



HOKKAIDO UNIVERSITY

Title	A study on food sustainability through online meal delivery and Japanese home cooking
Author(s)	符, 瑞
Degree Grantor	北海道大学
Degree Name	博士(環境科学)
Dissertation Number	甲第16719号
Issue Date	2026-03-25
DOI	https://doi.org/10.14943/doctoral.k16719
Doc URL	https://hdl.handle.net/2115/99564
Type	doctoral thesis
File Information	FU_Rui.pdf, 全文



A study on food sustainability through online meal delivery and Japanese
home cooking
(オンラインミールデリバリーと日本の家庭料理を通じた食の持
続可能性に関する研究)

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Abstract

This dissertation examines how sustainability challenges in contemporary food systems are reflected in everyday eating by focusing on two connected aspects: the rapid global expansion of online meal delivery services (OMDS) and current practices of Japanese home cooking. Food systems involve environmental, health, and social concerns, which are reflected in how food is accessed, prepared, and consumed in daily life, making everyday eating practices an important entry point for understanding food-system sustainability. By analyzing OMDS and household cooking as two key sites of everyday food practice, this study investigates how changes in food access interact with cooking practices and food-related judgment in shaping contemporary eating.

Chapter 2 presents a systematic mapping review of research on OMDS. Using the Web of Science database, the study identified 128 English-language journal articles published between 2000 and 2022 through keyword searches combining meal delivery and sustainability-related terms. Among these, 50 articles explicitly addressed impacts relevant to the SDGs. To assess SDG relevance, the study combined text mining, which identified and counted SDG-related keywords in the full texts, with close reading to confirm how those terms were used in context and whether they referred to concrete environmental, social, health, or economic impacts associated with OMDS. The literature most frequently discusses packaging waste, food waste, delivery-related CO₂ emissions, precarious working conditions for delivery riders, nutritional risks linked to convenience-oriented consumption, and economic effects such as flexible employment opportunities and competitive pressure on small independent restaurants. However, existing research remains fragmented: most studies examine single outcomes in isolation, and only a small number analyze environmental, social, and economic impacts within the same analytical framework. In addition, several important longer-term effects remain insufficiently studied, including changes in children's food learning when home cooking is replaced by delivery, the implications of OMDS use for the division of household labor, and whether platform-based work promotes or constrains social mobility over time.

Chapter 3 analyzes sustainability-relevant features of contemporary Japanese home cooking through a dish-level content analysis of recipes from NHK's *Today's Cooking*. The study compiled 120 recipes introduced between 2023 and 2025 and coded each recipe for protein sources, seasoning types, cooking methods, and salt content. The results show that protein sources are distributed in line with national consumption statistics, with greater reliance on pork, chicken, fish, and soy products than on beef. Seasonal ingredients are used extensively. Fermented seasonings such as miso, soy sauce, and mirin appear frequently, and many dishes rely on simple techniques such as pickling, simmering, and light stir-frying. Nutritionally, the average salt content per recipe is below daily intake guidelines established by the World Health Organization and Japan's Ministry of Health, Labour and Welfare. However, because the analysis focuses on individual dishes rather than daily menus, it cannot determine how these recipes are combined within complete meals or across the course of a day. Certain combinations of dishes could therefore exceed recommended salt intake levels. The recipe corpus reflects several features associated with the UNESCO recognition of *washoku*, including the use of diverse and fresh ingredients, attention to

nutritional balance, and the use of seasonal products. At the same time, the high prevalence of fish-based recipes highlights a potential tension between nutritional goals and marine resource conservation, which cannot be assessed accurately without more detailed analysis of species composition and fishing origins. The recipe analysis shows how sustainability-related choices and constraints are embedded in everyday cooking, and suggests that this approach can be extended to cookbooks, cooking classes, and similar culinary materials, making it applicable to the study of home cooking in different countries.

This dissertation develops a complementary analytical approach that combines system-level analysis of food access through online meal delivery services with practice-level analysis of home cooking. This approach provides a more grounded basis for evaluating sustainability in everyday eating, moving beyond aggregate consumption indicators to focus on culturally embedded recipes and routine food-related decisions.

Acknowledgments

As I place the final full stop on this doctoral dissertation, I find myself reflecting on the many hands and hearts that have carried me along this long and winding journey. It is with profound gratitude that I extend my thanks to all those who have supported, guided, and inspired me throughout these years.

My deepest appreciation goes to my supervisor, Professor Yasuhiro Yamanaka, whose mentorship has been an unwavering light from the very beginning. His dedication knew no boundaries of time or effort. He generously transformed every moment, whether in the midst of his busy schedule or in brief intervals between tasks, into opportunities for guidance and encouragement. His mentorship extended far beyond academic supervision. He cared for his students' future paths, their growth, and their well-being. When I began my doctoral studies, the world was in the grip of the COVID-19 pandemic, and I remained in China for two and a half years. During that period, our conversations took place entirely online. Through those countless virtual meetings, I came to know the bookshelf behind his desk, the light in his office, and the tone of his thoughtful comments. When I finally arrived in Japan and met him in person for the first time, it was a curious mix of freshness and familiarity. The excitement of seeing him in real life was accompanied by the comfort of greeting someone whose voice and guidance had already become part of my everyday life.

I am equally indebted to my co-author, Professor Gregory Trencher of Kyoto University. His guidance has left a vivid mark on my academic writing, quite literally in the form of manuscripts covered with red annotations. His feedback spanned every scale, from the architecture of arguments and focus of ideas to the subtle rhythm of English expression. He taught me not only the craft of academic communication, such as how to weave linking sentences, and choose words with precision, but also the discipline of developing a well-structured and meaningful discussion. Through his guidance, I learned how to identify the central focus of an argument, to recognize where deeper analysis was required, and to pursue that depth with both academic rigor and creative sensitivity. Each “red” draft was not a mark of failure but a living lesson, and I still revisit them to remind myself of the standard he helped me reach.

My sincere thanks also go to the anonymous reviewers and journal editors whose comments sharpened my thinking and strengthened my publications. Their recognition and constructive critique shaped the final outcomes of my research. (My gratitude, I must confess, does not quite extend to the first submission of my first paper, which endured nearly a year of waiting, an academic lesson in patience if ever there was one.)

I would also like to express my gratitude to my fellow members of Professor Yamanaka's seminar for their encouragement and insightful discussions.

To my family, my greatest source of strength, words will never be enough. Coming alone to a foreign country while leaving behind my young child was the hardest decision of my life. My family carried the weight so that I could walk this path. There is a saying in Chinese: “When you feel life is easy, it is because someone else is carrying the weight for you.” I know exactly who those “someone” are. To my child, I want to say: I will always feel the regret of missing moments of your childhood. In times of anxiety and exhaustion, your photos and videos became my quiet salvation. And I want you to remember this always: before you

become anyone's wife, mother, employee, or friend, you are first and foremost yourself. Live for that self with courage and joy.

Finally, my heartfelt gratitude goes to Professor Manami Fujikura of J. F. Oberlin University. She was my mentor during my master's studies, but more than that, she was a friend, a guide, and a bridge into the world of environmental education. I still smile when I recall how she laughed when I confessed to turning sushi into fried rice because I could not yet enjoy raw fish. She welcomed me warmly to her home for takoyaki party and opened doors to invaluable experiences, introducing me to the Japanese Environmental Education Forum (JEEF) and involving me in the Kiyosato Meeting. It was through her that I first learned to see the world through the lens of society, nature, and education. Without her encouragement and example, I would not be standing here today, completing this journey at Hokkaido University.

The genesis of this research on meal delivery services can be traced to my experiences in China, where I witnessed its rapid rise firsthand. From breakfast to midnight snacks, from a single cup of milk tea to a full hotpot meal, almost anything could be delivered within 30 minutes. This convenience became indispensable during the pandemic, when delivery provided a contact-free way to enjoy restaurant meals. In contrast, after coming to Japan, I found the delivery ecosystem far less prevalent—and as a frugal student, the extra service fees often made me hesitate to order at all. This contrast first sparked my curiosity. Later, during the review of my initial manuscript, a comment noting an overemphasis on China prompted me to look beyond its borders. I discovered that meal delivery was not only maturing in many developed economies but also thriving in emerging regions such as Africa, revealing its far-reaching implications for global sustainability.

The idea of analyzing menus from NHK's Today's Cooking arose from a practical question. As *washoku* is recognized by UNESCO for its sustainability and harmony with nature, I became interested in how these values are reflected in Japanese dietary life. Yet how could one study home cooking without intruding into private kitchens? The program's wide national reach offered an ideal opportunity to explore everyday dietary practices through its broadcast menus. When I first presented this unconventional approach to my supervisor, Professor Yamanaka, he responded with understandable skepticism—"Can this really work?"—yet continued to guide me with patience and insight. His feedback refined my arguments, and together we weathered what he called the "storm revision mode." Through these challenges, the two papers that form the core of this dissertation finally came to life.

To every person who has accompanied, encouraged, or believed in me along this road, thank you from the bottom of my heart.

1. Introduction	1
1.1 Food, sustainability, and a pressing global challenge	2
1.2 From global challenge to everyday practice: food access and judgement in contemporary eating	3
1.3 Research focus and analytical framework	4
1.4 Scholarly and social contributions	5
1.5 Organization of the dissertation	6
2. How might the spread of online meal-delivery services impact achievement of the SDGs?	7
Abstract	8
2.2 Methodology	11
2.2.1 Scope of analysis	11
2.2.2 Search strategy	12
2.2.3 Screening	12
2.2.4 Analysis and coding of literature	13
2.3 Results and discussion	15
2.3.1 Characteristics and thematic focus of the literature	15
2.3.2 Analysis of sustainability impacts	18
2.3.3 Frequently discussed impacts	20
2.3.3.1 Health topics related to SDG 3	20
2.3.3.2 Climate change and clean energy related to SDG 13 and 7	23
2.3.3.3 Waste problems related to SDG 12	25
2.3.3.4 Decent work issues related to SDG 8	26
2.3.3.5 Sustainable communities related to SDG 11	26
2.3.4 Marginally discussed perspectives	27
2.3.5 Missing perspectives	28
2.4 Conclusions	29
2.5 Limitations	30
Abstract	32
3.1 Introduction	33
3.2. Materials and methods	36
3.3 Results	37
3.3.1. Protein sources and meat consumption patterns	37
3.3.2. Plant-based protein sources	39
3.3.3 Fermented and non-fermented seasonings	40
3.3.4. Pickled foods in traditional practices	41
3.3.5. Health-driven and environmentally sustainable cooking methods	41
3.3.6. Seasonal alignment in ingredient selection and culinary practice	42
3.3.7. Salt content and public health considerations	42
3.4. Discussion	43
3.4.1. Bridging culinary heritage and sustainable protein strategies	43
3.4.2. Culinary techniques as health-sustainability intermediaries	45
3.4.3. Seasonality in ingredients and sustainable diets	45
3.4.4. Fermented seasonings as nutritional and ecological substitutes	46
3.4.5. Limitations	47

3.5. Conclusions	47
4. Conclusions	49
4.1 Summary of Chapter 2 and Chapter 3	50
4.2 Connecting food access and everyday cooking	50
4.3 Reframing food sustainability as a relational practice	51
4.4 Future directions and scholarly implications	52
References	54

1. Introduction

1.1 Food, sustainability, and a pressing global challenge

Food occupies a unique and foundational place in the sustainability discourse. It sustains not only human life but also cultural identity, social relationships, and the global economy. Yet the ways food is produced, distributed, and consumed now place immense pressure on the Earth's ecosystems, contributing significantly to climate change, biodiversity loss, and resource depletion (Foley et al., 2011). These environmental disruptions also deepen social and economic inequalities, forming a cycle that undermines both ecological and human well-being. In recent decades, the interdependence between food systems and sustainable development has become one of the major areas of focus in global research and policy (Béné et al., 2019; Moreno-Miranda & Dries, 2022). Food is now viewed not only as a biological necessity but as an integrated system linking environmental, economic, and cultural dimensions. Within this system, environmental integrity, human health, and cultural identity are deeply interconnected.

At the global level, the modern food system stands as a remarkable achievement of technological innovation, yet it has also generated a profound sustainability dilemma. Industrial agriculture, mechanized processing, and international trade have made food more abundant and affordable than at any point in history. However, these achievements have been accompanied by escalating ecological pressures that now threaten planetary boundaries. Agriculture and livestock production together occupy roughly 40% of the world's arable land and account for nearly 70% of all freshwater withdrawn for human use (Fanzo et al., 2021). Moreover, recent analyses reveal that agrifood systems are now responsible for nearly one-third of total anthropogenic greenhouse gas emissions (FAO, 2021). These environmental inefficiencies are compounded by systemic failures on the consumption side of the food system. Food waste represents a striking manifestation of global imbalance. Each year, more than one trillion U.S. dollars' worth of edible food, accounting for approximately one-third of total production, is discarded, contributing to an estimated 8 to 10% of global greenhouse gas emissions and consuming nearly 30% of the world's agricultural land (UN Environment Programme, 2024).

Paradoxically, the modern food system generates both ecological and social contradictions. While vast amounts of food are wasted each year, 783 million people globally face hunger (UN, 2024), and 150 million children under five suffer stunted growth from chronic malnutrition (WHO, 2025). Despite a decline in relative undernourishment, 673 million people remained hungry in 2024, even as adult obesity rose from 12.1% in 2012 to 15.8% in 2022 (FAO, 2025a). This coexistence of excess and deprivation reveals deep structural inequities in access, distribution, and diet quality — proving that sustainability challenges are not just about production efficiency, but rooted in social and economic systems that drive both overconsumption and hunger.

At this juncture, the global food system stands at a crossroads. On one side lies a century of technological achievement that has dramatically expanded supply and reduced hunger; on the other lies an intensifying convergence of ecological degradation, health disparities, and social fragmentation. Addressing these tensions requires greater attention not only to production processes but also to the everyday realities of food consumption—including how food is accessed, eaten, shared, and given meaning in daily life.

In everyday contexts, these realities are shaped by broader social and temporal

constraints. Combined with increasing time constraints and the rise of dual-income households, these changes have contributed to a decline in opportunities for home-based cooking and a growing reliance on packaged and ready-to-eat foods (Jabs & Devine, 2006). As access to ready-to-eat food becomes increasingly efficient, the cultural practices and embodied knowledge involved in cooking and dietary judgment do not necessarily develop at the same pace. This dissertation therefore investigates how sustainability-related tensions emerge within ordinary eating practices, focusing on how shifts in food access interact with everyday judgments about how food is selected, prepared, and valued, and how these dynamics shape the possibilities for maintaining sustainable diets.

1.2 From global challenge to everyday practice: food access and judgement in contemporary eating

In response to such contradictions, the international community has positioned food transformation as integral to the United Nations Sustainable Development Goals (SDGs). As the FAO notes, sustainable agrifood systems represent the foundation of the 2030 Agenda, linking economic development with social equity and environmental protection. Because of their integrative nature, transformations in these systems influence all seventeen Sustainable Development Goals and determine the extent to which they can be achieved (FAO, 2025b). How societies eat and manage food resources will therefore decisively shape the achievement of sustainability targets. Earlier sustainability efforts concentrated mainly on increasing agricultural productivity and efficiency (World Bank Group, 2022), but the debate has gradually expanded to encompass consumption and dietary behavior. This shift reflects the recognition that people's eating habits, together with the ways they prepare, share, and dispose of food, profoundly affect both ecosystems and human health. Defined jointly by FAO and the WHO, sustainable healthy diets are "dietary patterns that promote all dimensions of individuals' health and well-being; have low environmental pressure and impact; are accessible, affordable, safe, and equitable; and are culturally acceptable" (FAO and WHO, 2019). Empirical evidence shows that shifting diets toward more plant-based or flexitarian patterns, together with reducing food loss and waste, can substantially lower greenhouse gas emissions and other environmental impacts of the global food system (Springmann et al., 2018). Yet such transitions cannot be realized through rational persuasion or regulation alone, because food practices are embedded in emotion, memory, and identity.

Sustainability encompasses not only technological and policy dimensions but also cultural and behavioral ones. Food practices, in particular, embody these dimensions: eating is a way we connect with others, and cooking is an act of care and creativity. Shifting to sustainable food systems means changing not only how food is produced and distributed but also how we think about and relate to food in our daily lives. According to Johnston et al. (2014), sustainable diets are shaped by social-cultural factors such as cultural norms, consumer knowledge and skills, and thus one promising pathway of change is through social learning processes in which environmental awareness becomes linked with everyday food practices. To truly understand food sustainability, we need to look beyond statistics and consider the daily choices and behaviors of individuals.

Urbanization, globalization, and technological innovation have drastically reshaped those decisions. The majority of the world's population now lives in cities, where food access is

increasingly mediated by retail networks such as supermarkets, convenience stores, and fast-food chains that have expanded globally, standardizing flavors and normalizing ready-to-eat consumption. While these developments bring convenience and diversity, they also accelerate resource use and erode local food traditions.

This transformation operates across economic, temporal, and cultural dimensions. Food is now designed for speed—quick preparation, minimal engagement, and constant availability. Earlier technologies such as refrigeration, microwaves, and frozen meals marked milestones in this pursuit of efficiency. In the digital era, online platforms extend this logic, integrating selection, ordering, and delivery into seamless digital processes. The COVID-19 pandemic accelerated this shift, embedding online meal-delivery services into everyday life worldwide. Yet, while such innovations improve accessibility, they also produce new environmental and ethical challenges—ranging from packaging waste to the carbon intensity of rapid-delivery logistics (Iimuro & Tabata, 2024). Moreover, modern technologies are reshaping how cooking is practiced and understood. As machines, apps, or delivery services take on tasks that were once part of meal preparation, opportunities for engaging with cooking skills and shared food-related routines may become less frequent in everyday life.

