (B2C), and consumer to consumer (C2C).
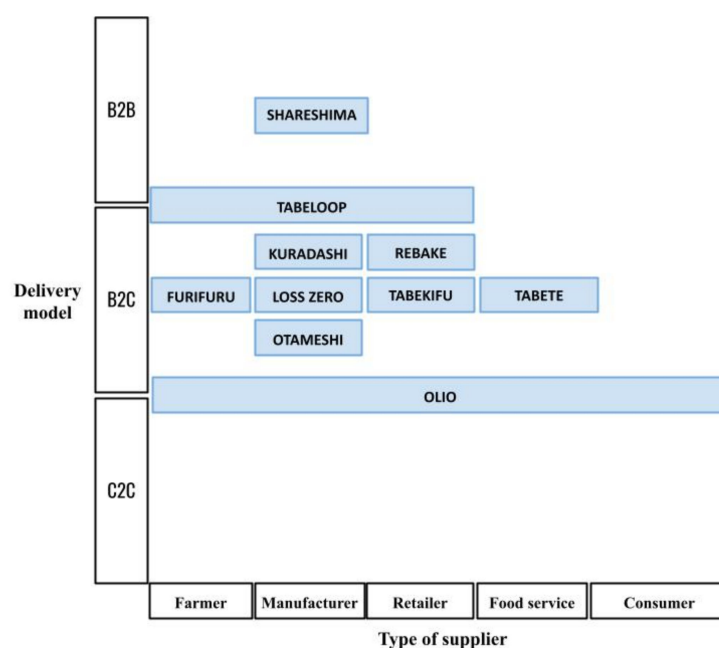
Figure 1. Platforms' visualisation. This figure provides a comparative view of the variety of food redistribution models available in Japan. Business to business (B2B), business to consumer (B2C), and consumer to consumer (C2C). Source: Authors (inspired by Sarti et al. [31]).

4.1.2. Challenges to ICT-Mediated Surplus Food Redistribution

Interviewing platform representatives revealed some of the barriers that surplus food redistribution platforms face when matching the supply and demand for surplus food (Table 4). Becoming profitable as a sustainable business is a central barrier to many platforms. Most interviewed platforms reported to be operating at loss, thereby evidencing the difficulties of combining sustainable impacts and business viability.

Table 4. Barriers identified on the ICT-mediated redistribution side.

Key Barriers	Summary of Interviewed Platforms' Experiences
Financial viability	All interviewed active food sharing platforms are struggling to become profitable, despite their for-profit sharing model.
Lack of active suppliers	Platforms significantly depend on the provision of surplus products from their registered suppliers.
Lack of active users	The number of users subscribed to the platforms does not reflect the number of users actively participating in food sharing.
Lack of awareness	While the Japanese public has recently been informed about the issue of food waste at the retail and food service levels, there is little awareness of food being wasted at the upper levels of the food supply chain.

Source: Authors.

Another struggle identified by platforms is the lack of active suppliers and users to sustain their activities. According to interviewed platforms, surplus food suppliers' limited engagement may be hindered by the fear that redistributing surplus food affects their brand image, lack of trained labour, cooperative or chain management restrictions, lack of trust towards food sharing platforms, or tendency to rely on long-established methods to manage surplus food.

Platforms operating at the upper-stream level of the food value chain observe that the perception of food loss at the production and manufacturing levels was generally low among consumers. As a result, it was highlighted that in order to optimise the sustainability of the entire food supply chain, FLW should be made visible at all stages of the food value chain, especially at the earlier stages, to shine a light on a lesser-known aspect of the food waste issue.

4.2. Consumer-Side Comprehensive Approach to ICT-Mediated Food Sharing

Based on respondents' answers to how likely they were to use online food sharing services, respondents were clustered into three segments: "previous users of food sharing services", "prospective users of food sharing services", and "not interested in using food sharing services". A socio-demographic analysis of the three clusters was performed to establish the average socio-demographic profile of each segment (Figure 2).

First of all, the study focused on identifying the average profile of previous users of food sharing platforms. A total of 1.79% of respondents (n = 179) declared to have previously used food sharing platforms. The socio-demographic category showed that more people identifying as male than female had previously used food sharing services. Despite a significant association between gender and the use of food sharing platforms, X^2 (2, 10,000) = 13 ($p < 0.01$), a pairwise z-test post hoc analysis revealed that this association was not significant for the difference between males and females among previous users (0.05 significance level, corrected by the Bonferroni method). A total of 4% of 15–29 year olds and 2% of 30–39 and 40–49 year olds declared to have previously used online food sharing services, while less than 1% of respondents older than 50 years old had previously tried such platforms. The use of food sharing services and other sharing platforms was shown to have a significant relationship with age X^2(10, 10,000) = 77 ($p < 0.001$). A significant difference was revealed between 15–29 and 40–49 year-old respondents, as well as 15–29 and 50–59 year-old respondents, and between 15–39 and 40–59 year-old respondents (0.05 significance level, corrected by the Bonferroni method). The population size of the

