

Designing Future Food System: Integrating Sustainable Design and Food Waste Hierarchy

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ABSTRACT

Food waste remains a critical global challenge, particularly in Sydney, Australia. Despite sufficient food production to satisfy market demands, issues of hunger persists alongside excessive waste. Existing research and cases studies frequently address discrete stages of the system, often lacking a comprehensive system perspective. This design project in collaboration with three non-profit organizations, targets small food retailers and young consumers (aged 18-24) to promote sustainable practices. Guided by the food waste hierarchy framework, the design emphasizes prevention through source reduction as the most effective intervention. Future informed by speculative design theory and systems analysis, particularly the concept of leverage points. The design project seeks to strengthen positive feedback loops within the food system, empowering stakeholders to drive systemic change. The research of this project aims to prevent food waste by redesigning all stages of the food system. Design version 1 introduces a platform to facilitate data sharing among stakeholders during retail and consumption stages, enabling better alignment with market demand and consumer behaviour. The main design works of version 1 include system maps, two applications and food labels. Future versions of the design will expand to all stages of the food system and fostering a sustainable future.

KEYWORDS

Future food system; Sustainable design; Food waste hierarchy; System design; Retail-consumer networks

1 Manifesto

As designers, we believe good design is simple and easy to understand. And it will allow people to feel happy from their heart. Design has the potential to bring happiness to people. According to Dilnot ^[1], designers` could not only design products but also change the world. And people now live in an `Anthropocene` age <sup>[2]</sup> and it could be defined as an age when human activities would affect environment and ecosystem significantly <sup>[3]</sup>. This means that it is important to consider and be aware of this impact on people`s lives and environment, as well as the whole world. Also, Tonkinewise ^[4] agrees that designers` design could contribute to a more sustainable environment in the future. Therefore, it is believed that design could solve some grand challenges and our design could have a positive effect on the world.

2 Introduction

Food loss and food waste is a significant global issue, with over 30% of annual food production-nearly 1.3 billion tons of food loss and waste. Meanwhile, there are still people who suffer hunger while the food production could supply the market`s demand and people`s need ^[5]. This issue exists in every stage of food supply chain, from production to consumption, and involves significant resource waste. In 2021 Australia, 2,600 litres of water are used for food production that ultimately goes to food waste, equivalent to five Sydney Harbours.

Food waste also contributes to environment degradation through methane and leachate emission. In 2024, 3.4 million households struggled with food security, while households accounted for almost 30% of total food waste ^[6], generating food waste 2.5 million tons annually and costing \$2500 per household. Additionally, 13.8 million tonnes of carbon dioxide emissions were generated from food waste in landfill ^[7].

3 Location

The location of this design project will be in New South Wales (NSW) Australia because NSW accounted for the largest population. In Australia, more than 30% of waste in every household`s garbage is food waste. The National Food Waste Benchmark data shows that NSW wastes approximately 1.7 million tons of food waste annually. Additionally, Households are the largest contributor, generating 688,800 tons of food waste each year. The location of the project will be more specific. In Sydney, the population is approximately 5,557,233 people in 2024 and represents 63% of the total NSW population. And Australian Government 2025 study shows the serious situation, Australia households including Sydney spend up to \$2500 each year on food waste.

4 Client and end users

Environment Protection Authority (EPA), DoSomething and Food bank will be the clients of this project because local

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councils and non-profit organizations design a number of programs and activities for the issue of food waste. Collaboration with them could help promote reducing food waste in Australia. For instance, EPA launched a program, “Love Food Hate Waste” to reduce food waste in NSW. Additionally, Food Bank has designed various campaigns to reduce food waste. One such campaign, “Stop Food Waste”, focuses on changing people’s behaviours and raising awareness on food waste. The top three contributors of food waste in NSW, which includes aged 18 to 24 young consumers, family with children and households whose income are over \$100,000 per year. Young people contribute to more food waste than older people and admit to waste over 30\$ of fresh food every fortnight^[8]. This shows that young people are likely to contribute to food waste significantly in NSW. In addition, small food retailers will be end users as well because they are disadvantaged groups in food retailing business compared with those big food retailers and they lack information of market to balance food demand. Therefore, 18-24 aged young people and small food retailers will be our end users in Sydney, NSW.

