

This is a repository copy of *Design Interventions for Sustainable Eating: Case Studies across UK and China*.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/id/eprint/213569/>

Version: Published Version

Article:

You, Fangzhou orcid.org/0000-0003-0581-8664, Jiang, Han, Liu, Yuelai et al. (1 more author) (2024) Design Interventions for Sustainable Eating: Case Studies across UK and China. International Journal of Advanced Design Research. pp. 26-36. ISSN: 2949-7825

<https://doi.org/10.1016/j.ijadr.2024.06.001>

Reuse

This article is distributed under the terms of the Creative Commons Attribution (CC BY) licence. This licence allows you to distribute, remix, tweak, and build upon the work, even commercially, as long as you credit the authors for the original work. More information and the full terms of the licence here:

<https://creativecommons.org/licenses/>

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



Design interventions for sustainable eating: Case studies across UK and China

Fangzhou You^a, Han Jiang^b, Yuelai Liu^c, Ying Jiang^{d,*}

^a School of Arts and Creative Technologies, University of York, Heslington, York, UK

^b School of Museum Studies, University of Leicester, Leicester, UK

^c College of Architecture and Urban Planning (CAUP), Tongji University, Shanghai, China

^d Shanghai Industrial Design Association, Shanghai, China

ARTICLE INFO

Keywords:

Design for sustainable eating
Behaviour change intervention
Technology-enabled behaviour change

ABSTRACT

The promotion of sustainable and healthy eating habits plays a pivotal role in enhancing the overall sustainability of food systems and addressing environmental pressures. Defined by the World Health Organization (WHO) as a lifestyle that is 'low in environmental impact, convenient, affordable, safe and fair, and culturally acceptable.' Recent technological advancements have expanded designers' exploration and innovative approaches to design for sustainable eating and reduce environmental impacts on food wastage. Design for Sustainable Behaviour (DfSB) has emerged as a valuable framework guiding the design, selection and evaluation of behaviour change interventions aimed at fostering responsible consumption and sustainable practices. This paper conducted four case studies to provide an overview of design practices in the field of design for sustainable eating via the lens of DfSB, focusing on technology-enabled behaviour change interventions to promote responsible food consumption. This paper contributes to the development of design interventions towards fostering sustainable eating behaviour whilst outlining the position of technology-enabled behaviour change. The findings provide design-focused insights for the creative industry in shaping sustainable food consumption towards a sustainable food system.

1. Introduction

Food waste is a pressing issue causing environmental impacts on climate, water, land and biodiversity throughout the food supply chain. The Food and Agriculture Organization (FAO) estimates that nearly one-third of all food produced for human use is lost or wasted each year; this is equivalent to 3.3 gigatonnes of CO₂ [1]. Many notions define food wastage as food loss and food waste. These terms correspond to wasted food that is at various stages. FAO [2] defines food waste as 'the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers.' In 2016, the UK government introduced the Eatwell Guide, emphasising plant-based foods and reducing the consumption of meat-based diet, which has the potential to reduce carbon emissions [3].

Meanwhile, food sustainability has been addressed as a behavioural issue in various fields. Chapman [4] states that 'the sustainability crisis is a behavioural issue, and not one simply of technology, production, and volume.' Such behavioural issues were identified throughout the entire supply chain in the public and private sectors. One of the major issues

discovered was food wastage. Behavioural issues in food consumption can be seen from the following phenomena: oversupply, food spoiling, incorrect purchase and individual consumer dietary habits, which contribute to potential reasons for food waste generation. In other words, food wasting behaviour can be regarded as an individual's actions that cause the decrease of consumable food from production to consumption.

In response to this issue, it is recognised that promoting sustainable eating and consumption could mitigate negative environmental impact and contribute to a sustainable food system in various contexts. For instance, previous study presented an approach of designing 'umamification' for plant-based dishes to contribute to consumers' adoption of plant-based food and thereby foster sustainable eating [5]. In addition to that, design guidelines for promoting sustainable cooking practice have seen potential to lead to designing for household appliances that encourage more sustainable cooking behaviours [6]. Seven types of behaviour change intervention are suggested to reduce airline food waste and promote sustainable passenger behaviour during airline services [7].

Technological innovation holds great promise for achieving greater efficiency improvements and facilitating behavioural changes [8], such

* Corresponding author.

E-mail addresses: fangzhou.you@york.ac.uk (F. You), hj164@leicester.ac.uk (H. Jiang), liuyuelai@gmail.com (Y. Liu), my.jiang@connect.polyu.hk (Y. Jiang).

<https://doi.org/10.1016/j.ijadr.2024.06.001>

Received 7 May 2024; Received in revised form 25 May 2024; Accepted 5 June 2024

2949-7825/© 2024 Northwestern Polytechnical University. Publishing services by Elsevier B.V. on behalf of KeAi Communications Co. Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

as using Internet of Things to manage food storage and consumption at home. Technologies have been used to drive innovation in food design, including the application of additive manufacturing technology to create new textures and add nutritional value [9]. Shifting from designing components of food to system and experience of eating, however, has been seen as an effective strategy of using technology to shape responsible consumer behaviour. For instance, 3D printing food can satisfy diversified user needs regarding customisation unlike traditional mass-production in the food industry [10]. The advancement of innovative technologies has great potential to support sustainable behavioural transitions [8].

This paper aims to address the research question regarding the role of technology in the design of interventions for promoting sustainable eating in the UK and China, by providing an overview of how design interventions leveraging on technologies should be considered in the design process to promote sustainable eating behaviour and reduce food waste. Specifically, this paper ascertains the role of technology in the design and implementation of behavioural change strategies to promote sustainable food consumption, drawing on four case studies. Technology, in this paper, refers to the general application of scientific knowledge for practical purposes in creative industries, including various forms of digital and non-digital media. This paper explores the broader possibilities of behaviour change interventions enabled by the diverse roles of technology, aiming to design sustainable eating practices within the realm of creative industries.

The next section presents the literature review revolving around DfSE, followed by the methodology in Sections 3. Section 4 identifies and discusses the four roles of technology in DfSE. The final section contains conclusions based on the findings and indicates possible future research directions.

2. Materials and methods

In this paper, Design for Sustainable Eating (DfSE) is defined as an emerging area of design research, which focuses on understanding and influencing consumer behaviour related to food consumption to address challenges such as overconsumption, food loss and wastage. The concept of ‘sustainable eating’ is proposed in response to the growing food demand of the increasing human population, often intertwined with complex factors in the food system, such as environmental health, business and nutrition [3].

