Food waste matters

Staging design to foster societal transitions

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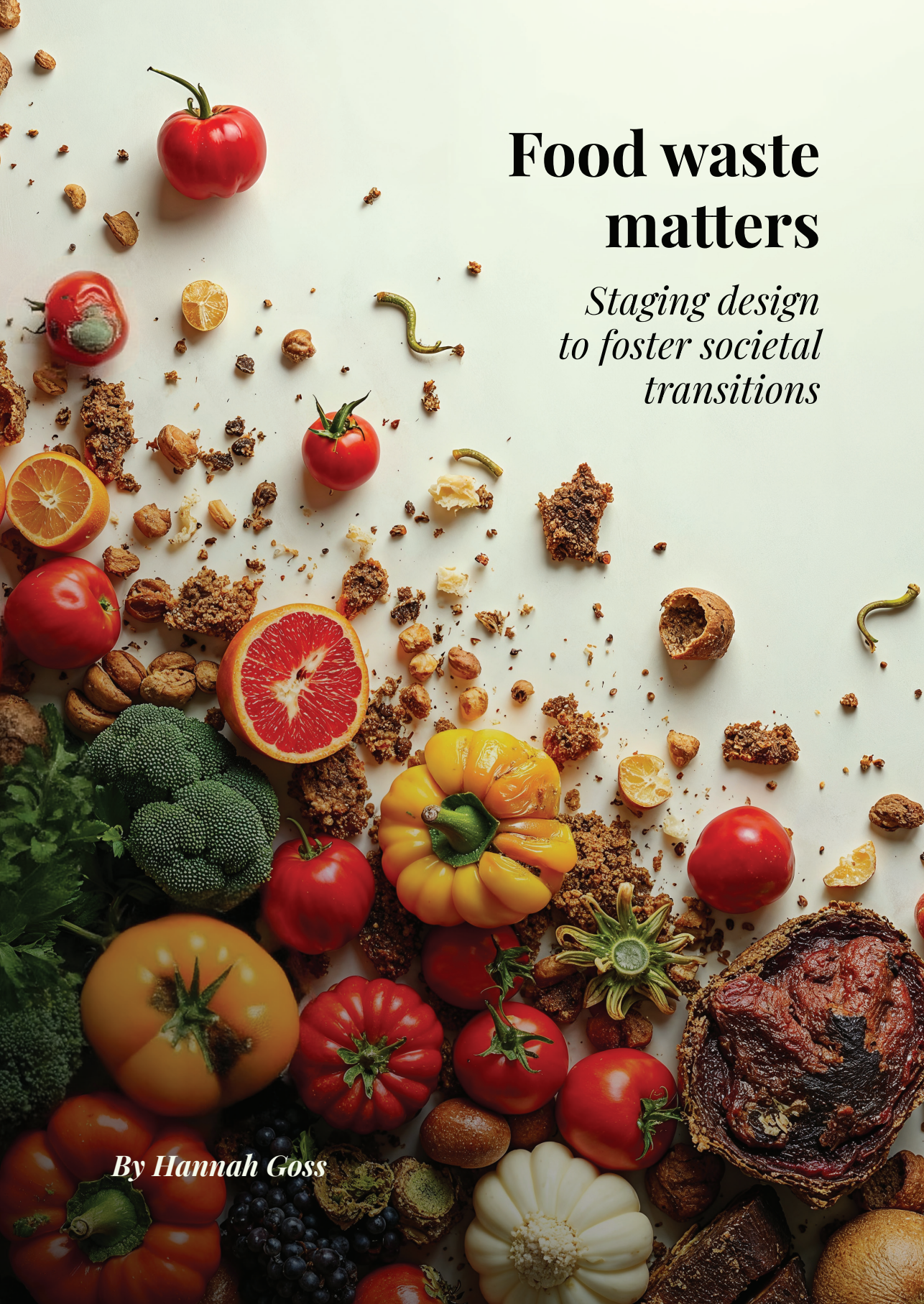

Food waste matters

Staging design to foster societal transitions

By Hannah Goss

Food waste matters

Staging design to foster societal transitions

Dissertation

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by

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A dissertation so novel, so rich, and so thick
It was even approved by Nynke, Jotte, and Rick

What can design contribute to transitions? That you will see
You might scratch your chin, you might disagree
That's part of academia, so it will be

Settle in, sit back, and start on page one
Design will shape futures for generations to come

— Inspired by Dr. Seuss

Table of Contents

PART TWO: FRAMING

PART THREE: EVALUATING

PART FOUR: GENERAL DISCUSSION AND CONCLUSIONS

Summary

Societies today face complex, interwoven challenges, such as food insecurity, biodiversity loss, resource depletion, and social inequality (Avelino et al., 2024; Geels et al., 2023). Addressing these issues demands transformative, multi-dimensional societal transitions. Transition design has emerged as a promising approach to facilitate and accelerate societal change by aligning short-term innovation with long-term goals (Irwin 2015; 2018). However, as an emerging field, transition design is still developing a deeper understanding of how designers can stage their expertise to contribute to transitions and what unique value design might bring.

This dissertation investigates how designers can apply their expertise in visioning, framing, and evaluating within transition design challenges. These areas represent fundamental areas of design expertise that hold particular significance for transition processes: *visioning* articulates long-term desirable futures that provide direction for change, *framing* connects systemic understanding to actionable interventions across multiple scales, and *evaluating* assesses the effectiveness of interventions in contributing to desired systemic transformation.

The research uses an iterative, exploratory approach, bridging theory and practice through sequential design steps. It is situated within the Dutch food system as part of the "Food Waste: From Excess to Enough" project, a collaboration between academic and industry partners aiming at reducing immediate food waste, while also contributing to a transition of the food system toward one that provides "enough" food for all with minimal waste.

This dissertation is structured across four parts comprising seven chapters, each building upon insights from previous ones to develop a comprehensive understanding of design's contributions in fostering societal transitions.

PART ONE: VISIONING

Visioning is crucial for setting the trajectory of transition design. **Chapter 2** presents a descriptive case study of how a design agency applies the Vision in Design method to envision a future food system for the Netherlands. The findings reveal three tensions for designers visioning in this transition context:

1. While designers are adept at making futures tangible by reflecting experiential everyday qualities, transition contexts require them to depict not only everyday life but also the dynamic relationships between systemic and experiential aspects.
2. While designers must understand current systems, a tension arises because they also need to constructively challenge these systems. They must balance radical provocations with the practical realities of stakeholders perspectives, ensuring that envisioned futures remain relatable and that stakeholders can see their evolving roles in the future.

3. While visioning seeks to create alignment and momentum around desirable futures, transition contexts introduce heightened moral and ethical demands. Designers must engage in and initiate normative debates about what is desirable, potentially challenging dominant stakeholder views.

These tensions highlight the need for new methods to support designers in contibuitng their expertise in visioning processes. This chapter resulted in the development of a vision of a future food system for the Netherlands—a vision that subsequently guided and informed later studies of this research.

PART TWO: FRAMING

This part shifts to framing system dynamics to inform where and how designers can intervene to foster desired transitions.

Chapter 3 introduces a conceptual framework that identifies 1) new systems principles that drive a transition, 2) new organisational roles that actors can adopt now, and 3) new behaviours and capabilities that people can adopt in the near future, as valuable aspects of a design frame. A research-through-design approach led to the creation of Adaptable Consumption, a new practice and intervention portfolio that supports waste-free and flexible behaviours in daily life while also driving broader systemic changes.

Chapter 4 explores how adaptable consumption can unfold meaningfully in households, thereby linking the micro-level consumer practices (i.e., the third aspect of the frame discussed above) to the broader transition goals outlined in the previous studies. Using cultural probes and interviews, five opportunity areas for supporting adaptable consumption in households were identified: 1) supporting flexible meal moments, 2) reclaiming food edibility, 3) reintegrating food into routines, 4) integrating feedback loops, and 5) playing into life-changing moments. Together, these opportunities highlight the interplay between behavioural, material, and social dimensions of food consumption, demonstrating how adaptable consumption can reduce waste and enhance household resilience.

Chapter 5 introduces a logical framework to help designers make informed design decisions and construct clear argumentation for how proposed interventions can foster desired systemic changes over time and scales. Tested through workshops, the framework helps designers articulate intervention strategies that align micro-level changes with broader system goals, offering a foundation for developing coherent and impact-oriented transition design portfolios.

Together, these chapters demonstrate how framing can ground design interventions in a nuanced understanding of system dynamics, organisational contexts, and everyday life. Our approach makes complex transition contexts accessible and actionable for design practice, and contributes practical tools and intervention strategies to support framing activities. Additionally, a portfolio of interventions was developed and tested in the final empirical chapter.

PART THREE: EVALUATING

Evaluation is essential for understanding the impact of interventions. **Chapter 6** presents a framework connecting five transition design activities—navigating scales, considering temporality, engaging actors, designing portfolios, and practising reflexivity—with three evaluative qualities of its outcomes: desirability, plausibility, and networkedness. The findings confirmed that the interventions designed in our transition design process were perceived as desirable, plausible, and networked by diverse actor groups. This chapter suggests that engaging in these five activities can lead to interventions that can foster desired transitions.

PART FOUR: GENERAL DISCUSSION AND CONCLUSIONS

The final part of this dissertation synthesises the research findings and discusses their broader implications. **Chapter 7** outlines the key contributions and insights of this doctoral research, exploring how designers can stage their expertise when designing for transitions. Key contributions include:

- *Strengthening transition design as a field:* This research advances transition design by articulating core areas of design expertise—visioning, framing, and evaluating—and providing empirical evidence and methodological support for their application. These contributions support the maturation of transition design practice and knowledge-building.
- *Practical impact on food system transformation:* The application of a transition design approach to fostering the Dutch food system towards less food waste demonstrates the tangible outcomes of this research. The introduction of adaptable consumption as a practice and a portfolio of systemic interventions offers new directions for reducing food waste and strengthening household and food system resilience.
- *Framework for evaluating transition design interventions:* We developed a novel framework that connects transition design activities with qualities for assessing its outcomes. This framework supports the structuring of transition design processes and understanding the effectiveness of its interventions in fostering desired transitions. Additionally, we demonstrate how incorporating quantitative testing into evaluation can strengthen transition design as an evidence-based practice.

Future research was proposed to explore additional design expertise not specifically studied in this work, for instance formgiving, to further understand how designers can contribute to transition design processes. Additionally, we propose that designers seek opportunities to engage longer with transitions to support taking on a moral agent-like role needed for such transformative processes.

Samenvatting

Samenlevingen staan vandaag de dag voor complexe, verweven uitdagingen, zoals voedselonzekerheid, verlies aan biodiversiteit, uitputting van hulpbronnen en sociale ongelijkheid (Avelino et al., 2024; Geels et al., 2023). Het aanpakken van deze uitdagingen vereist transformatieve, multidimensionale maatschappelijke transities. Transitieontwerp is naar voren gekomen als een veelbelovende benadering om maatschappelijke verandering te faciliteren en te versnellen door korte-termijn innovatie af te stemmen op lange-termijn doelen (Irwin 2015; 2018). Echter, als opkomend vakgebied is transitieontwerp nog steeds een beter begrip aan het ontwikkelen van hoe ontwerpers hun expertise kunnen inzetten om bij te dragen aan transities en welke unieke waarde ontwerp zou kunnen brengen.

Dit proefschrift onderzoekt hoe ontwerpers hun expertise kunnen toepassen in visieontwikkeling, framing en evaluatie binnen transitieontwerp uitdagingen. Deze gebieden vertegenwoordigen fundamentele gebieden van ontwerpexpertise die bijzondere betekenis hebben voor transitieprocessen: visieontwikkeling articuleert wenselijke toekomstbeelden op lange termijn die richting geven aan verandering, framing verbindt systemisch begrip met uitvoerbare interventies, en evaluatie beoordeelt de effectiviteit van interventies in het bijdragen aan gewenste gewenste systemische transformatie.

Het onderzoek gebruikt een iteratieve, exploratieve benadering, die theorie en praktijk verbindt door opeenvolgende ontwerpstappen. Het is gesitueerd binnen het Nederlandse voedselsysteem als onderdeel van het “Food Waste: From Excess to Enough” project, een samenwerking tussen academische en industriële partners gericht op het bedrijfsleven met als doel om directe voedselverspilling te verminderen en tegelijkertijd bij te dragen aan de transitie van het voedselsysteem naar een systeem dat “voldoende” voedsel voor iedereen levert met minimale verspilling.

Het proefschrift is gestructureerd in vier delen bestaande uit zeven hoofdstukken, die elk voortbouwen op inzichten uit voorgaande delen om een uitgebreid begrip te ontwikkelen van de bijdragen van ontwerp aan het bevorderen van maatschappelijke transities.

DEEL EEN: VISIEONTWIKKELING

Visieontwikkeling is cruciaal voor het bepalen van het traject van transitieontwerp. **Hoofdstuk 2** presenteert een casestudy van hoe een ontwerpbureau de Vision in Design methode toepast om een toekomstig voedselsysteem voor Nederland te visualiseren. De bevindingen onthullen drie spanningsvelden voor ontwerpers die visies ontwikkelen in deze transitiecontext:

1. Hoewel ontwerpers bedreven zijn in het tastbaar maken van toekomstbeelden door ervaringsgerichte alledaagse kwaliteiten te weerspiegelen, vereisen

transitiecontexten dat ze niet alleen het dagelijks leven in kaart brengen, maar ook de dynamische relaties tussen systemische en ervaringsgerichte aspecten.

2. Hoewel ontwerpers de huidige systemen moeten begrijpen, ontstaat er een spanning omdat ze deze systemen ook constructief moeten uitdagen. Ze moeten radicale provocaties in balans brengen met de praktische realiteit van perspectieven van belanghebbenden, waarbij ze ervoor zorgen dat gevisualiseerde toekomsten herkenbaar blijven en dat belanghebbenden hun veranderende rollen in de toekomst kunnen zien.
3. Hoewel visieontwikkeling streeft naar het creëren van afstemming en momentum rond wenselijke toekomsten, introduceren transitiecontexten verhoogde morele en ethische eisen. Ontwerpers moeten deelnemen aan en normatieve debatten initiëren over wat als wenselijk wordt beschouwd, wat mogelijk dominante standpunten van belanghebbenden uitdaagt.

Deze spanningsvelden benadrukken de behoefte aan nieuwe methoden om ontwerpers te ondersteunen bij het inbrengen van hun expertise in visieontwikkelingsprocessen. Dit hoofdstuk resulteerde in de ontwikkeling van een visie op een toekomstig voedselsysteem in Nederland—een visie die vervolgens de latere studies van dit onderzoek heeft geleid en geïnformeerd.

DEEL TWEE: FRAMING

Dit deel verschuift naar het framen van systeemdynamiek om te bepalen waar en hoe ontwerpers kunnen interveniëren om transities te bevorderen.

Hoofdstuk 3 introduceert een conceptueel framework dat 1) nieuwe systeemprincipes die een transitie aandrijven, 2) nieuwe organisatorische rollen die actoren nu kunnen aannemen, en 3) nieuwe gedragingen en capaciteiten die mensen in de nabije toekomst kunnen aannemen identificeert als waardevolle aspecten van een design frame. Een research-through-design benadering leidde tot de creatie van Aanpasbare Consumptie, een nieuwe practice en nieuw interventieportfolio dat afvalvrije en flexibele gedragingen in het dagelijks leven ondersteunt en tegelijkertijd bredere systemische veranderingen stimuleert.

Hoofdstuk 4 onderzoekt hoe Aanpasbare Consumptie zinvol kan ontvouwen in huishoudens, waardoor de microniveau consumenten practices (d.w.z. het derde aspect van het frame dat hierboven wordt besproken) worden verbonden met de bredere transitiedoelen die in de vorige studies zijn geschetst. Met behulp van culturele probes en interviews werden vijf kansgebieden geïdentificeerd voor het ondersteunen van Aanpasbare Consumptie in huishoudens: 1) het ondersteunen van flexibele maaltijdmomenten, 2) het herdefiniëren van eetbaarheid van voedsel, 3) het herintegreren van voedsel in routines, 4) het integreren van feedbackloops, en 5) het inspelen op levensveranderende momenten. Samen benadrukken deze kansen het samenspel tussen gedragsmatige, materiële en sociale dimensies van voedsel-

consumptie, en tonen ze hoe Aanpasbare Consumptie verspilling kan verminderen en de veerkracht van huishoudens kan versterken.

Hoofdstuk 5 introduceert een logical framework om ontwerpers te helpen geïnformeerde ontwerpbeslissingen te nemen en duidelijke argumentatie op te bouwen voor hoe voorgestelde interventies gewenste systemische veranderingen kunnen bevorderen in de loop van de tijd en systeemschalen. Getest door middel van workshops, helpt het framework ontwerpers bij het articuleren van interventiestrategieën die veranderingen op microniveau afstemmen op bredere systeemdoelen, wat een basis biedt voor het ontwikkelen van coherente en impactgerichte transitieontwerp-portfolio's.

Samen tonen deze hoofdstukken aan hoe framing ontwerpinterventies kan baseren op een genuanceerd begrip van systeemdynamiek, organisatorische contexten en het dagelijks leven. Onze benadering maakt complexe transitiecontexten toegankelijk en uitvoerbaar voor de ontwerppraktijk, en draagt praktische tools en interventiestrategieën bij om framing-activiteiten te ondersteunen. Daarnaast werd een portfolio van interventies ontwikkeld en getest in het laatste empirische hoofdstuk.

DEEL DRIE: EVALUEREN

Evaluatie is essentieel voor het begrijpen van de impact van interventies. **Hoofdstuk 6** presenteert een framework dat vijf transitieontwerp-activiteiten verbindt—navigeren tussen schaalniveaus, rekening houden met temporaliteit, betrekken van actoren, ontwerpen van portfolio's en het beoefenen van reflexiviteit—met drie evaluatieve kwaliteiten van de resultaten: wenselijkheid, plausibiliteit en verbondenheid. De bevindingen bevestigden dat de interventies die in ons transitieontwerpproces zijn ontworpen, door diverse actorengroepen als wenselijk, plausibel en verbonden werden ervaren. Dit hoofdstuk suggereert dat het uitvoeren van deze vijf activiteiten kan leiden tot interventies die gewenste transities kunnen bevorderen.