5 Case studies

According to the local food system, this is the existing cycle how foods process from production to consumption and then waste recovery. The research evidence proved that there are food waste and food loss in every stage of the food cycle. Thus, the current food system needs to be improved in order to address food waste issue.



Figure 1 The existing limitations in current food system

Source: Own work.

Existing case studies have employed the food recovery hierarchy, prioritizing their approaches upper levels approaches such as reuse through sharing economy models. For instance, OzHarvest Market-Rescue Food Supermarket in Australia and Charity Fridge-Sharing Fridge for Communities in Dubai. However, these cases faced challenges in some areas due to supply and demand imbalance. In particular, some individuals might purchase more than they need, which affected the overall effectiveness of the program. Additionally, strategies in recycling and reusing food waste were unsuccessful and ineffective in Australia, primarily due to insufficient volume and lack of public awareness^[9]. Therefore, the design would focus on the prevention stage, though few precedents directly target on food waste prevention as primary issues. Prevention strategies include raising awareness through social media, such as restaurants post videos to sell salvaged food on TikTok or other Apps which help to reduce the food waste in restaurants. QR Fridge Magnets and Samsung’s AI fridge, which sends notification to users before food expires and helps reduce food waste and save cost. Additionally, innovations cases might able to change human behaviours regarding food waste prevention. For instance, IDEO London designed a future kitchen for IKEA, which enable users to store food in transparent environment and buy less food. Woolworths Metro- the first vertical farm in Australia that bring urban garden to consumers and reduce food loss from transportation by growing farms in urban space. And Plant-Based Meat -new alternative dairy products that could reduce resource consumption by growing a part of protein like real meat^[10].

These cases highlight the need for a holistic approach to prevent food waste, addressing both awareness and systemic improvements. The figure indicates that most existing case studies address food waste issue only at some stages and lack connection with the entire system. This could be identified as a significant gap.

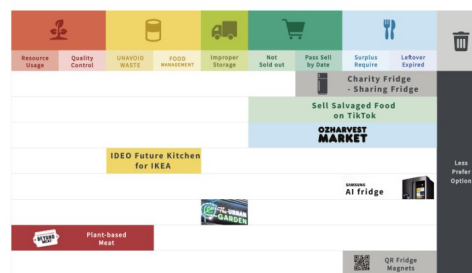


Figure 2 Analysis of previous case studies with food system

Source: Invertigro, halpin, bencic.

6 Conceptual framework

The research topic will focus on food waste, a significant global challenge both in Australia and globally. We aim to design solutions bring our end users happiness and promote sustainability. The study would explore the background and impacts of this issue, examining its underlying causes, reviewing previous case studies, and focusing on the needs and experiences of our end-users. Previous cases studies show the gap of this issue that most of them only focus on alleviating the issues in some stages of the system and lack connection of the whole system.

The food waste hierarchy, particularly and food waste recovery hierarchies inspire solutions to address this issue from prevention stage through source reduction. Prevention strategies are the most beneficial solutions in the framework of the food waste hierarchy ^[11]. It could help to prevent food surplus by the management of food production and consumption. Also, it could also reduce avoidable food waste (food could be eaten) in the food supply chain. In addition, previous cases of reusing and recycling food waste are not effective in Australia. Thus, the research will initially focus on prevention stage in the hierarchies.

Moreover, speculate design theory inspire to imagine different possibilities of the future food system. In Speculative everything: design, fiction, and social dreaming, Dune and Raby ^[12] suggest that designers could use design as a tool to imagine four different kinds of future, including probable, plausible, possible and preferable future. In It's Just Going to be a Lotta Hard Work – Radical Sustainability Innovation, Tonkinwise ^[13] also points out that creative ideas and design could apply to sustainable issues or big challenges. So it is believed that designers' capability could expand to other fields and design a better future food system.