municipality in which respondents live was also a relevant correlation, $X^2(6, 10,000) = 56$ ($p < 0.001$). A pairwise z-test post hoc analysis revealed that this association was significant for the difference between previous users living in areas with a population size of more than 50,000 and less than 50,000 inhabitants (0.05 significance level, corrected by the Bonferroni method). As such, respondents living in moderately populated areas of more than 50,000 and highly populated areas of more than 200,000 inhabitants were comparatively more likely to have previously used online food sharing services. Two-person households (1%) were shown to be less likely to use food sharing platforms than one-person households (2%), which is larger than two-person households $X^2(8, 10,000) = 34$ ($p < 0.001$). This was confirmed by the pairwise z-test post hoc analysis (0.05 significance level, corrected by the Bonferroni method). These results suggest that online food sharing platforms tend to be more attractive to younger users, individuals living alone or in large households, and individuals residing in moderately to highly populated areas of Japan.
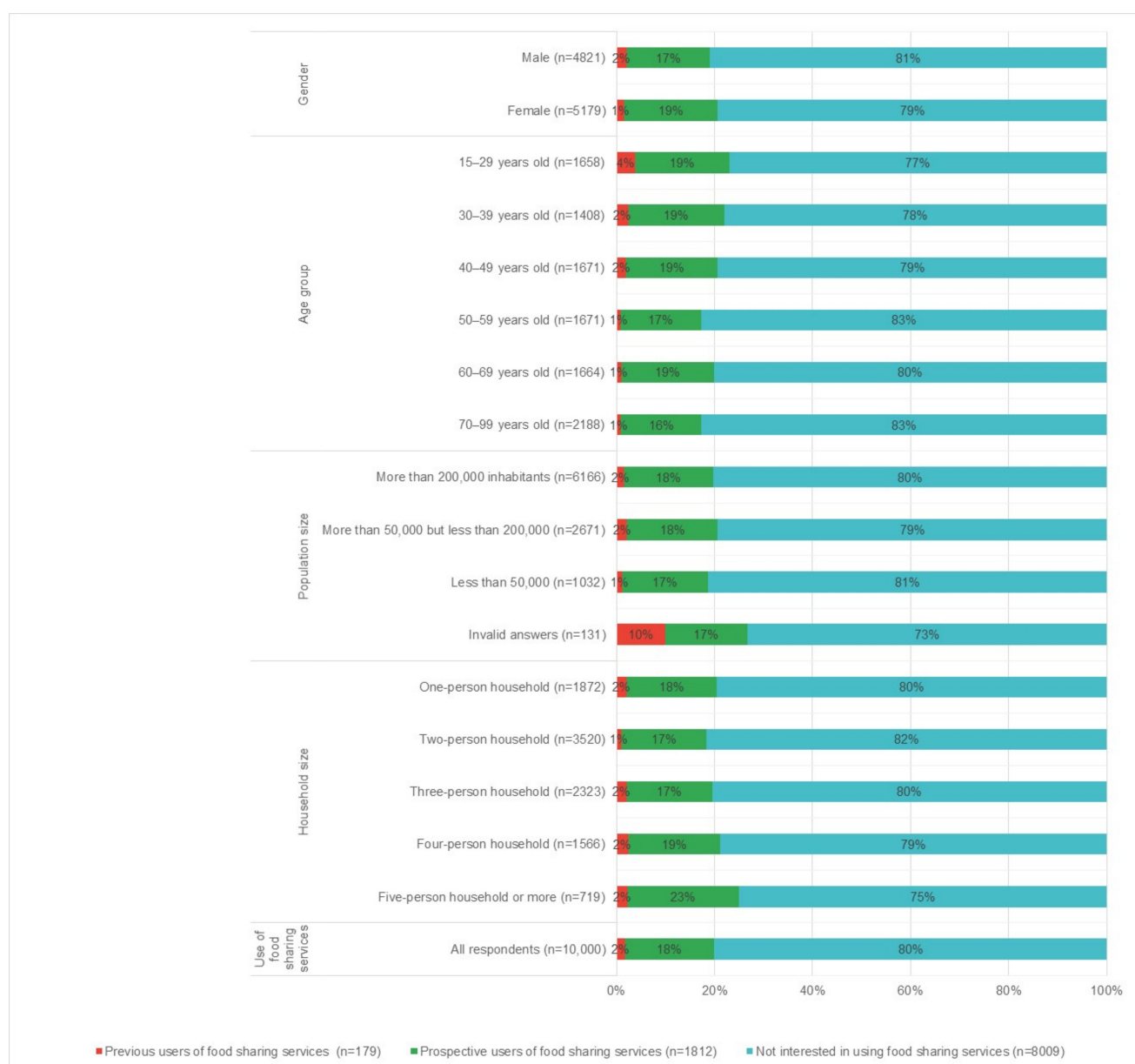
Figure 2. Demographic distribution of the three clusters.