2.1. Design interventions for behaviour change

Behaviour change is an expected outcome of the Design for

Sustainable Behaviour process. Ceschin and Gaziulusoy [11] position DfSB as an application of Design for Behaviour Change (DfBC): ‘*when design for behavioural change is applied to support the adoption of sustainable innovations and behaviours, we can speak of design for sustainable behaviour.*’ Behaviour change interventions are seen as an important element to DfBC in the field of sustainability. The DfSB framework consists of five steps to guide the design and development of ethical behaviour change interventions, as shown in Fig. 1 [12].

A general process of DfSB starts from understanding the problematic behaviour in the context, such as investigating factors influencing food wasting behaviour at household level. Once a target behaviour has been identified and specified according to step two, it comes with selecting and applying suitable behaviour change strategies tailored to drive the desired behaviour change. The final step requires design interventions to be evaluated and ascertain if behaviour has been changed towards resulting in sustainable consequences effectively. Through the five-step process, appropriate behaviour change strategies can be selected and then applied in the development of behaviour change interventions leading to desired behavioural outcomes. This paper primarily focuses on the evaluation of behaviour change, reviewing case studies on sustainable eating at product, service and system levels.

There are different levels of behaviour change strategies. Lilley [13] proposed the Axis of Influence to induce sustainable behaviour through product design: eco-feedback, behaviour steering and persuasive technology. It categorised three levels of intervention, including guide, maintain and ensure. Eco-feedback typically aims to decrease energy consumption through information provision; behaviour steering devices can rely on affordances and constraints to encourage a reduction in consumption; persuasive technologies enable user behaviour change with technical support. Fig. 2 shows the Axis of Influence, indicating that user-led and product-led decision-making have different levels of influence and control over behaviour. Strategies for designing sustainable behaviour can be developed based on this framework.

A promising evaluation framework of the effectiveness of behaviour change interventions has three indicators, including actual behaviour change, intervention functionality and sustainable consequence [14]. In other words, there are three criteria to be used to evaluate the effectiveness of behaviour change interventions, respectively.

- Behaviour change: whether the user changes behaviour because of intervention?
- Intervention functionality: Is the installed intervention useable and functional to the user?
- Sustainable consequences: whether the intervention has ecological, social and economic impacts on the user?

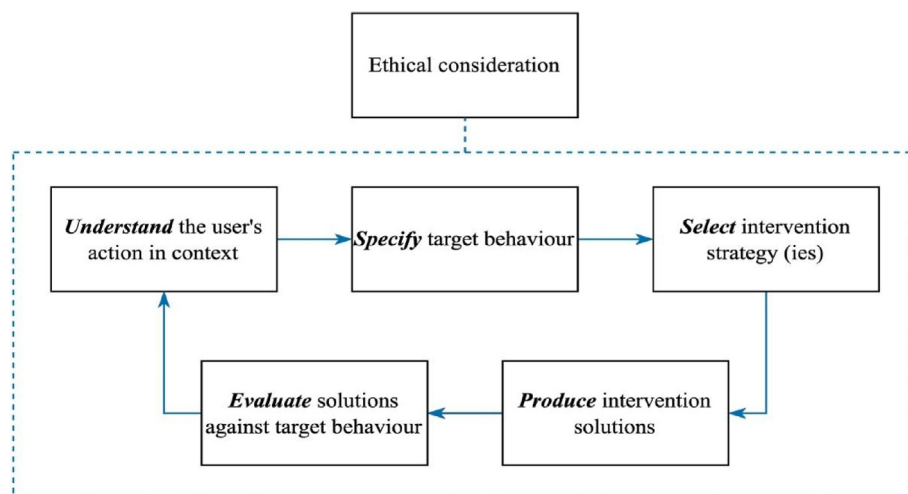


Fig. 1. Design for Sustainable Behaviour design process (Image originally created by Lilley and Wilson [12, p. 128]).

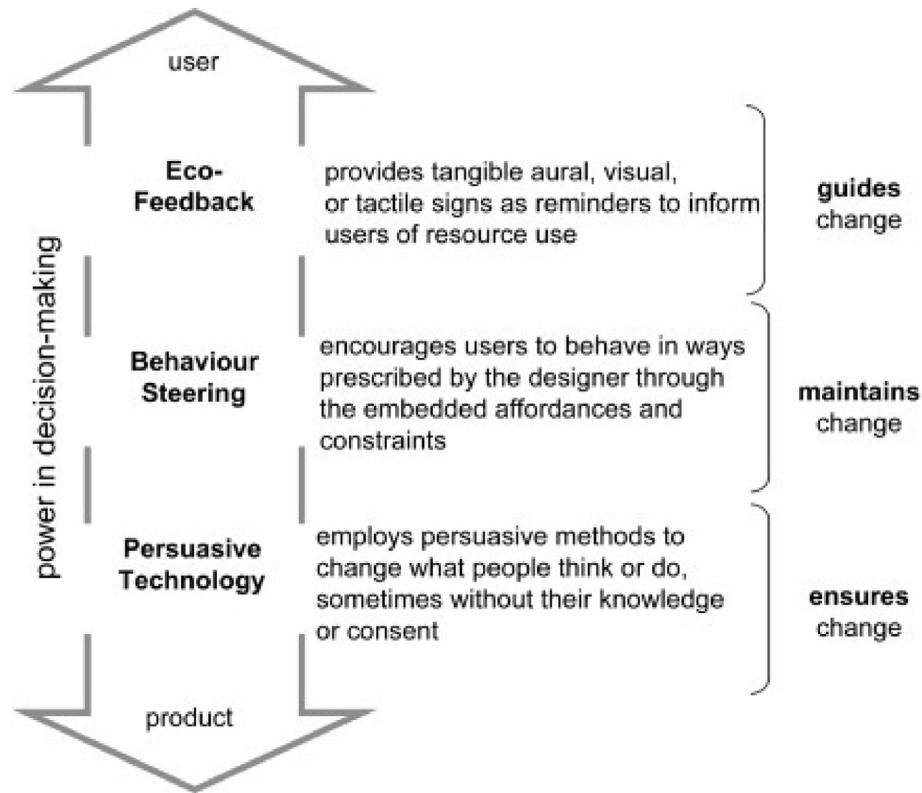


Fig. 2. The Axis of Influence (Image originally created by Lilley [13]).

2.2. Case studies of design for sustainable eating

The methodological choice in this paper was analysing the role of technology in promoting sustainable eating through design research using case studies. A case study is defined as a detailed examination of a single example or individual unit [15], emphasising developmental factors in relation to the environment. The application of case study follows a constructionist in which analysis takes place within each case to identify design interventions deployed in specific contexts [16]. In this paper, we explore four cases of Design for Sustainable Eating (DfSE) at the product, service, and system levels. Based on this method, the paper provides an overview of the themes guiding case selection. As shown in Fig. 3, which illustrates the key features of DfSE, it presents the nexus between behaviour change strategies, technology-facilitated design interventions and responsible food consumption.