DEEL VIER: ALGEMENE DISCUSSIE EN CONCLUSIES

Het laatste deel van dit proefschrift synthetiseert de onderzoeksresultaten en bespreekt hun bredere implicaties. **Hoofdstuk 7** schetst de belangrijkste bijdragen en inzichten van dit doctoraatsonderzoek, en verkent hoe ontwerpers hun expertise kunnen inzetten bij het ontwerpen voor transities. Belangrijke bijdragen zijn onder andere:

- *Versterking van transitieontwerp als vakgebied:* Dit onderzoek bevordert transitieontwerp door kerngebieden van ontwerpexpertise te articuleren—visieontwikkeling, framing en evalueren—en door empirisch bewijs en methodologische ondersteuning te bieden voor hun toepassing. Deze bijdragen ondersteunen de ontwikkeling van de transitieontwerppraktijk en kennisopbouw.
- *Praktische impact op de transformatie van het voedselsysteem:* De

toepassing van een transitieontwerp-benadering voor het bevorderen van het Nederlandse voedselsysteem richting minder voedselverspilling toont de tastbare resultaten van dit onderzoek. De introductie van Aanpasbare Consumptie als een practice en een portfolio van systemische interventies biedt nieuwe richtingen voor het verminderen van voedselverspilling en het versterken van de veerkracht van huishoudens en het voedselsysteem.

– *Framework voor het evalueren van transitieontwerp-interventies:* We hebben een nieuw framework ontwikkeld dat transitieontwerp-activiteiten verbindt met kwaliteiten voor het beoordelen van resultaten. Dit framework ondersteunt de structurering van transitieontwerpprocessen en het inzicht in de effectiviteit van de interventies bij het bevorderen van gewenste transities. Daarnaast laten we zien hoe de integratie van kwantitatieve tests in evaluatie transitieontwerp kan versterken als een evidence-based praktijk. We tonen aan hoe het integreren van kwantitatief testen in evaluatie transitieontwerp kan versterken als een evidence-based praktijk.

Toekomstig onderzoek werd voorgesteld om aanvullende ontwerpexpertise te verkennen die niet specifiek is bestudeerd in dit werk, waaronder vormgeving, om verder te begrijpen hoe ontwerpers kunnen bijdragen aan transitieontwerpprocessen. Daarnaast stellen we voor dat ontwerpers mogelijk een langere betrokkenheid bij transities zouden kunnen nastreven om het aannemen van een moral actor-achtige rol binnen deze transformatieve processen te ondersteunen.

Figure 0-1 | *Liquid Landscapes* by Tone Bjordam, depicting three possible future Earth states: an ice-age-like state (left), a hothouse state (right), and a fragile yet stable state (centre). Image credits: © Tone Bjordam. Reprinted with permission.

Trajectories

In the autumn of 2024, I attended the Relating Systems Thinking and Design Conference in Oslo, Norway. As the lights dimmed in a room filled with design researchers, systems thinkers, practitioners, and students, a multimedia presentation titled *Liquid Landscapes* by Tone Bjordam unfolded on the screen. Inspired by the scientific article *"Trajectories of the Earth System in the Anthropocene"* (Steffen et al., 2018), the artwork depicted three possible futures for our planet: a frozen ice-age-like state, an overheated tropical hothouse state, and a fragile yet stable state that can enable human flourishing (Figure 0-1). As I watched the vivid depictions of possible futures unfold, I reflected on the interconnectedness of the challenges humanity faces and the potential for collective action to alter these trajectories. Bjordam's work serves as a powerful reminder that the paths we choose today will shape the possibilities of tomorrow, and that through deliberate and thoughtful actions, we can navigate toward more sustainable and equitable futures. This dissertation explores how we might consciously shape these trajectories through transition design.

Chapter 01

General introduction

This introductory chapter outlines the research topic explored in this dissertation, it gives an introduction to transition design as a field and practice, and presents the research methodology employed. It concludes with an overview of the dissertation's structure, providing a guide for the reader through the subsequent chapters. Throughout this dissertation, the pronoun "we" is used to refer to the author of this dissertation and co-authors of the articles included in this dissertation.

1.1. Transition design: what is it and where did it come from?

The challenges of our time are deeply interconnected, spanning environmental, social, and economic domains (Fisher et al., 2021). Climate change, biodiversity loss, resource depletion, social inequality, economic instability, and food insecurity are not isolated crises but symptoms of systemic patterns that shape modern life (Rockström et al., 2009). Economies thrive on extraction and overconsumption, governance systems struggle to manage complexity, and cultural norms often reinforce unsustainable behaviours (Rockström et al., 2009). Together, these patterns destabilise ecosystems, exacerbate inequities, and threaten the foundations of both human and ecological well-being. As societies grapples with these immense challenges, cutting across scales, disciplines, geographies, and sectors (Geels, 2004), discussions frequently carry a tone of despair. This leads to feelings of helplessness, anxiety, and the perception that the necessary changes may not come quickly enough or at a sufficient scale (Lee et al., 2023; Pihkala, 2020). Yet, while the complexity is undeniable, the trajectories of societies are not predetermined (Steffen et al., 2018). The future is shaped by collective actions, and through thoughtful, innovative responses it remains possible to shift current trajectories toward more sustainable, equitable, and desirable alternatives.

Addressing these societal crises necessitates fundamental shifts in societal systems, often referred to as sustainability transitions (Loorbach, 2007). These transitions are understood as long-term, multi-dimensional, and transformative processes that reorient systems of production and consumption toward more sustainable, just, and resilient alternatives (Loorbach, 2022; Markard et al., 2012; Oates & Verveld, 2024). Unfolding over decades, they involve diverse actors driving technological, social, organisational, and institutional innovations that enable present and future generations to flourish (Avelino et al., 2024; Ceschin & Gaziulusoy, 2016; Markard et al., 2012). For instance, the agro-food system—historically shaped by industrial agriculture—is beginning to adopt alternative practices such as plant-based proteins, circular food economies, and community-supported agriculture (Peeters et al., 2024). These developments disrupt entrenched structures and open pathways for more resilient, localised, and equitable food systems. The urgency of fostering such transitions, from food to healthcare to energy, is heightened by the rapidly narrowing window of opportunity to address these escalating crises (Rockström et al., 2009). Meeting this challenge requires innovative approaches that align short-term actions with long-term societal and planetary goals (Loorbach et al., 2017).

Against this backdrop, this dissertation investigates the role of design in fostering societal transitions toward more sustainable alternatives. It focuses specifically on transition design (Irwin, 2015), a specialised field and practice situated at the intersection of design and sustainability transitions. Transition design seeks

to guide societies toward desired futures states through systemic interventions, requiring expertise both in navigating complex systems and in devising innovative solutions to enable systemic change. This research applies a specific transition design approach to the Dutch food system, aiming to ensure sufficient food for all while minimising food waste. In doing so, it contributes to the maturation of transition design as an emerging field and practice. Throughout this dissertation, the terms "transition design" and "designing for transitions" are used interchangeably to represent work at the intersection of design research and practice and sustainability transitions research and practice.

The following sections in this chapter present the theoretical and conceptual foundations that underpin this research. First, key concepts related to sustainability transitions, designing for systems change, and transition design are introduced. This is followed by a description of the Dutch food system to contextualise the research and a description of why we consider this research a case of transition design. Finally, the research methodology is outlined.

1.1.1. Sustainability transitions

Over the past three decades, the challenge of promoting and governing transitions towards sustainability has received increasing attention in both scientific research (e.g., Köhler et al., 2019; Loorbach et al., 2015) and policy arenas (e.g., Hainsch et al., 2022; OECD, 2015). As mentioned previously, sustainability transitions are complex processes through which established societal systems evolve into more sustainable modes of production and consumption (e.g., Geels & Schot, 2010; Kemp & Rotmans, 2005). They are inherently multi-dimensional, involving shifts in technologies, organisational structures, governance, societal norms, and cultural practices. Importantly, transitions unfold over extended periods, often over several decades, and require the active involvement of a broad range of actors, including policymakers, businesses, and civil society (Geels & Schot, 2010).

Sustainability transitions research builds on the foundations of complexity science, systems thinking, and evolutionary economics (Loorbach et al., 2017). Rather than focusing on isolated technological fixes, this field emphasises systemic approaches that acknowledge the interconnectedness of various sectors to reach sustainability goals (Loorbach et al., 2017). Central to transitions research is the recognition that sustainability is not a fixed endpoint but ongoing processes of balancing ecological, social, and economic needs (Hjorth & Madani, 2014). Achieving this balance requires analysing systemic interactions, anticipating future scenarios, and navigating uncertainties (Wiek et al., 2011). For instance, transitioning to a sustainable food system aimed at reducing food waste involves not only technological advancements, such as improved food preservation and waste processing technologies, but also behavioural changes among consumers (e.g., throwing away less), innovative business models (e.g., production reduction strategies), supportive policy interventions (e.g., food package regulations), and

enhanced logistical infrastructures (e.g., distribution systems to redirect surplus food).

Efforts to achieve sustainability transitions often encounter significant challenges due to systemic dynamics that resist change, including strong path dependencies and lock-ins across sectors, such as food supply, energy, and transportation (Goldstein et al., 2023). These sectors, understood as socio-technical systems, are shaped by historical decisions and entrenched structures (Rip & Kemp, 1998). They comprise networks of actors (individuals, firms, and organisations), institutions (societal norms, regulations, and standards), material artefacts (e.g., products and services), and knowledge (Geels, 2004), which together form the core components of socio-technical systems. Interactions between these elements deliver essential services to society. However, because user practices, technologies, business models, organisational structures, political frameworks, and institutional regulations are deeply interconnected, these systems exhibit significant resistance to change, making transformative shifts toward sustainable alternatives particularly difficult (Rip & Kemp, 1998).

Theoretical concepts and frameworks in the field of transitions

Theoretically, several frameworks have gained significant attention in the field of transition studies, providing valuable insights into the dynamics of systems change. Markard et al. (2012) identified the following as being central to the field including, *strategic niche management* (Kemp et al., 1998; Schot & Geels, 2013), *the multi-level perspective* (Geels, 2002; Geels & Schot, 2007; Smith et al., 2010), *transition management* (Loorbach, 2007; Loorbach et al., 2015), and *technological innovation systems* (Hekkert et al., 2007; Markard, 2020). These frameworks are built upon key concepts of how societal levels function and how their interactions play a central role in understanding the evolution toward fundamentally different alternatives. Before introducing the frameworks, I will first explain two of the key concepts used in transition studies: regimes and niches.

Regimes are a central concept within transitions research and refer to the established and relatively stable patterns of rules, routines, and practices that structure how actors interact, make decisions, and maintain existing structures within a particular system (Geels & Schot, 2010; Rip & Kemp, 1998). These patterns are embedded in the various dimensions of society (e.g., cultures, practices, institutional structures, infrastructures) and shape the course and pace of innovation towards a trajectory of incremental changes (Geels, 2002; Geels, 2005; Schot & Kanger, 2018). Regimes act as sets of 'unwritten rules' that guide how systems operate, offering stability and predictability while resisting sudden change. These established norms, routines, and structures shape everyday behaviours and influence what kinds of changes are viewed as possible. Scholars in transition studies typically focus on destabilising regimes that produce unsustainable patterns to understand what

factors can support the emergence of new sustainable alternatives (e.g., Geels, 2002; Raven et al., 2012; Smith et al., 2005).

Niches are closely related to the concept of regimes. Niches are protected spaces—such as experimental domains or niche markets—where radical innovations can develop without being subject to the dominant regime pressures (Geels & Raven, 2006; Geels, 2002). Over time, innovations within niches can gain momentum through social learning, experimentation, and network formation, eventually challenging and transforming the regime's established rules, routines, and structures (Geels & Raven, 2006; Geels & Schot, 2007).

Strategic niche management is the first framework described, and builds on the dynamics between regimes and niches by intentionally supporting niche development to trigger regime shifts and enable large-scale system innovation (Schot & Geels, 2013). In the earlier years of transition studies, the focus was often on niches, leading to critiques that this approach neglected the influence and dynamics of the regime (Smith et al., 2005). However, subsequent research highlights that niches are not entirely isolated from regimes; in fact, they can emerge within or be supported by the regime itself (Schot & Geels, 2013).

The multi-level perspective (MLP) is the second framework, and also builds on the dynamics of regimes and niches to explain long-term societal transitions (Geels, 2002). The MLP introduces a third conceptual level, the *landscape*, which encompasses broader external factors such as socio-political shifts and environmental pressures. The landscape evolves slowly but can exert pressure on regimes, destabilising them and creating opportunities for niches to emerge and challenge the status quo. The interaction and alignment between niches, regimes, and landscapes over time shape the pathways through which transitions unfold. Scholars use the MLP to study historical transitions, such as the adoption of biogas (Geels & Raven, 2006), as well as to assess possible future transitions, such as toward sustainable mobility (Köhler et al., 2009).

Schot and Geels (2013) outline four transition pathways that describe the dynamic interactions between niches, regimes, and landscapes in systemic change: transformation, de-alignment and re-alignment, substitution, and reconfiguration. *Transformation* occurs when regime actors respond incrementally to moderate landscape pressures by integrating niche innovations. *De-alignment and re-alignment* occurs when significant landscape disruptions destabilise the existing regime, creating space for multiple competing niches to emerge, followed by the eventual stabilisation of a new regime. In *substitution*, niche innovations compete with and replace the existing regime, often triggered by abrupt landscape shocks. Lastly, *reconfiguration* involves a symbiotic relationship between niche innovations and the regime, where innovations are adopted, prompting regime actors to adjust and explore further novelties.

The third framework, *technological innovation systems* (TIS), examines how new technologies emerge and develop within specific institutional contexts (Carlsson

& Stankiewicz, 1991). TIS actively explores the dynamic interactions between firms, institutions, and technologies, showing how these interactions drive the generation, diffusion, and utilisation of innovations that catalyse transitions across various sectors (Hekkert et al., 2007). By identifying drivers and barriers to innovation, TIS research informs policymakers on how to nurture specific technological systems, address institutional failures, and overcome market barriers.

The fourth framework, *transition management*, offers a more practical approach to governing transitions toward sustainability (Loorbach, 2007). It operates through four interconnected activities: strategic activities focussing on long-term visioning and goal setting; tactical activities establishing new patterns and structures in the mid-term; operational activities implementing experimental projects and testing innovations in real-world contexts; and reflexive activities monitoring, evaluating, and adapting processes to ensure continuous learning and alignment with overarching goals (Loorbach, 2010). The transition management approach has been widely applied in action research and policy projects, particularly at regional and local levels where cities actively manage sustainability transitions (Loorbach & Rotmans, 2010; Roorda et al., 2012). Building on insights from transition management, the X-Curve has recently emerged as a framework that highlights the simultaneous processes of breakdown and build-up that characterise systems in transition (Hebinck et al., 2022). This dual focus highlights the delicate interplay between dismantling entrenched regimes and nurturing the innovations that will replace them.

Together, these three concepts (i.e., niche, regime, and landscape) and five key frameworks (plus the X-curve) describe and explain the processes that drive change in complex societal systems, emphasising the roles of innovation, governance, and system dynamics in facilitating transitions toward more sustainable alternatives. These frameworks informed our thinking and understanding of designing for transitions. While most of the frameworks and concepts are reflected across the different chapters and studies, the TIS framework is more peripheral. This is because TIS is technology oriented, and the other frameworks better suit the impact-driven paradigm of design that start with the value for society.

1.1.2. Designing for systems change

Alongside the emergence of transition studies, the field of design evolved in response to the urgent need for solutions to complex societal challenges. Traditionally, design focused on creating objects that prioritised efficiency, usability, and aesthetics (Papanek, 1973). However, as the broader societal consequences of design became increasingly apparent, designers began to reflect critically on their work and their role in shaping societies (Papanek, 1973). This introspection led to the development of design fields and practices that reimagined how design can positively influence behaviours, cultures, and systems in response to the pressing societal and planetary crises (Ceschin & Gaziulusoy, 2016; Tromp & Hekkert, 2018; Verganti, 2009).

Figure 1-1, illustrates this broadening, highlighting how design expanded not only in the scope of the challenges, but also introduced new outcomes, perspectives, and knowledge areas (Buchanan, 1992, 2019; Norman & Stappers, 2015). This expansion of design's scope and impact has culminated in today's landscape, where designers increasingly engage with challenges characterised by complexity, context specificity, value conflict, and ambiguity over outcomes. In response to these sophisticated demands, systemic design emerged as a field and practice that integrates systems thinking and design (Ryan, 2014). Meaning that systemic design combines the systemic perspective of understanding interdependencies and emergent properties of systems with the creative, action-oriented, and human-centred qualities of design (Ryan, 2014; UK Design Council, 2021).

Recently, the UK Design Council's (2021), outlined four roles of systemic designers: *system thinker* who perceives interconnectedness and navigates between micro and macro perspectives, *leader and storyteller* who crafts compelling narratives and secures buy-in, *designer and maker* who leverages technical and creative skills to implement solutions, and *connector and convener* who fosters relationships and creates collaborative spaces. When taking on these roles, systemic designers can aim to design interventions that offer specific values while minimising adverse systemic effects, referred to as system-conscious design. Alternatively, they can seek to fundamentally shift a system through design, referred to as system-shifting design (UK Design Council, 2021; van der Bijl-Brouwer, 2023).

While systemic design offers a comprehensive set of perspectives and methods for integrating systems thinking with design practice (UK Design Council, 2021), it serves as a foundation for more specialised approaches addressing specific types of systemic challenges, such as transition design.