Following this, the study established the average profile of consumers most likely to engage in online food sharing. Based on the collected responses, individuals who ex-

pressed interest in using food sharing platforms totalled 18% (*n* = 1812). It was observed that people identifying as female (17%) were more likely to be interested in using food sharing services than others (0.05 significance level, corrected by the Bonferroni method). Respondents living in areas with a population size of more than 50,000 and less than 50,000 inhabitants showed more interest in using food sharing services (0.05 significance level, corrected by the Bonferroni method). Associations with other socio-demographic criteria were not revealed to be significant for prospective users of food sharing services (0.05 significance level, corrected by the Bonferroni method). As such, the results suggest that prospective users of online food sharing platforms would be more likely to be female and living in moderately and highly populated areas of Japan.

Having established a demographic profile of current and prospective online food sharers, a cross-analysis of respondents' level of interest in using food sharing platforms with their motives and barriers to actively engaging in food waste prevention and food sharing was used to determine their drivers of behaviour change (Figures 3 and 4).

The survey investigated respondents' attitudes towards food waste by inquiring why they see food waste as an issue and their motivations to reduce it. Participants expressed a generally high problem awareness towards food waste and widely acknowledged that food should not be thrown away. The largest concern associated with food waste was the ethical implications of wasting food when others suffer from hunger (58%), closely followed by the waste of resources and energy (45%). While a minority of respondents (12%) declared that they do not see food waste as an issue, it is observed that this response was shared by a larger portion of individuals not interested in food sharing (94%) compared to other responses.

Observing the food waste prevention approaches adopted by respondents shows that most respondents adopted a precautionary approach against food waste at the consumer level ("Only buying the necessary amount of food", "Trying not to have left-over food"). Interestingly, respondents from the current users' and prospective users' clusters were more likely to adopt a more active approach to food waste prevention such as taking home leftover food from restaurants or sharing surplus food with family and neighbours (0.05 significance level, corrected by the Bonferroni method). This analysis confirms the hypothesis of an active engagement with FLW prevention measures being generally associated with a higher disposition to participate in (online) food sharing.

When asked about obstacles faced when trying to reduce food waste emissions, most respondents (29%) declared not to face any particular barriers. However, the smaller ratio of previous and prospective online food sharers for respondents declaring not to face any barriers in preventing food waste suggested the presence of barriers for individuals seen as more actively engaged and interested in the prevention of food waste. The main barriers to food waste prevention cited by most respondents interested in using online food sharing were food safety concerns (33%), convenience in food preparation (26%), and the desire to be a good provider (26%).

Regarding the likelihood to engage in food sharing in their neighbourhood, a significant association with the use of food sharing platforms was observed, $X^2(4, 10,000) = (1974)$, $p = (0)$. Current and prospective users of food sharing platforms were more likely to share food in their neighbourhood (0.05 significance level, corrected by the Bonferroni method).

Motives given by respondents interested in the prospect of engaging in online food sharing were financial savings (*n* = 1157), limited concerns regarding food safety (*n* = 1101), and, to a lesser extent, the contribution to food waste reduction (*n* = 804). The most significant barriers for individuals interested in food sharing are concerns over food safety (*n* = 60) and the reluctance to get involved in a neighbourhood (*n* = 51).