Three criteria for evaluating the effectiveness of behaviour change intervention have been considered in the study, including actual

behaviour change, intervention functionality and sustainable consequence.

3. Results

3.1. Behaviour change interventions at the product level: a case study of eco-chocolates

Around 70 % of the globe's cocoa beans are cultivated in West Africa [17]. Cocoa holds significant economic importance for West African farmers, many of whom possess limited land holdings and lack the means to afford chocolate themselves. However, the cultivation of this plant and the chocolate manufactures as a whole is also contributing to profound issues in the region and blamed for the exploitative nature, concerning child labourer and deforestation [17]. In the UK, chocolate products are highly popular, with consumers estimated to purchase approximately 111 g of chocolate bars (filled and solid) per week [18]. In a world increasingly concerned about sustainable food consumption, the innovative concept of cocoa-free chocolate has emerged leveraging on material science and technology.

WNWN Food Labs, a food technology company based in London, introduced a collection of ecological chocolate bars at Design for Planet Festival 2023 [19]. These innovative chocolate bars are reported to have a lower carbon footprint compared to conventional chocolate products. This initiative aligns with the vision of promoting sustainable consumption and mitigating negative environmental impacts through the chocolate supply chain.

Leveraging innovative technology and food science, the company focuses on developing cocoa-free chocolate alternatives that mimic the taste and texture of conventional chocolate, without relying on cocoa beans. Whilst this approach has been promoted as a more responsible and ethical means of chocolate production and consumption, the extent to which WNWN chocolate can effectively enhance sustainable consumption patterns amongst chocolate consumers and reduce environmental

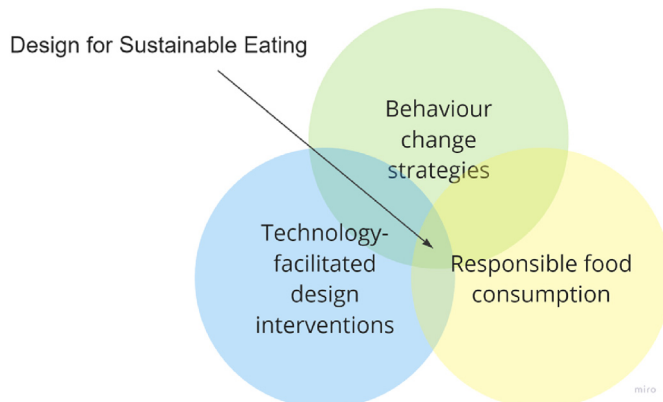


Fig. 3. The features of DfSE.

impacts throughout the manufacturing process remains unclear.

The authors purchased a trio of WNNN cocoa-free chocolate batches online (<https://www.wnnnfoodlabs.com/shop/>) and conducted a secondary data analysis using web-based content, as presented in Fig. 4.

This data collection and analysis requires a rapid turnaround of web-based data collection without direct interaction between researchers and target users, resulting in less biased data. However, web-based data has limitations due to its dynamic nature and the difficulty in measuring its content accurately [20]. The aim is to gather insights from potential consumers of sustainable chocolates, focusing on actual behaviour change, intervention functionality and sustainable consequence.

At the product level, design innovation behind cocoa-free chocolate centres on sustainability. WNNN Food Labs' research and development emphasise the sensory experience, ensuring that their cocoa-free alternatives offer the familiar taste and indulgence associated with traditional chocolate. The trio of chocolate bars mimic the packaging and iconic tastes of three famous chocolate brands, respectively Terry's chocolate orange, Tony's Choclonely and Cadbury dairy milk hazelnut chocolate.

The criteria of actual behaviour change and intervention functionality in this case refers to consumers' purchase motivation and their shifting towards chocolate alternatives to foster sustainable eating. One reviewer rated this product 4 out of 5 for ingredients and creativity, recognising the quality and innovation value of the chocolate alternative. However, in terms of motivation to repurchase, the reviewer commented, *'I'll chalk the high cost down to experimentation and development, though, as its new to the market, but it needs to come down in price substantially to stand a chance of converting chocolate lovers, let alone chocolate manufacturers.'* Though technology plays a critical role in innovating sustainable alternatives for chocolate consumers, it is still important for them to consider economic factors, such as price. Therefore, it is necessary to find a balance between technology-enabled design interventions and the cost for consumers to achieve actual behaviour change in sustainable eating.

Sustainable consequences in this case can be observed from a reviewer's comment on cardboard packaging, *'the 48 g bars come in identical*

sized recyclable cardboard boxes' and ingredients. As they pointed out, *'I like the fact that there's minimal ingredients used here, and that the recipe incorporates fermentation and roasting in much the same way as traditional cacao-based chocolate.'* But they also felt disappointed about the taste and texture, compared to traditional chocolate, *'it's another leap forward in creating a cocoa-free chocolate alternative, and should be applauded. I suspect we're only a few years off a research team developing a wonder product that can fool even the most devoted chocoholic into believing it's chocolate, but we're not quite there yet.'* In summary, the taste is a critical factor to consumers' behaviour change towards consuming sustainable chocolate and thereby likely to minimise the negative impact of traditional chocolate manufacturing.

Through the lens of DfSB, the intervention strategy of Win-Win Chocolate can be attributed to the application of persuasive technology. This is evident in the company's marketing, packaging design, and food science, aimed at encouraging consumers to sustainably choose their eating options.

Despite the progressive strides of technology-enabled behaviour change intervention, challenges persist in integrating sustainable eating practices. For instance, a reviewer is concerned about the danger of green-washing, *'a cheeky PR stunt from WNNN (inspired by Tony's Choclonely's clone bars campaign) to highlight their cocoa-free chocolate.'* Applying ethical behaviour change interventions that respect users' rights and consent is critical. Previous studies have identified public concerns regarding data collection and security in the highly technological scenario and access on personal eating practices [8]. In the context of food service provision, consumers can be given more freedom in decision-making by offering transparency in marketing strategies, such as using authentic packaging design, and product manufacturing procedures.