In response to these disruptions, counter-movements have arisen to reclaim food as a source of ecological awareness and cultural belonging. Initiatives such as “Slow Food,” (Slow Food, 2025) and “Farm to Fork,” (European Commission, 2025) advocate food systems that are high-quality, environmentally responsible and socially just, emphasising cultural diversity, fair livelihoods and healthy, sustainable diets. The recognition by UNESCO of culinary practices as intangible cultural heritage highlights how traditional foodways support social identity and cultural continuity, and as noted by UNESCO, many such practices also “promote a varied diet that respects ecosystems and maintains genetic biodiversity (Bessière, 2013; UNESCO, 2025). These developments suggest that the challenge for sustainable eating lies in how efficiency-oriented food systems are integrated into everyday practices and food-related judgment.

Although sustainability research has increasingly called for broader perspectives on food systems, scholarly attention remains uneven. Most studies continue to prioritize production-oriented metrics such as carbon footprints, yield efficiency, or trade flows, while giving limited attention to the cultural and communicative dimensions of eating. This neglect restricts understanding of how sustainability is interpreted and practiced in everyday contexts. Food systems are not only physical infrastructures but also social and cultural systems through which values of health, responsibility, and pleasure are negotiated. They are mediated through diverse channels—television, advertising, recipe media, and digital platforms—that shape collective perceptions of what counts as “sustainable” or “desirable” food.

1.3 Research focus and analytical framework

This recognition forms the conceptual foundation of the present research. Food sustainability is shaped by everyday practices through which food is accessed, prepared, and valued, as well as by the technological systems that organize these practices. Contemporary food environments compel individuals to navigate constant trade-offs between efficiency and meaning, innovation and memory. Understanding how these tensions unfold in everyday life offers critical insight into whether global sustainability goals can translate into practical

realities. Accordingly, this dissertation proceeds from the awareness that food mirrors the broader sustainability paradox: while technological innovation promises solutions, it also deepens dependence on external systems; while cultural traditions offer moral guidance, they risk idealization. The central question motivating this study is how individuals and societies negotiate these competing logics—how they balance convenience with conscience, speed with care, and progress with preservation.

Building upon these insights, this dissertation investigates two pivotal dimensions of contemporary food systems: efficiency-oriented forms of food access and everyday cooking practices. Rather than treating sustainability as located in a single domain, the study brings together analyses of food acquisition and food preparation to clarify how sustainability-related tensions are negotiated across different sites of everyday eating.

For this purpose, the dissertation combines a global review of research on online meal-delivery services with a practice-based analysis of home cooking. Although the analysis draws on empirical materials from Japan, its primary aim is not to characterize a national dietary pattern but to develop an analytical approach to home cooking as a practice through which food-related judgment, cultural knowledge, and sustainability concerns are enacted. The structure of the dissertation and the relationship between the two studies are summarized in Table 1.1

Table 1.1 Overview of the two studies examined in this dissertation

Analytical Dimension	Study 1: Online meal delivery services (Chapter 2)	Study 2: Home cooking practices (Chapter 3)
Primary research object	Online meal delivery services	Home cooking practices
Position in food system	Food access and consumption mediated by digital platforms	Domestic food preparation
Geographical scope	Global	Empirical materials from Japan
Empirical materials	Peer-reviewed international research literature	Recipes from NHK Today's Cooking
Methodological approach	Systematic literature review	Dish-level analysis
Temporal scope	Contemporary and rapidly expanding phenomenon	Longitudinal archive
Analytical focus	Sustainability implications of digitally mediated food access	Sustainability as enacted through everyday cooking practices
Role in overall argument	Illuminates challenges associated with efficiency-oriented food access	Reveals the role of cultural knowledge and practice in sustaining food-related values

1.4 Scholarly and social contributions

The dissertation's contributions are both scholarly and practical. Academically, it broadens the field of sustainability studies by bringing cultural, media, and practice-based perspectives into discussions traditionally dominated by environmental science and policy. It also introduces the dish-level method as a new analytical framework for examining how sustainability is embodied in domestic cooking and media representation.

Socially, the findings indicate that sustainable transformation involves aligning innovation with cultural continuity, with everyday cooking practices serving as important sites

for cultivating habits that reconcile convenience and tradition; policymakers and educators can therefore draw on cultural knowledge and media to design interventions that are both effective and culturally resonant.

Finally, the dissertation offers a reflexive contribution to scholarship itself. By combining a systematic review with a practice-based cultural analysis, the study shows how understandings of sustainability are shaped through both lived experience and scholarly interpretation. This methodological diversity reflects an effort to connect global patterns with local realities, and quantitative analysis with qualitative insight, paralleling the very tensions that sustainability seeks to resolve.

1.5 Organization of the dissertation

Chapter 1 has outlined the research background, conceptual framework, academic significance, and contributions of this study. Chapter 2 presents the first investigation, “How might the spread of online meal delivery services impact achievement of the SDGs?”, synthesizing current scholarship on digital food systems and their sustainability implications. Chapter 3 then turns to “Traditional wisdom for modern sustainability: A dish-level analysis of Japanese home cooking in NHK Today’s Cooking”, exploring how traditional culinary sensibilities such as balance and seasonality are expressed in everyday cooking as forms of sustainability. Chapter 4 concludes by bringing together insights from both studies to discuss their implications for sustainability research and practice, focusing on how changes in food access and everyday cooking practices shape the ways sustainability is understood and negotiated in daily eating..

2. How might the spread of online meal-delivery services impact achievement of the SDGs?

Abstract

The development of the online meal-delivery industry is a double-edged sword, with potential to both hamper and drive progress towards achievement of the Sustainable Development Goals (SDGs). Yet most studies examining this industry have been conducted from the narrow perspective of specific academic fields, focusing on single issues or on individual cases. In this paper, by drawing upon the thematic foci of the SDGs as an analytical framework, we conducted a systematic and objective review to assess consequences of the online meal-delivery's development for sustainable development. After selecting and reviewing 128 peer-reviewed articles identified on Web of Science, we systematically coded their contents, and examined key trends along with knowledge gaps. The review shows that direct consequences for the SDGs—for instance, human health, plastic waste, carbon emissions, and labor conditions—have been thoroughly discussed. Conversely, we found a lack of attention to other indirect but important consequences, including impacts on poverty, hunger, education, and gender equality, which are yet to be thoroughly investigated. Particularly, our findings point to a need for more knowledge on how the industry is impacting food access in light of the “digital divide” between IT-literate consumers and those possessing less familiarity with digital technologies, how employment opportunities contribute to poverty alleviation or exacerbation of class gaps, and how the meal-delivery industry can contribute to achieving zero hunger by increasing food access to vulnerable populations. Our findings generate important insights to guide the formulation of more targeted countermeasures to address issues that risk hindering achievement of sustainable development.

2.1 Introduction

With the increasing popularity, development and diffusion of the Internet, smartphones and digital payments, the online meal-delivery market is rapidly expanding worldwide. Online meal-delivery is the process of ordering ready-to-eat meals from a commercial entity, typically via an application on an Internet-connected device. The COVID-19 pandemic has considerably accelerated the use of meal-delivery services, since restaurants in many countries were forced to suspend dine-in services and were only allowed to operate via meal-delivery, or other contactless distribution methods (Meena and Kumar, 2022). Consequently, many restaurants have shifted their focus to meal-delivery, which has since become the key driver for their sales and revenue growth (Chotigo and Kadono, 2021). In 2026, the global revenue of this market is expected to reach US \$474.3 billion, with the number of online meal-delivery users reaching 2.69 billion (Statista, 2022).

The rise and popularity of digital meal-delivery services marks a fundamental change in our “food environment”, referring to the interlinked physical, economic, political and social conditions shaping the production and consumption of food (Horta et al., 2020). Contemporary food environments have already experienced major changes due to globalization, urbanization, and rising incomes (WHO European Office, 2021a). Yet digital technologies, such as mobile terminal technologies and the spread of wireless internet infrastructure, are propelling these transformations further, complicating an already complex system that influences food-related behaviors and eating practices (Fernandez and Raine, 2021; WHO European Office, 2021a). The emergence of digital food-consumption practices, of which apps and meal-delivery are core components, is one of the hallmarks of this transformation, providing both opportunities and barriers to efforts to promote healthy eating and sustainable development.

Indeed, on September 23, 2021, the United Nations (UN) Food Systems Summit was held during the General Assembly in New York. Declaring that “Changing food systems is not only possible but necessary, for our planet, for people, for prosperity”, this summit set a transformative agenda for food production and consumption, linking this shared global challenge to efforts to achieve the Sustainable Development Goals (SDGs) by 2030. This call for action builds on the multiple references to food systems in the SDGs. For instance, SDG 2 advocates for sustainable agriculture and the proper functioning of food commodity markets, while SDG 3 states a need to promote access to adequate nutrition to contribute to disease prevention, good health, and cognitive development (United Nations, 2021). Furthermore, the production and consumption of food directly impact poverty (SDG 1), climate change (SDG 13) and biodiversity (SDG 15), and are also strongly relevant for education (SDG 4), gender quality (SDG 5), and decent work (SDG 8). Food systems are even considered as one of the entry points or key transitions that can have catalytic and multiplier effects across the SDGs (see UN Sustainable Development Group, 2023).

Conversely, the environmental and societal externalities of industrial food systems — including greenhouse gas (GHG) emissions, deforestation, destruction of biodiversity, waste, use of dangerous chemicals and societal harms — all hamper progress towards these goals (Dekker et al., 2020). While many of these externalities are associated with food production, consumption behavior is an equally critical driver of the sustainability of food system (see Polzin et al., 2023). Indeed, dietary choices, such as plant-based or animal-based diets, and

purchasing habits, such as seasonality and local sourcing, are crucial in shaping greenhouse gas emissions, land use and biodiversity impacts, often in locations far away from consumption activity (see Springmann et al., 2018). Additionally, rising incomes, population growth, and increasingly diverse food purchasing channels contribute to increased food waste, particularly in developing countries (see Barrera and Hertel, 2021). This growing issue of food waste, alongside persistent global hunger, poses a significant social challenge. Furthermore, excessive purchases of high calorie foods have been linked to problems such as obesity, diabetes, and impaired mental health (see Barrera and Hertel, 2023). And since many environmental and societal impacts are interlinked, both food production and consumption influence multiple SDGs in both positive and negative ways (see Kennedy et al., 2020).

Online meal-delivery services are an important driving force for this transformation, exerting considerable impacts in terms of food access, innovation, job creation, economic livelihoods, etc. Furthermore, since such impacts can be both positive and negative (Li et al., 2020), the development of online meal-delivery services can either hinder or drive progress towards SDGs. Thus, there is a pressing need to deepen our understanding of the various impacts caused by the spread of online meal-delivery services so that this digital transformation of our food system can become a critical driving force to achieve the SDGs by 2030.

Following the accelerating uptake of online meal-delivery services around the world, associated research has rapidly accumulated. However, it suffers from multiple limitations. First, interdisciplinary and holistic discussions are lacking, since a considerable number of studies have been conducted from the narrow perspective of specific academic fields, be they nutrition and dietetics (Zhao et al., 2021), public, environmental and occupational health (Keeble et al., 2021), or business and economics (Umer et al., 2021). Second, numerous studies have highlighted several problems that are accompanying the digitally driven spread of meal-delivery services. These include discussion of whether the food offerings on meal-delivery apps are healthy or not (Brar and Minaker, 2021), environmental impacts such as plastic waste generation, food waste, and carbon emissions (Liu, 2020; Zhang et al., 2022), and working conditions for delivery riders (Abilio et al., 2021). Yet these analyses are typically focused on single issues or on individual case studies. Conversely, there is a lack of studies that identify common issues running across a large number of cases around the world. Although a cross-cutting perspective by Jia and colleagues (2022) raises concerns that the rapid increase of meal delivery apps has potential to hamper progress towards many SDGs, the rapidly accumulating evidence of diverse sustainability impacts in the scientific literature has yet to be comprehensively and systematically assessed. Similarly, another study by Li et al. (2020) identifies overarching issues cutting across several geographies and academic fields. However, the focus on grey literature similarly leaves unexamined the rapidly accumulating scientific literature discussing online meal-delivery impacts.

To address these gaps, we carried out a literature review to systematically investigate the manifold impacts of online meal-delivery services on sustainable development through the lens of the 17 SDGs. Our research proceeds from the following question: What types of impacts with relevance for sustainability are discussed in the literature on meal-delivery services, and how might they affect achievement of the SDGs?

To answer this question, we systematically searched for academic papers on Web of

Science, identifying 128 papers published since 2014 that we examine herein. We employed a mapping review approach, drawing on established methodologies (James et al., 2016; Granheim et al., 2021; Trencher et al., 2023) to systematically code the contents of these studies, and subsequently examine key trends using visualizations of both quantitative and qualitative evidence.

This study's novelty and contribution to the literature are at least three-fold. Firstly, by integrating the experiences of numerous and diverse meal-delivery initiatives across the world, this study provides the most comprehensive view to date of diverse impacts and their implications for sustainable development. Second, the SDGs provides an ideal framework to objectively identify multiple issues undermining the sustainability of the digital meal delivery industry. Additionally, the multi-faceted perspective is also suited to discussing interlinkages and tradeoffs across impacts as well as potential positive contributions to sustainable development. Third, by systematically identifying commonly discussed themes in the literature as well as underrepresented or yet to be researched areas, our analysis identifies several promising avenues for carrying out future research.

2.2 Methodology

2.2.1 Scope of analysis

When using "meal-delivery" or "food-delivery" in the subsequent discussions, we refer to a service in which the general public uses an app or website from a mobile device like a smart phone, tablet or computer to order ready-to-eat meals from restaurants or independent meal-delivery companies, which are then delivered to the consumers by delivery riders (Fig. 2.1). In previous scholarly work, many studies on meal-delivery used the item "food delivery" (Zhao et al., 2021; Sharma et al., 2021; Keeble et al., 2021). However, the word "food" includes ready-to-eat meals along with specific ingredients and foods, such as vegetables, meat and organic food. In this study, we exclude such applications and limit the scope of our analysis to the delivery of ready-to-eat meals prepared by restaurants and commercial kitchens. Meanwhile, we use the term "meal-delivery" when referring to ready-to-eat meals, and "food" when pointing to edible substances more broadly.



Fig. 2.1 A simplified representation of the app-based meal-delivery process based on WHO (2021b)

2.2.2 Search strategy

To identify relevant publications, we used Web of Science, the world's most authoritative and widely used database of academic research (Birkle et al., 2020), carrying out the search on March 31, 2022. The search string was as follows: (food-delivery OR meal-delivery) AND (sustainable OR sustainability OR SDG* OR Agenda 2030 OR environment* OR societ* OR social OR econom*) AND (Year Published: 2000-2022) AND (Language: English) AND (Document Type: Article OR Review).

Our search extracted articles or reviews in English that contained “meal-delivery” or “food-delivery” in the article title, keywords or abstract. To locate publications engaging with perspectives relevant to the SDGs, the search string included “sustainable”, “sustainability”, “SDGs”, and “Agenda 2030”. However, few papers to date have explicitly discussed the connection between the development of meal-delivery and the achievement of the SDGs. To overcome this limitation and identify papers from a broader set of literature that nonetheless discusses varied impacts from the development of the meal-delivery industry on society, the environment, and the economy, we expanded the search scope to include these keywords. Finally, we limited the publication year to 2000 for the reason that online meal-delivery is a relatively young industry, recognizing that some of the first companies in continental Europe were founded in 2000 and 2001 (WHO European Office, 2021b).

Recognizing that many scholars use Scopus for literature reviews, we validated the soundness of our decision to only use Web of Science by performing a test on Scopus using the same search settings outlined above. The above search procedure yielded 350 and 295 hits respectively. Upon comparing the two datasets, we found that Web of Science provided a more comprehensive set of results, including all those available in Scopus. Consequently, we proceeded with the Web of Science results for our further analysis.

2.2.3 Screening

We then used a procedure summarized in Figure 2.2 to identify a sample of relevant papers for the review. First, we used the Web of Science field classification settings to exclude those found to discuss meal-delivery from perspectives unsuited to the focus of our study. These included the life sciences such as zoology and neurology, chemistry and oceanography, amongst which irrelevant discussions included animal fodder deliveries and medical experiments, for instance. Second, we then checked the abstracts of the excluded 150 papers. After finding that two had a suitable focus, we subsequently added these to our sample. Third, we then screened the titles and abstracts of the resulting 202 papers for eligibility, omitting those that did not explicitly mention the act of ordering ready-to-eat meals among the general public. This resulted in the elimination of 74 papers. These included those focused on specific users (e.g., children, the elderly, the homeless, etc.) and deliveries of food ingredients rather than ready-to-eat meals. This reduced the sample to 128 publications that were then subjected to a full-text reading. Of these, we found 50 papers that explicitly discussed sustainability-related impacts in the online meal-delivery industry. We subjected these papers to our coding analysis of which the results appear in Table 1 and Figure 7. The remaining 78 publications, although not explicitly discussing sustainability impacts, still provided us with important insights into the nature of the industry's development along with its various consequences. For example, many of these papers explore the demographics and

behavior of consumers, barriers to usage, service failures, and so forth. Because such discussions still allow us to infer indirect or secondary connections between meal-delivery and the SDGs, we included these papers in the corpus of literature (see Supplementary material 1) upon which we now perform our review.