Responses also allowed us to identify the criteria considered most important to engage in food surplus sharing for prospective online food sharers: guaranteed quality (*n* = 1124) and price (*n* = 889). The preferred surplus food providers were supermarkets or convenience stores (*n* = 1258), farmers (*n* = 971), and manufacturers (*n* = 961).
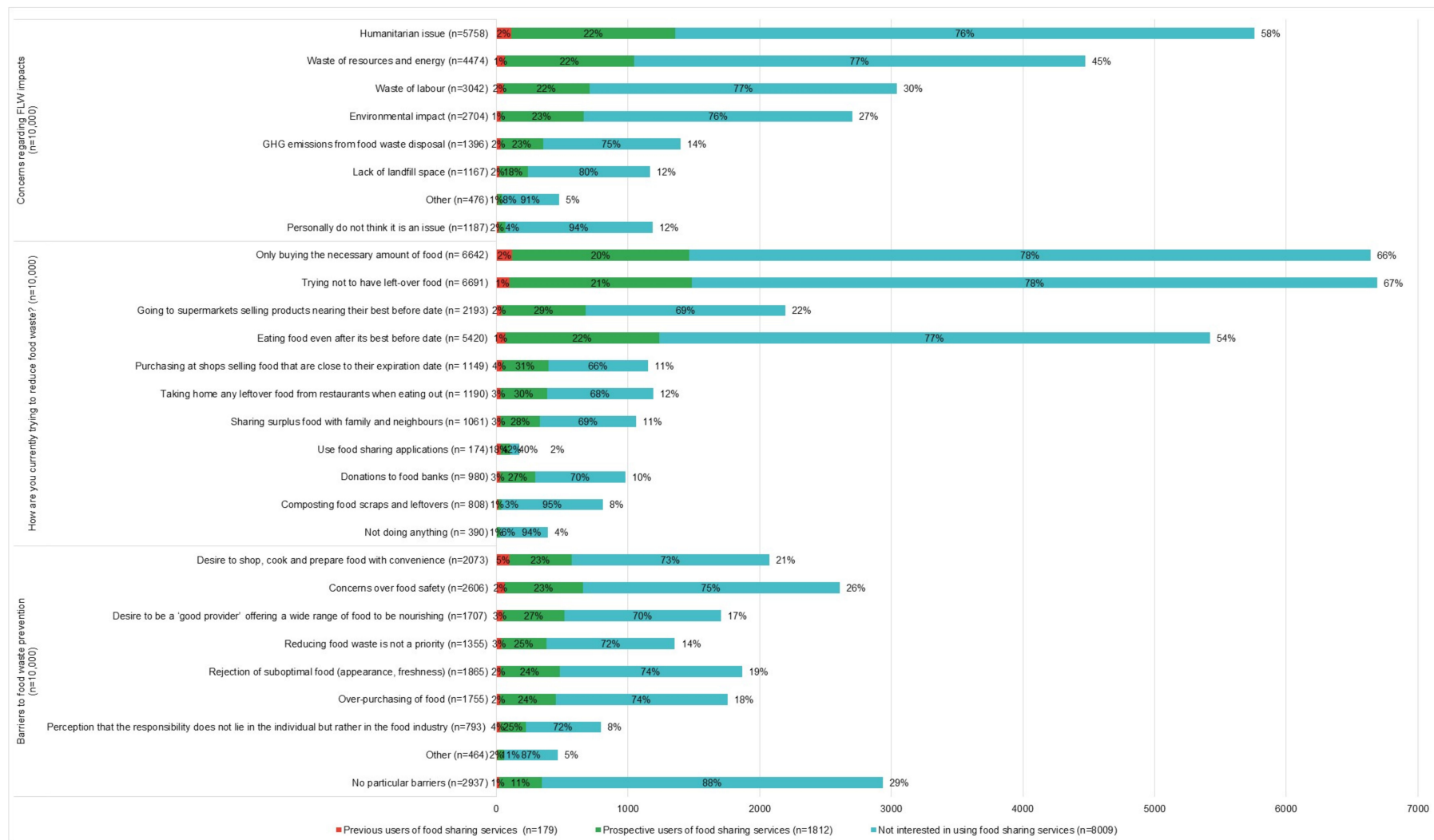
Figure 3. Cluster analysis from the ratios of multi-choice distribution of responses on the food waste prevention actions and their barriers.
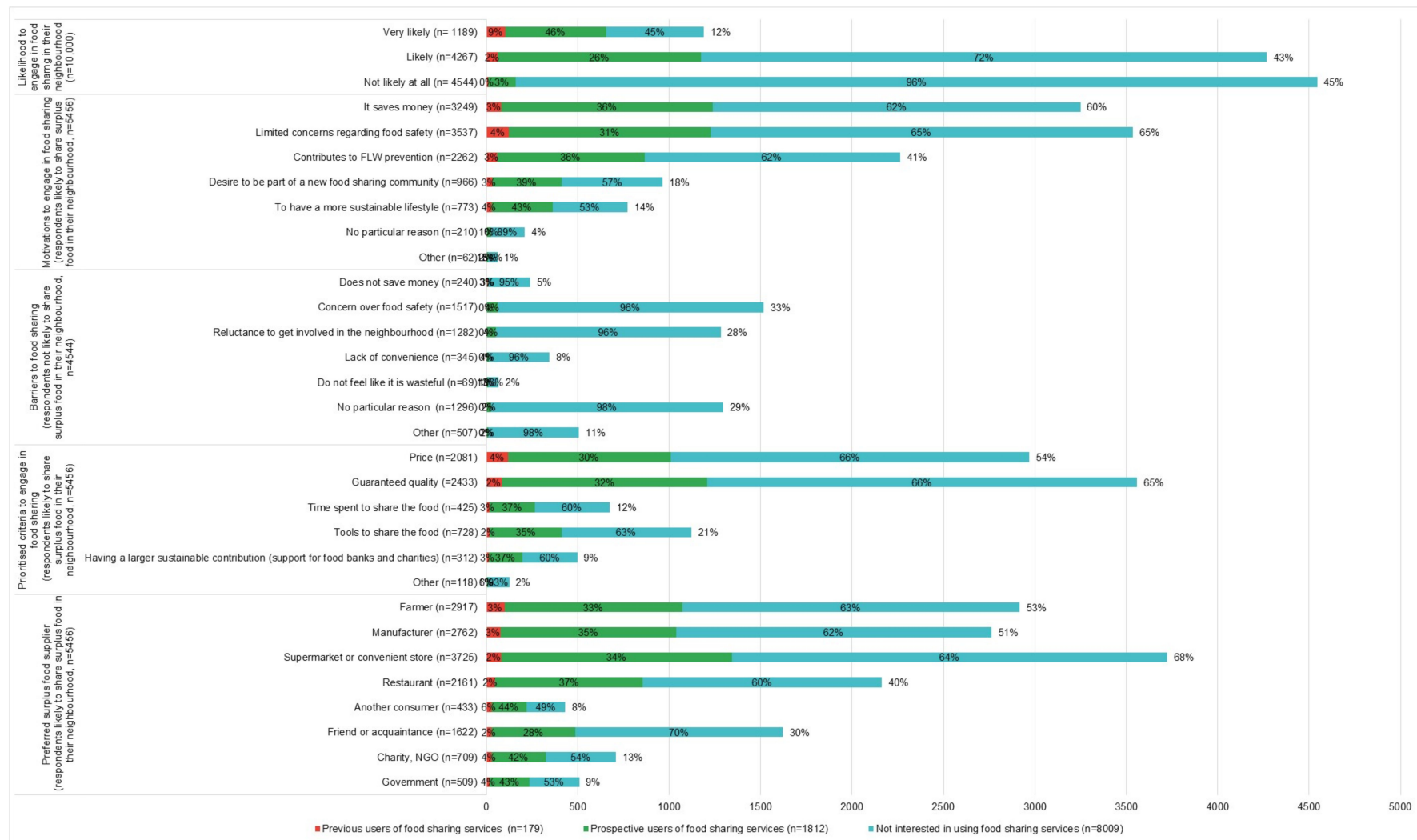
Figure 4. Cluster analysis from the ratios of multi-choice distribution of responses on food sharing.