3.2. Behaviour change interventions at the service level: a case study of a food waste saving app

In the UK, approximately 70 % of food waste is produced in households [21]. Consequently, any technology that helps consumers prevent food from going directly from the fridge to the trash has the potential to make a significant impact. Olio, the world's largest food-sharing network with over seven million users, is a platform aiming to achieve this goal. It is a free application that connects neighbours and enables them to identify and share surplus food. Users can easily upload a photo and description of the food, and nearby individuals can collect it, thus reducing unnecessary waste. Olio also collaborates with businesses to minimise food waste through their 'Food Waste Heroes' volunteer programme. Businesses in the UK, Jersey, Stockholm, or the Bay Area can request Olio to dispatch volunteers to collect and redistribute their surplus food. These volunteers are often residents who have registered as food-saving volunteers, as presented in Fig. 5. Olio allows users to personalise their food or non-food free collection within the APP by adjusting item availability, collection distance and source of food (personal or volunteer), see Fig. 6.

It has embedded a forum with goals to provide a sense of community to combat food waste beyond individual levels, as shown in Fig. 7.

Olio operates as a consumer-to-consumer service, fostering public engagement to solve food waste issues and share responsibility. Through the lens of DfSB, Olio is seen applying a behaviour steering strategy to allow users have power over their food waste reduction behaviours. Incentives are incorporated in the digital services through notifications about new offers on discounted food bags or by displaying nearby free food to the users. Consumers' opt-in for becoming a food waste hero expects eco-conscious volunteers with high motivation to reduce food waste. As of 2024, this APP scores 4.9 out of 5 in Apple APP store, with most reviews praising the smooth communication and collection processes. However, some critical reviews point to concerns such as high frequency of notifications, delayed updates for item availability, and subscription advertisements. These critical reviews indicate that



Fig. 4. Win-win chocolates.



Fig. 5. Food waste heroes.

economic factors may play a role in user expectations and experiences with the APP.

Another similar food saving APP is Too Good To Go, which focuses on reducing food waste through a business-to-customer approach. This app connects customers with restaurants and stores nearby, allowing them to sell surplus food at discounted prices. Consumers can browse nearby participating businesses through the APP and purchase their surplus food at reduced rates. It was found that users value Too Good To Go's functional features, including real-time service, ease-of-use, and anytime orders [22]. Whilst both Olio and Too Good To Go aim to reduce food waste, they operate differently and emphasise distinct aspects of food waste reduction. For instance, Too Good To Go involves monetary transactions where users pay for the surplus food they purchase from businesses. Olio supports free sharing of surplus food items amongst individuals and local communities, with no monetary transactions involved. Even though Olio now has an option for purchasing food items from local communities, offering consumers more freedom in decision-making.

Both Too Good To Go and Olio leverage digital platforms to enable food waste reduction at the service level and foster sustainable eating practices through raising awareness, guiding sustainable eating behaviour, and building sustainable eating communities. In particular, technologies designed to facilitate user-driven participation and sustain long-

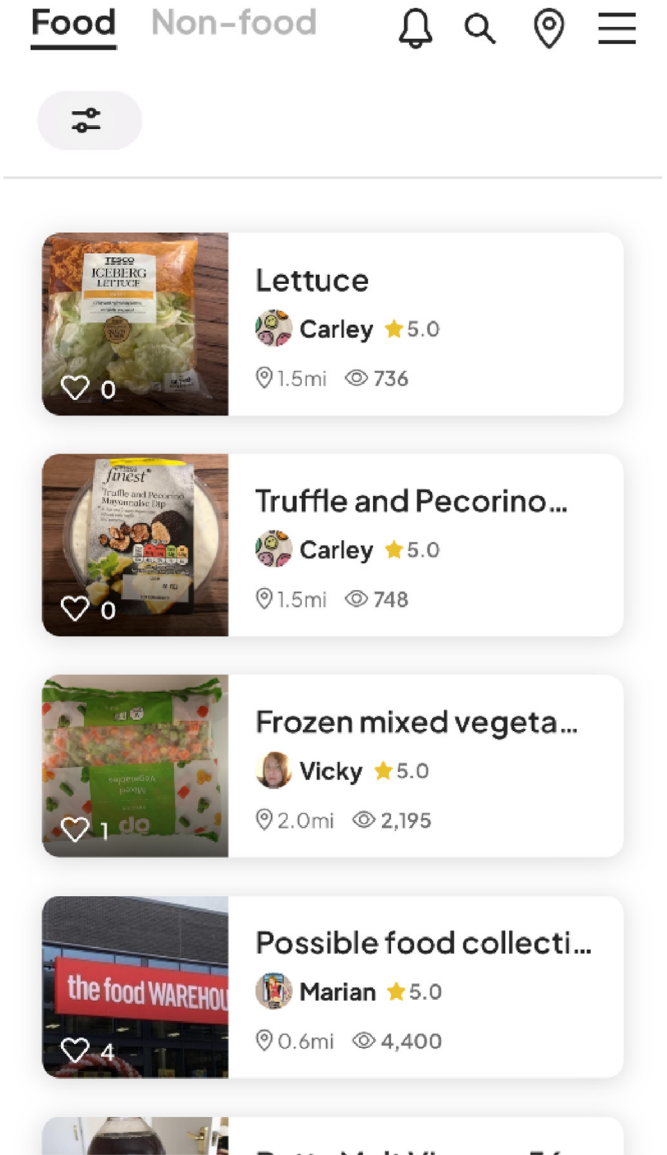


Fig. 6. Olio food sharing features.

term engagement should prioritise user autonomy (freedom of decision-making), provide support for their positive practices, and explore innovative technologies to achieve these objectives [23].

In terms of achieving actual behaviour change, it is evident that sustainable eating behaviours have been influenced by user reviews and activity levels of the two apps. Participation is a contributing factor to sustainable eating practices, especially when technical support offers an accessible platform to a broader audience, providing various formats and options to engage in food waste reduction at both micro (personal food swapping) and macro (volunteering) levels.

As for intervention functionality, technology plays a significant role in facilitating the sharing of food information and promoting ecological awareness through forums and goal setting for APP users. This enhances freedom of choice and provides channels to facilitate sustainable eating behaviour. It has been found that three key enablers to reduce food waste through food sharing practices, respectively pro-environmental