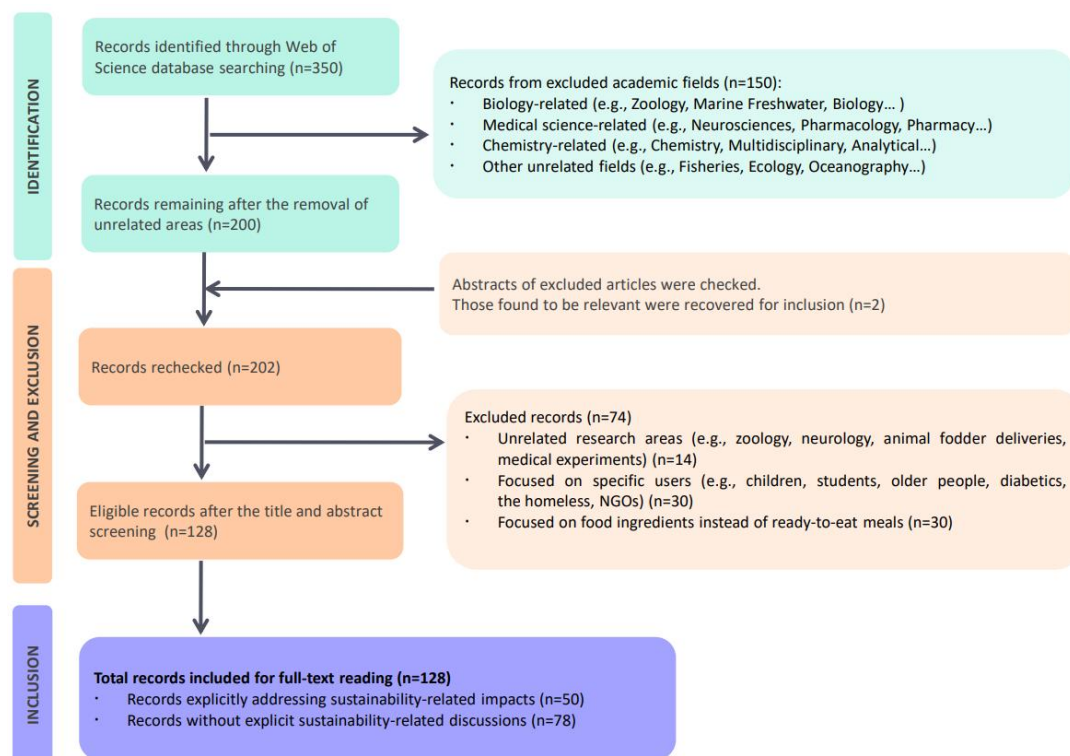


Fig. 2.2 Flowchart showing the systematic process for selecting relevant studies

2.2.4 Analysis and coding of literature

As shown in Fig. 2.3, we analyzed the corpus of 128 papers from both a macro, meso and then micro perspective. The macro-level analysis aimed to objectively identify overall thematic trends by creating quantitative descriptions of the dataset. As a first step, we used text mining to identify the most commonly discussed keywords and concepts across the entire dataset. As a second step from a meso perspective, we built visualizations of the thematic foci of individual papers after coding their contents according to variables described in Supplementary Material 2 (Table S1). Finally, in a third step carried out at the micro-level, we aimed to deepen qualitative understanding of the literature by discussing the main themes identified from the macro-level analysis and then identifying knowledge gaps. This discussion was organized into three sections: frequently discussed impacts, seldomly discussed perspectives, and missing perspectives.

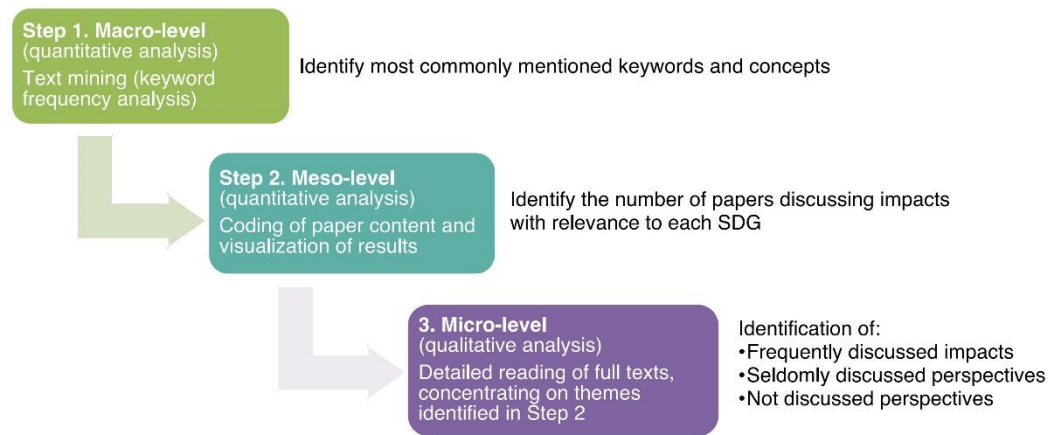


Fig. 2.3. Research design and methods used for analysis

For step one, when implementing the text-mining procedure, we built a list of ten keywords for each SDG (Supplementary Material 2 Table S2). We started by selecting up to five of the most frequently used keywords from each SDG’s description within the document *Transforming our world: the 2030 Agenda for Sustainable Development* (United Nations, 2015). We then selected the remaining keywords to arrive at a total of ten by examining the most commonly used concepts and keywords on the official UN-SDG website and *The Sustainable Development Goals Report 2023* (see United Nations, 2023). We utilized KH coder, an open-source software for text mining, to calculate the frequency of keyword appearances in the aforementioned documents. Keywords were lemmatized to the root term to identify all related words. For instance, “transport*” captures mentions of “transport” “transportation” and “transported”. Subsequently, we contracted a data service firm to count the occurrence of the keywords in the full texts of all articles in our corpus, using the keyword lists for each SDG we provided. We then created visualizations to show the frequency of all keywords appearing 100 or more times in the corpus. The results allowed us to identify key issues or goals most mentioned in our corpus.

The coding analysis conducted in the second step addresses the limitation of the text-mining method used in the first step, which cannot capture the context in which particular keywords are used. During the coding process, we systematically examined each article that referenced SDG-related keywords to assess the extent to which the issues were mentioned or addressed. Specifically, we categorized mentions sustainability related impacts represented a primary focus, a minor focus, or a passing mention. To ensure accuracy, we only coded a paper as discussing a particular SDG if an explicit mention was made about a relevant societal or environmental impact in the online meal-delivery industry or if a strong correlation was observed. For instance when keywords such as “school” and “education”—closely associated with SDG 4—were identified, we inferred the paper’s relevance to SDG 4 only if these words were used to discuss connections between education and the meal-delivery industry. Conversely, if the paper merely presented statistical data on meal-delivery workers’ educational background as part of a statistical analysis without providing deeper discussions from the perspective of SDG 4, we did not categorize it under that goal. Additionally, we incorporated variables such as publication year, country of investigation, and field of

publication, utilizing data from the Web of Science database.

In the final step, we read the papers in full to build a more detailed and qualitative picture of the nature of discussions about various impacts of the online meal-delivery industry. Using the results of the coding analysis, we focused our qualitative discussion on the most frequently discussed impacts and topics, while also identifying seldomly discussed or undiscussed topics.

2.3 Results and discussion

2.3.1 Characteristics and thematic focus of the literature

As shown in Fig. 2.4, the bulk of studies has emerged since 2019, indicating a rapid growth of scholarly interest in the development of the meal-delivery industry along with its various impacts. This surge of scholarly interest points to the timeliness of this review of key discussions in this field. Moreover, among the 128 papers, 43 mentioned COVID-19, thus testifying to the pandemic's driving influence on the sudden expansion of the industry.

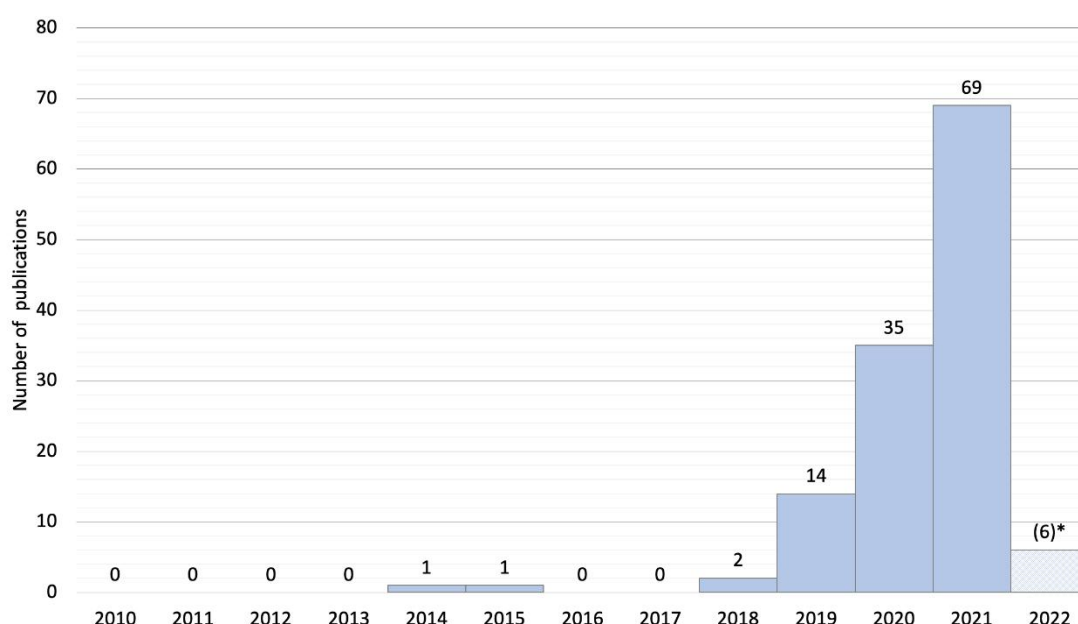


Fig. 2.4 Publication years of the corpus (n=128)

Note: Data for 2022 is limited to January 1st to March 31th.

The research to date has predominantly concentrated on activities in Asian countries, such as China and South Korea (Fig. 2.5). In particular, studies on China dominate the literature, making up 24% of publications. This can largely be explained by the rapid growth of the market in this country. Western countries have also received attention in the literature, notably English-speaking countries such as the USA, Australia and the UK along with Italy and other European nations. The studies on the global north mostly focus on how digital food ordering affects health and wellness from the perspective of the individual or public health, and whether the users of these applications might become overweight or obese (Partridge et al., 2020; Keeble et al., 2020,2021; Brar and Minaker, 2021). Meanwhile, other researchers

taking interest in developments in these regions have examined issues of how meal-delivery app algorithms work (Belanche et al., 2020; Ahn and Kwon, 2021; van Doorn and Chen, 2021) and the logistical patterns that lead to a more profitable meal-delivery business (Steever et al., 2019; Niu et al., 2021).

Conversely, our results also show an absence of articles focused on Africa within the corpus. Although the online meal-delivery market in Africa is still in its infancy, it is expected to grow and diversify in the coming years due to rapidly increasing urban populations and the rising demand for convenient and quick meal options. Indeed, online meal-delivery services have already begun to penetrate into some countries on the continent. For instance, Uber Eats operates in Kenya and South Africa (see Uber Technologies Inc., 2024a, 2024b) and Jumia Food in Algeria, Côte d'Ivoire, Kenya, Morocco, Nigeria, Tunisia, Ghana, Senegal, Egypt, Kenya and Uganda (see Jumia, 2024). However, although this emergence of the meal-delivery industry in the African context is discussed in the scholarship (see Bannor and Amponsah, 2024), the corpus contains no explicit discussions about issues affecting Africa from an SDG perspective.

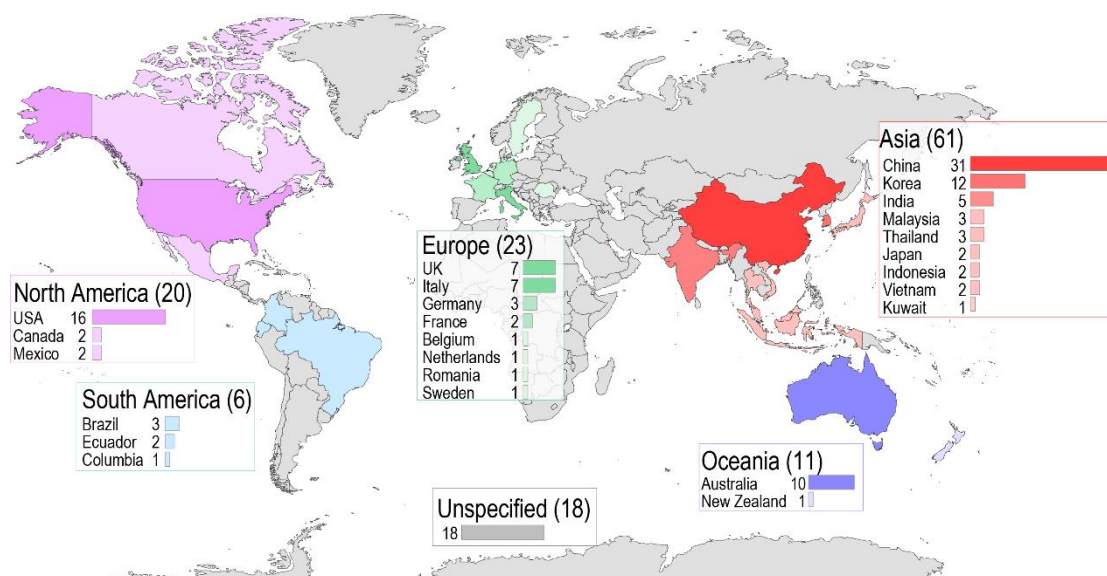


Fig. 2.5 Investigation areas of the literature (n=128)

Note: Some studies discussing multiple countries appear in the results of multiple regions.

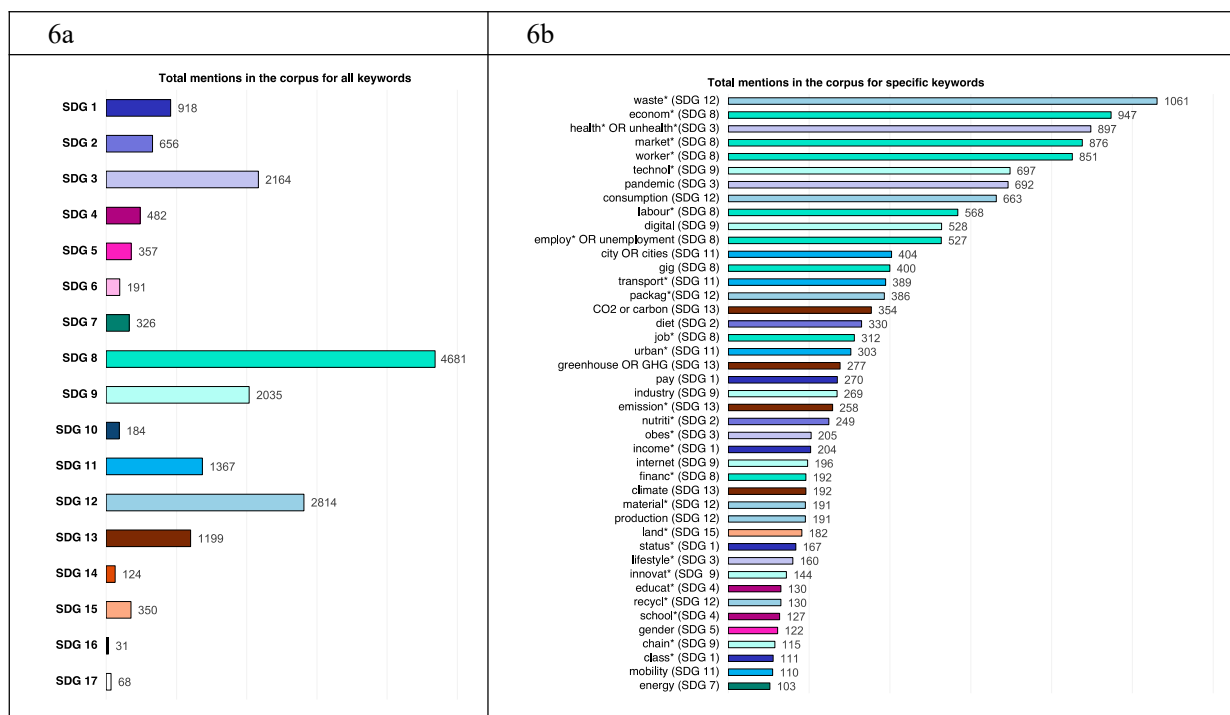


Fig. 2.6 Frequency of SDG-related words in the corpus

(6a) Width of bars and numbers show the total mentions for all 10 keywords used for each SDG (Supplementary Material Table S2). (6b) Width of bars and numbers show the frequency of all keywords appearing 100 or more times in the corpus.

The results of the text mining analysis (Fig. 2.6) indicate strong attention to SDGs 8, 12, 3 and 9. In terms of specific keywords, discussions relevant to SDG 8 frequently involve references to the economy, markets, jobs, workers, employment conditions, the nature of gig work, and financial aspects. Investigations evoking sustainability aspects pertinent to SDG 12 mainly refer to waste, packaging and consumption behavior. Dimensions relevant to SDG 3 are also frequently mentioned, namely health, the pandemic, obesity and lifestyles. Mentions of the technology-based nature of the meal-delivery industry and its structural characteristics hold relevance to SDG 9, chiefly comprising of keywords such as digital, internet, innovation and supply chains. The text mining results also show frequent mention of carbon and CO2 emissions, highlighting consideration of impacts relevant to climate change and SDG 13. Conversely, our results reveal a relatively lower frequency of keywords of relevance to SDGs 6, 10, 14, 16, and 17. This indicates that the literature has paid less attention to impacts and issues that pertain to freshwater and marine resources and eco-systems, social and economic inequalities, peace and justice, and capacity-building, partnerships, or international cooperation.