5. Discussion, Implications, and Recommendations on the Convergences and Divergences Observed between Food Sharing Platforms and Consumers

5.1. Targeted Users' Profile

The consumer side analysis developed an in-depth understanding of how and why people behave in a certain way around surplus food and food sharing practices. The collected data indicates the market feasibility of ICT-mediated food sharing in Japan, as a potential solution to prevent food waste. The survey allowed us to narrow down demographic groups declaring interest in engaging in ICT-mediated food sharing. According to this, young and middle-aged individuals were identified as key user profiles. Individuals living alone or with a household of more than two members and those in highly populated areas were also more likely to have shared food online. Consumers identifying as female were more likely to show an interest in engaging in online food sharing.

The platforms' analysis revealed a slight divergence between users' and platforms' expectations. Services redistributing surplus food from restaurants and catering were more likely to target consumers who have a strong interest in food and eating out and people who are curious to try new food-related experiences. E-commerce surplus food redistributors communicated that their main users were middle-aged users identifying as females purchasing large amounts of discounted food to provide for their household (Appendix C).

5.2. Surplus Food Redistribution Model

The sample of ten food sharing platforms included platforms redistributing surplus food from all levels of the food supply chain. The manufacturing and retailing stages were covered by most food sharing services (six and five platforms, respectively) and the majority of platforms directed the food surplus to consumers (nine platforms).

Most initiatives operating in Japan adopted a B2C model to redistribute surplus food. In B2C models, the surplus food is collected from distributors including retailers, restaurants, cafes, and bakeries to be redistributed to the final consumer. The online platform serves an intermediary role for the food suppliers to post their available surplus food and for potential food recipients to check offers. The financial transaction is usually made on the platform. The food can either be collected directly at the store or delivered to the recipient. Recipients benefit from the food being sold with a discount on the initial price and suppliers can reduce their waste disposal costs, increase their profits, and improve their public image by raising awareness about food wastage and sustainability issues. Despite the availability of C2C food redistribution services in Japan, the service appeared to be rarely utilised, confirming that trust might be an issue when it comes to food sharing outside of the known community. The fact that the most common donors remained businesses and that recipients were mostly individual consumers reflects traditional food supply patterns. This observation echoes the study made by Davies and Evans showing that urban food sharing generally reflects traditional patterns of production and consumption [49]. Nevertheless, many of the drivers and objectives pursued by food sharing initiatives operating in Japan reflect most of the academic observations made on overseas initiatives. Initiative owners have expressed convictions echoing underlying motivations identified by previous food sharing studies such as anti-consumerism convictions and strong awareness on food waste [37]. Many of the interviewed initiatives declared to have been influenced by ICT and food sharing services available outside of Japan.

In order to determine the most user-friendly approach to online food sharing, survey respondents were inquired about their preferred means to share surplus food. Respondents' most preferred suppliers of surplus food were retailers, farmers, and manufacturers. While patterns of food redistribution facilitated by ICT were seen to generally mirror traditional food supply channels, rather than driving their reconfiguration, the survey evidenced an interest from consumers to receive surplus food from the upper levels of the food supply chain. This highlights the potential demand to further develop alternative food redistribution networks revaluing surplus food to optimise the sustainability of the food supply chain.