In addition, theories of system analysis apply in this design project. In Leverage points: places to intervene in a system, Meadows ^[14] suggests that twelve leverage points could promote a big change for the whole system when making a small change on them. Also, the seventh point, gain around driving positive feedback loops is likely to empower end-users to change the system. This insight has highlighted the critical issue of system's inability to provide timely feedback. So the final design of central platform will focus on improving the feedback loop in the food system. Therefore, these theories allow us to analyse previous food system deeply and design a better future food system in a more creative perspective.

7 Objectives aim

In version 1 of the design, the design objective is to prevent the issue of food waste by improvement of retailing and consumption stages in the existing food system by using the platform. Specifically, version 1 of the platform will connect different stakeholders and prevent food waste in retailing and consumption stages. It will also share and collect data on markets demands and useful information for retailers and consumers. For instance, it will provide small retailers with consumers' demand statistics and enable them to sell food directly to consumers. For consumers, the platform will offer food storage tips and recipes, particularly targeting young consumers. The project aims to reduce food waste, with the expected outcome of eliminating food waste in Sydney.

8 New food system

According to the existing food system, food waste and food loss occurred in every stage from the production to consumption ^[15]. In addition, by 2030, the world may face a critical shortage of food because of limited resources and growing global population ^[16]. Consequently, the food system needs to be redesigned to prevent food waste in a more sustainable way and utilize resources more effectively.

The new food system should involve collaboration among all food stages. As the unpredictable demand of consumers and the time gap of feedback time within the food supply chain, the highest number of food loss was distributed by over-supply and surplus requirement before the consumption stage. Therefore, it will use the centre platform to connect all the stages together, for collecting all the food supply and demand information such as proportion, quality, type, and behaviour. The main concept is to prevent food loss through balancing food and need. When the demand is fulfilled, it could increase production, and when the supply is over, it could promote consumers to have more demand.



Figure 3 New food system diagram

Source: Own work.

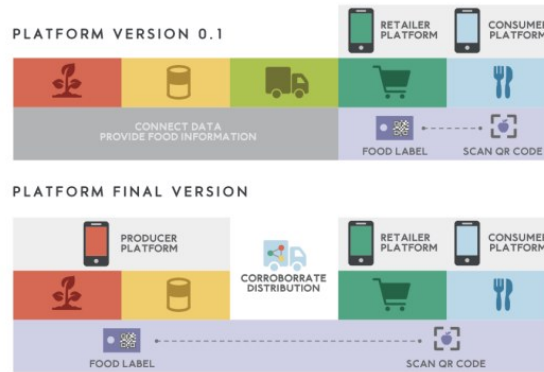


Figure 4 Different versions of platform

Source: Own work.



Figure 5 Different features of platform

Source: Own work.

However, it might be overly complex to reshape the whole system simultaneously. Therefore, it could initiate change in a small area to achieve a significant impact ^[17]. In the platform version 1, it will focus on two critical stages involving food waste: access and consumption. Subsequently, it would develop a further version to expand to all the stages in the food system.

9 Consumer platform

In version 1, the platform focus on retailing and consumption stages, featuring two applications: consumer App and retailer App. The consumer App allows consumers to manage their food storage by scanning QR code labels, providing detailed food information such as condition, quality, calories and cooking time. Cartoon faces visually indicate food condition. Users can remotely manage their storage, preventing duplicate purchases and overbuying, and receive notifications before food expiring.



Figure 6 Consumer platform

Source: Own work.

The App also generates customized recipes and shopping plans based on existing food, recommending daily recipes and promotions from retailer. It offers various recipes by difficulty and cooking time, suggests kitchenware, and links to retailer promotions. Consumers can purchase directly from retailers' online stores when supplies run low, reducing over-purchasing and balancing food demand.



Figure 7 Interface design of consumer platform

Source: Own work.

Furthermore, the App facilitates food sharing and exchange among users, posting surplus food for others to claim at low prices. Users earn points for posting items, promoting food reuse. The App also connects consumers to nearby retail stores, supporting small business and reducing unsold inventory. All these features aim to prevent and reduce food waste during consumption.

10 Retailer platform

The retailer App has similar features with consumer App but it includes unique features designed for business operations. It offers stock management, allowing retailers to scan products labels to add new stock and view detailed information such as name, condition, producer, location, and expiry date. This feature connects retailers and producers to the platform, facilitating efficient food storage management and reducing overstocking and expired food. Retailers can also share or sell unsalable or leftover food on the platform, accessing ingredients and cooking tools when needed.