1.1.3. Transition design: an emerging field

Transition design emerged alongside social and systemic design as part of a broader evolution of design practice (Figure 1-1) (Ceschin & Gaziulusoy, 2016; Voûte et al., 2020). Distinguished by its explicit emphasis on sustainability and long-term orientation, transition design specifically aims to facilitate sustainability transitions by fostering collaboration among diverse stakeholders and guiding the evolution of systems toward more desirable futures (Irwin, 2015; Irwin, 2018; Irwin et al., 2020). While drawing on many systemic design principles, transition design applies these concepts directly to the challenge of enabling long-term transformative change for sustainability. This emphasis on sustainability is interpreted in the broadest sense, tackling environmental, social, and ethical dimensions (Van Steenbergen & Schipper, 2017). Transition design, like systemic design, is rooted in the premise that societal challenges are interconnected and require coordinated, multi-dimensional responses to enable desired systemic changes (Irwin et al., 2020). It positions design as a catalyst for such changes by enabling stakeholders to envision and collaboratively shape desirable futures while developing interventions that can facilitate and enact

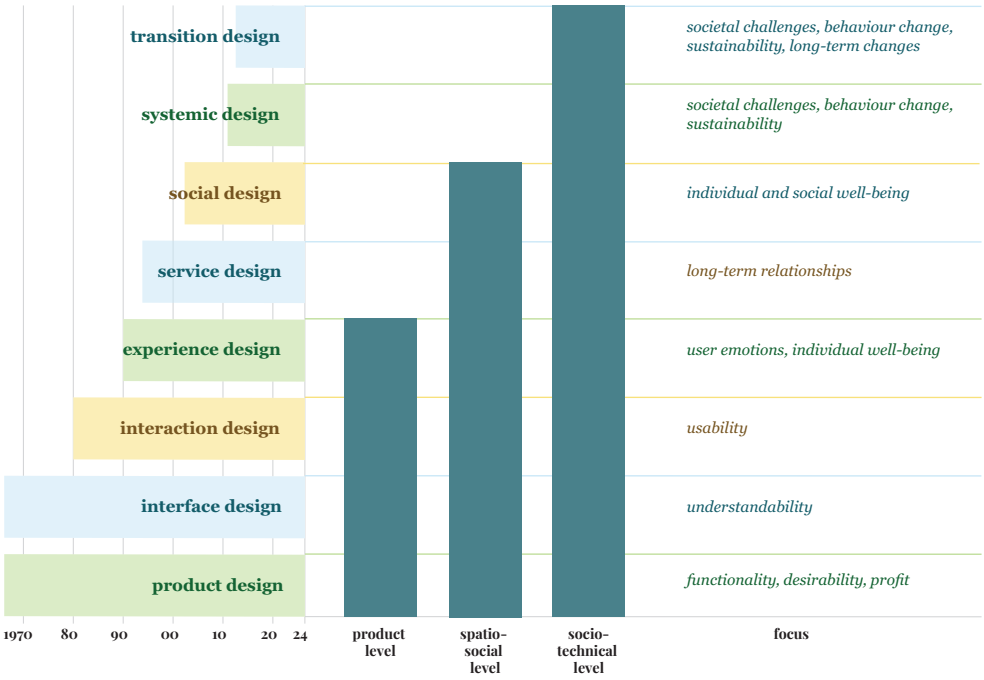


Figure 1-1 | Broadening of the design field. Adapted from Voûte et al. (2020) for the design types and from Ceschin and Gaziulusoy (2016) for the design levels.

changes in the present toward desired long-term changes. It builds on the strengths of design practices, such as co-creation, iteration, and human-centred approaches, while integrating insights from transition studies, such as the multi-level dynamics of systems that provide insights in the breakdown and build-up of systems over time. This combination provides a unique lens for design to contribute to addressing urgent global challenges and supporting transformative societal shifts.

In the past decade, the recognition and application of transition design have gained traction in both academia and practice. This growing prominence is evidenced by the establishment of a dedicated transitions track at the Design Research Society Conference (the largest design research conference globally), the specialised PhD program in Transition Design at Carnegie Mellon University, and the Dutch Research Council's (NWO) 'Transitions and Behaviour' funding call which supports this doctoral research along with 11 other projects aimed at understanding and accelerating societal transitions. Furthermore, practical applications of transition design, such as visioning low-carbon urban futures in Australia (Gaziulusoy & Ryan, 2017b), supporting pathways for renewable energy transitions in Finland (Hyysalo et al., 2019), or fostering sustainable water systems in California (Irwin & Kossoff, 2017a, 2017b), underscore its efficacy and potential to address complex challenges while remaining contextually relevant.

One of the foundational contributions to transition design is Irwin's (2015) transition design framework. This framework outlines four co-evolving areas of

knowledge and practice for transition designers: visioning, theories of change, new ways of designing, and mindset and posture. *Visioning* involves imagining and articulating desirable futures that inspire collective action. *Theories of change* is about understanding change mechanisms and patterns towards formulating systemic interventions to achieve desired effects. *New ways of designing* emphasises design approaches that foster experimentation, open-endedness, collaboration, and co-creation across diverse stakeholders. Finally, *mindset and posture* highlight the reflective and adaptive qualities necessary for engaging meaningfully with systemic complexity. Together, these areas support designers in engaging with long-term systems change. While this framework laid the groundwork for understanding transition design, advancements in understanding the competences and skills for transition designers within this framework are minimal.

Shortly after the introduction of the transition design framework by Irwin (2015), Gaziulusoy and Ryan (2017a) identified three key roles that designers play in transitions: *inquiry,* involving participatory and human-centred approaches to analyse, synthesise, and address complex societal challenges; *process,* focusing on collaborative iteration, prototyping, and facilitating deliberations; and *outputs,* emphasising visually communicating future possibilities and co-developing stakeholder-driven scenario prototypes. Together *inquiry* and *process* influence how the problem and solution are framed and how knowledge is gained and synthesised. While these roles highlight significant aspects of designs contributions to transitions and relate to the theoretical components of Irwin's (2015) framework, they do not fully explain what designers do, how they do it, the expertise that is valuable in these roles, or why designers should fulfill these roles rather than professionals from other disciplines.

Despite the evolution of transition design, the field faces challenges of fragmentation due to diverse approaches, methods, and techniques (Valtonen, 2021; van Arkel & Tromp, 2024). This fragmentation, combined with the field's relative youth, underscores the need for deeper empirical case studies and experimentation to understand how designers adapt their expertise across diverse contexts (Dorst, 2019b). As transition design continues to engage with complex system transformations, scholars emphasise the crucial role designers can play ((Irwin, 2015)(Gaziulusoy and Ryan, 2017a)(UK Design Council, 2021)(van Arkel and Tromp, 2024) (Dorst, 2019b)). However, as the field broadens, there is a risk that the depth of expertise in core design competencies being built upon in the discipline may become diluted.

In response to these challenges and knowledge gaps, this dissertation seeks to understand expertise crucial for both the design discipline and transition designers working towards systemic change. By doing so, it aims to strengthen the foundation of transition design practice and knowledge-building. While designers draw on a wide range of skills, this dissertation focuses on three areas of expertise: visioning, framing, and evaluating. These areas of expertise were chosen for several reasons. Firstly, they

represent fundamental areas of design expertise that hold particular significance for transition processes. Secondly, they can be studied sequentially and systematically within a transition design process: *visioning* a long-term desirable future provides a trajectory for the transition design process; *framing* the dynamics of a system to reveal what supports or hinders progress toward an envisioned future helps identify opportunities for intervention; and *evaluating* transition design interventions offers insights into their potential effectiveness in contributing to desired changes. Thirdly, together they provide a foundation for exploring transition design in greater depth, though they are not claimed to represent the entirety of necessary expertise. The final framework resulting from this dissertation incorporates a broader and more diverse perspective. Finally, as transition design rarely occurs in isolation, visioning, framing, and evaluating serve as entry points that provide sufficient detail and diversity for examining how transition design can be enacted and the expertise it demands.

In this dissertation, we investigate these areas of expertise within the context of the Dutch food system. However, the insights generated are intended to be relevant to transition design processes more broadly. The Dutch food system and its relevance to this research are introduced in the next section.

1.2. Transitioning the Dutch food system: the FETE consortium

Food systems worldwide face mounting societal and environmental challenges, including resource inefficiency, environmental degradation, and large-scale food waste (Beddington et al., 2012). These challenges highlight systemic inefficiencies that threaten both planetary boundaries and human well-being, and, as such, exemplifies the societal systems transition design seeks to address.

Food waste, defined as food that is still suitable for human consumption but nonetheless discarded, is a particularly visible manifestation of system inefficiencies. Shockingly, one-third of all food produced for human consumption is lost or wasted each year (Beddington et al., 2012; van Dooren & Knüppe, 2020). This level of waste strains resources, exacerbates food insecurity, and results in considerable economic and environmental costs (UNEP, 2024). Consequently, reducing food waste is widely recognised as one of the most crucial strategies for alleviating the pressures on the world's remaining ecosystems and mitigating the impacts of climate change (Bajželj et al., 2020; Beddington et al., 2012; Stuart, 2009).

Within a global context, the Netherlands is widely considered a leader in agricultural production and innovation (Berkhout et al., 2018; Government of the Netherlands, n.d). Yet, despite its leadership, the Dutch food system exhibits many of the same vulnerabilities found in other affluent nations. The system is shaped by expectations of abundance and convenience, prioritising excess and variety to meet consumer demand for constant food availability (Evans, 2011, 2014; FAO, 2020).

While this approach may enhance consumer satisfaction, it also incurs significant societal and environmental consequences. For example, Dutch households remain a major source of food waste: in 2020, consumers wasted an average of 33.4 kilograms of edible food per person, accounting for 36% of total food waste in the country (Soethoudt & Vollebregt, 2023). Although the Netherlands has made progress in reducing its food waste levels, reaching the Sustainability Development Goal target 12.3 of halving food waste by 2030 remains a considerable challenge (Lieshout & Knüppe, 2022).

In response, the food waste transition research project "From Excess To Enough" (FETE) and its consortium was established in 2020 (https://www.wur.nl/en/article/research-on-food-waste.htm). Partially funded by the Dutch Research Council (NWO), the FETE project carries out research that supports the Netherlands in reaching its target towards halving food waste. The project brings together three Dutch universities and eight commercial and non-profit organisations within the food system. The academic partners, Delft University of Technology, Wageningen University, and the University of Groningen, contribute expertise in consumer psychology, retail environments, (food) experience design, behaviour change, and systemic design. The industry partners include a diverse group of actors with different perspectives and roles within the food system, including a national nutrition centre, a food waste foundation, an IT consultancy, a frozen food manufacturer, a preservation and processing food manufacturer, a waste collector, a food-focused business school, and a meal delivery service company. Together, these partners share a common goal of discovering how new consumer and retail practices, grounded in innovative business models, can drive a transition of the Dutch food system toward one focused on "enough" food for all with minimal waste.

The FETE is organised around three interrelated research lines that address critical points to reduce food waste: 1) *Reducing Food Waste by Design,* which focuses on resolving value conflicts across the food system through systemic design interventions; 2) *Shifting Consumer Mindsets*, which examines the behavioural drivers behind food waste, particularly the tendency to over-provision; and 3) *Redesigning Retail Concepts*, which explores how retail practices can be transformed to align supply more closely with consumer demand. By bringing together academic research and industry expertise, the project seeks to discover how new consumer and retail practices, grounded in innovative business models, can drive a transition of the Dutch food system toward one focused on "enough" food for all with minimal waste. Within the FETE project, the doctoral research presented in this dissertation focuses on the first research line: designing systemic interventions to reduce food waste.

1.2.1. FETE as transition design

We consider this research, and the FETE project, a case of transition design as it is characterised by a multi-stakeholder consortium structured around a shared

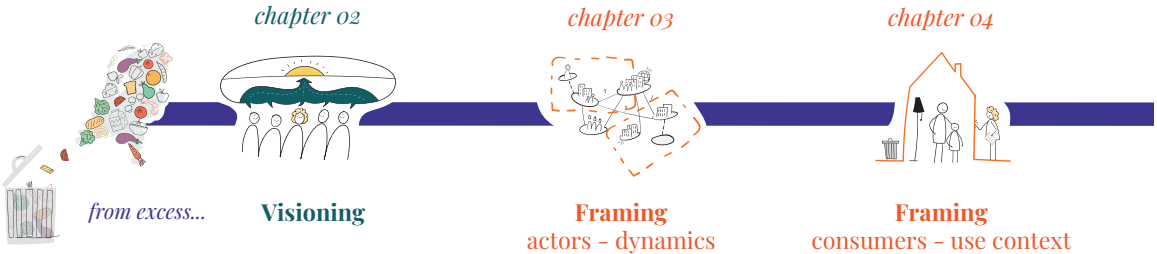
transition goal. The FETE partners—public and private organisations operating at both the regime and niche levels (Loorbach, 2007)—serves as essential collaborators, producing knowledge, products, and services to foster a food system based on principles of "enough". The partners possess substantial domain knowledge and hold agency within their respective organisations, which is crucial for driving systemic change (Gaziulusoy & Ryan, 2017b; Loorbach, 2007). Furthermore, the consortium is committed to a five-year collaboration focused on facilitating a transition of the Dutch food system. While citizens and citizen-led initiatives can offer valuable models for grassroot transitions (e.g., Transition Town movement (Hopkins, 2018), these were not included in this dissertation given the specific context of the research.

1.3. Research methodology

This dissertation aims to advance transition design by investigating how design expertise in visioning, framing, and evaluating can foster systemic change. The research is conceptualised as a specific transition design process, aimed at developing interventions to support the transition of the Dutch food system towards one that caters for "enough". Each study is orchestrated as a step within this process forming a primarily qualitative, exploratory, and iterative design trajectory (see Figure 1-2). As a trained designer, the choice to engage directly in a transition design process enabled me to identify design-specific knowledge gaps and develop valuable insights, rather than studying the three areas of expertise from a more distant perspective.

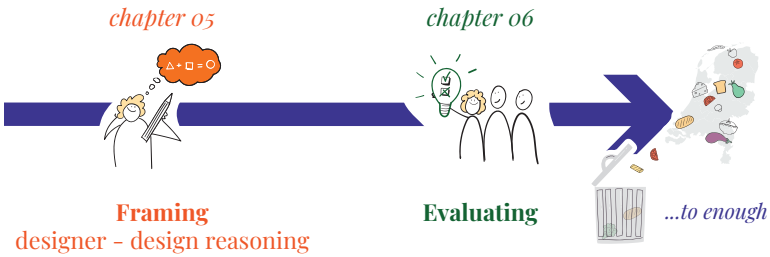
The design process and subsequent studies ultimately lead to a portfolio of interventions that aim to reduce food waste. In the final study, these interventions are quantitatively evaluated to assess their potential for widescale impact. In this way, the dissertation represents a design-led inquiry that not only provides insights for the specific transition context but also contributes to articulating and understanding core expertise of designers working within transition challenges. As a young and evolving field, transition design still requires the development of its knowledge base. This research design allowed for a deeper investigation into transition design practice, i.e., what transition designers do but also why and how they do it, ensuring that the theoretical insights were tested and refined through practical application.

The remainder of this section details each study, outlining the research questions and corresponding methods. Figure 1–2 on the next page provides an overview of the empirical research chapters, including their methods, research questions, and key findings.



	Design Step 1 | Study 1	Design Step 2 | Study 2	Design Step 3 | Study 3
Research Questions	- What is design-led visioning in a transition context? - What challenges and successes do designers encounter in visioning within a transition context?	- How can designers frame system dynamics to support innovation proposals that foster desired transitions?	- How do households engage with adaptable consumption, including their barriers and motivations to do so? - What opportunities exist to support households in adopting adaptable consumption behaviours towards less food waste?
Research Method	- **Descriptive single case** study of a design agency engaged in transition design vision development.	- **Research- through-design** study consisting of 5 experiments.	- **Contextmapping** study with 11 Dutch households with children (43 participants).
Knowledge Outcome	- Identification of key tensions between transition contexts and the application of design expertise in visioning processes.	- Framework that outlines systems principles, organisational roles, and people's behaviours and capabilities as key concepts for aligning short-term innovation efforts with long-term systemic change.	- Identification of 5 opportunities to stimulate adaptable consumption in households and highlights key barriers for doing so.
Process Outcome	- A vision of a future food system that caters to enough food for everyone with hardly any food waste.	- Introduces the concept of Adaptable Consumption, which is supported by a portfolio of 7 innovation directions aimed at reducing food waste.	- Input for redesigning interventions, addressing conflicting concerns, and aligning food waste reduction efforts with everyday household practices.
Output	- **Journal article in Design Studies (2024).** - Conference poster at the NWO Transition and Behaviour Conference (2022). - Animated video and report (2022).	- **Journal article in the International Journal of Design (2025).** - Conference paper at Relating Systems Thinking and Design (2021). - Conference paper at the 10th International Association for Societies of Design Research Conference (2023).	- **Journal article in Sustainable Production and Consumption (2025).**

Figure 1-2 | Overview of the design steps and associated empirical studies conducted in this doctoral research, including the corresponding research questions, methods, and main outcomes.



Design Step 4 | Study 4

- How can designers reason toward interventions that foster societal transitions, and how can a logical framework support this reasoning?

- **2 design workshops** where designers apply a proposed transition design logical framework to develop intervetions for a complex societal challenge.

- Articulation of a transition design logical framework for fostering transitions by mediating system-level and individual-level values and behaviours.

- Iteration of the intervention portfolio, increasing their potential to foster systemic change by integrating actor and consumer feedback.

- **Conference paper at the 13th Relating Systems Thinking and Design Conference (2025).**

Design Step 5 | Study 5

- What is the perceived effectiveness of interventions resulting from a transition design process?

- **Mixed methods** study with 312 consumers, food system actors, and experts.

- Framework which connects five crucial transition design activities (navigating scales, temporality, actor networks, portfolio framing, and reflexivity) and three qualities for its outcomes (desirability, plausibility, and networkedness).

- Critical considerations for taking steps towards resource mobilisation and implementation of interventions.