The initiatives investigated in this study did not claim to offer a miraculous solution to the issue of food waste and unsustainable food systems. Rather, they were seeking to show the possibility of an alternative consumption model revaluing surplus food. As pointed out by Weymes and Davies, restructuring the current food system cannot be the sole responsibility of food sharing platforms [15]. The urgent responsibility to rethink the failing food system falls with each and every stakeholder across the food supply chain.

5.3. Barriers

The emerging use of ICT to facilitate surplus food redistribution is challenging existing food safety regulations and common food practices based on mainstream food systems. The resulting frictions with food stakeholders provide the opportunity to reconsider outdated food systems.

Findings evidenced the main obstacles to be tackled to expand food sharing practices. The lack of financial viability of food sharing activities was seen as a common barrier for most food sharing services. This difficulty is shared by most business model innovations for sustainability. However, regulatory changes and incremental adjustments in their models and processes may improve their viability over time [50]. Another barrier identified was the platforms' dependence on the emission of surplus food and thus on the inherent unsustainability of food supply chains. As a way to bridge this obstacle, platforms strive to gather as many suppliers as possible to build a larger pool to increase matching opportunities with users' needs. Nevertheless, interviewed platforms identified a number of obstacles to the efficient redistribution of surplus food on the suppliers' side. The most significant obstacles are the lack of knowledge and redistribution capacity. While surplus food redistribution relies greatly on the motivation of individual staff, strong engagement is often hindered by the quick turnover of staff and general lack of labour to efficiently manage surplus food and avoid the more straightforward disposal. This is evidenced by Tabete's experience. While over 2500 food businesses are registered to the platform, very few of them display their surplus food on the platform. The interview revealed that the registration process was led by business managers, but daily staff suffered from a lack of capacity and time to properly ensure the redistribution of surplus food through the platform. Many obstacles to efficient food redistribution from suppliers were also highlighted in the literature. Among all, many surplus food donors were shown to avoid drawing attention to the amount of surplus food they emit, as it could be seen as a sign of inefficiency and compromise their reputation [17]. Additionally, redistributing freshly prepared surplus food from the food service stage in a timely manner was shown to especially demand high efficiency and organisation [22]. The key challenge in conducting a food redistribution service is the variety of actors with varying and sometimes conflicting values and interests that platforms are confronted with. As new and alternative intermediaries between different stages of the food supply chain, food sharing platforms often struggle to understand and meet the different needs of their partners [14]. Examining these varying interests and expectations can help to bridge these differences and facilitate their cooperation.

On the consumers' side, a key obstacle was the reluctance to buy or consume surplus food, due to its perception as substandard or unsafe [36]. Many survey respondents declared that trust concerns around food safety and alternative food supply channels were key barriers to engaging in surplus food sharing. The low levels of active engagement from users could also be explained by the new behaviour and lifestyle promoted by food sharing platforms which might seem inaccessible to many. While the idea of food sharing might be appealing, concretely changing either business routines or lifestyles might be an extra step that many are not ready to take. Despite consumers' interest in the service, a lack of trust or inconvenience to incorporate new behaviours into their everyday life might be possible reasons for not actively engaging in food sharing. As outlined by Hebrok and Boks, there is an array of structural factors defining or restraining individuals' food provisioning practices beyond high awareness of food waste issues [33].

Food waste reduction interventions need to anticipate such needs and limitations and be designed as a way to increase socio-cultural, financial, and geographic accessibility. Users' distrust concerning the safety of redistributed food could be bridged through new regulations ensuring that platforms can guarantee compliance with food safety standards and provide random checks on redistributed items [31]. The use of ICT in matching food surplus and needs is put forward as a way to build trust within the sharing community through reputation building and fraud prevention mechanisms to prevent the misuse of donations [25]. Another challenge will be to increase trust towards non-traditional food suppliers, as well as food sharers beyond the known community [29]. Overall, Falcone and Imbert highlight the need to act on collective behaviour as food consumption is closely linked with other behaviours and routines [51].

5.4. Motivations to Use Food Sharing Platforms

The survey identified key motivations to adopt food waste reduction practices according to individuals interested in food sharing platforms. Estimating the level of sustainability consciousness and efforts to prevent food waste for every type of demographic profile is key to formulating appropriate and effective strategies to tackle food waste.