Figure 8 Retailer platform

Source: Own work.

In contrast with consumer App, a key difference is the sales planning feature, enabling retailers to create, edit and manage daily, weekly, and monthly sales plans. The platform provides data-driven sales strategies and market analysis from experienced professionals. Retailers can directly sell food to consumers, manage online store products, and adjust prices and quantities. This allows retailers to achieve more precise understanding of market demand and to optimize their sales plan. Consequently, these features would enhance sales performance while minimizing leftover and unsalable food, ultimately food waste in the consumption stage.

11 New food label

The demand for packaged food is increasing in our daily life due to its convenience, presenting both opportunities and challenges for stakeholders in the food system and packaging industry. Food Labeling is an essential part of packaged food. Consumers rely on labels to obtain essential information about the product, including its freshness and shelf life through the expiry date on labels. There are two main functions: market-related aspects like brand identification and promotion, and consumer-focused protective measures.

Research indicated that consumer confusion and misunderstanding of expiration dates (use-by and best-before) which leads to food waste. Recent advancements in food packaging, particularly nanotechnology, offer solutions^[18]. For instance, nano film technology invented by Yangzhou University enables real-time monitoring of food conditions through color changes, reflecting freshness without opening the package. Additionally, the label is designed to be compatible with various types of packaging materials, meeting the specific packing and design requirements of different products. This technology is cost-effective, reducing costs by over 80% compared to existing methods like Vaccine Vial Monitor. Utilizing this technology in different stages of food system could enable consumers clearly distinguish whether the food

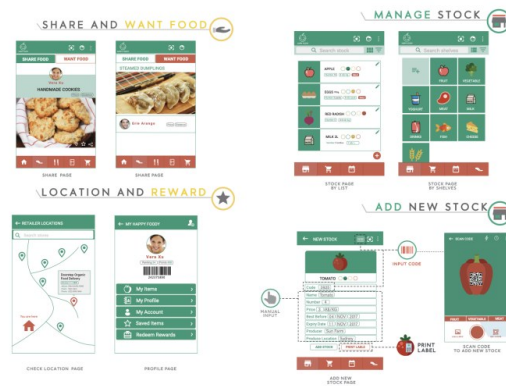


Figure 9 Interface design of retailers platform

Source: Own work.

is eatable or not, to reduce the food waste causing by the confusion.

Furthermore, the food label design addresses the food waste issue by integrating nanotechnology. The labels include bot text and graphic versions to indicate food conditions, which are also displayed on their consumer application. Once consumers scan the QR code on the labels, the app records their information, assisting in managing their food inventory. The notification for fruits ranges from immature to spoiled conditions, while those for meat and other foods is from fresh to spoiled conditions. This design aims to reduce food waste by clarifying food types and encouraging consumer engagement through a unique labeling approach.



Figure 10 Emoji faces show food condition

Source: Own work.

12 Conclusion

In conclusion, this design project focus on addressing the food waste issue in Sydney, targeting small food store retailers and young consumers aged 18-24. In design version 1, It introduces a system map, two application design, and food labels to prevent food waste by enhancing retailing and consumption stages. The version 1 platform connects stakeholders, share market data, and provides retailers with consumer demand statistics while offering consumers food storage tips and recipes. Future versions of the design will encompass to every stages of the food system, therefore promoting a sustainable future.

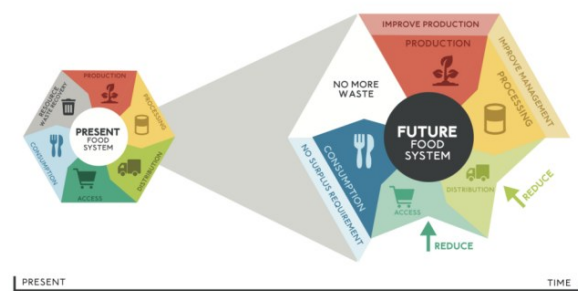


Figure 11 Food system from present to future

Source: Own work.