- **Journal article under review at Contexts — The Systemic Design Journal.**

1.3.1. Research questions and designs

This doctoral research aims to deepen the understanding of transition design and three areas of expertise for designers aiming to foster societal transitions. To achieve this, the research is guided by the following aim:

> ***Research aim:*** *To understand how design can stage its expertise in visioning, framing, and evaluating to foster complex societal transitions.*

Within this aim, the word *stage* implies that design expertise is deliberately positioned and applied in the processes of visioning, framing, and evaluating. It suggests a purposeful use of design skills and knowledge to facilitate desired systemic change, particularly in navigating the complexities of societal transitions. To investigate these areas of expertise, five empirical studies were conducted. Each study addressed specific research questions related to a particular aspect of transition design, with the research contextualised within the ongoing transition of the Dutch food system.

Study 1 - Visioning

The research questions for study 1 were:

> ***Research question 1a:*** *What is design-led visioning in a transition context?*

> ***Research question 1b:*** *What challenges and successes do designers encounter in visioning within a transition context?*

To address these research questions, a **descriptive case study** (Yin, 2009) was conducted, following a design agency tasked with developing a vision for the research consotrium "From Excess To Enough" (FETE) (Chapter 2). Descriptive case studies are well-suited for investigating contemporary phenomena within real-life contexts, especially when the boundaries between the phenomenon and its context are not clearly defined. The use of this method allowed for an in-depth exploration of how designers apply their visioning expertise when working in transition contexts. Following Yin (2009), data was collected from multiple sources, including surveys, interviews, observations, reports, and design artefacts, contributing to a comprehensive understanding of the visioning process. Triangulation of these sources, alongside collaborative coding and analysis involving multiple researchers, enhanced the robustness and reliability of the findings (Corbin & Strauss, 1990). The outcomes of this first study highlighted three main tensions for designers in applying their expertise in transition visioning processes. Moreover, the established vision provided a trajectory for the subsequent phases of the FETE transition design process.

Study 2 – Framing (system actors: system dynamics)

The second study focused on exploring where and how FETE could intervene in the food system to foster the envisioned long-term changes. This exploration was guided by the following research question:

> ***Research question 2:*** *How can designers frame system dynamics to support innovation proposals that foster desired transitions?*

This question was addressed through a **research-through-design study** which involved five design experiments conducted with design practitioners, design students, and food system actors (Chapter 3). Research-through-design is an iterative methodology that uses design activities to generate knowledge (Stappers, 2007; Stappers & Giaccardi, 2017). The experiments investigated how changes to the framing of the system dynamics inform the development of interventions, with each experiment building upon the insights gained from the previous ones (Redström, 2017). To ensure the validity of the findings, the study engaged diverse participant groups and analysed results across multiple experiments (Krogh & Koskinen, 2020). This iterative and participatory approach ensured that the proposed framing was grounded in theoretical perspectives and real-world experiences.

The experiments culminated in the development of a conceptual framework for designing new practices in transitions. This framework highlights that 1) systems principles that drive the future system, 2) organisational roles that stakeholders can play in the transition, and 3) changes in people's behaviour and capabilities that are required for the transition, are key to identifying what future practice(s) to design for, in order to foster desired transitions. The framework informed the creation of Adaptable Consumption, a new practice to foster the transition to "enough", and a intervention portfolio that supports waste-free and flexible behaviours in daily life while contributing to broader systemic changes.

Study 3 – Framing (consumers: use context)

While the practice of adaptable consumption developed in study 2 integrated the views of the FETE partners, further exploration was needed to understand how it could unfold and become meaningful in people's daily lives. This understanding would help link micro-level consumer practices (i.e., the third part of the conceptual framework above) to the broader transition goals outlined in the previous studies. This led to the formulation of the research questions for study 3:

> ***Research question 3a:*** *How do households engage with adaptable consumption, including their barriers and motivations to do so?*

> ***Research question 3b:*** *What opportunities exist to support households in adopting adaptable consumption behaviours towards less food waste?*

To gain insights into how Dutch households engage in adaptable consumption to reduce food waste, we conducted a **context mapping study** (Chapter 4) using cultural probes and interviews (Sleeswijk Visser et al., 2005). Context mapping is effective in complex, real-world settings where both explicit and unspoken aspects of participants' experiences are crucial (Sanders & Stappers, 2012). The cultural probe booklet designed and used in the study provided rich, exploratory insights into household food practices, capturing nuanced behaviours and attitudes towards adaptable consumption. To enhance the reliability of the findings, data were collected from a diverse sample of 11 households (43 participants) across different geographic locations in the Netherlands, representing a variety of family compositions. Combining cultural probes with semi-structured interviews facilitated data triangulation and offered a comprehensive understanding of the barriers and motivations influencing households' engagement in adaptable consumption. This study identified five key opportunities to support consumers in adopting this new consumption practice and related interventions. These findings were integrated into the redesign of the practice and interventions.

Study 4 – Framing (designer: reasoning process)

To synthesise the insights from system actors (Study 2) and consumers (Study 3) toward the vision (Study 1), we developed a logical framework to represent the transition design rationale underpinning the intervention portfolio. The framework aimed to guide designers in making informed design decisions and constructing clear arguments for how proposed interventions can foster desired transitions. To further investigate this rationale, we formulated the following research question:

> ***Research question 4:*** *How can designers reason toward interventions that foster societal transitions, and how can a logical framework support this reasoning?*

The framework was applied and evaluated in two **design workshops** (Chapter 5). Workshops are a widely used method in design research and practice for engaging participants in activities such as conceptualising interventions (Gaziulusoy & Ryan, 2017b; Sanders & Stappers, 2012). These particular workshops involved both design practitioners and design students, and served two purposes: first, to assess how effectively the framework supports designers in proposing interventions that foster desired transitions while reasoning across system scales and timeframes; and second, to refine the adaptable consumption interventions previously developed during Study 2 using the logical framework.

Study 5 - Evaluating

In the final study, the updated portfolio of interventions developed for the FETE project was evaluated to explore the following research question:

Research question 5: *What is the perceived effectiveness of interventions resulting from a transition design process?*

To answer this question, we first developed a framework connecting five essential transition design activities with three evaluative qualities. The five activities include: 1) navigating scales from micro to macro levels, 2) considering temporality from present to far future, 3) engaging and repositioning actors from individual actors to actor networks, 4) framing and designing from single solutions to portfolios, and 5) practising reflexivity from activities to outcomes. These activities were linked to three evaluative qualities: desirability, plausibility, and networkedness of interventions.

Following the framework development, we evaluated the interventions developed in this research through an embedded mixed-methods approach (Study 5) that combined quantitative assessment with qualitative insights (Creswell & Creswell, 2017). A diverse group of stakeholders (n = 312) including consumers, companies, and experts participated in a survey where they evaluated interventions presented as drawings accompanied by short stories describing the interventions in use within daily life contexts (Tromp & Hekkert, 2016; van der Maden, 2024).

1.4. Dissertation structure and overview

This dissertation comprises seven chapters, organised into four main parts. As shown in Figure 1–2, five chapters report empirical studies, each investigating a specific aspect of the transition design process through a different research method. These studies, based on journal articles or conference papers, reflect the research undertaken to address the dissertation's research questions. The dissertation builds sequentially, with each part and chapter expanding on insights from the previous ones:

- **Part one** focuses on **visioning** expertise in transition design, presenting a case study that explores how a design agency developed a vision for a future food system (Chapter 2). This vision serves as a trajectory for the transition addressed in subsequent chapters.
- **Part two** focuses on **framing** expertise, presenting three chapters (Chapters 3–5) that examine how designers engage with, understand, and synthesise system dynamics to design meaningful interventions for people and the wider system.
- **Part three** focuses on **evaluating** expertise, presenting a conceptual framework for evaluation within transition design to ensure that interventions are effective in realising systemic change (Chapter 6).
- **Part four** presents the **general discussion**, synthesising insights from the preceding chapters, summarising the findings, and discussing their implications for research, practice, and education (Chapter 7).

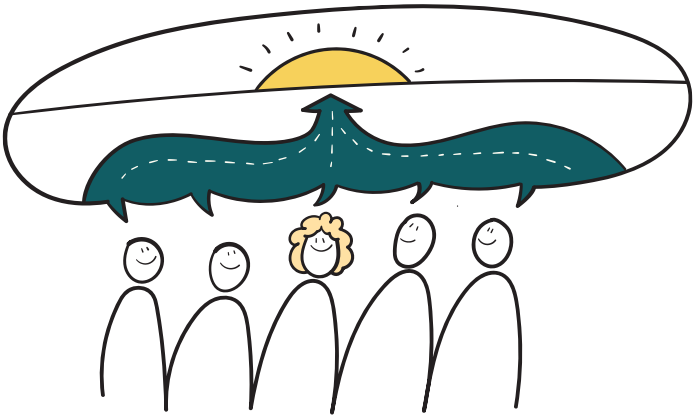
Although this structure supports a cumulative narrative, it may introduce some redundancy across chapters. To enhance clarity and provide guidance, each part and chapter begins with a preface outlining its objectives and contributions to the overarching narrative. Minor modifications have been made to the original papers for consistency in this compiled format, including adjustments to grammar, font, colour, and numbering. Appendices from the original papers have been relocated to the end of the dissertation, references have been consolidated into a comprehensive list, acknowledgements have been integrated into the dissertation acknowledgements, and declarations of no interest have been omitted.

part one
Visioning

Visioning plays a crucial role in transition design. It connects present actions with long-term ambitions, fosters collective commitment, aligns diverse actors around shared goals, and makes the future tangible. Despite its importance, design visioning remains underexplored within transition design, warranting further investigation.

Part 1 of this dissertation, Visioning, addresses this gap through a case study of how a design agency developed a future food system vision within a transition design process. While various design methodologies can support visioning in transitions, this study examines a specific case using a meaning-driven visioning process. Through this detailed examination, Part 1 establishes a foundational understanding of how design expertise can shape compelling future narratives that both challenge existing paradigms and create actionable pathways.

Although this case study, and as such Part 1, does not capture the full breadth of visioning practices in transition design, it provides valuable insights into the specific contributions, tensions, and methodological considerations associated with applying design expertise in visioning for transition processes.



Design Step 1

developing a vision of a future food system

Chapter 02

Design capability when visioning for transitions: a case study of a new food system

This chapter is previously published as:

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In recent years, designers increasingly engage in transition challenges, developing visions of long-term futures. Yet little is known about how designers must adapt their visioning approaches within transition contexts. This chapter presents the first empirical study of this doctoral research, contributing to the "From Excess to Enough" (FETE) project consortium's efforts to mobilise partners in transitioning the Dutch food system toward "enough" food for all with minimal waste. Through a single descriptive case study following a design agency developing a vision of a future food system, this chapter identifies tensions for design visioning expertise when applied in a transition context. These tensions highlight the need to better position design in transition visioning processes to: challenge current systems while helping actors see their place in envisioned futures; address moral issues through reflexive processes; and effectively represent dynamic relationships that connect experiential and system qualities in envisioned futures. This chapter concludes by considering methodological developments needed to better stage design expertise in visioning processes for transitions.

2.1. Introduction

In recent years, design has become more engaged with designing for transitions, such as in the domains of energy, mobility, and food. Transitions refer to complex, long-term, and non-linear processes of systemic change with an explicit directionality towards a sustainable society (Loorbach, 2007). There are four types of activities involved in fostering transitions: strategic activities that form long-term visions leading to changes in the socio-technical system, tactical activities that implement agendas within an actor-network, operational activities that involve experimentation and learning by doing in protected spaces outside the dominant system, and reflexive activities that involve monitoring, evaluating and learning of ongoing societal change (Loorbach, 2010). Therefore, one way to guide transition processes is through the formulation of a vision that fosters collectivity and mobilises change toward more sustainable and just futures. Such visions and pathways to the vision require domain expertise, taking years to accumulate, to reflect the complexity of the related change domains. While designers have traditionally been highlighted as particularly relevant for the operational level of transitions, i.e., through developing innovations for experimentation (Ceschin & Gaziulusoy, 2016; Manzini, 2016), recent developments show designers being active in strategic activities as well, i.e., the visioning processes of transitions (Gaziulusoy & Brezet, 2015; Gaziulusoy & Ryan, 2015, 2017a, 2017b; Mok & Hyysalo, 2018; Quist et al., 2001).

Transitions have been framed as design challenges (Gaziulusoy & Ryan, 2015) with designers bringing valuable expertise to transition projects. For instance, a designer's skill to imagine and depict futures others want to act upon, to reframe and challenge existing practices, to develop new artefacts and images that foster dialogues around the future, and to integrate diverse disciplinary and stakeholder perspectives (de Koning, 2019; Gaziulusoy & Ryan, 2015, 2017a, 2017b; Irwin, 2015; Loorbach, 2022; Norman & Stappers, 2015; Ryan et al., 2015). Additionally, participatory design approaches to vision building is a way to create higher ownership and to mobilise system actors, or front runners as referred to in transition management (Loorbach, 2007), towards the vision (Gaziulusoy & Ryan, 2015, 2017a, 2017b; Hyysalo et al., 2019). Yet, given that few transition design projects come into practice and few case studies exist that discuss visioning as part of them, there is a lot to learn about how designers can optimally stage their capabilities in this context. To gain more understanding of design capability in visioning for transitions, this paper studies the work of a professional design agency that was hired to envision a future food system—one that would not overproduce and waste food like the current system but actually cater for just enough. This transition goal is what joins the efforts of a consortium working in the food (waste) transition, including multiple researchers and food organisations. This case offers an opportunity for in-depth insight into how design visioning capability is applied in a transition challenge, expanding our knowledge of the current boundaries and roles of design theory and practice, and

informing future research into design visioning for transitions and methodological development.

In the following sections, we describe the state-of-the-art of how design capabilities are staged in visioning for transitions and what opportunities and challenges this presents. Hereafter, we use the terms 'designing for transitions' and 'transition design' interchangeably to refer to work at the intersection of transition research and practice and design research and practice (Ceschin & Gaziulusoy, 2016; Gaziulusoy & Brezet, 2015; Gaziulusoy & Ryan, 2015, 2017a, 2017b; Irwin, 2015; Mok & Hyysalo, 2018).

2.2. Design visioning for transitions

Visions in transition design encompass compelling and inspiring depictions of preferable futures characterised by desirable social, economic, and environmental outcomes (Irwin, 2015). These visions serve as a reference for transition processes, providing clear direction for transformative design efforts. This conceptualisation of preferable futures necessitates a long-term perspective that considers radically new socio-technical systems (Verganti, 2008). Consequently, design visions in this context challenge prevailing assumptions, explore and envision futures that promote sustainability and equity, and as such, pose normative questions (Junginger & Sangiorgi, 2009; Lockton & Candy, 2019). The designed artefacts in these envisioning processes, e.g., scenarios and images, then act as boundary objects that support the questioning, debating, and discussion of futures that people want or do not want (Dunne & Raby, 2013; Junginger & Sangiorgi, 2009; Sangiorgi, 2011). The timeframe for these visions vary, with some scholars arguing for visions that are 40 or 50 years ahead as they represent the next generation (Jansen, 2003; Robinson et al., 2011), while others argue that visions beyond 25 years tend to be too futuristic and detached from present reality, making them less relatable to broader stakeholders and less capable of identifying relevant signals of change (Gaziulusoy & Ryan, 2017b). Ideally, transition visions are not so unrealistic that they are unachievable but also not so conservative that they do not inspire or drive change (Wiek & Iwaniec, 2014).

Due to the collective and political nature of transitions, participatory approaches to envisioning are standard (Gaziulusoy & Ryan, 2017a, 2017b; Hyysalo et al., 2019; Mok & Hyysalo, 2018; Quist et al., 2001; Ryan et al., 2015). In such approaches, the role of the designer, and as such the positioning of their capabilities, can vary greatly. For example, Gaziulusoy and Ryan (2017a, 2017b) and Ryan et al. (2015) engaged with professional designers in developing 'glimpses of the future' and engaged participants in role-playing within prototyped scenarios. This supported them in co-developing visions of urban futures in Australia in 2040. Along with their general design capability, designers were onboarded with systemic thinking skills and sustainability expertise. This was to ensure outputs were systemic, relating to multiple system levels (city, precinct, or neighbourhood), and depicted the changes

(technological innovations, behavioural elements, products and services) needed to reach the desired transition goal, i.e., low carbon and resilient cities. In this case, the designer was prepared to address the systemic complexity of sustainable cities while generating design artefacts that participants (from the built environment sector, peak bodies, consultants, local governments, advocacy groups, social entrepreneurs, and research organisations) could relate to. This supported them in negotiating the future systems in terms of their functions and their physical manifestations, and allowed the identification of critical value differences within the stakeholders.

In a study of the renewable energy transition in Finland, Mok and Hyysalo (2018), applied a Value-Sensitive Design (VSD) approach when exploring solar panel integration on heritage sites. The case investigated how human values inform the siting of solar panels in culturally sensitive locations and how the prevailing values can be negotiated and overcome through the proposition of alternative solutions. The project involved interviews with stakeholders (from the building site, solar technology providers, architect constituencies, and the National Board of Antiquities), as well as on-site experimentation of solar panel integration and further visualisation in the form of architectural renders of how to expand solar integration across the site. In this case, design was strategically positioned to reveal the likely 'reverse salients' (i.e., things that might hold the current system in place) by bringing a level of concreteness, grounding discussions around the values at stake, and supporting reflection on actual responses to solar integration rather than hypothetical responses. Therefore, the transition goal revolved around the adoption of solar energy on heritage sites and was relatively explicit and clear. Consequently, the participatory process and application of design capability were focused on identifying what was at stake when transitioning, the values at the core of stakeholders' resistance to change, and how these could be negotiated through alternative solutions. Building on this, Hyysalo et al. (2019) used codesign to support participants in iteratively developing mid-term pathways in the Finnish energy transition.

These examples illustrate that designers bring tools and methods that support participation in the visioning process, addressing important topics such as representation in, ownership of, and responsibility for the directions taken in a transition. The designed artefacts help navigate social, ethical, political, and cultural questions related to the future. Nevertheless, a transition context is a challenging context for designers to operate in, potentially restricting some of their capabilities at times. For instance, in discussing design artefacts that represent potential elements of the future, stakeholders may be drawn into an assessment of their plausibility while the aim is to discuss their desirability (Gaziulusoy & Ryan, 2017b). The perception of resource constraints and institutional and structural barriers can also hinder the generation of radical or novel artefacts (Gaziulusoy & Ryan, 2017b; Robinson et al., 2011; Wiek et al., 2013). Robinson et al. (2011) argue that equipping participants with process knowledge is essential for effective and equitable participation in envisioning processes. However, communicating such knowledge is not always

possible due to the methodological messiness of design visioning processes in transitions (Gaziulusoy & Ryan, 2017b; Loorbach, 2007; Robinson et al., 2011).