While this macro-level analysis identifies key areas where the corpus of literature has discussed sustainability dimensions in the online meal-delivery industry, the text-mining analysis is unable to quantify the number of publications that have engaged with each theme or the extent of this engagement. We thus address this objective in the following section.

2.3.2 Analysis of sustainability impacts

We read the full texts of the entire sample of relevant publications (n=128) with the goal of extracting discussions on how online meal-delivery services might impact the achievements of the SDGs.

Table 2.1 compiles the particular SDGs given attention in the papers that explicitly discuss sustainability impacts along with the academic field of the paper, following the categories suggested by Web of Science.

With respect to academic disciplines, we found that most papers fall in the fields of environmental science, nutrition, and engineering. Results also indicate that the type of academic field significantly influences the nature of the discussions about meal-delivery. For example, scholars from the fields of environmental sciences and engineering along with science and technology tend to evoke environmental issues like plastic waste, climate problem or road congestion. These discussions are strongly interrelated with SDG 12 and 13. Publications from disciplines such as nutrition, environmental and occupational health are generally more attentive to health-related issues, which concern SDG 3. Meanwhile, publications from business and economics, and policy or law related fields tend to discuss social issues, such as women in gig work, worker demographics and labor conditions, and employment protection as well as difficulties in ordering meals online among older adults. Finally, papers dealing with the topics of sustainable cities and communities (SDG 11) are usually found in the fields related to geography, transportation, and so on. This analysis also demonstrates SDG related discussions that are yet to find traction in the literature. For instance, across all fields, there is a noticeable lack of engagement with SDG 1, 2, 4, 6, 10, 16 and 17. This suggests that the correlation between online meal-delivery and ending poverty and hunger, quality education, etc., have not been fully cognized yet.

Table 2.1 SDGs emphasized in each academic field

	SDGs																Number
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17 of papers
Environmental Sciences & Ecology			5				2	3			1	7	11	1	1		17
Nutrition & Dietetics			10		1			2	1			1	1				10
Engineering			1								3	5	6				9
Science & Technology			1				2	1				4	5				7
Business & Economics			1		1		1	4	1		1		2				7
Public, Environmental & Occupational Health			4														4
Geography			2					1			2						3
Psychology			1									1	1				2
Urban Studies			1								2		1				2
Transportation			1								2		1				2
Sociology			1					1				1	1				2
Social Sciences			1		1			1					1				2
Government & Law								2									2
Energy & Fuels												1	1				2
Toxicology			1									1		1	1		1
Thermodynamics													1				1
Telecommunications			1									1					1
Public Administration											1						1
Food Science & Technology												1	1				1
Construction & Building Technology												1					1
Computer Science			1										1				1

Note: This table compiles coding results for all papers explicitly discussing impacts with relevance to the SDGs. There are 26 papers with relevance to one goal, 15 papers to 2 goals, 6 papers to 3 goals, and 3 papers to 4 goals. One paper may be classified into more than one research field.

Figure 2.7 compiles the results for the analysis of SDG-related impacts discussed in the coded publications. If a relevant perspective of the SDGs appeared in parts of the findings or conclusion, we considered it as main context of the paper. On the other hand, if it appeared elsewhere, we coded it as “minor context”.

Based on these results, we organize the remainder of our results into three sections. The first section summarizes the state of debates about frequently discussed topics, namely SDGs 3, 8, 11, 12 and 13. In the second section, we summarize the state of discussions appearing less frequently in the literature, then identifying opportunities for further research. Finally, in the third section, we identify topics which, although highly relevant for the sustainability of meal-delivery, are conspicuously missing from the literature (SDGs 1, 2, 4).

It should be noted that when making claims about different kinds of sustainability impacts caused by the meal-delivery industry, we were often confronted with a lack of comprehensive or rigorous evidence in the reviewed publications. We thus supplemented the corpus by integrating knowledge gained from our own research with additional documents

(both grey and academic) from outside the sample. These documents are marked with “see” inside the citation bracket.

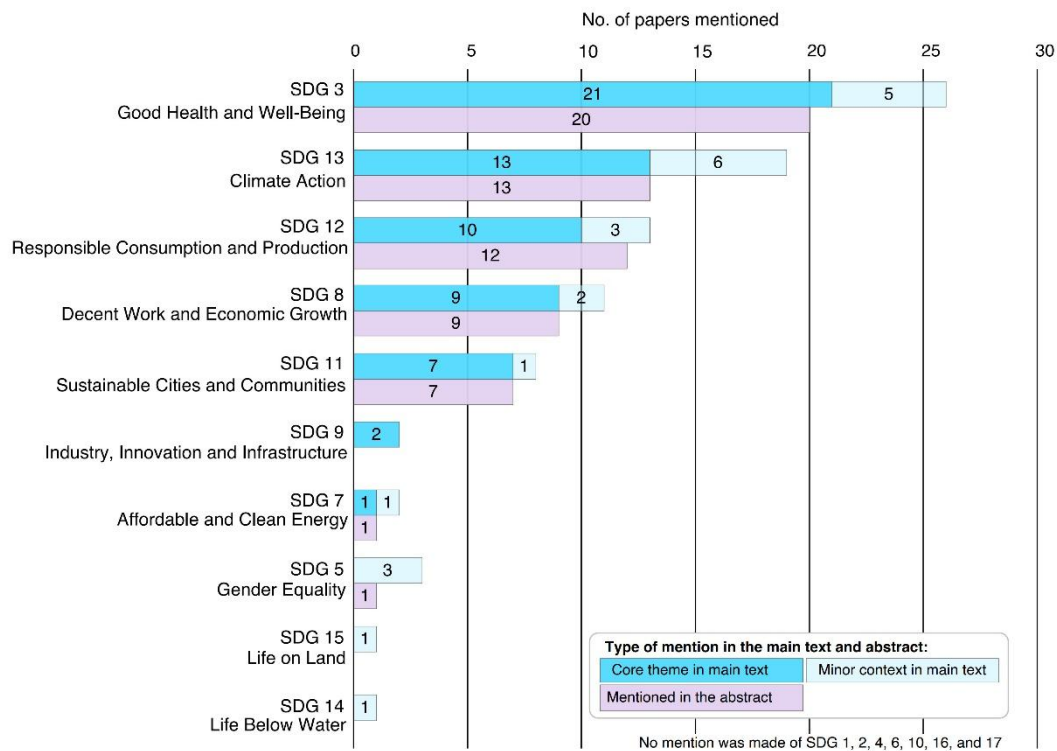


Fig. 2.7 Number of papers discussing meal-delivery impacts with relevance for SDGs

Note: This figure compiles coding results for all papers explicitly discussing impacts with relevance to the SDGs. There are 26 papers with relevance to one goal, 15 papers to 2 goals, 6 papers to 3 goals, and 3 papers to 4 goals. No mention was made of goals 1, 2, 4, 6, 10, 16, and 17.

2.3.3 Frequently discussed impacts

2.3.3.1 Health topics related to SDG 3

Topics with relevance to SDG 3 were by the far the most frequently discussed in the literature, discussed in 26 of the 50 papers. As shown in Table 2.2 below, the health issues triggered by meal delivery are mainly those related to users (discussed by 19 papers), with discussions about delivery riders mentioned in 7 papers.

In the sections below we unpack the details of these discussions.

Table 2.2 Topics related to SDG 3

No. of publications		No. of publications	
For users	19	For riders	7
Unhealthy diets associated with obesity	12	Traffic accidents	4
Promotion of sedentary lifestyle	2	Risk of infection with COVID-19	2
Effective regulation of ghost kitchens	2	Irregular eating pattern	1
Reduced communication with others when dining alone	2		
Higher risk of emotional overeating	1		
Risk of ingesting harmful chemicals from meal-delivery containers	1		

The negative consequences of unhealthy meal-delivery options for public health are highlighted by several studies, with particular attention given to increased obesity risks. Research has shown that the popularity of meal-delivery services has expanded the obesogenic nature of the contemporary food environment (Fernandez and Raine, 2021; Keeble et al., 2021; Maimaiti et al., 2018). Indeed, most of the food provided through delivery services contains more fat, salt, and calories than when home-cooked (Keeble et al., 2021). Although many restaurants also sell salads and other healthy menu options, the overwhelming majority of popular foods are still those seems unhealthy (Fernandez and Raine, 2021).

However, risks of increased obesity not only stem from the nature of delivered meals themselves, but also from consumption habits. Following the rapid growth of the meal-delivery industry, many platforms have leveraged marketing strategies such as low delivery prices and various discounts to promote sales. A study by Zhang et al. (2022) highlights the potential health consequences of this trend, finding that more than half of surveyed consumers have admitted a tendency to buy more food than needed in order to meet the delivery starting price or as a means of taking advantage of various discounts.

In addition, several researchers have focused on linkages between plastic containers and health (Wang, XH., et al., 2021; Maimaiti et al., 2020). Since most containers used for delivered food are made of plastic, if leaked into foods and then ingested, the phthalic acid esters (PAEs) contained in these pose potential risks to human health (Wang, XH., et al., 2021). Although PAEs are widely used plasticizers and additives in food packaging, they are also classified as carcinogenic, toxic, and endocrine-disrupting compounds, which have adverse effects on the developmental stage of organisms (see Anne and Paulauskiene, 2021).

Interest in health-related topics is also driven by concerns related to “ghost kitchens” (see Cai et al., 2021; Keeble et al., 2021; Horta et al., 2021). As a part of the restaurant industry’s response to the skyrocketing demand for off-premise dining and delivery by third-party online providers, ghost kitchens have stepped in to meet demand (see Rivera, 2019). Ghost kitchens are also known as “virtual restaurants” or “cloud kitchens”. Such kitchens conduct food operations exclusively for the purpose of delivery, having no dining areas or physical storefronts visible to the general public (see Volpe, 2020). It is this hidden nature of such enterprises that provides scope for minimal hygiene and sanitation regulation. Consequently, in most cases users will place orders from these restaurants without knowing where or how the food is prepared (see WHO European Office, 2021b). Moreover, it is not easy for customers to verify whether ghost kitchens are in compliance with hygiene regulations. Due to the virtual nature of the meal-delivery industry, consumers placing orders cannot view health inspection certifications (e.g. lettered grades) as easily as if visiting a traditional restaurant, where proof of inspection is often displayed in storefronts or dining areas. Although the food safety regulations for ghost kitchens are generally the same as for traditional restaurants, the absence of dine-in spaces and the operational focus on delivery reduces exposure to the public eye, thereby creating barriers to the oversight of food safety practices. In this context, some researchers have raised concerns about the difficulties in regulating such businesses and assuring adherence to hygiene standards (Keeble et al., 2021; Horta et al., 2021).

People’s health can be affected not only by the delivered food itself, but also by the

sedentary lifestyle behaviors brought about by dependence on delivered meals (Partridge et al., 2020). Not only does the convenience of ordering pre-cooked food spare the labor of cooking and dish washing, but such a lifestyle can also decrease physical energy expenditure by keeping the consumer at work or at home and by eliminating the need to go out grocery shopping. For such reasons, several researchers have raised concerns that frequent consumption of delivered meals could further exacerbate sedentary lifestyles, thereby increasing the risk of negative health outcomes (Maimaiti et al., 2018; Li and Wang, 2022).

In addition, some studies (Maimaiti et al., 2018; Fernandez and Raine, 2021) point out that lifestyle changes brought about by increasing consumption of delivered meals might also affect mental health. Concretely, concerns have been raised that growing tendencies for consumers to eat alone can result in reduced opportunities to communicate with others, which can then negatively impact social skills. Since eating a meal can also be a social activity that strengthens individuals' relationships with others (see Cruwys et al., 2015), the significance of this act reaches far beyond the physical nutrition gained from consuming food. Yet eating alone may deprive people of social interactions and enjoyment, which is detrimental to mental health (see Tani et al., 2015). Indeed, studies out of Korea (see Jang et al., 2021) and Japan (see Tani et al., 2015) have shown that eating alone may raise the risk of depression. Such discussions indicate that besides the topic of physical health, future research should also focus on the often more subtle impacts of meal-delivery services on mental health.

Emerging debates in the literature also prompt questions about the kinds of impacts that may arise for other household members when those in charge of daily cooking increase their consumption of delivered meals. Several scholars have investigated the demographics of meal-delivery users, focusing on attributes such as age, gender, education, and so forth. We already know that most users are men, educated, and have children (Keeble et al., 2020; Keeble et al., 2021). These bodies of research also indicate that families with children are more inclined to use meal-delivery services. What impact, then, might this have on family members? For mothers, ordering a meal online instead of cooking can reduce the duration of unpaid housework to some extent. This may be helpful to realize SDG 5, gender equality, in the short term. Yet increasing one's ingestion of delivered food may also bring about negative consequences, especially with respect to the healthy growth of children. Although we did not find any investigations of the relationship between delivered meals and health impacts in other family members in the reviewed publications, the wider literature provides hints about this issue. For instance, some studies (see Ishikawa et al., 2019; Torslev et al., 2021) have discussed how learning to cook together with parents can positively affect a child's development. One benefit highlighted is that children's eating habits improve, resulting in less picky eating or playing with food at the table. The act of "cooking" per se thus has an educational significance and is conducive to improving a child's autonomy (see Torslev et al., 2021). This significance is two-fold: first, learning cooking at home enhances children's understanding of the world around them; second, it equips them with an important skill that will serve them well into adulthood (see Lavelle et al., 2019). Consequently, if children become used to ordering and eating delivered food, they will lose a valuable educational opportunity that could impact on their long-term health and development. Yet addressing such questions poses challenges for academic research, since they necessitate longitudinal observations to fully understand the long-term effects of frequent consumption of online meal

deliveries.

In addition to consumers, consequences for health and well-being have also been discussed from the perspective of the safety of delivery riders. In the meal-delivery industry, a rider's work is "a race against time", since the salary is mainly determined by the commission, and the more orders delivered within a certain time period, the higher the income. Moreover, most online meal-delivery platforms have set a maximum delivery time. This trend allows customers to make a complaint if the food is not delivered on time. Meal-delivery riders must therefore navigate periods of high pressure that require rapid driving or riding from the point of pick-up to the consumer. Such conditions are conducive to dangerous driving behavior, such as ignoring traffic lights or looking at mobile phones when on the move (Li et al., 2020). Indeed, a survey on 160 riders in Australia revealed that about half of them have either directly incurred injuries due to dangerous driving or indirectly heard of other riders sustaining injuries during deliveries (Allen et al., 2021). Fortunately, the issue of rider safety has been recognized and improved in some regions. In the case of New South Wales in Australia, meal-delivery platforms, worker groups, local councils, and state government agencies collaborated to identify specific work practices that elevate the risk of injury during delivery. Subsequently, new safety legislation was enacted requiring meal-delivery platforms to provide riders with induction training and personal protective equipment and to maintain training records (see New South Wales Government, 2021). Meanwhile, in Dubai the government has implemented the "Riders' Corner Initiative" aimed at cutting the number of road accidents caused due to fatigue and poor health among delivery riders (see Webster, 2023). Using facilities at the Dubai Healthcare City, this initiative offers riders free eye and health check-ups, water refills, vitamins, and rest spaces. While such examples highlight increasing attention to rider safety in developed countries where meal-delivery service is more widespread, there remains a need to address delivery driver injuries in the context of developing economies.

Aside from issues stemming from risky traffic behavior, an additional health concern for delivery riders pertains to increased risks of contracting an infectious disease such as COVID-19. Indeed, during the pandemic and lockdowns in some cities, through coming into physical contact with large numbers of people each day, drivers have faced comparatively higher risks of infection (Tran et al., 2022). For such reasons, some researchers have argued that the companies dispatching riders as well as the platforms providing meal-delivery services should conduct regular health checks on delivery riders (Ortiz-Prado et al., 2021).

A final concern raised is that due to the high-pressure environment, delivery riders are frequently unable to eat at regular times during working hours. One study (Wang et al., 2021) draws attention to the unhealthy tendency for most riders to skip breakfast or delay meals in order to cope with peak periods of order deliveries. Indeed, studies have shown that not only is skipping breakfast associated with hypertension, diabetes, and increased risk of cerebrovascular problems (see Kim et al., 2020), but there is also a link between skipping breakfast and obesity (see Mogre et al., 2013; Ardeshtarijani et al., 2019).

2.3.3.2 Climate change and clean energy related to SDG 13 and 7

Climate impacts from CO₂ emissions caused by delivery vehicles and the use and disposal of single-use packaging have attracted considerable attention in the literature.

In response to escalating pressures to reduce energy-related emissions while increasing the speed and efficiency of deliveries, many companies and areas are turning to e-bikes. Examples discussed in the literature include the industry-wide transition in China to electric mobility (Wang and He, 2021) and efforts by Deliveroo in the UK (Galati 2020) to provide e-bike rentals to its riders. In San Francisco, policymakers have been working to expand uptake of e-bikes for delivery services across the city as part of broader efforts to transition away from fossil-fuel-powered vehicles (see SF Gov, 2023). Despite such efforts, a lack of charging infrastructure has posed a barrier to the uptake of delivery methods that leverage electric mobility. To surmount this problem, Galati (2020) argues that while it is important for operators of meal-delivery services to actively incentivize delivery personnel to use electric or cycle-based methods, on the other hand, the government should also improve the reliability of existing charging piles and accelerate the rollout of additional infrastructure.