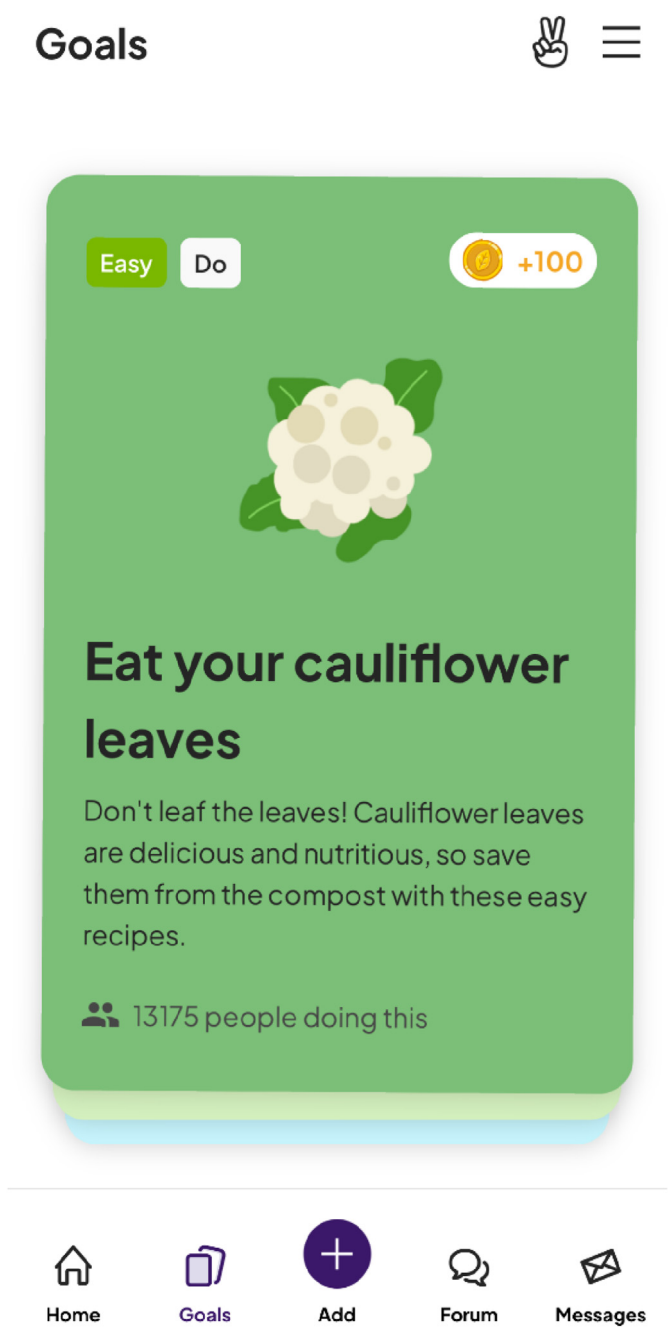


Fig. 7. Goals in the olio.

behaviour and economic awareness, skills, and collaborative behaviours [19]. To summarise, digital technologies bridge the gap between food producers and consumers and foster sustainable consumption behaviour with empowered skills and tools (mobile APPs). In addition, a community-based approach is applied to engage like-minded people in adopting sustainable eating habits.

Finally, sustainable consequences are observable from statistics. As of 2018, 697,108 items of food have been shared across 41 countries via Olio [24]. As for Too Good To Go, 200 million meals have been saved across 17 countries [25].

3.3. Behaviour change intervention at the system level in the UK and China

3.3.1. Fruit routes project at Loughborough University

The Fruit Routes, an award-winning project established in 2011 at

Loughborough University, is an award-winning project featuring over 150 trees that create an enriched habitat for people, plants, insects and animals on campus. It is a natural space for cultural activities and outdoor learning as a campus living lab. Funded by the University Estates and Facilities Management Service, the project aligns with the Biodiversity Action Plan and is overseen by the Fruit Routes Steering Group. The group comprises university staff, students, and local community members, including project founder Anne-Marie Culhane. The purpose of this project is [26]:

- To share and enhance the biodiversity on campus;
- To connect staff, students and local people in a creative and educational way;
- To get in touch with the campus as living and learning landscape;
- To support local food culture;
- To reduce our ecological footprint.

The routes include fruit, nut trees and edible plants along footpaths across the university campus. Fruit Routes' produce is available for students, staff and the local community to enjoy. People are encouraged to harvest fruits from the route as they ripen to encourage zero food waste and appreciation of local produce. A range of activities and walks are hosted throughout the year, such as an annual harvest event, spring-time walks, bake-offs and foraging, which are open to all, as shown in Figs. 8 and 9.

Not only the cultural activities and walks, handbooks and a map for harvesting are designed to empower the community to learn how and when to pick edible nuts and fruits, how to cook once picked and how to reduce food waste by making most of the produce of the Fruit Routes, as shown in Fig. 10.

The project has fully digitised the above-mentioned resources on their digital platforms, including a blog, Twitter and Instagram accounts to publish digital versions of recipe book and map, along with events (<https://fruitroutesloughborough.com/the-route/>). Participants can download E-handbooks and maps to explore the campus fruit walk and pick fruits, edible plants to engaging in sustainable foraging.

In this case, participants of the Fruit Route events are connected as a community to learn skills and knowledge of biodiversity, local food culture and reduce climate impacts by foraging on campus. All the resources made freely accessible to the public, which facilitates broader participation and supports the dissemination of activities and outcomes.

In terms of the formats of digitised materials, the project offers



Fig. 8. Identifying fruit trees.



Fig. 9. Fruit routes Spring walk.

accessible ways to obtain the map and food recipe with options for printed and digital versions. A wide range of activities including installation, design, film, poetry, food harvesting, workshops and talks, performance and walks, are introduced by this project to reach broader audiences. Participants have the flexibility to choose between attending face-to-face events or exploring self-guided learning materials that are available to them.

The year 2020 marks the 10-year anniversary of the project. It systematically influences people's attitude, awareness and behaviours to lead to a more sustainable and pro-environmental practice at individual, community and societal levels. As part of the sustainable outcomes of the project, the maintenance of campus biodiversity has facilitated the introduction of honeybees since 2013. The profit from selling Loughborough gold honey is used for looking after the university's 12 colonies of honeybees [27], as shown in Fig. 11.

3.3.2. Community garden initiative led by the Shanghai Clover nature school teenager nature experience service centre and Tongji University

In a similar vein, the public engagement in promoting sustainable eating receives a growing attention in China, with an idea of building community gardens in urban areas. Community gardens are defined as

places for growing food (fruits, vegetables and livestock) and non-edible plants in a communal, collective, progressive and cooperative setting. Participation in community gardening has been found having positive effects on health, wellbeing and sustainable food consumption [28].

In the vibrant city of Shanghai, situated on the eastern coast of China, a pioneering community garden initiative has taken root since 2014, marking the first participatory community garden planning and public green space innovation. The Shanghai Clover Nature School Teenager Nature Experience Service Centre and Tongji University have led the initiative. The public engagement enabled by the initiative has expanded from the nearby community of the university, local districts in Shanghai and then to the whole country. The initiative defines community gardens as 'open space for public co-building and sharing.' This initiative outlines five phases involved in building community gardens [29], drawing from the projects initiated between 2014 and 2019, as shown in Table 1.