Designers imagine new realities and conceptualise innovations that positively contribute to the lives of individuals, organisations, and society. This expertise is deemed valuable in light of transitions. However, we also recognise that transition challenges stretch design capability during visioning processes and as such, there is more to learn about what implications this has. From the literature, we see that design's human-centred and integrative thinking capabilities are stretched beyond end-users to explore the perspectives, needs, and aspirations of diverse stakeholders across various levels of the system. While this enables the imagination of new products and services that shift relationships between actors, it complexifies the process, asking designers to give form to system dynamics. We also recognise that the more active engagement of experts and other stakeholders in the process presents tension for designers to imagine radically new futures, to be confident enough to challenge the status quo, and to be able to defend underrepresented human values. By following a design agency to envision a future food system for a consortium working in the food waste transition, we want to gain a better understanding of how the designers stage their expertise, where they experience possible tensions, and how this can help to identify ways to support methodological development for design visioning in transitions.

2.3. Methodology

Our case study covers the careful observation and documentation of the visioning process for the consortium FETE (dealing with the food system transition 'From Excess To Enough'). Case studies are valuable for understanding contemporary phenomena within a real-life context and when posing 'how' or 'why' questions (Yin, 2009). Single case studies are particularly instrumental in research where there are few reported cases and an in-depth understanding of the phenomena is required (Yin, 2009). For this study, we collected data from various sources to capture the visioning process in which professional designers, researchers, and multiple stakeholders collaborated. We triangulated these insights to ensure the construct and internal validity of the findings (Corbin & Strauss, 1990; Yin, 2009).

2.3.1. Case setting

Food systems encompass all the actors and interactions involved in producing, processing, distributing, consuming, and disposing of food, as well as the policies and cultural norms that shape these processes (FAO, 2013; UNEP, 2021). Unfortunately, food distribution is highly unequal globally, leading to poverty and famine in some countries while others experience abundance. Globally, food waste accounts for 8-10% of global greenhouse gas emissions and contributes significantly to climate change, nature and biodiversity loss, and pollution and waste (FAO,

2013; UNEP, 2021). With the expected population growth by 2050, the food system faces additional pressures to meet rising food demand while mitigating negative consequences (Godfray et al., 2010; van Geffen et al., 2020). Achieving this systemic change requires a comprehensive approach, addressing consumer-related, retailer-related, and macroenvironmental issues (Aschemann-Witzel et al., 2015; Schanes et al., 2018).

The FETE consortium initiated a 5-year project (September 2020-2025) to explore how to partake in a transition to a food system that avoids food waste. FETE brings together three Dutch universities and nine commercial and nonprofit organisations within the food system. The university partners bring expertise in consumer psychology, retail environments, (food) experience design, design for behaviour change, and systemic design, and include three Ph.D. candidates and one post-doctoral researcher[1]. The food system partners in the consortium include a national nutrition centre, a food waste foundation, an IT consultancy firm, two food manufacturers, a waste collector, a food focused business school, a meal delivery service company, and a fruit and vegetable wholesaler. These academic and industry partners have a shared interest to learn what consumer and retail practices, grounded in potentially new business models, can help foster the transition to a food system driven by the concept of 'enough' rather than 'excess'. This paper focuses on the initial year of the project, highlighting how a design visioning process delivered a vision of a food system that should guide the consortium's efforts to take a steering role in the food (waste) transition. Given the geographical location and expertise of the research group, the vision focuses on the Dutch food system as part of a global system that runs on overproduction and excessive food purchase, ultimately leading to extensive food waste.

We consider FETE as a representative case of transition design since 1) the multi-stakeholder consortium is set-up around a transition goal, 2) it includes public and private organisations producing knowledge, products and services at both the regime and niche level (Loorbach, 2007, pp. 139-140), 3) the representatives possess substantial domain knowledge and have agency within their organisation (Gaziulusoy & Ryan, 2017b), and 4) the consortium is committed to a 5-year collaboration on the transition. What makes the project unique is that the content of the vision is not only needed to spur innovation but also needs to link to the objectives of three Ph.D. studies—complexifying the process. While the system stakeholders are committed to the 5-year research on the transition, are interested to learn, and have a shared ambition to make change happen, there was no process outlined or explicit commitment that ensured experimentation along the envisioned transition paths.

1 The PhD candidates are located at the University of Groningen, Wageningen University, and Delft University of Technology, and each has two supervisors. The postdoctoral researcher is positioned at Wageningen University.

2.3.2. Visioning approach

An Amsterdam-based design and innovation agency was hired to develop the vision for FETE. The agency allocated 144 h over 8 months to deliver the vision and assigned two senior designers with 15+ years of experience and two junior designers with 2+ years of experience to the project. The agency uses the Vision in Design (ViP) approach in all its projects. Below we briefly explain the ViP approach as prescribed to support the discussion of the positioning of design capability. Later we will describe the situations where tensions occurred and adaptions were made by the designers. For an elaborate and detailed account of the method, see Hekkert and van Dijk (2011, pp. 133-187).

The Vision in Design method guides designers in developing design proposals based on the effect they want their design to have on people and society, including what new behaviours it should facilitate (Figure 2-1). The method asks designers to conceptualise this effect in reference to an anticipated future context, including positive and negative developments, to deliberately avoid fixation on problems in the current context. So, while a design challenge may be informed by the problems of today, the method helps designers work with the opportunities the future brings. While the outlook and description of this future are as neutral as possible—reflecting plausible and possible futures (steps 1-3)—the conceptualisation of innovation as a response to the future is deliberately normative transforming toward preferable futures (steps 4-7). The method involves interviewing experts from various disciplines to gather information that describes aspects of the future world, yet leaves the interpretation, framing, and meaning derived from this information to the designers. The method encourages the exploration of interconnections, integrating multiple perspectives, and adjusting boundaries when more information is gathered. The method is deliberately staging the responsibility and authenticity of designers as central in order for them to deliver original design proposals that they can defend. The founders of the method criticise customer-oriented design (i.e., designs based on what people say they want) and call for a deeper understanding of human values to drive design decisions. Although the method does not exclude the participation of stakeholders, it does ask designers to become owners of the process.

2.3.3. Data collection

The data collection in the present study focused on capturing the visioning activity. Following (Dorst, 2008), our conceptual framework (Figure 2-2) included the object of the design activity, the actors involved, the context in which the design took place, the design process as applied, and the design outcome.

Between November 2020 and June 2021, we followed the design agency in their visioning process. The authors triangulated data from observations, interviews, questionnaires, documentation, and design artefacts (i.e., visual outputs), as is recommended for rigorous qualitative research and to enhance internal validity

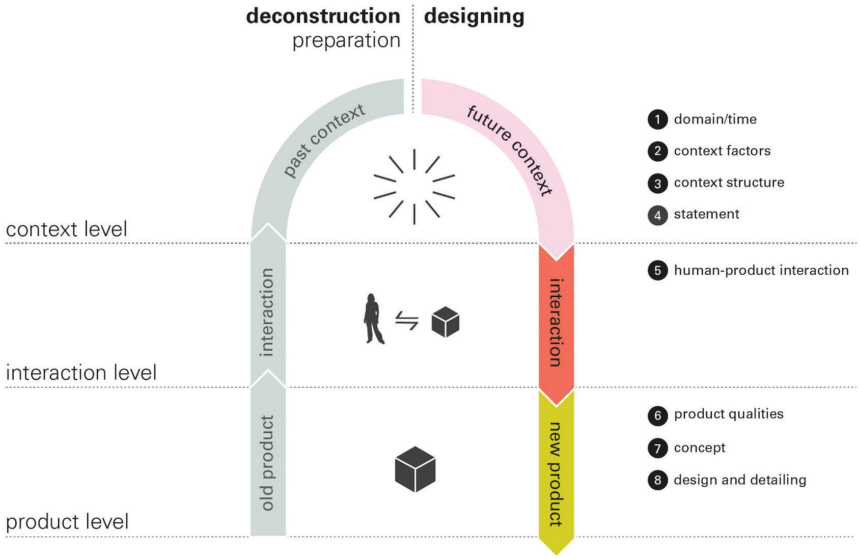


Figure 2-1 | The stages, layered levels, and design steps of the Vision in Design Method (Reprinted with permission from Hekkert and van Dijk (2011, p. 133). © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

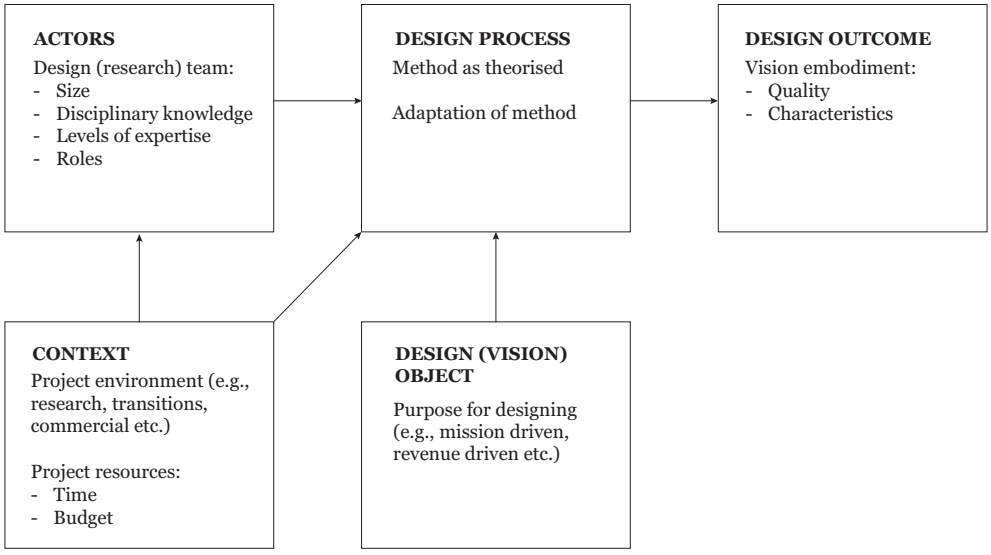


Figure 2-2 | Conceptual framework showing the main things to be studies—key factors, variables, and their relationships. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

(Patton, 2002; Yin, 2009). The first author participated in all design activities but did not have a decision-making role. The first author joined 40 online meetings with the designers during the 8-month project. This provided insight into the actions and decisions taken within the visioning process. On occasion, meetings included FETE researchers. The first author took notes of what was discussed in the meetings, specifically noting aspects related to the conceptual framework. In addition to notes, process documentation and physical artefacts, i.e., Miro boards being worked in, sketches, ideation post-its, draft and final reports, and email correspondence related to the envisioning process, were collected to triangulate and complement insights gained through observation and interviews.

After the draft and the final version of the vision were presented to the consortium and other experts who participated in the visioning, questionnaires were sent. The questionnaires gathered insight into the assessed quality and value of the vision for various actors. The questions invited reflections on how inspired and stimulated they felt to imagine possible futures, how motivated they were to actively take steps toward the vision, what aspects of the vision they found desirable, feasible, and viable, and how well they were positioned to move towards the vision including any barriers or conflicts they anticipated.

The first questionnaire, sent after the presentation of the draft vision developed by the design agency, contained 11 open-ended questions and 5 statements with a Likert scale. It was sent to 24 participants from 13 different organisations, implying that in many cases multiple individuals from the same organisation were invited to participate. The individuals who received the questionnaire, as part of the consortium or that participated in the visioning interviews as external partners, all held strategic roles within their respective organisations. In total, 10 responses were recorded representing 6 FETE partners (the national nutrition centre, food waste foundation, IT consultancy firm, meal delivery service company, fruit and vegetable wholesaler, and a food manufacturer), an additional education institution, and a Dutch Ministry. While not all FETE partners responded, the responses represent different perspectives and roles within the food system. The second questionnaire, sent after the presentation of the final vision, contained 3 open-ended questions and 12 statements with a Likert scale. It was sent to 19 participants from 9 different organisations. In total, 6 responses were recorded from 5 different FETE partners: two from the IT consultancy firm, and one from the national nutrition centre, food waste foundation, meal delivery service company, and fruit and vegetable wholesaler. The responses represent different perspectives and roles within the food system, and there was a high overlap with the organisations that responded to questionnaire 1.

Upon completion of the project, the first author, following an interview guide, conducted semi-structured interviews with the four designers working on the project and two researchers from the FETE research team who provided the brief (from the University of Groningen and Wageningen University). Related to the conceptual framework, the interviews focused on five themes: the interviewee's

Table 2-1 | Overview of data collected during the case study.

Data source	Description	Reason of collection
Process documentation and artefacts	3 Miro boards, 2 iterations of system sketches, and 2 reports (1 intermediate & 1 final), and over 50 email correspondences.	Real-time logging of the visioning process to report how decisions were made to get to the final vision.
In-depth interviews	6 semi-structured individual interviews with the designers and two project leaders of FETE (audio recorded).	Individual and in-depth reflections of team members on the quality of the visioning process and vision.
Participant as observer	A notebook of personal notes.	Capturing insights that deemed noteworthy from a research perspective.

background, adaptions of the method, the visioning process and outcome, the value of designers visioning for transitions, and collaboration. Through these themes, we aimed to deepen our understanding of how design capabilities flourished or were challenged in the visioning process. The interviews were conducted online via Zoom, lasted between 60 and 90 min, and were audio recorded (see Table 2-1).

2.3.4. Data analysis

Following the writing of the case report, a two-step inductive thematic analysis process was undertaken. The first step focused on identifying intriguing challenges or needs of the context that hinted toward tensions with design capability. All the data was entered into Atlas.ti, software for qualitative analysis. Following Graneheim and Lundman (2004), the written transcripts, questionnaire data, and case notes were broken down into meaning units (interviewee quotes), accompanied by condensed meaning units (interpretation of quote by the researcher) and labelled with a code (Table 2-2).

The second step focused on deepening our understanding of the themes revealed in step 1 by framing the condensed meaning units (researcher interpretation) as challenges or successes. Table 2-3 shows examples of how this process was undertaken. This process supported us in better explaining and understanding the codes, as well as exploring the interaction between them, such as if some codes came at the cost of others and, as such, what tensions they presented. Throughout the analysis, we took steps to reduce researcher bias and increase the internal validity and reliability of the results. The authors discussed interpretations of the quotes, and the authors who were less involved with the visioning process took an outsider perspective challenging emerging interpretations (Yin, 2009). Additionally, the second author accessed the data and followed the same analytical procedure confirming or challenging the findings of the first author, thereby enhancing the validity of the findings (Corbin & Strauss, 1990; Yin, 2009). In the next section, we describe the visioning process undertaken by the design agency.

Table 2-2 | Overview of codes.

Codes
Abstracting between system levels
Aligning toward a future
Balancing trade-offs in the future
Bringing together different expertise
Catering to more complexity
Catering to the client
Challenging the current system
Challenging disciplinary blinders
Discussing and reflecting on the future
Embracing a wider scope
Encouraging responses through tangibility
Engaging stakeholders in the process
Exploring alternative futures
Looking at the future in new ways
Triggering stakeholders to see their place in the future
Trusting the process

Table 2-3 | Examples of how the transcripts of the interviews were analysed.

Interviewee words	Researcher interpretation of challenges and successes	Codes
"The project was called future food practices. At first really on consumer behaviour within this future context. Then it made sense to have more focus on products that the consumer uses throughout his day or life. But in the end, the system changes were much more interesting and valuable, and that required thinking about a new food system including what makes the world a better place." — Designer	Expanding the scope from daily food practices to new food systems supports asking normative questions about the future	Catering to more complexity
"In this project, it was really important to have something to talk about and trigger the stakeholders to sort of see their place in the system, see where they should be, where it matches their values, and where they want impact." — Designer	The visualisations of the systems anchored discussions and triggered stakeholders to reflect on their values and roles in the future	Triggering stakeholders to see their place in the future
"There were so many stakeholders involved, it felt like okay this is on a project management level something to get everybody working together to make something. That was not about the vision, the vision then becomes a means for something else. At the same time, the means, the vision itself seemed to be very important. So there were two outcomes to me, what I saw what was needed." — Designer	The visioning had two goals that at times competed: a project management goal to bring FETE together and an innovation goal to develop a quality vision	Engaging stakeholders in the process Exploring alternative futures

2.4. Case report: the FETE visioning process and outcomes

Due to COVID, this project was executed entirely online. The designers invited others to be involved through online environments, including some that they were not familiar with. They used Miro, an online collaborative platform to collaborate on the content, and the online video platforms Zoom, Microsoft Teams, and Gather to support meetings and breakout rooms. All sessions lasted between 1 and 2.5 h.

2.4.1. Step 1 Establishing project scope, domain, and kicking off the project

In line with the ViP method, the design agency, together with the university partners, scoped the project to 'future food practices in the Netherlands in 2030' and outlined that the vision should move consortium partners out of their comfort zone and be thought-provoking. For the project kick-off, a 1h session was organised with all consortium partners for which they were asked to bring two context factors related to food practices, i.e., developments, trends, states, or principles that shape future food practices. During the session, the designers introduced the visioning method and had the partners experience moving from steps 2 to 3 (factors to context structure) in the method, engaging them in the process while at the same time gathering first impressions of how stakeholders viewed future food practices.