On the consumer side, the data analysis helped to verify the applicable hypothesis to determine whether a high level of engagement with FLW prevention measures can generally be associated with a higher disposition to participate in (online) food sharing. While the use of ICT offers a facilitation tool to support sharing, a pre-established active engagement in sharing activities and community was seen as a key factor in engaging in ICT-mediated food sharing [42]. Price consciousness is also positively linked with respondents' willingness to share food. This correlates with other findings in the literature suggesting that economic benefits are generally the main drivers to food sharing despite a growing realisation of food waste related sustainability issues [25,51]. Comparatively, status-seeking within a food sharing community or the appeal of a sustainable lifestyle does not appear to drive interest to share food. The survey emphasised that while respondents widely acknowledged that food should not be thrown away, the connection between environmental issues and food waste appeared not to be well established. This echoes the assumptions of several initiative owners on the general lack of concern for the environmental impacts of food waste observed on the consumer's side when faced with a consumption decision. This finding suggests a key difference from observed overseas cases of food sharers who regard food sharing as a practice to express a subtle resistance to the food system and its established norms [51]. Nevertheless, the survey carried limitations in its design as it focuses on behavioural and attitudinal factors influencing consumers' intention and attitude. Previous research demonstrated the weak link between attitude and behaviour especially when it comes to food.

Most initiatives highlighted their provision of tasty, new, or healthy food. For most initiatives, the main selling point to attract users was access to tasty, affordable, and new food. This was justified by platform representatives who revealed that sustainable benefits on their own were not a key selling point for their consumers. As such, food is mainly considered to be a form of an "entry point" to sustainability. Contributions to sustainability were rather presented as secondary outcomes of using the platform and eating the redistributed surplus food. As highlighted above, several platforms recognised the difficulty for many of their consumers to adopt sustainable behaviours while pursuing their everyday life. This is why many of the food sharing platforms targeting consumers focused their offers on the opportunity to have a sustainable impact without hindering their convenience. The common idea seen is that "one can contribute to sustainable development by eating" (translated from an interview). Additionally, platforms offer food businesses the opportunity to apply their corporate social responsibility (CSR) by allowing them to revalue their surplus product to be rescued by consumers. As such, offering surplus food on food sharing platforms would be a way to not only have a positive societal impact but to further improve participating businesses' public image. All in all, what all platforms

operating in Japan have in common is their motivation to raise users' awareness of food waste issues, promote food sharing practices, and encourage behavioural change towards sustainable lifestyles. Despite the general lack of monitoring of sustainable impacts, investigated platforms were developed with sustainable motivations in mind and desires to communicate on larger issues around food waste and sustainability. As such, while the extent to which food connects to multiple aspects of sustainability might not be a major attraction point for prospective users, sustainability should remain a goal and an additional reason offered to participate in food sharing.

5.5. Recommendations and Limitations

All in all, surplus food redistribution in Japan has been characterised by mixed results. ICT-mediated redistribution platforms are still working their way towards trust and capacity building to have a larger position in the food supply system. While food sharing platforms operating in Japan remain in the process of testing the market and developing their specificity to better adapt to local needs and expectations, the examination highlighted many similarities between the Japanese and overseas food sharing mechanisms. All examined initiatives were seen to embed sustainability into their purpose but demonstrated limited comprehensive reports on their sustainability impacts. While the initiatives investigated in this study did not claim to offer a transformative solution to the issue of food waste and unsustainable food systems, they show the possibility of an alternative consumption model revaluing surplus food. They marginally contribute to solving the issue by revaluing and redirecting a portion of the flow of surplus edible food from landfills towards human consumption. By doing so, platforms put a spotlight on the large-scale food waste issue both nationally and globally and raise awareness on larger sustainability issues. While there is a limited guarantee that the resulting awareness of sustainability issues will trigger a large-scale behavioural shift, the sustainable transition will partly rely on heightened public awareness of complex food and societal systems.

The main obstacle to food sharing identified in the survey is distrust regarding food safety. This evidences a lack of appropriate regulations ensuring the correct preservations of food products destined to be shared. The evidenced barriers also highlight the need for the Japanese application of a food redistribution and donation policy approach. While the Japanese legislation formulated policies on the prevention and recycling of food waste, it fails to encourage the redistribution of edible surplus food for human consumption. Such recovery policy may incorporate tax incentives for donors, the development of an efficient matching system between donors and the needy to facilitate redistribution, and limited liability regulations for surplus food donors [52]. While focusing only on limiting liability of food donors will not solve the underlying causes of food poverty and food waste, there is an urgent need to rethink the current food system and determine who is responsible for evaluating the qualities of the redistributed food and ensuring their safe redistribution [49]. In the creation of an alternative distribution channel for sub-optimal or surplus food, actors across the food supply chain will benefit from an increased ability to match the existing demand for quality products. While the difficulty to eliminate food waste was acknowledged in the course of conducting interviews, such redistribution channels offer a last recourse to value non-standard products or surplus food, thereby rescuing them from being discarded. A multiplication of alternative food supply channels would offer more options for consumers who are willing to purchase products deemed below mainstream market standards and provide a bridging solution to minimise the amount of surplus food ultimately wasted.