The team has been dedicated to systematically practicing participatory community planning nationwide, linking various local forces to engage in spatial regeneration actions, aiming to cultivate and empower the social community. The edible community garden stands out as a successful example to enabling local residents to obtain fresh produce in the city and being a part of urban green space management and maintenance [30]. The idea of edible landscaping and public participation are the most important features of promoting sustainable behaviour in terms



Fig. 11. University's honey sale during the fruit route walk event.

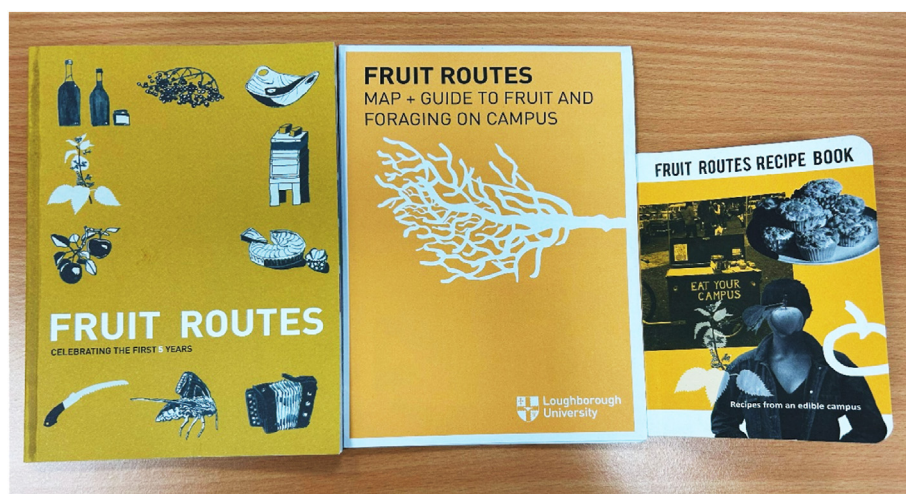


Fig. 10. A fruit routes map, a recipe book and a booklet.

Table 1
Five phases of community garden initiative.

No	Phase	Number of projects
1	Researchers' initiative with community involvement	45
2	Co-construction by enterprises, NGOs, and residents	3
3	Fostering community leader to drive community participation	10
4	Community's independent proposal, construction, and management	1
5	Social initiatives with researchers' instructions	11

of food consumption, and can be scaled up in diverse contexts, including residential areas, parks, and schools. This initiative has addressed the constraints of building edible gardens in urban public spaces, such as land scarcity and communal management amongst different stakeholders in a high-density city like Shanghai. Previous project, the 'Blooming Dongming,' has provided empirical evidence on converting residents from 'consumers' to 'prosumers' through the construction of community gardens at the Dongming subdistrict community in Shanghai, as shown in Fig. 12.

It was found that effective intervention of public engagement in community gardening is to establish residents' interests of space construction, space use, value-sharing to form a unified community consciousness, which consists of the awareness of shared interests, emotions, values, and lifestyles [31].

In 2018, interactive technologies have been studied and trialled primarily for raising participants' awareness of reducing food waste and encouraging resource recycling. For instance, design-related technologies have been applied to design-oriented guidance to bridge the gaps between designers and non-designers (local residents) in the process of spatial planning and management [32]. There are four dimensions of technology-powered behaviour change interventions through three means described as follows.

- Developing community awareness via community gardening [31];
- Establishing grassroots governance for residents [33];
- Introducing public art education [34].

Community gardens can contribute to ecological wellbeing and sustainability by reducing greenhouse gas emissions associated with food production and transportation [35]. The effectiveness of behaviour change interventions have been proved by public engagement in sustainable eating activities. It was also found to address the difficulty of grassroots governance amongst residents and identify a successful pathway leading the proactive participation and long-term interventions on sustainable eating, as shown in Figs. 13 and 14.

As shown in Figs. 1–13, this project focuses on creating a shared space for organic farming in the urban area. Specifically, selected plant varieties include fruit trees, herbs, vegetables, and traditional crops suitable for local cultivation. The entire garden abstains from using pesticides and chemical fertilisers, providing a friendly and self-balancing ecological environment for humans, animals and plants. For residents, the garden offers abundant participatory activities such as observation, touch, smell, planting, and harvesting, thus serving as an excellent educational resource to cultivate sustainable eating behaviour.

In the case of the community garden initiative, behaviour change has been evidenced with the creation of more than 260 community gardens in different types of communities in 12 districts in Shanghai, supported more than 1200 residents' autonomous mini community gardens. More than 1500 creative workshops were run to provide design, construction, management, maintenance and education to enhance the continuous public engagement.

Through ecological awareness raising, coupled with participatory activities, the initiative succeeds in aligning with individuals' values and promoting responsible eating behaviour through participating in urban



Fig. 12. The Dongming community garden (Image courtesy of Shanghai Clover Nature School Teenager Nature Experience Service Centre).

farming and planting. A sense of belonging enabled through community awareness building promotes community self-governance and development, thereby contributing to sustainable consequences. Nevertheless, the concerns have been raised in relation to the public's lack of interest or time and awareness of participation. Pilot experiments should be conducted to explore effective ways to enable self-empowerment and growth for the benefit of individuals.

4. Discussion

It is possible to answer the research question proposed at the beginning. From the four case studies examined, the authors evaluate and identify that technologies serve not only as a provider of sustainable sourcing information, but also media for consumer education and a community-based approach for raising awareness. Its primary function is to encourage the choice and consumption of ecological chocolate alternatives. The power in decision-making lies in ensuring consumers are informed about sustainable options. Table 2 summarises the four case studies in aspects of the role of technology, desired behaviour target, and Intervention strategies, power in decision-making.

Moreover, technology can function as catalysts for enhancing logistical efficiency and distribution, whilst also fostering community building. The APPs facilitate food sharing and saving engagement to maintain participation and collaboration amongst users.

Technology also plays a vital role in enabling knowledge exchange and community building, particularly focusing on local food culture and foraging skills. By leveraging technology, broader audiences are actively engaged in community-based food activities, ensuring inclusivity and widespread participation.

The role of facilitator of societal community and grassroots governance has been identified in the fourth case study in which behaviour change interventions have been achieved through the application of interactive technologies through formats as public arts and self-organised management. It should be noted that the interventions in this case not only guide but are also able to maintain the effectiveness of behaviour change with the desired sustainable impacts in the long run.