2.4.2. Step 2 Generation of context factors

Next, the designers generated and collected 217 factors, i.e., building blocks of a future world (Figure 2-3). The factors were collected by reviewing literature and conducting 18 semi-structured interviews with experts knowledgeable of the Dutch food system, e.g., a sustainable food policy officer at the Ministry of Agriculture, Nature and Food Quality, an ecological nutritionist from a national nutrition centre, and a professor of Transitions and Transition Management. Together, the designers and researchers decided on the selection of the experts to interview. Many of the interviewees were experts in the current system rather than experts with an outsider look on the system (e.g., an anthropologist or demographer). This was partly because of the need to include all consortium partners in the interviews and partly because experts with different expertise were unavailable to participate. The interviews were conducted by the designers in pairs, occurred online via Microsoft Teams, were audio recorded, and lasted about 60 min. Following an interview guide, the designers prompted participants to provide concrete examples of how they saw food practices evolving based on their disciplinary expertise. The designers separately analysed the interviews and translated them into factors. The factors were compared, compiled, and verified with the interviewed experts to ensure the correct interpretation.

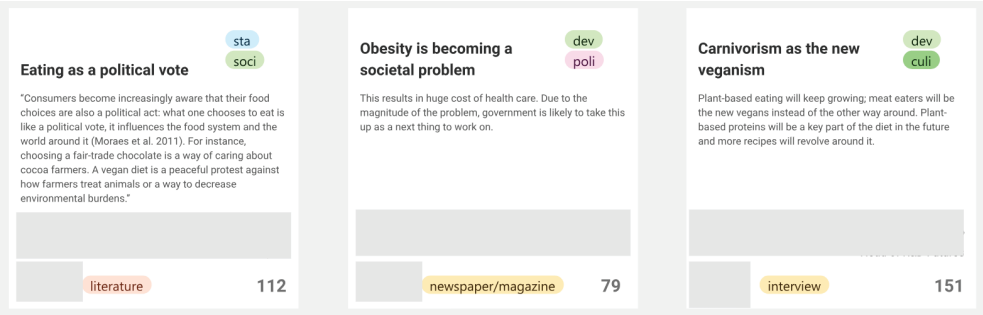


Figure 2-3 | Examples of 3 factors collected. Privacy information about the designers and interviewees has been concealed. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

2.4.3. Step 3 Structuring the context

Clustering the factors to make a coherent image of the future occurred over six sessions. In the first clustering session, the designers invited the FETE researchers so that they could utilise the researchers' expertise as an additional source of information, offer further insight into the process, and communicate the outcomes of the expert interviews. During the session, one factor at a time was read aloud and placed in a Miro canvas, starting a new cluster or expanding an existing cluster based on group discussion of its current and potential meanings. In the first session, 60 of the 217 factors were clustered. The designers completed the clustering in the subsequent three sessions, forming 11 clusters, each illustrating a driver in changing food practices (see Table 2-4). In the final two sessions, the designers wrote short summaries of each cluster (up to 300 words) to sharpen their meaning.

Next, the lead designer interpreted how these driving forces would shape consumption behaviours and translated the clusters into a three-by-three matrix to explain the future habitual practices of people when dealing with food—this was an iterative and fuzzy process. The framework's purpose was to reveal the variety of possible food-related behaviours in the future (what is plausible and possible?) and support decision-making regarding which behaviours to intervene with in the future (what is desirable?). At an interim presentation of the framework, the FETE researchers felt that the behavioural framework lacked explicit links to food waste. To address this feedback, the designers rewrote each cell as a 'modus operandi' informing various types of behaviours—from food purchase and preparation to the discarding of food. In the final framework (Figure 2-4), the vertical axis refers to the scope of people's worldview, what people consider their sphere of influence, and what people unconsciously perceive as the context to which their actions relate. The horizontal axis refers to people's way of dealing with the complexity of life and the food system.

Table 2-4 | The 11 driving forces (clusters) formed.

1. The paralysing complexity of conflicting concerns
2. The comfortable graspability of single messages
3. Headspace from outsourcing and efficient routines
4. Curbing choice to counter collapse
5. Narrative fictions elevate the eating experience
6. Eating as an act of autonomous resistance
7. Food to control one's body and mind
8. Food as a delicious mirage in the mind
9. The power of the extraordinary experience
10. The power of demand and activism
11. Rethinking the commons

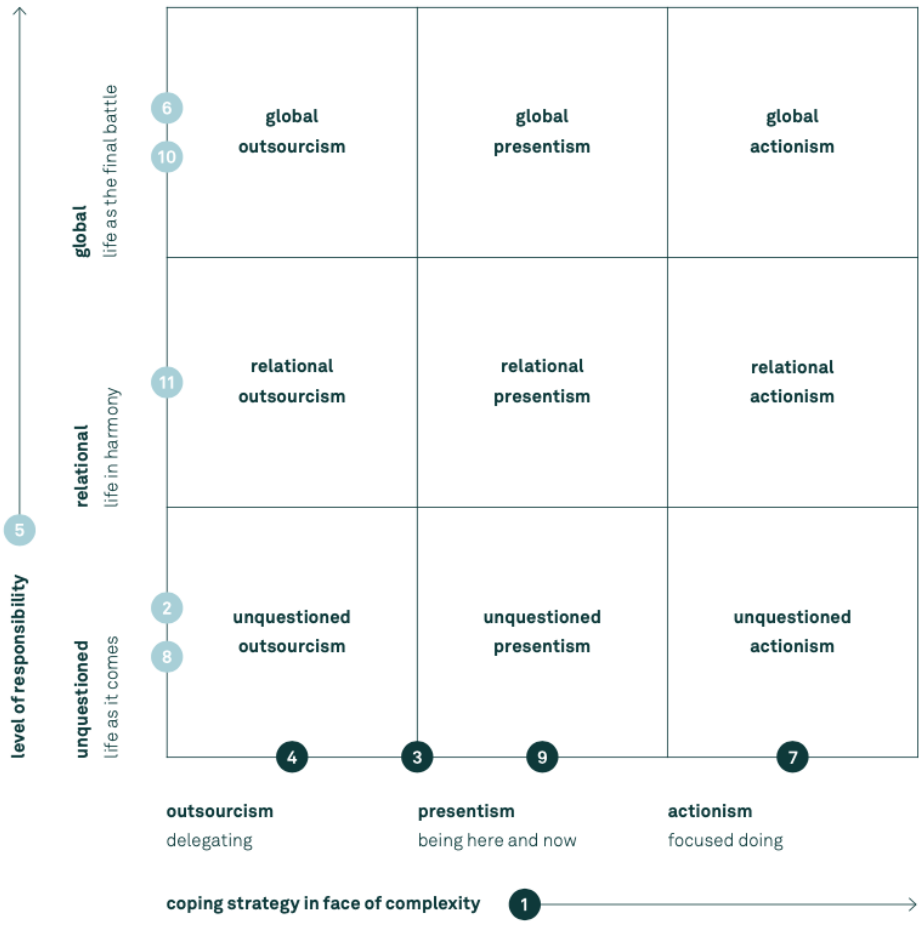


Figure 2-4 | The strategic framework representing the nine behavioural drivers in future food practices. The numbers refer to the driving forces (clusters) that were developed in step 3 of the method. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

2.4.4. Step 4 Statement definition and positioning

When presenting the final framework, the designers wanted to engage the consortium in the process and have them provide input on which patterns of behaviours informed by a modus operandi the designers should focus their transition efforts on. Therefore, in smaller breakout rooms, the designers posed two questions: For the transition from excess to enough, *1) how should the consortium respond to the future based on the practices that will evolve if we do nothing? And 2) where do you see the biggest levers for change?* To respond effectively to these questions, stakeholders wanted to quantify the future food waste levels for each of the practices. The lack of this knowledge hindered the consortium in making choices about which behaviours the designers should prioritise. This lack of positioning meant that the designers could not formulate a design focus (i.e., called 'statement' in the method, step 4) and needed to adapt their process. Additionally, the meeting confronted the designers with the fact that the transition context required multiple behaviours to be considered and linked. Without a statement as a backdrop for describing the interaction qualities that create a desired effect for people, the designers skipped the next step, step 5, defining human-product interaction, and went straight to ideating the new systems.

2.4.5. Step 6 System ideation

To kick-off ideation, the designers met with the FETE researchers to begin developing ideas for each practice (i.e., the patterns of behaviour informed by the modi operandi or cells of the framework). The lead designer instructed everyone to use post-it notes in Miro to capture examples and ideas for each cell of the framework. Once all cells had several ideas, the designers began building system narratives. The future context focused on the consumer level, describing nine dominant modi operandi (i.e., food practices), but a clear connection with system dynamics was lacking. When forming the new systems, the designers focused on user practices and zoomed into the everyday life of people. However, the researchers also wanted to learn, based on this everyday life, what future food systems that cater to enough could look like including the roles of retailers, producers, the government, etc. At this stage, the designers felt confronted and continued to let go of the method. They tried multiple strategies to think of food practices more systemically.

The first strategy mapped the modi operandi and corresponding practices temporally on five timelines: day, week, month, year, and life, to develop scenarios that illustrate how people switch modes and link those switches to food waste (Figure 2-5). They considered more dynamics, such as the role of seasons, the interaction between the behaviours, and what system infrastructure would support such changes. Other strategies included looking at the supply chain to link the practices and corresponding ideas to different stages from farm to fork, as well as considering what new roles actors may have (e.g., considering consumers as producers).

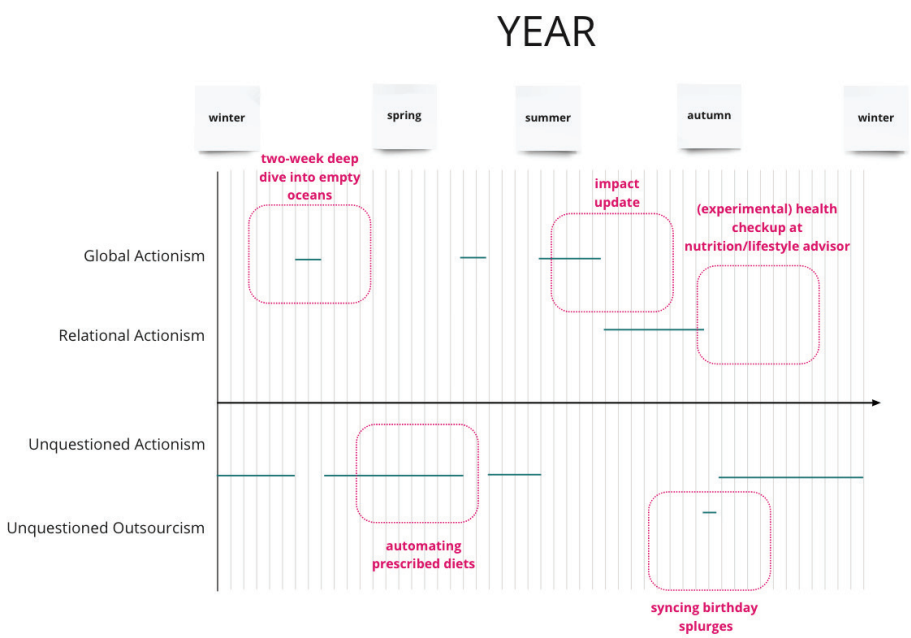


Figure 2-5 | Example of the temporal strategy employed by the designers. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

Over 7 sessions, 4 systems that represented a future food system that caters to enough were developed. System 1, 'Monitoring the food system', uses data to optimise food flows throughout the supply chain. System 2, 'Vitalising the food system', repositions food consumption into a large set of lifestyle choices. System 3, 'Sharing the food system', views social identity formation as an important driver in the food system. System 4, 'Opening the food system', aims to develop public responsibility to take care of our natural environment.

2.4.6. Step 7 Concepting the systems

To give form to the systems, the designers created drawings with the overall system dynamics (Figure 2-6 and Figure 2-7) and described the system infrastructure, its effects on food production, and the components of the system with regard to processing, purchasing and consumption, and resource and waste recovery. To communicate individual behaviour, they developed day-in-the-life scenarios following consumers through the system and included concepts of new products and services that supported the narrative (Figure 2-8). These design artefacts aimed to help stakeholders step into the system and respond to the propositions.

When presenting the systems to the stakeholders, they were asked to reflect on which system they found most inspiring, desirable, and likely; and which system they thought lends itself best for the transition from excess to enough. These questions served as a way to align the consortium within the broader food (waste)

transition and determine a direction for innovation efforts. However, the consortium differed greatly in their responses.

The scope of the project for the design agency ended with the presentation of the 4 systems. However, to ensure the collective efforts of the consortium were moving in the same direction, the first and second authors combined the four systems into one unified vision (Figure 2-9). This was done by identifying consumption behaviours of a system that caters to enough. For example, if people have the knowledge to adapt portion sizes with different products, they are better able to prepare enough food with less food waste. Then, for each system, the role and value of consumers, retailers, and producers were identified, along with the interactions between these actors. With consideration of the consortium feedback, a unified system was developed focussing on four system principles describing actors' interactions: 'embracing flexibility', 'regulating vitality', 'recognising the value of food', and 'optimising through learning'.

A report, and then a 3-min video developed in collaboration with an animator (Figure 2-10), were made to communicate the unified vision within and outside the consortium. Therefore, the vision was the primary deliverable, merging the anticipation of a plausible future with a vision of a desirable future. The innovation concepts developed (steps 6 and 7) served to illustrate the future context and inspire future innovations rather than represent implementable designs.

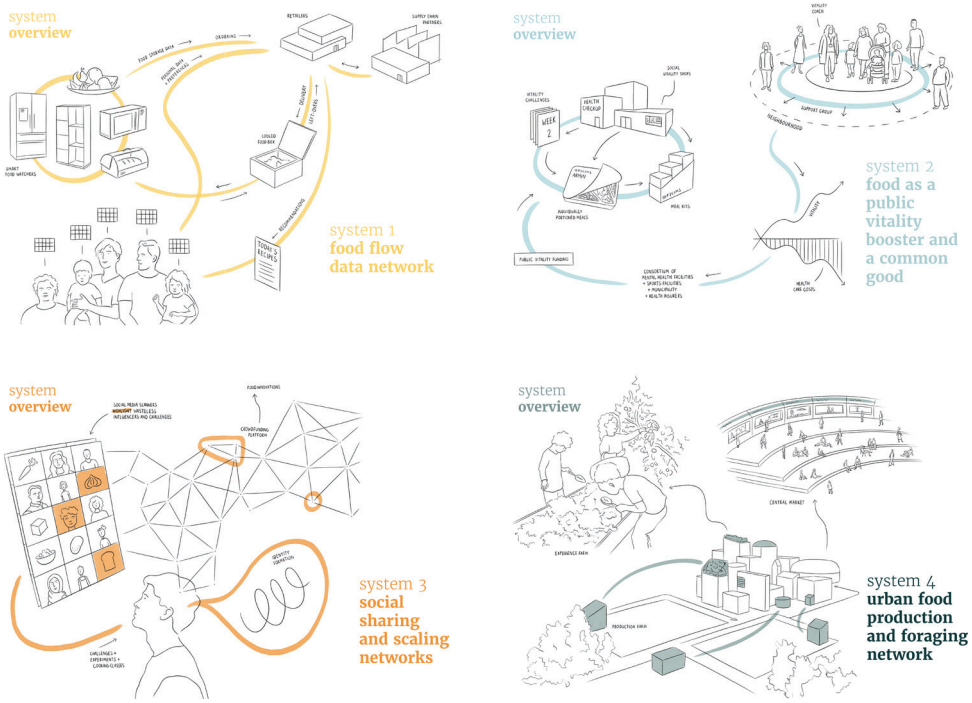
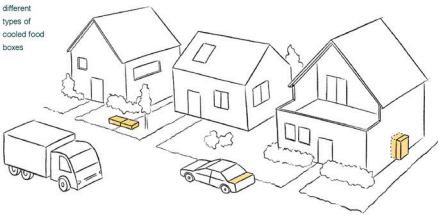


Figure 2-6 | Overview of the four systems developed by the design agency. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

scenario
description
enjoying food together



step 1
smart food ordering

unquestioned outsourcism

It is Monday. Nicolas works from home and is responsible for dinner preparation tonight. During the week, their smart food watcher measures what goes in and out of the kitchen. The food watcher has a continuous overview of the available ingredients in the house. Today, they are notified that they have some bread leftovers that can only be kept for one more day. The food watcher orders some additional ingredients that will suggest a complete and healthy meal based on the bread leftovers. The algorithm of the smart food watcher learns about the family's food behaviour and attitudes. Over the course of time this results in more meals with fresh ingredients, as there is less food stored that can potentially go bad.

step 2
delivery of ingredients in the food box

unquestioned presentism

The ingredients are delivered in their cooled food box next to the door. This box can be accessed from outside the house by delivery services, so Nicolas does not have to stay at home. Whenever Nicolas and his family spontaneously change their plans, they can also put food leftovers that they won't eat themselves in the food box. Electrical 'food repurposing' trucks will pick up the leftovers that will be put to good use for someone else or as nutrients. Nicolas empties the food box from inside the house and stores most of the products in their freshness fridge. This fridge adapts the temperature of the different storage compartments to the type of ingredients to optimize their freshness, while offering suggestions for where to place which food, saving as much space as possible.

step 3
eating together

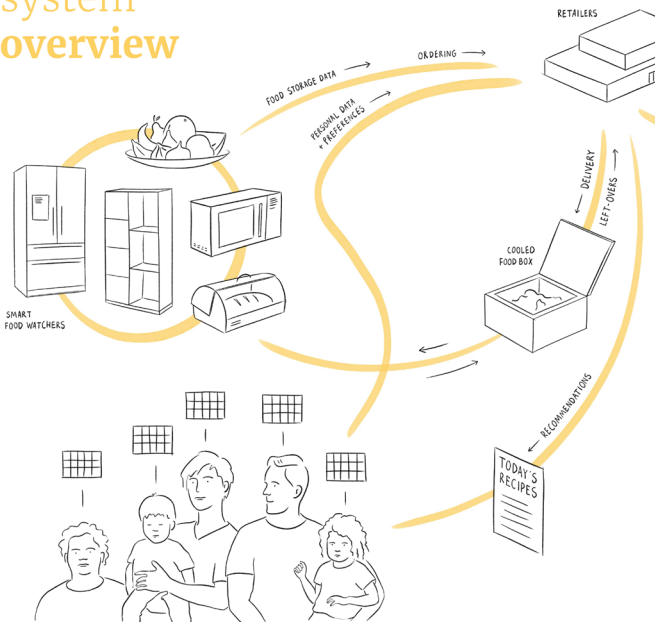
relational presentism

Not going to a shop saves Nicolas time and energy – so he can spend that time and energy to connect with his family instead. Today, he has a busy schedule and therefore the smart food watcher has ordered easy meal components that maximise nutritional value of the bread based meal whilst only little preparation is needed. This way, they have more time to have a relaxed dinner together and talk through their days. Other days, when Nicolas and his family have more time, they get meal components that are fun to prepare together and help shape meaningful bonds through the common effort that they are making. Sometimes, the meal components are accompanied by a food preparation game which helps them even more to immerse in the moment together.

main characters
Nicolas and Jacob, fathers of a family of five

Figure 2-7 | A visual describing the overview of System 1, which focuses on using data to optimise food flows throughout the supply chain. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

system
overview



effects on food waste

This transitional food system focuses on new technology to solve food waste issues. Algorithms are used to optimize food flows, technology is ingrained into people's kitchen appliances, and food that is not consumed immediately is reused or its nutrients are retrieved.
Retailers play a crucial role in applying the algorithms and using information obtained from households to allow for fast at-home delivery and for optimization in the supply chain. This facilitates a decrease of food losses throughout the supply chain. Through the smart food watchers, retailers can advertise novel food products to consumers, and promote the use of seasonal products, which could decrease food losses throughout the supply chain. It also increases the power that retailers hold in the food system.
The system aims to make household food management as easy as possible, and food waste becomes mostly out-of-sight for consumers. They can simply place non-used ingredients and leftover food back into the food system, without needing to worry about it.