While bicycles and e-bikes are widely used for meal-delivery, some studies describe attempts to leverage drones as an emerging means of promoting decarbonization (Hwang and Kim, 2019; Kim and Hwang, 2020). Apart from reducing delivery-related emissions, drone delivery offers distinct advantages compared to delivery with human riders (Mathew et al., 2021). One major benefit is that drone delivery is unaffected by road conditions. Furthermore, this method allows enterprises to cut distances by designing “as the crow flies” routes, thereby reducing delivery costs and time. Aerit, based in Stockholm, exemplifies this approach, offering continuous drone-delivery services in select locations across Sweden since 2022 (see Internationales Verkehrswesen, 2022). Further companies experimenting with drone delivery include Domino’s and KFC, offering restaurant-to-consumer delivery and Swiggy and Zomato, offering platform-to-consumer delivery. Despite potential climate and economic benefits, the risk of accidents from drones has been raised (Hwang and Kim, 2019). However, since drone delivery remains largely uncommon in most countries, rigorous empirical studies are needed to substantiate claims regarding its advantages, disadvantages and impacts on carbon emissions.

In addition to fuel consumed by vehicles used during the delivery of orders, other sources of CO₂ emissions such as packaging have also caught the attention of researchers (Arunan and Crawford, 2021; Xie et al., 2021; Zhang et al., 2022). One study in Australia evaluated the emissions associated with the production and disposal of takeaway packaging used by meal-delivery services. Across the packaging lifecycle, the authors found that the production of raw materials contributes greater than 50% of total packaging-related CO₂ emissions (Arunan and Crawford, 2021). Meanwhile, other studies (Xie et al., 2021; Zhang et al., 2022) point out that the treatment of packaging waste through methods such as incineration and landfill also constitute an important source of CO₂ emissions across the packaging lifecycle.

These studies point to a pressing need to decarbonize the full lifecycle of the meal-delivery industry, not only by electrifying delivery-vehicle fleets, but also by integrating models of sustainable packaging. On the supply-side, reducing packaging materials would be an important step in this direction. On the consumer-side, measures such as choosing to eat in a nearby restaurant (Xie et al., 2021) or reducing the use of disposable tableware would also make an important contribution to cut CO₂ emissions directly and indirectly.

2.3.3.3 Waste problems related to SDG 12

As described above, following the rapid growth of meal-delivery services, concerns have been increasingly raised about waste, particularly related to plastic containers and leftover food.

Both the production and consumption of plastic containers have increased dramatically with the development of meal-delivery. Bangkok is a glaring example of such problems. An investigation by Liu et al. (2021) discovered that soiled plastic items from meal-delivery services, such as takeaway bags and containers, which are difficult to reuse and recycle, comprised more than 80% of municipal solid waste in 2020. Internationally, the meal delivery service is piloting reusable packaging initiatives in several countries and areas. In the United States, Uber Eats has partnered with Deliver Zero, a company that offers returnable and reusable food containers to restaurants to reduce wastage and emissions. When placing an Uber Eats order, customers in the United States can easily find participating restaurants by searching for those offering a “Deliver Zero” option. Once the order is finished, customers receive a text outlining their options for returning: drop the packaging back at the original restaurant or any other participating Deliver Zero venue, or schedule a pickup by a Deliver Zero partnered courier (see Dabo, 2023). While these actions promise to contribute to the reduction of packaging waste, their success strongly depends on consumer adoption. Research on consumer perceptions and the drivers and barriers of adopting reusable packaging is thus an important topic for future study.

Research also suggests that the disposal of packaging waste may influence the achievement of SDG 14, “Life below Water,” and SDG 15, “Life on Land.” Not only can impacts arise from littering or mismanaged treatment of end-of-life packaging (see Issifu and Sumaila, 2020), but the harmful substances contained in plastic packaging which are then emitted during incineration or degradation in the environment can potentially pollute terrestrial and marine eco-systems, negatively affecting the health of animals, plants and humans (Maimaiti et al., 2018). A flagrant example is the case of plastic pollution in the marine environment of which the online meal-delivery industry is an important source in some geographies (Liu et al., 2021).

Besides packaging waste, some studies focus on the issue of food waste, examining its characteristics and underlying drivers (Liu et al., 2021; Zhang et al., 2022). One study in Italy showed that the bulk of food loss is due to unavoidable waste; namely inedible food components, such as fruit peel and cores, eggshells, bones etc. (see Amicarelli and Bux, 2020). Yet the nature of food waste issues varies across regions. For example, in China, the main components of food waste have been found to consist of edible portions rather than unavoidable waste (Zhang et al., 2022). As for the problem of why food loss occurs, some studies point to industry tactics such as minimum order amounts needed to qualify for free delivery, discounts, and other promotions that incentivize over-ordering (Fernandez and Raine, 2021). Other drivers include oversized portions and dissatisfactory tastes (Liu et al., 2021).

The literature offers several important hints on how waste-related issues can be overcome. On the demand-side, Zhang et al. (2022) argue that consumers can be educated about the environmental impacts of meal-delivery through information campaigns and then incentivized to select more environmentally friendly options through reward schemes. On the supply-side, efforts can be made to adjust prices on meal-delivery platforms to avoid

overordering, which would then contribute to the reduction of packaging. Meanwhile, Liu et al. (2021) contend that suppliers should shift their current focus on the beautification of packaging to reducing environmental impacts through sustainable packaging. For example, paper-based packaging is often seen as a more sustainable alternative to plastic or Styrofoam by virtue of its recyclability and biodegradability compared to other synthetic alternatives (see Deshwal et al., 2019).

2.3.3.4 Decent work issues related to SDG 8

While creating many new job opportunities (cooks, delivery riders, IT engineers, etc.), the online meal-delivery industry has also exerted considerable impacts on upstream and downstream segments across the supply chain (manufacturing of disposable tableware and electric bicycles, etc.), in many cases contributing to their prosperity (Li et al., 2021). Other positive impacts have also occurred, namely that of providing delivery riders with the option to work flexibly during desired working hours and win more income in accord with effort.

Conversely, however, the nature of such “gig work” means that opportunities for workers are often irregular in terms of income, working conditions, social protection, skill utilization, and the right to collective bargaining (see International Labour Organization, 2021). Specifically, compared to regular employees, most delivery riders are deprived from receiving the same benefits and protections such as paid vacation, sick leave and various subsidies and dismissal expenses due to their status as independent contractors (Allen, 2021). As already mentioned, delivery work is a race against time, which raises the risk of traffic accidents. Yet in the case of sustaining an injury or causing damage to others during delivery, riders must mostly bear the responsibilities and expenses alone. However, fortunately, delivery riders are fighting to get recognition and protection. Courts around the world are also struggling to characterize the employment relationships resulting from these disparities (see Defossez, 2022).

Some studies also suggest that job-hopping is prevalent among meal-delivery riders. In China, Wang et al. (2021) surveyed delivery riders regarding their motivation, income, working environment, education, etc. and found that most have less than one year’s work experience. The high job-hopping rate has been associated with the low barriers to employment with respect to necessary qualifications. Wang et al. (2021) and Maimaiti et al. (2018) have noted that online meal-delivery enterprises recruit riders through a simple process, with most possessing an education at or below the high-school level. This employment model is not without benefits, since job-hopping per se provides an important career and lifestyle choice, allowing many younger workers to find their career path by trying out jobs in different areas. Yet job-hopping also creates negative consequences. Not only can this tendency deny delivery riders the opportunities to develop more advanced skill sets that lead to higher paying and more stable employment, but the nature of delivery work, being unstable and often lowly paid, also reinforces the inclination towards job-hopping.

2.3.3.5 Sustainable communities related to SDG 11

SDG 11 aims to renew and plan cities and other human settlements in a way that offers opportunities for all, with access to basic services, energy, housing, transportation and green public spaces, while reducing resource use and environmental impact. The development of the

online meal-delivery industry has exerted impacts of relevance to this goal, with two themes abridged in particular.

The first issue concerns road traffic safety. Some scholars have problematized the tendency for many delivery riders to crowd on the curbside when waiting to pick up meals. This has been reported to interfere with traffic flows and cause safety problems in densely populated urban areas (Galati et al., 2020). To tackle this problem, a study by Fotouhi et al. (2021) investigated the possible enactment of curbside regulations in the US to limit the number of drivers simultaneously waiting outside restaurants, thereby providing insights to state and local communities in designing legislative frameworks to manage the traffic impacts of the industry.

Second, some scholars have examined meal-delivery from the perspective of healthy communities (Shi et al., 2021; Li and Wang, 2022). Food accessibility is a critical determinant of tendencies to choose meal-delivery services (Li and Wang, 2022). If people live in an area with a lower density of local food markets or longer distances to supermarkets and other forms of healthy food stores, they are more likely to use meal-delivery services. To realize more sustainable cities, this research thus points to the need to create more opportunities to access healthy, fresh and affordable food to reduce dependence on the delivery of pre-cooked meals. More importantly, perhaps, integration of such objectives into urban planning would also create other co-benefits. For instance, SDG 11.6 aims to “reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management.” By decreasing the frequency of ordering meals online, creating more sustainable cities with better food accessibility could thus help to reduce road use during delivery and packaging waste as well as the CO₂ emissions resulting from these activities.

2.3.4 Marginally discussed perspectives

Figure 6 indicates several goals that are only marginally discussed in the reviewed literature. Here we discuss two sets of issues related to SDG 5 and 9, summarizing the key debates and suggesting potential opportunities for future research.

First, we believe that the development of the online meal-delivery industry is highly pertinent to SDG 5—the goal of achieving gender equality. Although we find few discussions from this perspective in the existing research, a handful of studies provide a glimpse of gender-relevant issues (Wang et al., 2021; Milkman et al., 2020; Shi et al., 2021). Of these, Wang et al. (2021) and Milkman et al. (2020) focus on gender and class, analyzing why women, especially mothers, choose gig work. The main reasons cited relate to the flexibility of working hours, which provides an attractive convenience for mothers juggling work and childcare (Wang et al., 2021; Milkman et al., 2020).

These potential benefits merit careful consideration. Though it is indisputable that the nature of gig work in the meal-delivery industry facilitates the balancing of family and work by virtue of the freedom to choose one’s working times, it is doubtful whether this alone is conducive to achieving gender equality. Three concerns underpin this view. First, the volume of women that have entered the workforce due to the rapid increase of the meal-delivery industry appears to be highly limited. With several studies finding that the majority of riders are male (Maimaiti et al., 2018; Barratt et al., 2020; Ortiz-Prado et al., 2021), meal-delivery work appears to be “a man’s game”. Second, even when undertaking gig work, women still

have to undertake much unpaid housework (see International Labour Organization, 2013). Additionally, increased opportunities for women or mothers to enter the workforce does not provide a fundamental solution to the deep-rooted expectation in many cultures that they should primarily assume responsibility for housework in the home. Third, the value of “flexibility” itself is also questionable. To obtain flexibility, women (and men) engaging in meal-delivery work must pay the price of forfeiting financial benefits compared to regular employment, such as social security and paid leave.

Another perspective that has only attracted marginal interest in the literature is the issue of the “digital divide” between older adults and the more IT-literate younger generation. In an increasingly digitalized world, full and equal participation in society largely depends on one’s ability to use modern technologies (see UNECE, 2023). However, this can vary by age, education, region, and so on. Especially, older adults frequently tend to suffer from limited access opportunities to use Internet-connected devices or from low familiarity or literacy, barriers that can deny them the opportunity to fully engage with today’s digital world (see Ma et al., 2020). This situation has relevance to SDG 9, which calls for reliable infrastructure to provide affordable and fair access to digital service to all. In this regard, Fernandez and Raine (2021) have drawn attention to the problem of aged-based inequalities around access to digital food services, pointing out that people aged over 55 years in the US are less likely to order meals online because of less familiarity with digital technology and fewer tendencies to surf the Internet compared to their younger counterparts. However, in an ageing society, online meal-delivery services also carry a huge potential to offer an accessible solution for seniors who may have difficulty preparing meals on their own. Such benefits may be particularly important for seniors with limited mobility, by helping them to maintain a regular eating schedule. These two perspectives point to both risks and opportunities with respect to potential impacts on the elderly generation. Therefore, a highly relevant sustainable development issue for scholars investigating the meal-delivery industry is how to ensure that the benefits of improved convenience and access to nutritious food are widely shared with all in the digital environment.

2.3.5 Missing perspectives

The review revealed several gaps where researchers are yet to engage with several important issues that relate to the manifold impacts of meal-delivery with relevance to the pursuit of sustainable development. We discuss two of the most glaring deficiencies below, also highlighting opportunities for future research.

First, we found no mention of consequences for SDG 1, the goal of reaching zero poverty. As discussed earlier, the rapid growth of online meal-delivery services has generated positive economic impacts, including employment creation and new business opportunities. To cite an example, Wolt, a European technology company known for its delivery platform for food and merchandise, draws attention to such benefits. Its website underscores how the absence of strict requirements for a deliverer’s language skills or educational background helps to create increased opportunities for the unemployed or individuals having a hard time finding work on the traditional labor market (Wolt, 2021). Indeed, evidence from our review suggests that the simple recruitment process and low educational requirements of delivery work is especially attractive for those coming from poorer classes (Wang et al., 2021).

But the reviewed literature also hints that not all impacts are positive. For example, most riders don't engage in delivery jobs as a lifelong career (Wang et al., 2021). Furthermore, compared to jobs requiring a higher skill set, delivery work tends to see lower wages (Umer, 2021). Like many service industries, it is low wages that allows the wealthier to reap the benefits of cheap labor.

We thus find a tension in claims around the positive and negative nature of the economic impacts exerted by the rapid expansion of the online meal-delivery industry. Not only does it remain to be seen if increasing opportunities to work as meal-delivery riders are helping to lift the poor out of poverty, but we foresee a risk that the meal-delivery industry's rapid growth may exacerbate poverty and the class gap to some extent. Examining these types of socio-economic consequences thus presents an important topic for future research.

Second, researchers have also been silent on the issue of SDG 2, zero hunger. Several studies have shown that populations who may find cooking physically or logistically challenging—e.g. older adults and individuals with limited mobility or health conditions—could benefit considerably from meal-delivery services (Fernandez and Raine, 2021). Moreover, meal-delivery services have the potential to increase food access to those in rural areas, which might benefit public health (Keeble et al., 2021). However, as previous studies showed (Kim and Hwang, 2020), the users of meal-delivery platforms tend to be those having attained a certain level of financial ease. More research is thus needed to understand how to leverage the potential of digital meal services to better serve vulnerable populations and groups who have been typically afflicted by hunger.

2.4 Conclusions

This study conducted the most in-depth review to date of the peer-reviewed literature engaging with the proliferation of online meal-delivery, systematically identifying its manifold impacts—both positive and negative—from the perspective of the SDGs. The review revealed that the rise of the digital meal industry is provoking an array of impacts around the world that have high relevance to the pursuit of sustainable development. Not only can our findings help us formulate more targeted and effective countermeasures to effectively address the issues that hinder the achievement of SDGs, but our identification of deficiencies and gaps in the academic discussions to date provide important hints for future research.

Our review shows that direct sustainability impacts, such as on human health, plastic waste, food loss, carbon emissions, and labor conditions, are well documented. However, other significant issues, such as gender equality, hunger, and poverty, remain underexplored. With respect to gender equality, we found that some researchers cite the flexible nature of working as a gig worker (delivery rider) as particularly attractive for women with children. Yet given the low pays, the instable nature of gig work, and inferior working conditions compared to regular employees, in the long term being a delivery rider might do little help to escape poverty. Rider work may also do little to improve the social status of women, since it does not lead to improvements in educational qualifications or work skills. Consuming ready-to-eat meals however can reduce time spent on housework for women, thereby aiding career development. These differing perspectives thus point to both risks and opportunities, highlighting how the wide-reaching transformations of our food environment triggered by the meal-delivery industry's rapid expansion both promote and hinder progress towards achieving

the SDGs.

Several insights for policy emerge from this review. First, on the operational side, there is a need to provide easy-to-locate nutrition information to customers to help guide healthier menu choices. Second, it is imperative that the meal-delivery industry reduces its environmental footprint. Utilizing bicycles or e-bikes can reduce carbon emissions in the delivery process (Galati et al. 2020). Additionally, to combat the prevalence of single-use plastic packaging, options such as biodegradable or reusable and returnable containers offer important pathways for shifting business models towards greater sustainability or circularity. Third, the reviewed literature underscores the need to guarantee the welfare of delivery riders. This includes measures to protect them from road accidents as well as reforming legal frameworks to ensure that riders earn a decent living. Some countries and companies are putting in place measures to this end. For instance, in 2021 the Spanish government reformed legislation to recognize riders working for delivery firms such as Deliveroo and Uber Eats as salaried employees rather than “gig” workers (see Euractiv, 2021). Fourth, there is a need to regulate and enforce hygiene standards for “ghost kitchens” to ensure they comply with food safety and management regulations.

2.5 Limitations

The methodological limitations of this study suggest important directions for future research. First, the results of our review are influenced by our choice of search string and database. To expand the corpus of knowledge for analysis, future studies could consider using multiple databases as well as incorporating grey literature. Second, acknowledging that our review was conducted in 2022, to ensure a current perspective we made efforts to incorporate more recent grey literature and academic works beyond the primary corpus when discussing key debates and gaps. However, with the literature consistently expanding, scholars could integrate studies published over the last two years to capture the most recent topical trends. Third, while we aimed to identify critical and frequently discussed issues, some trends identified in our study may not universally apply to all regions. Moreover, while studies on practices in the Chinese market feature prominently in the corpus of literature, we found much less coverage of regions in the Global South like Africa and South America. The rapidly evolving economies and consumption patterns in these regions warrant follow-up studies. Fourth, although current discussions often emphasize the negative impacts of the industry, it is important to also acknowledge its potential to make positive outcomes towards sustainable development. For instance, by increasing access to affordable and nutritious food, adopting carbon-free delivery methods, and abolishing single-use plastics, the online food delivery industry could become a model of circularity and sustainable consumption. Research into potential positive contributions for sustainable development is therefore an important future task for scholars. Finally, we see a need for empirical studies to validate claims about the online meal industry's impact on sustainable development.