Incorporating technology into behaviour change interventions offers many potentials, yet it also presents potential pitfalls that need thoughtful attention. For example, user data security, as the collection and processing of personal information must be carefully managed to safeguard privacy and prevent unauthorised access. Additionally, ensuring transparency in behaviour change interventions is essential; users should be provided with clear and comprehensive information of how technology would influence their behaviour to make informed



Fig. 13. Knowledge and Innovation Community Garden (Image courtesy of Shanghai Clover Nature School).



Fig. 14. Herb garden(Image courtesy of Shanghai Clover Nature School).

Table 2
Technology-enabled behaviour change interventions.

Case	The role of technology	Desired behaviour target	Power in decision-making
Win chocolates	The provider of sustainable sourcing and consumer education	The choice and consumption of ecological chocolate alternatives	Ensure
Olio and Too Good To Go	The catalysts of efficient coordination and distribution Community building	Food sharing and saving engagement	Maintain
Fruit route project	The enabler of knowledge exchanging and community building	Local food culture and foraging skills and participation	Guide
The community garden initiative	The facilitator of societal community and grassroots governance	Community-based grassroots governance and organic farming	Guide and Maintain

decisions about participation. Protecting users’ freedom of decision-making is critical in behaviour change interventions. For instance,

users should be informed about design interventions applied to steer their wasteful consumption to respect their rights. This highlights the importance of ethical considerations as a foundational element of behaviour change interventions that leverage technology. By addressing these challenges, technology-enabled behaviour change interventions can mitigate potential risks and negative impacts on users.

Returning to the three levels of intervention created by Lilley [13], this paper provides a broader definition of guide, maintain and ensure, based on the four case studies at the product, service and system levels. In this paper, guide refers to non-intrusive guidance offering opportunities for individuals to make informed decisions about their current behaviours and thus to make sustainable choice. Maintain represents a further step towards guiding sustainable behaviours through an incentive mechanism. This mechanism does not necessarily associate with monetary benefits. In cases three and four, the incentive mechanism can be observed as the access to fresh food obtained through public engagement in gardening activities. Ensure describes a more intrusive and sometimes restrictive intervention aimed at ensuring that sustainable activities can be achieved with minimal cognitive effort from individuals. However, this type of intervention may be at risk of depriving individuals of their freedom of choice or influence sustainable behaviour without obtaining informed consent from those being intervened.

As mentioned in Section 3, three criteria can be applied to the evaluation of behaviour change interventions. In addition, it is suggested to use a series of ethical assessment questions to guide the technology-enabled behaviour change interventions [36], such as.

- Is the level of user control over the design intervention acceptably weighted against the intent and motivation of the designer?
- Are the intended outcomes of the design intervention ethical?
- Have unintended interactions between the user and the design intervention been predicted and are ethical?

5. Conclusions

The change towards more sustainable food consumption is essential for improving the sustainability of food systems and mitigating environmental pressures. Design interventions are deemed as potential solutions to bring responsible consumption behavioural patterns to the end consumers. This paper ascertains technology-enabled behaviour change interventions at product, service and system levels, revealing their roles and abilities leading positive changes to individual and broader audience in the field of DfSE. This paper sampled four case studies through the lens of DfSB, exploring the role of various technologies in the design and development of behaviour change interventions at different scales. Returning to the research question posed at the beginning of this paper, it is now possible to state four roles of technology in the current practice of behaviour change interventions, including the provider of sustainable sourcing and consumer education, the catalysts of efficient logistical distribution and community building, the enabler of knowledge exchanging and community building, along with the facilitator of societal community and grassroots governance.

This paper contributes to the development of design interventions aimed at fostering sustainable eating behaviour whilst highlighting various ways technology can facilitate behaviour change towards more sustainable food consumption across the UK and China. It should be noted that the four case studies selected in this paper are not intended to compare design interventions between cultures, but rather to review how their unique approaches influence sustainable food consumption practices at the system level. The findings of the four case studies provide an overview and practical insights for future intervention development for sustainable eating. This paper has examined design interventions facilitated with technologies and their roles through the lens of DfSB, respectively. Future research may shed light on underexposed research areas, such as the ethical implications on technology-driven interventions across cultures.