Figure 2-8 | The beginning of a scenario exploring how a family would experience System 1, the data-driven system, in their daily life. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

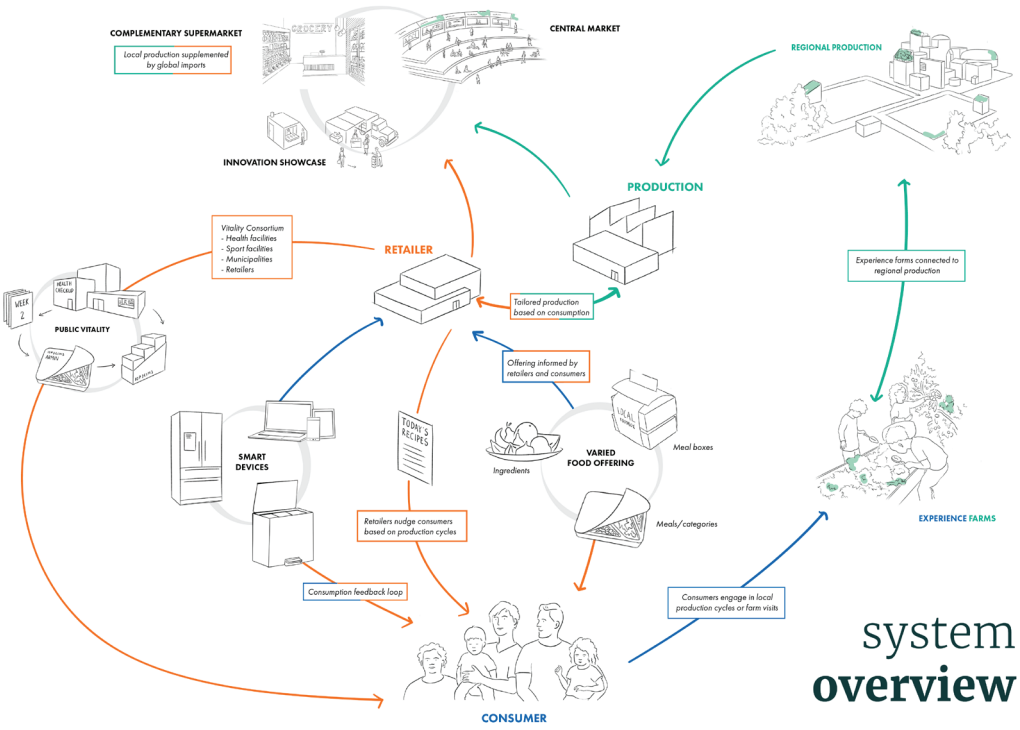


Figure 2-9 | The system overview of the unified vision, illustrating the relationship between the elements. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

Figure 2-10 | Screenshots from the animated video providing a feeling for the formgiving applied. © 2024 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by Elsevier Ltd.

2.5. Findings and discussion

In analysing the FETE visioning process, we found several tensions that indicate the need for better support to improve design capability in visioning for transitions—of which some are confirming earlier work. We unpack these tensions and consider how they relate to the position of the designer in the process, as well as the quality of the eventual vision. We discuss how potential choices in the process and/or methodological support could strengthen the role of design in developing visions for transitions.

First, we observed an ongoing tension between exploring alternative futures that challenge the current system on the one hand and depicting probable futures that allow stakeholders to see their place in the future on the other. One of the decisions in the process that affected this tension was the choice of experts to be interviewed. The need to include people from the consortium who largely represent the status quo and provide an insider perspective limited the capacity to include experts with an outsider perspective—one that provides alternative ways of looking at food production and consumption.

> *'The more you start with a set of insider experts, the less room you have to find other angles. And it's not always that in the other angles the answer comes but I think it needs to be there for the exploration. For the sake of having a 360 view, this selection process was compromising'.*
>
> – *Designer*

A key consideration is the purpose of the vision and, therefore, the steps taken to increase the quality of the vision in light of this purpose. In this case, a key purpose was to engage the consortium in the process and bring a sense of collectiveness to the transition. However, to foster the transition, it should also spur innovation that fosters the desired change (i.e., transformative knowledge in Gaziulusoy and Ryan (2017b). Therefore, the designers tried to balance making the vision inspirational to ideate from with making it relatable for the stakeholders. This meant adapting the language used throughout the envisioning process and removing some ideas that were seen as improbable or too specific. For instance, one early idea was 'urban food foraging', the practice of identifying and collecting the wild foods growing around the city as a way to engage in dialogues of food justice and environmental land use emphasising the centrality of food in caring for others and the environment. Some partners felt this was too niche and did not relate to a large enough consumer segment.

> *'As designers, we're usually making these visions inspirational for ourselves, so we get an itch to start designing. I think a bit of that was lost when we made [the vision] more relatable and*

> *approachable. But in the end, it's not us who need to work with it, it's all the stakeholders in the project team, which was fine.'*
>
> – *Designer*

While the designers took ownership of the vision content, reducing stakeholders' cognitive load (in terms of complexity), minimising the time asked from stakeholders, and minimising the reliance on stakeholders' system thinking skills (issues raised by Robinson et al. (2011), Hyysalo et al. (2019), and Loorbach (2007)), the designers did not manage to position themselves in a way to challenge stakeholders in their ideas about the future.

The designer's lack of domain knowledge is an influential factor in this case as it negatively influenced some stakeholders' confidence in the designer's ability to envision new food systems. The timeframe allocated for the project, 144 h, also limited the opportunity for the designers to gain the requisite domain knowledge and manage the design visioning needed to deliver a high-quality vision that mobilises the stakeholders. Nevertheless, it is naïve to think designers alone would be able to attain the domain expertise needed to present internally consistent scenarios for such a complex domain (Gaziulusoy & Ryan, 2017b; Wiek & Iwaniec, 2014). Moreover, it should be questioned if such a situation is even desirable. As noted by Gaziulusoy and Ryan (2017a), designers are skilled at connecting otherwise unconnected ideas and thereby represent new ideas and interactions in visioning processes, and this is (likely) aided by the outsider perspective they have in transition visioning processes. This paradox became clearly apparent in our case study: the more the designers felt a lack of trust from the stakeholders, the more they tried to conform to stakeholders' input, and the less daring and challenging their ideas became. However, the less challenging and daring the designers' ideas were, the less trust the stakeholders had in the designers' ability to challenge their thinking.

> *'There comes a point when the project lead suddenly finds the narrative in his mind and is like "okay, I believe in this". You have to believe in the future you present yourself. If you believe in the message, it is easier to transfer it to others.'*
>
> – *Designer*

From this paradox, we see that the information feeding into the envisioning process should be equally aimed at supporting an understanding of the status quo and at helping to challenge the status quo. This means that design's capability to combine various sources of information and do research into areas that may be seemingly unrelated to the challenge at hand should somehow be safeguarded, in order for designers to imagine radically new futures, relationships, and products and services. Additionally, more care should be taken in considering how to support designers to productively challenge the current thinking of stakeholders and not only

learn from them. This may be by 1) positioning design experts in a core team with other experts, like transition researchers or domain experts, to explore possibilities prior to validation with system stakeholders; 2) engaging individuals working for the involved organisations who might be better equipped to assess the vision in terms of its innovation potential (e.g., R&D developers) and not only including individuals who have the mandate to enact changes (e.g., managers); and 3) explicating to the individuals involved that part of the transition process and design approach is to challenge their thinking, articulating potential friction (e.g. voicing that they, as stakeholders, might be part of the problem hindering the transition) and being able to make explicit methodological steps for this process.

We also see added tension in terms of who is responsible for safeguarding the values that drive the transition (e.g., sustainability and equity), seeing this as a designer's responsibility on the one hand while shifting this responsibility to the stakeholders on the other (Gaziulusoy & Ryan, 2017b; Hyysalo et al., 2019; Köhler et al., 2019). This raises attention to the concerns around the ambiguous nature of values and for better ways to engage with values, morals, and ethics in transition design visioning processes (Borning & Muller, 2012; van Wynsberghe, 2013). While this is already happening around the adoption of new technologies (e.g., as in Value-Sensitive Design (Friedman, 1996; Mok & Hyysalo, 2018)), supporting designers in explicitly engaging with moral and ethical questions in their practice is relatively underdeveloped (Chan, 2018). During the process, we observed several controversial and moral discussions being avoided or ending without closure. For instance, a concept proposed by the designers involved government tracking of food flows through individual consumption data, raising concerns about data privacy. While some stakeholders were uncomfortable with personal data collection, others saw it as an opportunity to shape consumer behaviour and were supportive of this future. This conversation ended without a collective perspective on how privacy 'should' be considered in a future food system.

> *'There were some controversial things, like the ethical discussions or discussion on what will be really good in terms of being in a food transition that we sometimes evaded. Maybe because these discussions lead to delays and potentially don't reach a common ground. I would just be very curious to have a really open-minded discussion on why certain ideas are bad'.*
>
> – *Designer*

So, while the designers were able to bring tangibility to the future, they were unable to cultivate an environment for deep reflection: What future do we want to see come true? The designed artefacts helped to relate to this question and revealed various value conflicts between and within stakeholders, yet the dialogue was not well supported. For instance, there was a discussion around the plausibility of certain developments, e.g., speed delivery of groceries and their desirability,

knowing it could help decrease food waste but also negatively affect the use of urban spaces and labour conditions. Additionally, participants may have different viewpoints themselves, depending on whether they respond as a representative of their organisation or personally.

> *'The vision should really provoke people to see things in a different way, and that's what we had with this whole idea of food for health. The idea is that a certain consumer segment really makes health focal in all their food purchases and that you better think about how the system can be set up in a way that the consumer doesn't buy seven salads a week, of which he trashes four or five? I think that is really something that is kind of thought provoking. But are we really going to live like that?'*
>
> – *Professor of Services Marketing*

> *'For my organisation, we rely on technology, data exchange and the collaboration of the bigger companies and bodies in the chain. So, the system with a focus on data is most desirable from a business opportunity point of view. Personally, I believe in "education" and bringing broader value as a way to bring about positive change'.*
>
> – *Vice President, Business Content Lead of IT Consulting Firm*

Ultimately, how to address these conflicting values and decide what vision would become leading in the transition is a core step the designers struggled with. Especially since the method that was used in our case study asks designers to take responsibility rather than leaving it up to the client or stakeholders. There is a need for an independent actor to articulate the underrepresented values and ask normative questions about the future we as a society want. Since the Vision in Design method stages the designer as this actor, adaptations to the method or additional tools should support the designer in taking on this role. We suggest further exploration into how to position stakeholders and designers to have moral discussions and equip designers in transition contexts to better support these reflexive processes and/ or collaborate with experts to do so (van der Bijl-Brouwer et al., 2021)—potentially including other disciplines, like philosophy.

Finally, we saw a tension in developing design artefacts as a way to communicate the experiential qualities of the system (i.e., in the everyday life of people), yet helping participants to see these as part of complex system dynamics. The designers used a combination of the system overview and the day-in-the-life scenario to communicate the vision, but the consortium partners began picking specific elements that presented innovation opportunities for their organisation

rather than viewing the systems as one whole which would require developing new relationships with other stakeholders.

> *'We were really searching for what the [FETE stakeholders] needed to be able to look into the future. In the end, they really needed tangible products. But the products were meant to explain the system, not present product opportunities. But that was tricky, because the system transitions were more interesting than the products. So, it's a bit of a waste that the focus for stakeholders became product level rather than the underlying big system changes.'*
>
> – *Designer*

The authors tried to address this by selecting and communicating four principles that represented the relationship between the systems, including the new dynamics between consumers, producers, and retailers. This process highlighted a challenge between giving form to things in a concrete enough way to aid in understanding while emphasising the new complexity behind it and leaving enough room for the imagination so that others feel they can move along the pathways toward the vision. Currently, designers use, for example, scenarios (e.g., Candy & Dunagan, 2017), metaphors (e.g., Lockton & Candy, 2019), and system mapping (e.g., Sevaldson, 2011) to communicate system dynamics and relationships often depicting certain system levels (e.g., city) and particular changes (Forlano & Mathew, 2014; Gaziulusoy & Ryan, 2017a). However, more exploration into how to support designers in connecting the experiential and system qualities in the future and giving form to the dynamic relationships between these, representing multiple changes and system levels simultaneously, is something we consider to need further exploration if we wish to position visualisation and experiential design capability better for fostering transitions.

2.6. Conclusion

In this paper, we articulated how design capability can be positioned in a transition design visioning process by following a design agency as they envisioned a new food system for a research group working on the food (waste) transition. We aimed to expand our knowledge of the current boundaries of design expertise in transition visioning processes. Central to our contribution is the unpacking and articulating of several tensions that emerged in the process for design expertise in transition contexts. These tensions indicate the need to better understand how to position design capability in transition visioning processes to support designers in productively challenging the current system yet supporting stakeholders in seeing their place in the future; in positioning designers to have moral discussions and/or equip them to better support such reflexive processes; and in supporting

designers in giving form to dynamic relationships and connecting the experiential and system qualities in the future. Given that this study follows one design visioning process in one transition context, it bears the danger that the findings are specific to the design method, designers themselves, or the specific case. As such, future research is needed to investigate the extent to which our findings are representative. Nevertheless, our findings provide further avenues for research and actionable insights for design for transitions methodology and practice.

part two

Framing

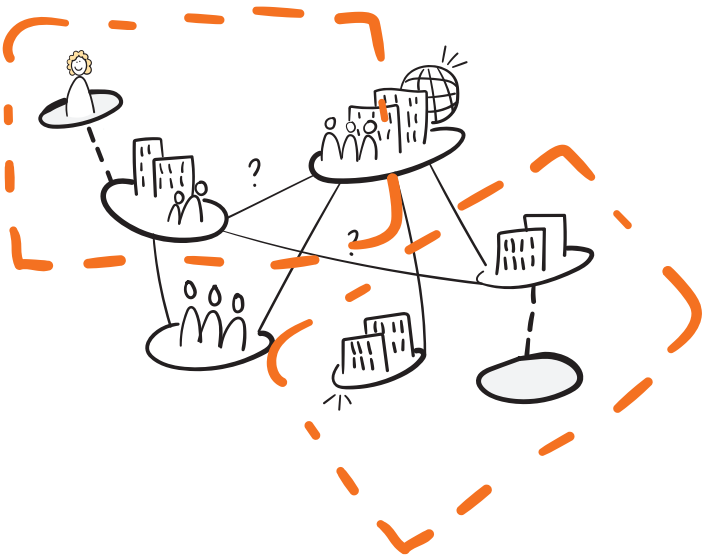
Framing in design involves shaping how a problem and solution space are perceived and understood. Through framing, designers can shift perspectives, open up new possibilities for intervention, and make informed design decisions. In transition design, little is known about how framing expertise is applied and what supports the framing activity. Part 2 of this dissertation, Framing, builds on the future vision developed in Part 1, and investigates how designers can determine where and how to intervene in a present system to foster the dynamics reflected in a vision. It explores framing in transitions across three chapters:

Chapter 3 investigates how designers can frame complex system dynamics to understand where and how to intervene to foster desired systemic changes. It presents a conceptual framework highlighting systems principles, organisational roles, and people's behaviour and capabilities as valuable concepts for innovation in transitions. This framing informed the creation of Adaptable Consumption and intervention portfolio that supports waste-free and flexible behaviours in daily life while contributing to broader systemic changes.

Chapter 4 deepens the exploration of people's capabilities and behaviors by examining how the proposed practice and interventions can become meaningful in daily life, linking micro-level consumer practices to broader transition goals.

Chapter 5 introduces a transition design rationale to guide intervention reasoning amid systemic complexity. Synthesising insights from both actor and consumer perspectives, it refines Adaptable Consumption and its portfolio through explicit transition design rationales. All intervention rationales are compiled in Appendix F

Together, these chapters demonstrate how strategic framing enables designers to bridge long-term systemic change with actionable interventions for diverse stakeholders.



Design Step 3

exploring system actors and system dynamics

Chapter 03

Framing system dynamics for designers innovating in transitions

This chapter is previously published as:

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To foster the envisioned food system changes outlined in the previous chapter, designers must determine where and how to intervene in order to replace existing practices with more desirable alternatives. As such, this first chapter of Part 2 presents a research-through-design study that explores the decision-making process of designers within transition contexts. Specifically, it investigates how the dimensions of scale and time can be incorporated into framing for innovation in transitions, and introduces a conceptual framework to support this process.