3. Traditional wisdom for modern sustainability: a dish-level analysis of Japanese home cooking in NHK Today's Cooking

Abstract

Background: Balancing nutrition security with environmental sustainability is a key priority in global food policy, with Sustainable Healthy Diets (SHDs) serving as a critical framework aligned with the UN Sustainable Development Goals (SDGs). Traditional Japanese cuisine reflects SHD principles through its emphasis on plant-based, seasonal, and minimally processed dishes. However, modern, globalized dietary patterns increasingly feature ultra-processed foods, raising concerns about health risks such as high sodium intake.

Methods: This study adopts a novel dish-level content analysis of 120 contemporary recipes from NHK Today's Cooking between 2023 and 2025, a TV program by Japan's national public broadcaster that is widely regarded as reflecting the practices of Japanese home cooking, to examine how SHDs pillars—nutritional diversity (e.g., varied protein sources), environmental sustainability (e.g., low-carbon ingredients), and cultural continuity (e.g., traditional techniques)—are embedded in Japanese home cooking. Unlike macro-level consumption or nutrition data, this dish-level approach reveals how individual dishes embody sustainability through ingredient selection, preparation methods, and cultural logic.

Results: Quantitatively, pork (33.3%) and seafood (19.2%) together dominated main protein sources, with minimal beef (2.5%) and a notable presence of soy-based foods (12.5%), supporting lower reliance on environmentally intensive red meat; mean salt content per person in main dishes was 2.16 ± 1.09 g (28.9% for men, 33.3% for women of Japan's daily salt targets), while recipe patterns emphasizing fermentation and seasonal alignment highlight possible pathways through which Japanese dietary practices can be considered ecologically efficient. Simultaneously, the analysis identifies emerging challenges, encompassing environmental issues such as overfishing and public health concerns like excessive sodium consumption.

Conclusions: By centering dishes as culturally meaningful units, and using media recipes as reproducible, representative datasets for monitoring dietary change, this approach offers a reproducible framework for assessing dietary sustainability in evolving global food systems.

3.1 Introduction

The global food system faces a dual imperative: to ensure adequate nutrition for a growing population while minimizing environmental degradation (Willett et al., 2019). These intertwined challenges have elevated the concept of Sustainable Healthy Diets (SHDs) as a central policy framework at the nexus of public health and ecological sustainability, particularly within the scope of the United Nations Sustainable Development Goals (SDGs). Defined by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), SHDs are “dietary patterns that promote all dimensions of individuals’ health and well-being; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable” (FAO, 2019). This integrative model seeks to reconcile nutritional adequacy, environmental stewardship, and cultural viability.

Traditional Japanese dietary practices, particularly those classified under *washoku*, have gained international recognition for their alignment with the principles of SHDs. Emphasizing moderation, variety, seasonality, and balance, *washoku* prioritizes plant-based ingredients, minimal processing, and the use of local and seasonal foods—characteristics closely associated with both favorable health outcomes and a reduced environmental footprint (Yatsuya & Tsugane, 2021). In recognition of its holistic approach to food, *washoku* was inscribed on the United Nations Educational, Scientific and Cultural Organization (UNESCO) Intangible Cultural Heritage list in 2013, as a comprehensive system of knowledge, practice, and ethics grounded in respect for nature and sustainable resource use (UNESCO, 2014). What sets this inscription apart is its exceptional national scope. *Washoku*’s UNESCO inscription is notable for its rare national scope, placing it alongside the “gastronomic meal of the French” and “traditional Mexican cuisine” as one of the few food-related recognitions that acknowledge an entire national dietary culture (Cang, 2019).

As defined by the Ministry of Health, Labour and Welfare (MHLW), the dietary format most closely associated with *washoku* is *ichiju-sansai*, consisting of one soup, one main dish, two side dishes, and a staple grain, typically rice (MHLW, 2015). This configuration exemplifies a nutritionally balanced and resource-efficient approach that aligns with both modern public health goals and ecological priorities. However, contemporary Japanese dietary practices have been reshaped by the forces of globalization, urbanization, and shifting consumer preferences. The expansion of convenience stores, fast-food chains, and ready-made meals has introduced a growing array of ultra-processed and Western-style foods into the daily diet (Marshall, 2019).

While *washoku* continues to serve as a cultural ideal and reference point, it is not without nutritional limitations. A prominent concern is the traditionally high sodium content of many Japanese dishes. Excessive sodium intake has been consistently linked to elevated risks of hypertension and cardiovascular disease (Takase et al., 2015). In 2010, Japan’s average daily salt intake was 12.7g—substantially higher than that of the United States (9.2 g/day)—and that of Western Europe averaged 9.7 g/day (Powles et al., 2013). Although recent decades have seen gradual improvements, national surveys still indicate that average intakes exceed recommended limits (Tsuchihashi, 2022). In response, public health initiatives such as “Health Japan 21” have been implemented to promote salt reduction

through educational campaigns, product reformulation, and improved nutrition labeling (Tanaka, 2023).

Simultaneously, the actual dietary landscape in Japan has become increasingly diverse and internationalized. In addition to traditional staples such as *udon*, *soba*, and sushi, many Japanese households now incorporate a wide variety of global dishes into their daily meals. Examples include Chinese-style mapo tofu, Korean *chijimi* (savory pancakes), Japanese-style adaptations of *ramen*, and Western imports like pizza and hamburgers. While such culinary diversification can enhance dietary variety and consumer enjoyment, it also introduces new public health and environmental challenges. The increasing reliance on ultra-processed foods and the declining prevalence of home-cooked meals have been associated with rising rates of obesity, hypertension, and other non-communicable diseases, as well as greater environmental impacts linked to resource-intensive food production (Baker et al., 2020; Monteiro et al., 2022). These developments call for a renewed examination of the relevance of traditional Japanese dietary practices in the context of contemporary SHDs frameworks.

Macro-level consumption data offer important insights into the broader nutritional transitions shaping the Japanese food system. For example, while per capita beef intake in Japan remains relatively modest compared to other countries in the Organisation for Economic Co-operation and Development (OECD), total meat consumption has steadily increased over recent decades and now approximates European averages. At the same time, Japan maintains a relatively high level of seafood consumption, reflecting both historical continuity and contemporary dietary preferences (FAO, 2022; OECD, 2023). These aggregated figures—comprising millions of individual food choices—provide valuable indicators of dietary transition at the national level.

Nevertheless, these national averages have limitations in illuminating how dietary changes unfold in real daily life. They may not fully capture how meals are selected and experienced in everyday domestic settings, nor do they reflect the cultural meanings, preparation methods, or social dynamics embedded in daily cooking practices. Understanding the actual composition of meals—as experienced in household kitchens and reflected in widely consumed recipes—is essential to grasp the nuanced transformations of Japanese dietary practices. Investigating the lived realities of what people cook and eat thus provides a more grounded and culturally informed perspective, complementing broad statistical trends with specificity.

Previous research on Japanese dietary practices, including *washoku*, spans multiple disciplinary domains. Nutritional studies emphasize the health benefits of traditional Japanese diets, citing reduced risks of chronic diseases linked to high consumption of vegetables, fish, and fermented foods (Willett et al., 2019; Yatsuya & Tsugane, 2021). Ethnographic and historical studies highlight *umami* and *dashi* as central to Japanese culinary tradition, showing how cultural and scientific factors have shaped changing perceptions of glutamate, from a key sensory element to a scientifically recognized flavor enhancer (Yamaguchi & Ninomiya, 2000). Scholars have also investigated the globalization of Japanese food—especially sushi—highlighting how the Japanese state and media leverage notions of authenticity and culinary nationalism to reassert cultural ownership amid the proliferation of hybridized international forms (Cwierka, 2006; Cang, 2019).

Policy-oriented studies focus on national initiatives such as “Healthy Japan 21” and the “Japanese Food Guide Spinning Top,” which aim to address rising rates of non-communicable diseases and declining food literacy through structured dietary education (Nakamura, 2008; 2011; Ishikawa et al., 2015). In the field of economics, research demonstrates that the global diffusion of Japanese food culture—proxied by indicators such as online searches for sushi—positively influences exports of related products like sake, revealing a cultural spillover effect in international trade (Bargain, 2023). These studies construct a multifaceted understanding of Japanese foodways as a dynamic interplay between health, culture, policy, and globalization.

However, the previous research lacks robust methodologies to systematically evaluate how the three interconnected pillars of sustainable diets—nutritional diversity, environmental sustainability and cultural heritage preservation—are operationalized, balanced, or compromised in routine household food practices.

To address this question, we conduct a dish-level content analysis of *Today’s Cooking*, a long-running culinary television program produced by NHK, Japan’s national public broadcasting organization. This program holds unparalleled sociological significance as a de facto archive of mainstream Japanese domestic food practices since 1957. Officially recognized by Guinness World Records as the world’s longest-running television cooking program (67 years as of November 2024), *Today’s Cooking* has aired approximately 15,500 episodes and introduced over 46,600 distinct recipes (Asahi Shimbun, 2023; Yomiuri Shimbun, 2023). Its development closely reflects Japan’s broader socio-demographic and nutritional transitions—beginning with efforts to combat postwar malnutrition, adapting to rising economic affluence, evolving household structures (evidenced by portion size reductions from five to four to two servings), and responding to shifting public health concerns, such as decreasing the salt content in pickled plums from 20% to 5% (Asahi Shimbun, 2023; Yomiuri Shimbun, 2023). In celebrating its 60th anniversary, NHK *Today’s Cooking* reflected on its mission as a public broadcaster, emphasizing the importance of providing recipes that go beyond catering to fleeting popular trends. According to the program’s creators, the intention is to highlight seasonality, nutritional balance, and the cultural and natural context of food using seasonal ingredients. In addition, recognizing the decline in traditional television viewership and the rise of internet-based information sources, the program has sought to maintain relevance by updating its website with recent recipes (Ujibashi & Ono, 2018; Ono, 2018). This approach preserves the educational and cultural values embedded in Japanese culinary traditions and illustrates how these values are represented in contemporary media. Previous studies and conference reports, using the monthly NHK paper media, have documented long-term trends, including a gradual decline in salt content (Sutani et al., 2015; Arimoto et al., 2023), suggesting that the program may serve as a useful archive for examining dish-level dietary patterns over time. According to the Japan Magazine Publishers Association, between October 2023 and September 2024, the combined monthly circulation of *Today’s Cooking* and *Today’s Cooking Beginners* was 299,117 copies, the highest among Japanese monthly cooking magazines (second place: *Lettuce Club*, 183,159 copies) (Japan Magazine Publishers Association, 2025). In addition, NHK’s Instagram account for the program has approximately 167,000 followers (NHK. [Today’s Cooking] Instagram Account, 2025), comparable to Japan’s representative

recipe-sharing site Cookpad with 193,000 followers (Cookpad, 2025).

As a highly trusted NHK production, the program offers a uniquely comprehensive dataset for examining how principles of sustainable and healthy diets are embedded—or compromised—in daily practice. By reviewing this extensive recipe corpus, all 120 recipes featured on the program’s homepage between April 2023 and April 2025, we evaluate key indicators of sustainability, including nutritional diversity (e.g., ingredient variety, protein source composition), environmental impact (e.g., frequency of high-carbon ingredients), and cultural continuity (e.g., persistence of traditional seasonings and preparation methods). This empirical approach enables us to trace how the three pillars of sustainable diets—health, environmental sustainability, and cultural relevance—have been negotiated and transformed over time within the lived realities of Japanese home cooking.

The methodological innovation of this study lies in reframing dietary assessment around prepared dishes rather than abstract food groups or nutrient counts. Dishes may serve as culturally legible, nutritionally dense, and environmentally meaningful units with the potential to provide insights into household dietary practices. This dish-level focus offers a framework for exploring how macro-level dietary trends might be reflected in home cooking practices. The framework also holds cross-cultural relevance, offering a model for examining dietary transitions across national contexts.

This study makes three key contributions. First, it provides an empirically grounded portrait of contemporary Japanese eating patterns by analyzing recipes featured on NHK Today’s Cooking, a nationally representative media corpus. This may reveal concrete patterns in ingredient use and meal composition relevant to real-world practices. Second, it illustrates how traditional dietary forms coexist with globalized culinary influences, challenging static notions of “authentic” Japanese food. By tracking recipe genres and incorporating foreign-origin dishes, we show how Japanese food culture negotiates hybridization while retaining distinct cultural markers. Third, it advances a practice-oriented approach to dietary sustainability, demonstrating how daily cooking mediates cultural continuity, nutritional adequacy, and environmental concerns. Assessing recipes by sustainability indicators—such as protein diversity, salt levels, and seasonality—links household practices to broader SHDs frameworks.

3.2. Materials and methods

This study draws on a dataset of 120 recipes featured on the official website of NHK Today’s Cooking between April 2023 and April 2025. The NHK Today’s Cooking creators indicate on the program’s official website that the platform serves as an entry point for introducing its current recipes (Ujibashi & Ōno, 2018; Ōno, 2018). The website operates as a rolling two-year archive, with older recipes replaced by new ones and no longer publicly accessible. Accordingly, all 120 recipes from this archive were collected for analysis, representing the current repertoire of Today’s Cooking, which may provide insights into patterns emphasized in contemporary Japanese home cooking. The sample includes a balanced representation of main dishes, side dishes, soups, and desserts, thus capturing the structural diversity of everyday Japanese meals. As an example, a screenshot of one complete recipe page, including all available information, is provided in the Supplemental Material. From all 120 dishes, the data were coded to construct a dataset containing dish

name, episode date, ingredients, cooking time, cooking steps, salt content (g) and calorie content (kcal) per serving.

For each recipe, structured coding was applied across four main dimensions:

1. **Protein Source:** Ingredients were classified based on their primary protein content (e.g., plant-based, seafood, poultry, red meat). When multiple protein sources were present, the dominant source was determined by the proportion of each protein source by weight (grams). Dishes with multiple significant protein inputs were categorized as composite-protein recipes. The representativeness of these categories was then verified by comparison with data from the Ministry of Agriculture, Forestry and Fisheries (MAFF).
2. **Traditional and Cultural Seasonings:** Seasonings were grouped into fermented (e.g., *miso*, soy sauce, *mirin*, sake, rice vinegar) and non-fermented types (e.g., salt, sugar, pepper) based on established culinary references (Yamaguchi & Ninomiya, 2000; van Wyk, 2024), with coding conducted by the first author and cross-checked by the second author, with discrepancies discussed and resolved to ensure consistency. Frequency counts for each seasoning category were recorded to evaluate reliance on traditional flavor profiles. Consistency with traditional *washoku* principles was then assessed.
3. **Cooking Methods:** Instructional text from each recipe was analyzed for high-frequency cooking verbs (e.g., boiling, stir-frying, pan-frying, steaming, deep-frying, mixing), which served as indicators of dominant cooking techniques.
4. **Nutritional and Cultural Indicators:** Where reported, salt content was recorded as a proxy for nutritional health. Additional variables—such as seasonal ingredient use and estimated cooking time—were included to assess cultural embeddedness and everyday practicality. It should be noted that only recipes with clearly defined serving sizes were included, while those labeled with ambiguous portion descriptions such as “easy-to make quantity” were excluded due to the inability to perform accurate calculations. For eligible recipes, the salt content was taken directly from the nutritional information provided on the official NHK recipe website, where values are standardized and reported on a per-person basis. Additionally, non-dish items such as desserts were excluded from the dataset to maintain analytical focus on main dishes, which better represent typical daily meals and their associated salt content in Japan. The obtained salt values were compared with WHO and MHLW guidelines to verify alignment with recommended intake levels.

Full recipe data and the corresponding coding details are provided in the Supplementary Material.

3.3 Results

3.3.1. Protein sources and meat consumption patterns

The 120 dishes featured in NHK Today's Cooking were classified into six primary categories based on their main ingredients: pork ($n = 40$), chicken ($n = 21$), beef ($n = 3$), fish and seafood ($n = 23$), meatless ($n = 19$), and non-dishes ($n = 18$), the last comprising items such as desserts and seasonings (Table 3.1). This reflects core features of the Japanese diet, including the predominance of pork and fish and the notably limited representation of beef.

Table 3.1. Ingredient-based classification of dishes from NHK Today's Cooking (n = 120).

Ingredient Category	Number of Recipes (n)	Percentage (%)
Pork	40	33.3
Fish and Seafood	23	19.2
Chicken	21	17.5
Beef	3	2.5
Meatless	19	15.8
Non-Dish Items	18	15.0

Note: "Non-dish Items" include recipes for desserts and sauces that are not considered standalone main dishes. Four recipes contained both pork and fish as primary ingredients and were counted in each applicable category.

A comparison between the dish-level protein source proportions in NHK Today's Cooking recipes and population-level data from the survey conducted by MAFF in 2023 reveals a close alignment in the relative distribution of protein sources (Figure 3.1). Although it is difficult with direct quantitative comparison due to variations in portion sizes and meat content per dish, this close alignment means the representativeness of our dataset. The same meat consumption trends—low beef intake and high seafood consumption relative to western countries—observed both in the MAFF population-level data and the NHK recipe dataset are confirmed in cross-regional data from FAO (Figure 3.2).