Funding

The authors acknowledges that this work receives fundings from the SEED Fellowship funded by the Arts and Humanities Research Council (AH/Y000722/1), United Kingdom, and the General Projects of Humanities and Social Sciences Research of the Ministry of Education, China (21YJCZH049).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] Food and Agriculture Organization, Food wastage footprint: impacts on natural resources [Online]. Available: <http://www.fao.org/nr/sustainability/food-loss-and-waste/en/>, 2013.
- [2] Food and Agricultural Organization, Food Loss and Food Waste, 2018, p. 1, <https://doi.org/10.1016/j.bmcl.2010.01.121>.
- [3] C. Pettinger, Sustainable eating: opportunities for nutrition professionals, *Nutr. Bull.* (2018) 226–237, <https://doi.org/10.1111/mbu.12335>.
- [4] J. Chapman, Design for (emotional) durability, *Des. Issues* 25 (4) (Oct. 2009) 29–35, <https://doi.org/10.1162/desi.2009.25.4.29>.
- [5] O.G. Mouritsen, K. Styrbaek, Design and “unamification” of vegetable dishes for sustainable eating, *Int. J. Food Des.* 5 (1) (Dec. 2020) 9–42, https://doi.org/10.1386/ijfd_00008.1.
- [6] K. Scherer, A. Dos Santos, D. Lilley, Design for sustainable behaviour: guidelines for cooking appliances, *Advanced Design Research* 1 (2) (Dec. 2023) 94–108, <https://doi.org/10.1016/j.ijadr.2023.12.003>.
- [7] F. You, T. Bhamra, D. Lilley, N. Clark, Design-led solutions for reducing airline food waste: A participatory approach to develop behaviour change interventions, *The Design Journal* (2024), <https://doi.org/10.1080/14606925.2024.2357469>.
- [8] A.R. Davies, Co-creating sustainable eating futures: technology, ICT and citizen–consumer ambivalence, *Futures* 62 (B) (2014) 181–193, <https://doi.org/10.1016/j.futures.2014.04.006>.
- [9] F.C. Godoi, S. Prakash, B.R. Bhandari, 3d printing technologies applied for food design: Status and prospects, *J. Food Eng.* 179 (Jun. 2016) 44–54, <https://doi.org/10.1016/j.jfoodeng.2016.01.025>.
- [10] K. Porter, J. Phipps, A. Szepekouski, S. Abidi, *3D Opportunity Serves it up: Additive Manufacturing and Food*, Deloitte University Press, 2024.
- [11] F. Ceschin, I. Gaziulusoy, Design for Sustainability: A Multi-Level Framework from Products to Socio-Technical Systems, 2019, <https://doi.org/10.4324/9780429456510>.
- [12] D. Lilley, G.T. Wilson, Design for sustainable behaviour, in: *Routledge Handbook of Sustainable Product Design*, Taylor & Francis, London, 2017, pp. 127–144, <https://doi.org/10.4324/9781315693309>.
- [13] D. Lilley, Design for sustainable behaviour: strategies and perceptions, *Des. Stud.* 30 (6) (Nov. 2009) 704–720, <https://doi.org/10.1016/j.destud.2009.05.001>.
- [14] G.T. Wilson, T. Bhamra, D. Lilley, Evaluating feedback interventions: a design for sustainable behaviour case study, *Int. J. Des.* 10 (2) (2016) 87–99.
- [15] B. Flyvbjerg, Case study, in: N.K. Denzin, Y.S. Lincoln (Eds.), *The Sage Handbook of Qualitative Research*, fourth ed., Sage, Thousand Oaks, 2011, pp. 301–316.
- [16] M. Easterby-Smith, R. Thorpe, P.R. Jackson, P.R. Jackson, *Management Research*, 4. ed., Sage Publ, Los Angeles, 2012.
- [17] WWF, Bittersweet: chocolate's impact on the environment [Online]. Available: <https://www.worldwildlife.org/magazine/issues/spring-2017/articles/bittersweet-chocolate-s-impact-on-the-environment>. (Accessed 20 November 2023).
- [18] F. & R. A. Department for Environment, National statistics-family food 2020/21 [Online]. Available: <https://www.gov.uk/government/statistics/family-food-2020-21>, 2022. (Accessed 21 November 2023).
- [19] Design Council, Design for Planet Festival 2023, 2023 [Online]. Available: <https://www.designcouncil.org.uk/our-events/design-for-planet-festival/>. (Accessed 18 October 2023).
- [20] I. Kim, J. Kuljis, Applying content analysis to web-based content, *J. Comput. Inf. Technol.* 18 (4) (2010) 369–375, <https://doi.org/10.2498/cit.1001924>.
- [21] A.L. Allison, F. Lorencatto, S. Michie, M. Miodownik, Barriers and enablers to food waste recycling: a mixed methods study amongst UK citizens, *Int. J. Environ. Res. Publ. Health* 19 (5) (2022), <https://doi.org/10.3390/ijerph19052729>.
- [22] T. Vo-Thanh, M. Zaman, R. Hasan, R.A. Rather, R. Lombardi, G. Secundo, How a mobile app can become a catalyst for sustainable social business: the case of Too Good to Go, *Technol. Forecast. Soc. Change* 171 (2021) 120962, <https://doi.org/10.1016/j.techfore.2021.120962>.
- [23] V. Righi, S. Sayago, A. Rosales, S.M. Ferreira, J. Blat, Co-designing with a community of older learners for over 10 years by moving user-driven participation from the margin to the centre, *CoDesign* 14 (1) (Jan. 2018) 32–44, <https://doi.org/10.1080/15710882.2018.1424206>.
- [24] J. Harvey, A. Smith, J. Goulding, I. Branco Illo, Food sharing, redistribution, and waste reduction via mobile applications: a social network analysis, *Ind. Market. Manag.* 88 (Jul. 2020) 437–448, <https://doi.org/10.1016/j.indmarman.2019.02.019>.
- [25] Too Good to Go, Too Good to Go Announces New Global Milestone: 200 Million Meals Saved, 2023 [Online]. Available: <https://www.toogoodtogo.com/en-gb/press/200-million>. (Accessed 7 February 2024).
- [26] J. Salter, A.-M. Culhane, Fruit Routes: Map and Guide to Fruit and Foraging on Campus, Loughborough University, 2016 [Online]. Available: <https://fruitroutes.loughborough.com/publications/>.
- [27] Loughborough University, The bees have been buzzy: raw honey sale [Online]. Available: <https://www.lboro.ac.uk/internal/news/2023/november/thebeeshavebeenbuzzyrawhoneysalenowon/>, 2023. (Accessed 9 February 2024).
- [28] C. Hume, J.A. Grieger, A. Kalamkarian, K. D'Onise, L.G. Smithers, Community gardens and their effects on diet, health, psychosocial and community outcomes: a systematic review, *BMC Publ. Health* 22 (1) (Jun. 2022) 1247, <https://doi.org/10.1186/s12889-022-13591-1>.
- [29] H. Kou, S. Zhang, Y. Liu, Community-engaged research for the promotion of healthy urban environments: a case study of community garden initiative in Shanghai, China, *Int. J. Environ. Res. Publ. Health* 16 (21) (Oct. 2019) 4145, <https://doi.org/10.3390/ijerph16214145>.
- [30] L. Yuelai, F. Haoyang, W. Min, Y. Keluan, and Y. Jianwei, 'From edible landscape to vital communities: Clover Nature School community gardens in Shanghai', *Landscape Architecture Frontiers*, vol. 5, no. 3, pp. 72–83.
- [31] L. Yuelai, W. Xie, J. Mao, Formation mechanism of governance community consciousness in urban micro-renewal: a case study of community garden, *Landscape Architecture* 30 (8) (2023) 20–26, <https://doi.org/10.12409/j.fjyl.202212310751>.

- [32] J. Mao, Y. Sun, Y. Liu, Research on the inclusive building mechanism of public space based on the joint governance hub —take Shanghai chuangzhi agricultural park as an example, *J. Guangxi Normal Univ. Nat. Sci. Ed.* 59 (3) (2023) 46–55, j.issn.1001-6597.2023.03.005.
- [33] Dongming Participatory Community Planning Guide, Dongming Road Street, 2022 [Online]. Available, <https://www.shjcdj.cn/djWeb/djweb/web/djweb/newestindex/newinfo.action?articleid=ff8080818d31d953018d71a4e4c239b3>. (Accessed 3 April 2024).
- [34] Y. Qi, Y. Liu, Local Autonomy and Diverse Integration: Exploration of Participatory Mechanisms in Public Art Practices in Shanghai Community Gardens, 2021, pp. 45–49, <https://doi.org/10.16272/j.cnki.cn11-1392/j.2021.11.002>. 装饰, no. 11.
- [35] M.H. Alemu, C. Grebitus, Towards sustainable urban food systems: analyzing contextual and intrapsychic drivers of growing food in small-scale urban agriculture, *PLoS One* 15 (12) (Dec. 2020) e0243949, <https://doi.org/10.1371/journal.pone.0243949>.
- [36] D. Lilley, G.T. Wilson, Integrating ethics into design for sustainable behaviour, *J. Des. Res.* 11 (3) (2013) 278–299, <https://doi.org/10.1504/JDR.2013.056593>.