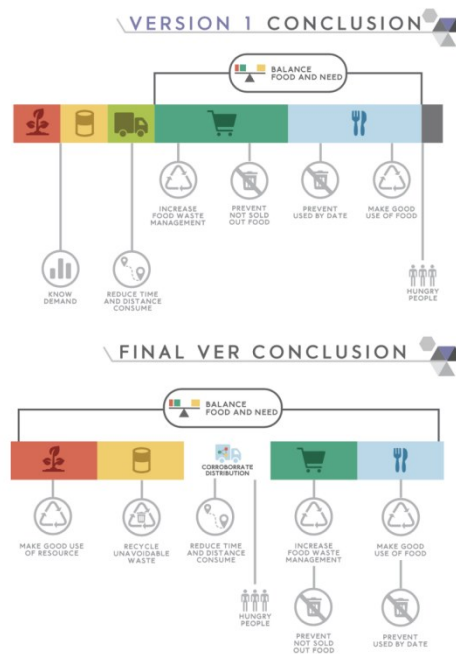


Figure 12 New food system from version 1 to final version

Source: Own work.

About the Author

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References

- [1] Dilnot C. Design as a socially significant activity: an introduction[J]. Design studies, 1982, 3(3): 139-146.
- [2] Crutzen P J. The "anthropocene"[M]//Earth system science in the anthropocene. Springer Berlin Heidelberg, 2006: 13-18.
- [3] Steffen W, Crutzen P J, McNeill J R. The Anthropocene: are humans now overwhelming the great forces of nature[J]. Ambio-Journal of Human Environment Research and Management, 2007, 36(8): 614-621.
- [4] Tonkinwise C. Practicing sustainability by design: global warming politics in a post-awareness world[J]. Scapes, 2007, 6: 4-14.
- [5] Mishra P, Singh N, Shrama C, et al. Landfill emissions and their impact on the environment[J]. Int J Eng Res Technol, 2020, 9(8): 617-622.
- [6] Van Biene M, Grant T, Kneller C, et al. National food waste strategy feasibility study-final report[J]. 2021.
- [7] Annual Volume of Greenhouse Gas Emissions from the Waste Sector in Australia from 2015 to 2025[EB/OL]. Statista's research department. (2025)[2025-09-01].
- [8] Hamilton C, Denniss R, Baker D G. Wasteful consumption in Australia[J]. 2005.
- [9] CRC F F W. Food waste Australian household attitudes and behaviours national benchmarking study final report[J]. 2020.
- [10] Smetana S, Ristic D, Pleissner D, et al. Meat substitutes: Resource demands and environmental footprints[J]. Resources, Conservation and Recycling, 2023, 190: 106831.
- [11] Papargyropoulou E, Lozano R, Steinberger J K, et al. The food waste hierarchy as a framework for the management of food surplus and food waste[J]. Journal of cleaner production, 2014, 76: 106-115.
- [12] Dunne A, Raby F. Speculative Everything, With a new preface by the authors: Design, Fiction, and Social Dreaming[J]. 2024.
- [13] Tonkinwise C. It's Just Going to be a Lotta Hard Work-Four Problematic and Five Potential Ways of Accomplishing Radical Sustainability Innovation[J]. Draft Paper. https://www.academia.edu/3844727/Its_Just_Going_to_be_a_Lotta_Hard_Work_Radical_Sustainability_Innovation, 2013.
- [14] Meadows D. Leverage points-places to intervene in a system[J]. 2015.
- [15] Fox T, Fimeche C. Global food: waste not, want not[J]. Institution of mechanical engineers, 2013: 1-31.
- [16] Agenda G. Shaping the future of global food systems: A scenarios analysis[C]//World Economic Forum. 2017: 1-28.
- [17] Vassallo S. The Way to Design[M/OL]. Foundation Capital, 2017. <https://www.goodreads.com/book/show/38349287-the-way-to-design>.
- [18] Zhao Z, Zhang B, Huang N, et al. Types of nanomaterials commonly used in food packaging, film formation techniques, and recent advances in their applications[J]. International Journal of Food Science and Technology, 2025, 60(1): vvae036.