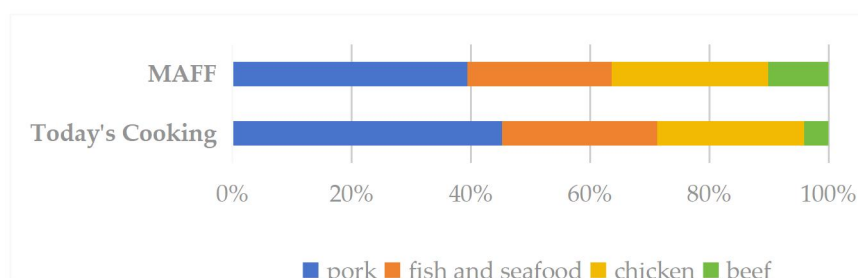


Figure 3.1. Distribution of protein sources in NHK Today's Cooking recipes (percentage of total dishes) and in national average daily per capita intake (grams per day), based on the 2022 Food Balance Sheet (MAFF, 2023). Note: Meatless and non-dish categories are excluded from this figure.

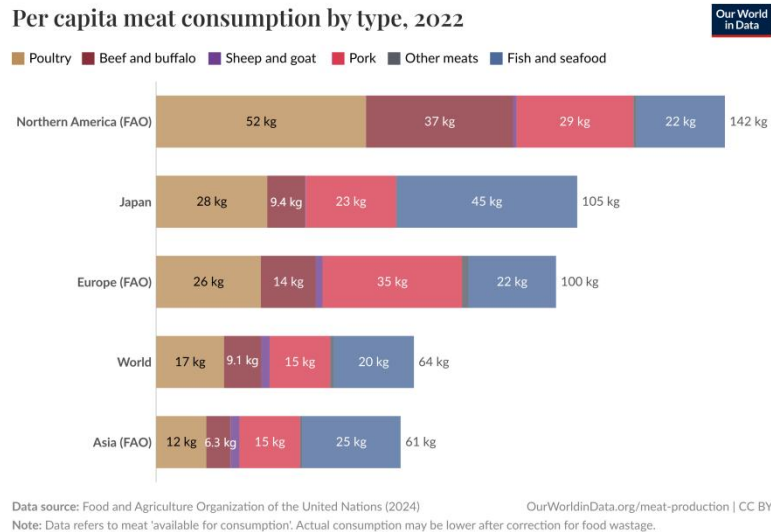


Figure 3.2. Per capita meat and seafood consumption by type (kg/year): Comparison of Japan with North America, Europe, Asia, and Global Averages (FAO Data) (FAO, 2022).

3.3.2. Plant-based protein sources

Beyond animal proteins, the Japanese diet extensively incorporates legumes—particularly soy-derived products such as *tofu*, *natto*, and *miso*—as nutritionally significant sources of plant-based protein deeply embedded in daily food culture. We found a total of 15 unique preparations, categorized by legume type and protein pairing (Table 3.2). Soy products dominate the legume category, with *tofu* featured in five distinct dishes: combined with beef ($n = 1$), chicken ($n = 1$), seafood ($n = 1$), and a fully meatless dish ($n = 2$). *Natto*, a fermented soybean product, appears in one dish paired with pork. *Miso*, another fermented soy derivative, is used in seven distinct dishes: two with pork, two with seafood (one of which also contains *tofu*), two meatless dishes (including one that also incorporates *tofu*), and one non-dish recipe used to prepare seasoning. To avoid double counting, two overlapping dishes containing both *tofu* and *miso* are counted under *tofu* only. Beyond soy, other legumes also contribute to dietary diversity. We identified four supplementary non-soy legume-based dishes: two with green beans, one with broad beans, and one with white kidney beans. This comprehensive incorporation of leguminous ingredients, particularly soy products, underscores the functional role of plant-derived proteins in traditional Japanese dietary patterns.

Table 3.2. Classification of legume-based preparations in NHK Today's Cooking ($n = 120$).

Legume Type	Preparation	Protein Pairing	Count	Notes
Soy Products	Tofu	With beef	1	
		With chicken	1	
		With fish/seafood	1	1 dish contains <i>miso</i>
		Meatless	2	1 dish contains <i>miso</i>
	Tofu subtotal		5	
	<i>Natto</i>	With pork	1	
	<i>Natto</i> subtotal		1	
	<i>Miso</i>	With pork	2	

Legume Type	Preparation	Protein Pairing	Count	Notes
Other legumes		With fish/seafood	2	1 dish contains tofu
		Meatless	2	1 dish contains tofu
		Non-dish item (seasoning)	1	
		<i>Miso</i> subtotal	5	Excluded 2 dishes with overlapping tofu
	Non-soy legumes	Green beans	2	
		Broad beans	1	
		White kidney beans	1	
	Other legumes subtotal		4	
	Total unique dishes		15	Excluded combo dishes

3.3.3 Fermented and non-fermented seasonings

In addition to their role as plant-based protein sources, legumes—particularly soybeans—also serve as the foundation for a range of traditional fermented seasonings that are indispensable to Japanese culinary practice. The seasoning usage reveals distinct patterns between fermented and non-fermented ingredients in Japanese cooking (Table 3.3). Non-fermented seasonings such as salt ($n = 72$), pepper ($n = 56$), and sugar ($n = 39$) were the most frequently used, reflecting their foundational role in basic taste adjustment. However, fermented seasonings also appeared prominently, led by soy sauce ($n = 52$), which contributes depth of flavor through its characteristic *umami* and savory profile.

Table 3.3. Frequency of seasonings used in NHK Today’s Cooking dishes ($n = 120$).

Category	Seasoning	Frequency	% Dish Penetration	Biochemical Signature
Fermented	Soy sauce	52	43.3%	Glutamates, peptides
	Sake/Wine	47	39.2%	Ethanol
	Vinegar	23	19.2%	Acetic acid
	<i>Mirin</i>	22	18.3%	Ethanol, reducing sugars
	<i>Miso</i>	7	5.8%	Isoflavone glucosides
Non-Fermented	Salt	72	60.0%	Sodium chloride
	Pepper	56	46.7%	Piperine
	Sugar	39	32.5%	Sucrose

Note: One recipe may include more than one seasoning; therefore, total counts exceed the number of recipes analyzed.

Sake or cooking wine ($n = 47$) was the most frequently used seasoning, contributing depth and *umami* across a wide range of preparations. Vinegar ($n = 23$) commonly added acidity and balance, particularly in cold dishes and pickles. *Mirin* ($n = 22$), a sweet rice wine, imparted mild sweetness and richness, especially in simmered dishes. *Miso* appeared less frequently ($n = 7$) but served a distinct role as a concentrated seasoning base, particularly in soups. Together, these findings highlight the significant role of fermented seasonings in shaping the overall flavor complexity of Japanese cuisine. While used less often than salt or pepper, their inclusion reflects a deep culinary tradition that values layered, balanced flavors,

often achieved through fermentation-derived depth and subtlety.

3.3.4. Pickled foods in traditional practices

Although pickled items (*tsukemono*) were present in only four recipes, their inclusion highlights a traditional strategy for food preservation that contributes meaningfully to sustainability in Japanese culinary practices. As shown in Table 3.4, these pickled preparations employ natural preservation agents such as salt, alcohol, vinegar, and sugar, extending shelf life significantly while maintaining palatability and nutritional value. Notably, honey pickled and traditionally salted plums (*ume*) can be stored for up to one year, demonstrating a preservation approach that reduces food waste and supports year-round ingredient availability. Even items with shorter shelf lives, such as the Taiwanese tea-infused plum, offer culturally distinctive flavors while illustrating diverse methods of fermentation and preservation.

Table 3.4. Pickled items identified in NHK Today's Cooking recipes (n = 120) and their preservation characteristics.

Pickle Type	Preservation Agents	Shelf Life
Honey-pickled plum	<i>Shochu</i> , Coarse salt, Honey	1 year.
Ginger variants	Vinegar, Salt, Sugar	6 months.
Traditional pickled plum	<i>Shochu</i> , Coarse salt	1 year.
Taiwanese tea-infused plum	Rum, Coarse salt, Tea polyphenols	1 month.
Mixed summer vegetable pickles	Vinegar, Salt, Sugar	Not specified.

3.3.5. Health-driven and environmentally sustainable cooking methods

In line with the sustainable principles reflected in traditional preservation techniques, the cooking methods featured in the dataset also suggest a preference for environmentally conscious practices (Table 3.5).

Table 3.5. Frequency of cooking methods in NHK Today's Cooking recipes (n = 102).

Cooking Method	Frequency	Prevalence (%)
Simmering/Boiling	54	52.9%
Pan-frying	42	41.2%
Stir-frying	37	36.3%
Steaming	18	17.6%
Deep-frying	10	9.8%
No-cooking or reheated	9	8.8%
Baking	2	2.0%
Pickling	2	2.0%
Total mentions	174	-

Note: 18 non-dish items (including dressings and desserts) were excluded from the initial 120 recipes (see Table 1).

Among the 102 recipes, 174 instances of cooking methods were recorded, as individual recipes often employed multiple techniques. The most prevalent methods were simmering or

boiling (54 mentions) and pan-frying (42), followed by stir-frying (37) and steaming (18). Less frequently used were deep-frying (10), no-cooking or reheated (9), baking (2), and pickling (2). The techniques of simmering/boiling, steaming, no-cooking/reheating, or pickling were intentionally employed, with 74 of 102 dishes using at least one of these methods (a simple binary choice of whether or not these techniques were used, with a χ^2 test yielding $p = 0.01$).

This distribution reflects a culinary emphasis on methods generally regarded as healthier and more sustainable. Techniques such as simmering, steaming, and no-cooking approaches typically require less added fat and energy-intensive processing, aligning with dietary practices that promote cardiovascular health and reduce environmental impact (Tada et al., 2011). The low frequency of deep-frying and heavy processing further suggests an alignment with public health goals. These findings support the interpretation of NHK Today's Cooking as a media platform that not only preserves culinary tradition but also subtly reinforces health-conscious and ecologically considerate food preparation methods.

3.3.6. Seasonal alignment in ingredient selection and culinary practice

Each recipe explicitly specifies its associated season, reflecting a deliberate emphasis on seasonality (*shun*), a core principle in traditional Japanese cuisine. This seasonal orientation is evident not only in the titles of the dishes but also in their ingredient compositions. For example, dishes such as “Spring Cabbage and Pork with Clam Steamed” (29 March 2023), “Pork and Spring Cabbage Oil Steamed” (2 April 2025), “Steamed New Onion” (26 May 2023), and “Korean-Style New Potato” (7 April 2023) prominently feature early-season vegetables like spring cabbage, new onions, and new potatoes. Similarly, “Summer Vegetable Mixed Pickles” (12 July 2023) include a diverse assortment of summer produce—cucumber, carrot, celery stalks, red and yellow bell peppers, okra, Japanese ginger (*myoga*), and ginger—corresponding with their peak seasonal availability. “Autumn Eggplant and Minced Meat Simmered Dish” (15 September 2023) exemplifies the use of autumn-specific ingredients, further illustrating a consistent pattern of seasonal alignment. Temporal ingredient utilization identifies cucumber as exhibiting peak occurrence in recipes from June through October, aligning with its classification as a quintessential summer vegetable in Japanese food culture. Lotus root demonstrates peak utilization from September to November, corresponding to its established cultural association as a representative autumn ingredient in Japan. These patterns highlight the intentional integration of seasonally characteristic vegetables within culinary practices. Taken together, these findings validate an ingredient selection framework that is intricately aligned with natural seasonal cycles. This not only underscores a cultural appreciation for seasonal freshness but also demonstrates an adherence to traditional Japanese culinary principles.

3.3.7. Salt content and public health considerations

Having established the seasonal orientation of ingredient selection, it is also important to evaluate the nutritional implications of these dishes—particularly in terms of salt content, which remains a critical public health concern in Japan. The mean salt content per person across 85 analyzed main dish recipes was 2.16 ± 1.09 g. This represents 28.9% or 33.3% of Japan's daily salt intake targets set by the MHLW in 2020 (<7.5 g/day for men; <6.5

g/day for women) (MHLW, 2020) and 43.3% of the WHO's stricter guideline (<5.0 g/day) (WHO, 2025). One recipe exceeded the WHO recommended daily salt intake limit of 5 g: Buta no Shôgayaki Nose Hiyashi Chûka (Chille Chinese Noodles with Ginger Pork) at 6.2 g (dataset numbers 63; see Supplementary Material). Although each dish accounts for only one of three daily meals, 55 dishes exceeded one-third of the WHO daily salt guideline (1.67 g), while 25 and 35 dishes exceeded one-third of the MHLW daily salt targets for men (2.50 g) and women (2.17 g), respectively. Even when accounting for typical accompaniments (e.g., soups, rice, side dishes), the recipes analyzed here exhibit salt content levels that are substantially below Japan's population average of 12.7 g/day (Powles et al., 2013). Main dishes introduced in Today's Cooking may anchor salt-reduced diets meeting global health targets.

Reflecting increasing public health awareness of high salt intake issue, NHK Today's Cooking has featured recipes that promote salt reduction while preserving cultural authenticity. For instance, the program introduced a low-salt version of pickled plum (*umeboshi*) containing only 5% salt—a significant reduction from conventional levels—described as “a user-friendly alternative that balances ease of preparation with reduced salt content, without being overly sweet like commercial honey plums.” Such adaptations show the program's responsiveness to dietary challenges and its role in promoting healthier versions of traditional Japanese cuisine

This finding reflects a form of intentional culinary adaptation, in which traditional food practices are preserved while aligning with contemporary public health objectives aimed at reducing salt-related health risks in Japan.

3.4. Discussion

By reviewing recipes from NHK Today's Cooking, this study identifies four interrelated dimensions that reflect the evolving integration of cultural heritage, health promotion, economic efficiency, and environmental responsibility within Japan's contemporary food practices.

Unlike prior research based on official nutritional surveys or food group statistics issued by agencies such as MAFF, our dish-level analysis captures the nuanced ways in which protein sources, seasonality, and traditional techniques are negotiated in actual meal composition. This approach enables the identification of sustainability indicators—such as low-carbon protein choices and use of fermentation—on a practice-oriented level. It also uncovers dynamics that are invisible in compositional data alone, such as the hybridization of global and local cuisines within a Japanese flavor framework.

3.4.1. Bridging culinary heritage and sustainable protein strategies

The protein composition evident in the dataset from Today's Cooking—dominated by pork (33.3%) and seafood (19.2%), with minimal inclusion of beef (2.5%)—reflects Japan's distinct dietary ecology shaped by both historical and environmental determinants (Sasaki et al., 2022). Pork and chicken frequently appear in traditional Japanese preparations, while also incorporating Vietnamese and Korean influences, demonstrating regional culinary adaptability. Seafood remains closely aligned with authentic *washoku* techniques, maintaining traditional preparation methods. In contrast, beef appears in only three dishes,

with two adopting foreign formats (Chinese stir-fry and Russian stroganoff) and just one employing domestic method, underscoring its limited cultural integration. Historically, limited arable land and resource constraints favored the production and consumption of less resource-intensive livestock such as pork and poultry, rather than cattle (Asian Productivity Organization, 1990). In recent decades, particular attention has been paid to greenhouse gas (GHG) emissions and land-use efficiency. Accordingly, Japan's per capita beef consumption remains relatively low at 7 kg/year—approximately 49% of the OECD average—indicating a long-term dietary structure with comparatively low beef intake compared to many other industrialized countries (OECD, 2023).

In 2022, Japan's total per capita meat consumption was approximately 105 kg annually, of which fish accounted for nearly 45 kg, markedly higher than the global averages of 64 kg total meat and 20 kg fish per person (FAO, 2022). This elevated reliance on seafood supports health outcomes aligned with SDG 3 (Good Health and Well-being), given fish's rich nutrient profile including high-quality protein and omega-3 fatty acids (Asian Productivity Organization, 1990). However, the substantial dependence on marine resources presents critical challenges for SDG 14 (Life Below Water). Prolonged fishing pressure and significant seafood imports have contributed to the severe depletion of key fish stocks, undermining marine biodiversity and ecosystem resilience (Goni, 1998; Mozaffarian & Rimm, 2006; Iue et al., 2022). This situation creates a sustainability paradox: nutritional benefits are achieved at the expense of marine ecosystem health.

To address this, implementing science-based fisheries management is essential, alongside accelerating the expansion of sustainable aquaculture to meet domestic demand without depleting wild resources. At the same time, promoting alternative proteins, such as plant-based meat substitutes, can reduce pressure on marine ecosystems and diversify diets. These strategies can be supported by Japan's historically low beef consumption and rich tradition of plant-based foods.

Within this dietary landscape, the presence of traditional soy-based foods—such as *tofu*, *natto*, and *miso*—in approximately 13% of recipes highlights the enduring cultural and nutritional role of plant-derived proteins. These foods are associated with enhanced ecological efficiency and improved nutritional outcomes (Messina et al., 2022). Importantly, four soy-inclusive dishes in the dataset also contain animal protein, illustrating a hybridized approach to protein sourcing that balances cultural preference with sustainability considerations.

From an environmental standpoint, the inclusion of soy is particularly consequential. Soy protein production entails significantly lower GHG emissions compared to ruminant-derived protein sources; for instance, life cycle assessments indicate that soy protein emits up to 150 times less CO₂-equivalents per kilogram of protein than beef (Thrane et al., 2024). Nutritionally, fermented soy products, a staple of traditional Japanese cuisine, provide all essential amino acids. Microbial fermentation breaks down proteins, enhancing their digestibility and absorption to improve nutritional value (Wang et al., 2023). This process reduces the risk of nutrient deficiencies when animal protein intake is limited.

This synergistic pattern—characterized by moderate consumption of non-ruminant animal proteins and the strategic integration of nutrient-dense plant-based sources—offers a referential model for reconciling nutritional adequacy with reduced environmental impact.

As such, it provides valuable insights for the development of sustainable dietary frameworks that are both culturally grounded and ecologically responsible.