6. Conclusions

This paper provides initial contributions to understanding the Japanese experience of ICT-mediated food sharing from both the supply and consumption sides. Recognising food as an entry point to sustainability, all investigated food sharing platforms embedded food waste reduction and sustainable objectives as their mission. However, a consumer-

side survey suggests that participation in food sharing was mainly driven by price consciousness and convenience orientation. Distrust towards the safety of redistributed food and reluctance to engage in a sharing community were some of the main barriers identified to engaging in food sharing. This initial exploration of platforms' redistribution model and consumers' behavioural determinants suggests relevant policy and infrastructural intervention designs to expand ICT-mediated food sharing and encourage consumers' behaviour change. Future research should further investigate the sustainable implications and possibilities of ICT-mediated food sharing.

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Appendix A

Table A1. Typology adapted from Michelini et al. [30].

Category	Variable
Organisation profile	Profit
	Non-profit
Technology	App
	Website
Delivery model	B2B
	B2C
	C2C
Type of donor	Farmer
	Manufacturer
	Wholesaler
	Food service
	Consumer
Type of beneficiary	Manufacturer
	Food service
	Consumer
	Non-profit organisations
Type of transaction	Donation
	Discount
Sustainable impact	Waste reduction
	Social contribution
Geographic area	Local
	National

Appendix B Survey Questions

Food Loss and Waste

1. Why do you think wasting food is an issue? (please select all appropriate options)

- humanitarian issues (about 900 million people are subject to food insecurity)
- waste of resources and energy used in the production and distribution of food
- waste of labour during production and distribution stages
- higher prices caused by wasting food
- environmental impact
- greenhouse gases emissions resulting from food waste disposal (decomposition or incineration)
- lack of landfill space
- other

2. How are you currently trying to reduce food waste? (please select all appropriate options)

- only buying the necessary amount of food
- trying not to have left-over food
- eating food even after its expiration date whenever possible
- purchasing at shops selling food that are close to their expiration date
- taking home any leftover food from restaurants when eating out
- use food sharing applications
- donations to food banks
- composting food scraps and leftovers
- not doing anything
- other

3. What are your personal motivations to reduce food waste? (please select all appropriate options)

- opportunity to save money
- doing the 'right' thing as taught
- feeling of guilt associated with wasting food due to social norms
- food management, meal planning
- other

4. What are some barriers you face in reducing food waste? (please select all appropriate options)

- desire to shop, cook and prepare food with convenience
- food safety concerns
- desire to be a 'good provider' offering a wide range of food to be nourishing
- lack of priority given to reducing food waste, bigger problems to worry about
- rejection of suboptimal food (appearance, freshness)
- perception that the responsibility does not lie in the individual but rather in the food industry
- other

Surplus food redistribution

5. How likely are you to share food within your neighbourhood?

- very likely
- likely
- not likely at all

6. (To respondents who answered "very likely" or "likely" for question 5) Why?

- it saves money
- limited concerns regarding food safety
- participates in reducing overall food waste
- to have a more sustainable lifestyle
- no particular reason
- other

7. (To respondents who answered "not likely at all" for question 5) Why not?

- does not save money
- concern over food safety
- do not feel like it's a waste
- no particular reason
- other

8. What do you think is the most appropriate discount rate for products approaching their expiry date?
   - 10%
   - 20%
   - 30%
   - 40%
   - 50%
   - over 50%

Food sharing

9. Have you heard about food sharing? (redistribution of surplus food at a discounted price or for free)
   - yes, I have heard about this
   - no, I have never heard of this

10. How likely are you to share surplus food in your neighbourhood?
    - Very likely, Why?
    - Not likely at all, why?

11. (To respondents who answered "very likely" for question 9) Why?
    - it saves money
    - limited concerns regarding food safety
    - participates in reducing overall food waste
    - interested in building new relationships through sharing
    - to have a more sustainable lifestyle
    - no particular reason
    - other

12. (To respondents who answered "not likely at all" for question 9) Why?
    - does not save money
    - concern over food safety
    - do not feel like it's a waste to not share
    - no desire to build new relationships in my neighbourhood
    - do not find it convenient
    - no particular reason
    - other

13. How likely are you to use food sharing services (app or website)?
    - already using food sharing services myself
    - have never personally used such services, but know people using them
    - already familiar with other types of sharing services and would like to try food sharing services
    - interested in food sharing services and would like to try to use them
    - interested in food sharing services but not likely to try to use them
    - no interest in food sharing services whatsoever
    - other

Appendix C

Table A2. Users' profile according to interviewed food sharing platforms.

Platform	Type of Users
Furifuru	Women in their thirties, often with a family 4/10 of men and 6/10 of women.
Kuradashi	We target people who are interested in issues of food waste. They happen to be mainly women in their 40's with children.
Shareshima	Food manufacturers
Tabekifu	Users in their 10's to 40's who like to eat out
Tabete	Women between their 20's and 40's

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