3.4.2. Culinary techniques as health-sustainability intermediaries

In the Japan Public Health Center (JPHC) baseline survey encompassing over 140,000 participants, boiling (comparable to simmering) was the predominant cooking method for meat across most regions (excluding Okinawa), followed by grilling and stirfrying; for vegetable dishes, boiling, raw preparation, and stir-frying were most frequently employed (Tsugane, 2001). This established pattern closely aligns with the cooking methods observed in our dataset (Table 3.5). The congruence between these datasets suggests that the culinary techniques captured in our analysis may reflect patterns commonly observed in Japanese cooking practices.

From both sustainability and health perspectives, the dominance of moisture-based methods—particularly simmering (54 mentions) and steaming (18)—is notable. These techniques require less oil and energy, supporting lower greenhouse gas emissions and better nutrient retention than high-heat, oil-intensive methods like deep-frying (10) or baking (2) (Miglio et al., 2008). Steaming, although not documented in national dietary surveys, appears frequently in the dataset and is associated with minimal nutrient loss, particularly of chlorophyll, soluble proteins, vitamin C, and glucosinolates (Yuan et al., 2009). Simmering is widely regarded as a gentle cooking method that helps preserve nutrients while requiring relatively low energy input. Stir-frying, when performed quickly with minimal oil, balances flavor enhancement with nutrient retention. The relatively limited use of frying and baking is notable in the dataset and may suggest dietary preferences that are mindful of health or ecological impact.

These findings underscore a culinary logic grounded in moderation and nutrient conservation—principles embedded in traditional Japanese cuisine. The convergence of historical and contemporary data points to a resilient dietary model that not only meets cultural and sensory expectations but also aligns with contemporary public health goals and environmental imperatives.

3.4.3. Seasonality in ingredients and sustainable diets

The explicit seasonal tagging of recipes in our dataset, alongside the frequent use of seasonal vegetables, highlights a fundamental aspect of traditional Japanese cuisine—its intrinsic alignment with seasonality. The dataset reveals a pronounced preference for ingredients that are in season, reflecting a culinary culture that adapts to natural cycles and local availability. This seasonal orientation is not merely cultural but also serves critical nutritional and ecological functions.

Seasonal food consumption is a well-documented feature of traditional Japanese diets (Ueda, 2022). Seasonal vegetables provide enhanced freshness, superior nutrient density, and greater flavor, which contribute to dietary satisfaction and health outcomes (Macdiarmid, 2014). In addition to nutritional gains, seasonal eating supports environmental sustainability by minimizing dependence on energy-intensive greenhouse production and long-distance transportation, thereby reducing the carbon footprint associated with food systems (Wu et al., 2024).

Our dataset’s explicit tagging corroborates these principles: a majority of vegetable ingredients correspond to well-known seasonal crops, including cabbages in spring, okras and cucumbers in summer, and root vegetables such as lotus roots in autumn. This adherence to seasonal cycles aligns with the traditional Japanese concept of *shun*, which emphasizes enjoying foods at their peak freshness and nutritional value (MAFF, 2025).

The integration of seasonality also complements the health-promoting attributes of the Japanese diet. Seasonal vegetables typically provide higher vitamin bioavailability when harvested at their peak, due to optimal growing conditions and minimal post-harvest nutrient loss (Phillips et al., 2018). From a sustainability perspective, prioritizing seasonal vegetables reduces food waste and energy inputs associated with artificial growth conditions, aligning with broader goals of sustainable food systems (Ladaru et al., 2020). This practice echoes findings from other studies documenting the environmental benefits of seasonal diets, which include reduced water use, land degradation, and greenhouse gas emissions (Stoessel et al., 2012).

3.4.4. Fermented seasonings as nutritional and ecological substitutes

The functional dominance of fermented seasonings in Japanese cuisine is quantitatively reflected in their displacement of discretionary additives. In our dataset, *mirin* (n = 22) substantially reduced added refined sugar: of the 39 recipes originally containing sugar, only 9 retained it after incorporating *mirin*—a 77% reduction. This substitution leverages *mirin*’s fermented sweetness and aligns with WHO sugar-reduction guidelines [54]. Similarly, soy sauce (n = 52) displaced added salt in 65% of salt-dependent recipes (72 → 25), offering equivalent *umami* depth with less salt per serving. This reduction is supported by research showing that soy peptides enhance salt taste perception, allowing reduced salt without loss of flavor (Jünger et al., 2022). *Miso* showed even greater salt-displacement efficacy, with only 1 of 7 *miso*-based recipes retaining added salt. Although the evidence for sugar reduction via soy-based seasonings is limited, the *umami* taste enhancement effect may contribute indirectly to reduced sugar usage by improving overall flavor complexity, which warrants further investigation.

Nutritionally, this displacement is complemented by fermentation-derived bioactives that offer additional health benefits. Fermentation enhances nutrient bioavailability, supports blood pressure regulation, promotes a more diverse gut microbiota, and produces compounds with antioxidant and anti-inflammatory properties (Entani et al., 1998; Nakahara et al., 2010; van Wyk, 2024). These physiological effects occur alongside improved sensory qualities, as microbial fermentation generates a broad spectrum of volatile compounds that enrich the depth and complexity of flavor.

From an environmental perspective, fermentation efficiently converts underutilized grains and legumes into nutrient-dense flavorings through relatively low-energy, biofriendly processes rather than energy-intensive methods (Faria et al., 2023). Furthermore, by-products such as soybean residue (*okara*) are valorized — repurposed into fertilizer, animal feed, or higher-value bioproducts — significantly reducing waste (Aussanasuwannakul et al., 2023).

3.4.5. Limitations

This study has four main limitations. First, nutritional composition (e.g., protein, vitamins, minerals) was not analyzed per dish, as recipes included ingredient lists without standardized nutritional profiles. Second, Japanese cuisine is characterized by strong regional diversity, yet national media may limit the research's ability to reflect local dietary differences. Third, the demographic characteristics of the program's audience and recipe users (e.g., age, socioeconomic status, and education) are unknown, which may limit the dataset's representativeness of general Japanese home cooking practices. Finally, although Today's Cooking offers detailed data on individual dishes, it remains unclear how these dishes are combined and consumed together in real-life meal settings. Therefore, future studies should conduct detailed nutritional profiling of dishes, incorporate region- and demographic-specific analyses, and employ real-time dietary recording methods to capture actual meal combinations.

3.5. Conclusions

This study offers a novel contribution to sustainable diet research by integrating diverse data sources beyond conventional academic materials. Specifically, we utilized recipe data from NHK's nationally broadcast cooking program, Today's Cooking, to explore potential insights into dietary practices as reflected in the recipes. This methodological innovation grounds the review in culturally embedded, widely disseminated recipes, offering insights that may inform connections between theoretical dietary models and household dietary practices. Such an approach offers a replicable framework for future studies seeking to align public-facing food media with academic inquiry into sustainable food systems.

Our findings affirm that contemporary home-cooked Japanese cuisine embodies a functional synthesis of nutrition, environmental stewardship, economic viability, and cultural continuity. This sustainability-oriented dietary paradigm is operationalized through several key practices: strategic protein sourcing that prioritizes low-trophic marine species and legume-based proteins; adherence to seasonal food procurement; flavor enhancement through fermentation rather than high resource inputs; and reliance on energy-efficient cooking methods. As a whole, these features reflect a culturally rooted approach to food that meets multiple dimensions of sustainability while preserving time-honored culinary traditions.

Nevertheless, the long-term viability of Japan's sustainable dietary model faces growing challenges amid globalization and shifting consumption norms. National survey data (2003-2015) reveal a marked decline in traditional "plant and fish" dietary patterns, paralleled by increased intake of bread, dairy, oils, and ultra-processed foods (Murakami et al., 2018). In addition, two critical challenges warrant attention. First, Japan's high per capita seafood consumption, while beneficial to public health due to its nutritional profile, places growing pressure on marine ecosystems. Overexploitation and habitat degradation necessitate more robust fisheries management and the development of alternative protein sources to ensure ecological sustainability. Second, high salt intake in the Japanese diet remains a persistent health concern, consistently linked to increased risks of hypertension and cardiovascular disease. Despite national dietary guidelines promoting salt reduction and specifying gender-specific daily intake targets, along with the inclusion of low-salt recipes

on widely disseminated programs like NHK Today's Cooking, sustained food reformulation and targeted public health interventions are still critically necessary. At the same time, since NHK Today's Cooking recipes may not fully correspond to actual daily food practices, further research is needed to assess real-world dietary behavior.

To address these emerging pressures, longitudinal analyses of dietary practices and nutrient trends are important and warrant further investigation. Moreover, future research must move beyond compositional analysis to explore the practical, social, and cultural determinants of dietary behavior. This includes evaluating the extent to which traditional food practices can be sustained amid the demands of modern, convenience-oriented lifestyles. Identifying culturally resonant, feasible strategies that align with both sustainability goals and contemporary life will be critical to guiding long-term dietary transitions in Japan and beyond.

4. Conclusions

4.1 Summary of Chapter 2 and Chapter 3

This dissertation examined how sustainability challenges in contemporary food systems appear in everyday eating by combining two complementary methods: a systematic mapping review of OMDS and a dish-level analysis of Japanese home cooking using recipes from NHK's Today's Cooking. The two approaches address different aspects of everyday food practice. The review analyzes how changes in food access through delivery platforms relate to multiple SDG-related impacts, while the recipe analysis examines how sustainability-related choices and constraints appear in Japanese home cooking. By linking evidence on food-access systems with evidence from cooking practices, this study clarifies how changes in food provision and everyday food preparation are involved in shaping sustainability-relevant eating practices.

Chapter 2 analyzed how the expansion of OMDS has generated both benefits and risks across multiple SDG-related dimensions. The review shows that the literature most often focuses on packaging waste ((Liu et al., 2021), delivery-related emissions (Xie et al., 2021), food waste (Liu et al., 2021), precarious working conditions for delivery riders (International Labour Organization, 2021), nutritional risks associated with convenience-oriented diets (Keeble et al., 2021), and economic effects such as competitive pressure on small independent restaurants together with new forms of flexible employment (Li et al., 2021). These findings indicate that OMDS simultaneously affects environmental performance, labor conditions, health outcomes, and food businesses. However, the review also shows that most studies examine these impacts in isolation. Only a small number of studies examine environmental, social, and economic effects within a single analytical framework. Long-term and indirect effects remain particularly underexamined, including changes in children's food learning when home cooking declines, the implications of delivery use for the division of household labor, and the long-term role of platform work in shaping social mobility. These gaps suggest that existing research documents important impacts but does not yet provide an integrated assessment of how OMDS influences sustainability across multiple dimensions.

Chapter 3 examined how sustainability-related considerations appear in contemporary Japanese home cooking through an analysis of 120 recipes broadcast on NHK's Today's Cooking between 2023 and 2025. The results show that ingredient choices broadly reflect national dietary patterns, with greater reliance on pork, chicken, fish, and soy products than on beef, frequent use of seasonal ingredients, and widespread use of fermented seasonings and low-oil cooking techniques. These features are consistent with public health recommendations and with characteristics associated with the UNESCO recognition of washoku, such as dietary balance and seasonality. At the same time, the analysis identifies clear constraints. Although the average salt content per dish is within recommended limits, certain combinations of dishes could exceed daily intake guidelines. In addition, the high share of fish-based dishes highlights a tension between nutritional goals and marine resource conservation, which cannot be evaluated accurately without information on species and fishing origins. Rather than presenting home cooking as inherently sustainable, the findings show that Japanese home cooking combines health-oriented practices with nutritional and environmental trade-offs that remain visible at the level of dishes.

4.2 Connecting food access and everyday cooking

Building on the findings summarized in the previous section, this section examines how changes in food-access systems and routine home cooking practices are connected in everyday eating.

OMDS and home cooking may appear to belong to different domains, one shaped by efficiency and technological innovation and the other by routine practice and culinary tradition. However, both directly structure the conditions under which everyday eating takes place. Previous studies have shown that digital delivery platforms reorganize the logistics of eating by compressing time and distance and prioritizing speed and convenience, thereby reshaping how food is prepared, and when it is consumed (Safira & Chikaraishi, 2023; Jia et al., 2024). Against this background, the findings of this dissertation show that such changes in food access are closely linked to household cooking routines and everyday food-related decisions.

Frequent use of OMDs alters not only food choice but also everyday meal planning and preparation. Reduced preparation time may limit opportunities for ingredient handling, seasoning decisions, and may increase reliance on ready-to-eat meals. At the same time, existing cooking habits influence how delivery services are used. Studies reviewed in Chapter 2 show that delivery use is more frequent among time-constrained households and younger consumers, and is often associated with reduced home cooking frequency and higher reliance on prepared foods (Keeble et al., 2021). In this sense, food-access systems shape cooking practices, and established cooking practices shape the frequency and patterns of delivery use.

The combined analysis therefore indicates that changes in delivery systems and everyday cooking practices influence sustainability-related outcomes through their ongoing interaction. OMDs change the conditions under which meals are planned and prepared by reducing the time and effort required for cooking and increasing reliance on ready-to-eat foods. Home cooking, in contrast, preserves opportunities for ingredient selection, seasoning adjustment, and portion control, through which nutritional and resource-related considerations can be incorporated into everyday meals.

This perspective highlights the limits of narrowly focused interventions. Policies that emphasize delivery efficiency alone may overlook changes in cooking participation and food knowledge, while initiatives that target individual dietary behavior alone may ignore the structural conditions created by changing food-access systems. Advancing sustainable food systems therefore requires policy approaches that address both how food reaches households and how everyday cooking practices are supported and maintained.

4.3 Reframing food sustainability as a relational practice

This dissertation proposes that food sustainability should be understood as a relational process that is realized through everyday interactions between food-access systems and home cooking practices. Rather than treating sustainability as a fixed property of particular foods, technologies, or dietary styles, the findings suggest that sustainability outcomes emerge through repeated decisions about how food is obtained, prepared, and consumed under specific social and institutional conditions.

Although previous studies have advanced understanding by quantifying environmental footprints, food loss, and dietary health outcomes (Poore & Nemecek, 2018; Limuro & Tabata, 2024), such approaches provide limited insight into how environmental, nutritional, and social

considerations are addressed together in everyday food practices. By contrast, the analyses in this dissertation instead show that sustainability is shaped through the ongoing coordination between changes in food provision and home cooking practices. From this perspective, sustainable eating depends not only on what food is available, but on how people apply everyday skills and judgments as they select ingredients, adjust seasoning, control portions, and evaluate meals within changing food environments. These routine decisions determine how abstract sustainability goals are translated into concrete behavior in daily life.

This relational view highlights that sustainability is not produced by isolated technologies or by the preservation of tradition alone. Instead, it emerges through the continuing alignment between evolving food-access systems and the practical knowledge embedded in home cooking.

4.4 Future directions and scholarly implications

The findings of this dissertation indicate that current transformations in food-access systems raise important questions about learning, labor, and long-term dietary practices that cannot be adequately assessed with existing evidence. Online meal delivery services are not only changing what people eat, but also how food-related knowledge is acquired, how household labor is organized, and how everyday eating practices develop over time. Because these processes shape both nutritional outcomes and social equity, understanding their longer-term implications is essential for evaluating the sustainability of digitalized food environments. The present study identifies several priorities for future research that follow from these concerns.

First, there is a strong need for longitudinal research on how sustained reliance on delivered meals influences children's food learning and dietary development. Chapter 2 showed that most existing studies focus on short-term consumption patterns and immediate nutritional indicators, while little is known about how reduced participation in cooking affects children's understanding of ingredients, preparation skills, and eating habits over time. These issues are central to sustainability because food literacy and cooking competence play an important role in shaping lifelong dietary behavior. Future research could follow households with different levels of OMDS use and examine changes in children's involvement in food preparation, food-related knowledge, and dietary preferences across developmental stages, using a combination of surveys, interviews, and skill-based assessments.

Second, further empirical research is needed to clarify how OMDS use affects the organization of unpaid food-related labor within households. Although some studies suggest that ordering meals reduces time spent cooking, the review in Chapter 2 shows that there is little direct evidence on whether this leads to more equal divisions of labor or simply shifts food-related work to other forms of domestic labor. Because household labor arrangements are closely related to gender equality, this question has important social implications. Future research could combine time-use data with qualitative interviews to examine whether delivery use leads to more equal divisions of domestic labor or simply redistributes food-related work within households.

Third, the dish-level analysis in Chapter 3 highlights the need to connect individual recipes to complete daily meal patterns. The present study examined dishes in isolation and therefore could not assess how recipes are combined across meals or how daily menus affect

cumulative nutrient intake and resource use. This limitation is important because sustainability outcomes depend on how individual dishes are combined into daily meals. Future research could examine full-day or multi-day menus by combining broadcast recipes with household meal records, in order to analyze how dishes are assembled into everyday meals and how nutritional and sustainability-related features accumulate across meals. Integrating recipe analysis with food diaries or dietary surveys would make it possible to examine how often particular dishes are eaten, how they are combined across meals, and how these patterns relate to nutritional intake and resource use in everyday diets.

Fourth, the analytical framework developed in this dissertation can be extended to other cultural and national contexts in order to examine how sustainability-related considerations are embedded in different culinary traditions and media environments. Applying the same coding criteria to cooking programs, cookbooks, or online recipe platforms in multiple countries would allow systematic comparison of ingredient choices, protein sources, seasoning practices, and seasonality. Such comparative research would help clarify how sustainability-related knowledge and adjustments are expressed through everyday cooking in different cultural settings, and how these practices respond to both local traditions and common social and environmental pressures.

Taken together, these directions suggest that future research on sustainable eating should move beyond isolated evaluations of technologies or diets and examine how changing food-access systems and everyday cooking practices jointly shape learning, labor, and long-term dietary behavior. Strengthening this empirical connection will be essential for designing policies and interventions that address sustainability not only at the level of food provision, but also at the level of home cooking practice and everyday decision making in increasingly digitalized food environments.

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Chapter 1

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