This chapter proposes that exploring and specifying 1) systems principles that drive the future system, 2) organisational roles that stakeholders can play in the transition, and 3) changes in people's behaviour and capabilities that are required for the transition, are key to identifying what future practice(s) to design for, in order to foster desired transitions. Additionally, it discusses the design activities and process artefacts developed and used to support investigation into framing for transitions in a way that aligns short-term innovation efforts with long-term systemic change. This chapter concludes with highlighting the study's contributions to advancing the understanding of framing in transition design, and hint toward some design activities and process artefacts to support this.

3.1. Introduction

Designers are increasingly engaging with challenges related to transitioning systems and driving systemic changes (Norman & Stappers, 2015). This has sparked important discussions about how designers cope with complexity and has led to new design practices like systemic design (Ryan, 2014), system-shifting design (Drew et al., 2022), and transition design (Irwin, 2015). While these new design practices support designers in relating to system dynamics and complexity, the emphasis has been on analysing these dynamics rather than integrating them to drive innovation. To support designers in their pursuit of fostering transitions, we need to develop a deeper understanding of how to frame system dynamics in a way that identifies opportunities for innovation that drive meaningful and desired system changes.

Transitions are conceptualised as long-term and large-scale changes in complex societal systems with a directionality toward desirable alternatives (e.g., Loorbach, 2007; Markard et al., 2012)–for instance, transitions within the energy system, transportation system, and agro-food system to become more just and sustainable. Such systems are considered complex because they are composed of numerous interconnected and interdependent components (e.g., actors, institutions, and material artefacts) that exhibit emergent behaviours, where the overall properties and behaviours of the system cannot be easily predicted from those of the individual components (e.g., Geels, 2002; Markard et al., 2012; Meadows, 2008). Despite this complexity, the main aim of transition research is to understand these processes and identify ways to advance and accelerate desired systemic changes (Loorbach et al., 2017). As transitions unfold, new products, services, business models, and organisations emerge, which (may) challenge and alter or complement the dominant system structures, cultures, and practices (Loorbach et al., 2017).

The ability of design to relate to people's everyday lives is key in helping societies shift to more just and sustainable alternatives (Gaziulusoy & Ryan, 2017a; Irwin, 2015). Not only can designers identify and address the problematic and persistent (consumption) patterns that contribute to complex societal challenges (Spurling et al., 2013), the human-centred approaches used in design can help to understand in what way desired changes are or can become meaningful for people and organisations (Tromp & Hekkert, 2018; van der Bijl-Brouwer & Dorst, 2017). According to Dorst (2011), designers engage in a reasoning process called design abduction. This reasoning process involves designers hypothesising about how their design proposals will deliver specific value to users and/or stakeholders. This process, depicted in Figure 3-1, comprises a what (design) and a how (mechanism) that together achieve a desired value (desired outcome) (Dorst, 2011). In design projects, designers often begin with an understanding of the value they seek to achieve and use frame(s) to explore and articulate how their design proposal and its working principle will lead to the intended value. Essentially, frames connect certain issues with solution directions. The process of proposing if/then statements (i.e.,

different frames) to predict how a mechanism will achieve desired values is called 'framing' (Dorst & Cross, 2001).

Framing is an essential design practice, occurring in the process of co-evolution between a frame and a solution (Dorst & Cross, 2001). To illustrate with an example: if a designer aims to create something to make people feel special (value) for a commercial internet provider, a birthday can be a frame to hypothesise what working principle might lead to this value. This frame can help to identify the mechanism of receiving personal attention (how), supporting the ideation of interventions, such as addressing people with their names in automated mailings (what). Throughout the framing activity, designers can evaluate if the proposed frame supports them in making design decisions and developing a clear argumentation and reasoning for a design proposal. In less complex design challenges, like in the example just used, this reasoning is relatively simple, while in the more complex transition design challenges there are more considerations to take into account while framing.

Figure 3-1 | Design reasoning framework adapted from Dorst (2011). © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

Reasoning toward a frame in transition design challenges is complex due to multi-stakeholder involvement, diverse knowledge fields, multiple problem owners, interconnected and dynamic problems, and the need to navigate multiple system scales (micro, meso, macro) and timeframes (now, near future, far future) simultaneously (Dorst, 2015; Loorbach et al., 2017). While transitions ultimately aim for sustainable and just societies, the tremendous scope of such challenges allows a large variety of interventions to move through such processes and (temporarily) establish the more desirable alternatives. Therefore, the framing that supports design reasoning to interventions should ensure design interventions are applicable in people's daily lives tomorrow and align with aims for nature and society over the next 30-50 years. As such, effective design reasoning for transitions requires a nuanced understanding of current system dynamics in light of desired future system dynamics to hypothesise what change mechanism(s) can foster desired values through design interventions.

Despite the recognised importance of framing in complex systems change (Dorst, 2019b), the framing needed to design interventions that foster transitions is underexplored and not methodologically well supported yet. Therefore, this paper focuses on understanding how designers can frame system dynamics in a way that supports them in making design decisions and developing a strong design reasoning for what innovations to propose to foster desired transitions. We apply a research-

through-design approach (Stappers & Giaccardi, 2017) to understand how long-term implications and short-term mechanisms are combined in the framing activity. To investigate the phenomenon of framing, we develop a process supported by various design activities and artefacts that are tested and refined over time. The findings in this paper expand knowledge about how designers apply their framing expertise for innovating in transition contexts, informing future research into framing and methodological development to support this key design activity. In the following section, we describe the state-of-the-art of how designers currently frame system dynamics for innovating for systems change and what challenges they face.

3.1.1. State-of-the-art

Over time, design has evolved from a practice focused on designing things to tackling complex societal challenges, thereby shifting emphasis from the utility to the meaning innovations offer (Dorst, 2015; Verganti, 2008). The future has long been embedded in design practice due to its commitment to innovation and change. By engaging in complex challenges, designers stimulate their futures awareness and incorporate broader timeframes within their design process (Candy & Dunagan, 2017). Adopting longer-term perspectives allows designers to go beyond the constraints of current socio-technical systems to envision alternative lifestyles that offer radical new meaning to people and society (Geels & Schot, 2007; Verganti & Öberg, 2013). This new meaning challenges and changes the current system structure into a preferred alternative, a shift supported by the human-centred approach of design practice. Human-centred design is a group of methods that places people's interests at the centre of the design process (van der Bijl-Brouwer & Dorst, 2017). They describe strategies for acquiring and integrating insights about human beings into products, services, and systems that fulfil people's needs and aspirations. In the context of complex societal challenges and transitions, human-centred knowledge is viewed as a positive design attribute as it supports designers in making change meaningful to people (Goss et al., 2024; Tromp & Hekkert, 2018).

Systemic design is a relatively new design practice that combines elements from design research and practice with systems thinking and complexity in methods for systems change (Ryan, 2014). In light of this study, we critically analysed and compared a selection of methods recently published in a systemic design methodology handbook aimed at supporting designers in analysing systems, i.e., Actors Map, Actants Map, Rich Context, Multi-capitals Model, and Story loop diagramming (Jones & Van Ael, 2022). The reviewed methods differ in what they deem most important to focus on in the analysis of system dynamics. Some methods build an understanding of system dynamics by analysing actor relationships and considering factors like relative power, influence, and shared or conflicting values. This perspective is illustrated by the Actors and Actants maps, which adopt an actor-centric view to understand how actors with significant influence can steer system changes and direct design efforts to focus on these actors. Other methods help to

build an understanding of system dynamics by analysing the transfer of resources and considering factors like knowledge, goods, and money. This is illustrated by the Rich Context, Multi-capitals Model, and the Story loop diagram, which seek to understand how shifts in these resources may trigger cascading effects throughout the system and direct design efforts toward resources that yield the most positive effect–also known as leverage points (Meadows, 2008).

While the reviewed methods help identify and define what should change, they do not reveal how to realise the desired values through innovation or what values it should offer people who will use it. In other words, they do not integrate the human-centred knowledge of design. For instance, understanding actor relationships can indicate who has the most power to change the system or which critical actor values are at stake relative to a transition. However, it does not indicate how design might address these to foster intended and desired values for people in day-to-day life and/or for stakeholders. This results in the systems perspective remaining disconnected from people's everyday lives. Although the Story Loop Diagram attempts to bridge this gap by adding narrative elements to contextualise the system's interactions, the resulting maps often remain overwhelming and impractical for innovation (Murphy & Jones, 2021). Additionally, while these methods support designers in understanding current systems, they do not explicitly relate this understanding to future dynamics. As a result, they fail to provide a nuanced understanding of current system dynamics in light of desired future systems. Consequently, they do not sufficiently support designers in addressing the temporal dimensions of transitions to hypothesise what change in the present can lead to desired changes considering the envisioned future system. With our focus on design intervening in people's daily lives to onboard them on a desired transition and recognising the gap in methods linking system analysis to the context of people over time, we reviewed the few transition design cases reported in the literature to learn how the designers made this step.

Reviewing transition design cases showed that designers explicitly take steps to bring in human-centred design and connect systemic values to the values offered to individuals in their daily lives. For instance, Hyysalo et al. (2019) use personas to help stakeholders relate to the people who need to change their behaviours in the near future to enact the desired transition. However, the personas failed to generate empathy and support stakeholders in exploring systemic changes beyond their own repertoire, resulting in outcomes focused on system-wide changes without clearly articulating their impacts on people's daily lives. In other research, Gaziulusoy and Ryan (2017b) work with descriptions of system dynamics to communicate the system level while at the same time communicating the qualities of day-to-day life. For instance, to communicate how decisions are made in a city in the far future, they explain a top-down, centralised economy as 'others doing it for the citizens' versus a bottom-up, decentralised economy as 'citizens doing it themselves'. They also use terms like density to describe how living in the city might feel. For example, a denser city might make life feel more hectic, while a less dense city might feel

calmer. These envisioned future dynamics serve as starting points to backcast to the present to consider what innovations to propose that might lead to the desired changes. Similarly, in Goss et al.'s (2024) study, the interaction between people and the food system is described as outsource-oriented or 'I want everything done for me' versus action-oriented or 'I want to do everything myself'. While these studies report on explicit descriptions of the (envisioned) relationship between citizens and organisations/authorities to understand the impact of different systemic realities on people's daily experiences, the economic and financial mechanisms necessary to implement these innovations are not as articulated in these descriptions, leading to some stakeholders questioning the feasibility of the proposals.

Other studies report on the use of social practices to explore and connect systemic values to the values offered to individuals. Social practices, as described by Reckwitz (2002), are routinized everyday actions that are habitually performed in (a large part of) a society. Bailey and Gamman (2022) use social practices to understand the drivers and features of violence among young people to bring a more just and safer urban environment. Viewing violence as a social practice uncovered key conditions in the broader system (i.e., in the social structures, cultural beliefs, and values of societal groups) that shape the enactment of violence in young people's lives. Another study by Wallace (2021) maps social practices related to overconsumption across different system scales and timeframes. For example, in the present, global trade and a culture of disposability normalize practices like early technological upgrades and shopping as a hobby. At the same time, a small but growing number of people engage in re-use, repair, and sharing communities. Wallace (2021) identifies interventions outside mainstream practices, such as repair cafés, that can challenge and alter the problematic system outcomes. However, both studies encountered challenges in bridging conceptual system mapping and practical application within stakeholder organisations. The difficulty lies in relating the insights associated with people's everyday lives to the stakeholders' innovation agendas. This highlights the need for the framing of system dynamics not only to facilitate a shift from system analysis to innovation synthesis from the perspective of the designer but also to align with the organisational stakeholders' goals and perspectives, enhancing their engagement with and uptake of innovation opportunities needed to drive systems change.

In summary, the literature shows that designers are increasingly working on complex systems change and transition challenges, applying their framing expertise and design skills to engage in and accelerate desired changes. However, understanding how to unite reasoning about system dynamics and value for people to support the conceptualisation of design interventions that foster desired transitions is lacking. Methods either seem to focus on mapping the system perspective but lacking a life-world perspective, or they focus on understanding current dynamics but fail to connect to a desired future. Examining cases reported in the literature, we found that designers use different strategies to shift from system analysis to people's everyday lives. Namely, by connecting system characteristics and individual behaviours

through the concept of social practices or by describing system characteristics with terminology that describes their meaning to the everyday lives of people. While these instances showed ways to connect system dynamics (macro level) to user value in the design of interventions (micro level), connections with the broader business context and organisational leverage points (meso level) for such interventions were lacking. Therefore, in the present study, we hope to gain a better understanding of the specifics of navigating system complexity, system scale, and time in a way that supports innovation for transitions and how this framing can be supported.

3.1.2. Method

We took a research-through-design approach to explore how designers can apply their framing expertise to frame system dynamics for innovating in transition design challenges. Research-through-design is an approach that explicitly uses design activities as a means of knowledge generation (Stappers, 2007; Stappers & Giaccardi, 2017). We adopted the research-through-design tactic of sequencing (Redström, 2017), iteratively shifting between literature and experimentation, to gain a more sophisticated understanding of the phenomenon of interest, in our case, framing for innovating in transitions. To this end, we reviewed literature related to complex systems change, including literature pertaining to system thinking and dynamics, organisational change, social innovation, transition studies, and systemic and transition design. While this body of literature offers theoretical accounts and examples of framing complex systems, research-through-design offers a structured way to integrate and apply this diverse knowledge in transition design processes.

In our experiments, we investigated what framing activities can result in a useful and convincing frame for innovating in transition design challenges and how to support this. This involved developing design activities and process artefacts to investigate various aspects of the framing and design activities. These artefacts were designed with a specific focus on systems complexity, scale, and time. Consequently, the specific outcomes of the experiments (i.e., proposals for design interventions) are secondary to the study's main objective. They serve primarily to investigate, evaluate, and validate the proposed framing and the integration of relevant concepts within the transition design process. Through these experiments, we gained a deeper understanding of the framing activity and how the design activities and process artefacts support designers in making design decisions and generating design proposals. Each experiment generated insights or raised questions, leading to new activities and process artefacts in subsequent experiments (Krogh & Koskinen, 2020, pp. 59-69).

We conducted five experiments over 2.5 years, ranging from single workshops (2 to 6 hours) to multi-day sessions. Participants included bachelor design students, design researchers and practitioners, and industry actors. Each experiment focused on different parts of the framing and design process, and we adapted each experiment to the characteristics and expertise levels of the participants. The different contexts

Table 3-1 | Research-through-design experiments.

#	Participating group	Study type	Participants	Duration	# of participants	Date
1	TU Delft	Project	Bachelor design students	20 hours over 3 days	60	September 2020
2	TU Delft	Project	Bachelor design students	20 hours over 3 days	60	September 2021
3	TU Delft	1 Workshop	Bachelor design students	2 hours	35	May 2022
4	Design Research Society Conference	1 Workshop	Design researchers and design practitioners	6 hours	12	June 2022
5	FETE Project Consortium	1 pre-interview and 2 Workshops	Actors in the food System	1 hour preparation, 8 hours over 2 days	6 in workshop one, 5 in workshop two	March 2023 – April 2023

and diversity of participants helped identify conceptual, methodological, and practical challenges when innovating in a transition design context–Table 3-1 details the context of the design experiments. All the experiments related to the transition of the Dutch food system to cater to enough food for all with minimal waste.

Led by the first and second authors, all experiments provided participants with background information related to the transition challenge, activities, and process artefacts provided. During the experiments, we took notes during observations and collected the outcomes of the transition design process. This allowed us to understand the framing within the individual experiments and also compare how the framing evolved across experiments. Aligned with the technique of sequencing (Redström, 2017), our process involved combining insights learned from observations during the design experiments with relevant insights from the literature. These were then used to adapt the activities and process artefacts for the next experiment.

The literature reviewed for this study included more than 35 articles related to complex systems change. With an abductive approach, we went back and forth between literature and practice to build a stronger understanding of framing, both in terms of what processual qualities are needed to support framing in transitions and what phenomenon constitutes a useful and convincing frame (Dubois & Gadde, 2002). Given the diversity of participants, when conceptual, methodological, or practical challenges emerged from the experiments, we reviewed relevant literature to seek insights that might inform adaptations related to the specific challenges. We

also reflected on whether the challenges were related to the specific participant group and their level of design expertise (for instance, in the experiments with bachelor students versus design practitioners) or if they related to conceptual challenges in the framing. These iterative cycles of experimentation, analysis, and adaption resulted in a nuanced understanding of how designers can frame system dynamics to innovate in transitions and hinted towards how this can be supported.

3.2. Overview of experiments

This section provides an overview of the research-through-design experiments conducted as part of the FETE (From Excess To Enough) research project. FETE is a collaboration involving three Dutch universities and eight organisations within the food system that are interested in reducing food waste now and partaking in a transition to a food system that caters to enough. In this section, we first summarise experiments one to four, focusing on the framing of each experiment, supporting literature, participant activities, and key learnings related to the proposed framing. A detailed explanation of the fifth and final experiment follows, showcasing the most refined design activities and process artefacts employed. As part of the FETE research project, a vision was developed with input from all FETE partners and other experts knowledgeable of the Dutch food system (for a detailed explanation of the visioning process, see Goss et al. (2024)). The vision presents a new Dutch food system that minimizes food waste by catering to people's different consumption practices, engaging consumers in consumption learning loops, adding value to food beyond nutrition, and bringing production cycles closer to consumers. This vision was used in some capacity in experiments 2 to 5–details to follow.

The purpose of these experiments is to advance our theoretical and practical understanding of the role of framing in supporting designers in navigating systems complexity, scales, and timeframes, as well as indicate what phenomena come together in a useful and convincing frame for innovating in transition design challenges. Accordingly, the specific innovation proposals of the experiments are of lesser importance and do not constitute the main contribution of the paper. Instead, they serve as a means to evaluate and validate the proposed frame and design activity.

3.2.1. Experiments 1 to 4

Experiment 1

Focus of framing: This experiment focused on how the meso-level (i.e., stakeholder perspectives) can be more integrated into the framing by exploring how stakeholder value conflicts can reveal design opportunities to accelerate desired transitions.

Supporting Literature Insights: Transitions require long-term visions of the future, articulating the societal changes an intervention aims to achieve (Irwin, 2015). Transitions challenge various actors' vested interests, power structures, and

business models, necessitating designers to understand these dynamics and address them through innovation (Eden & Ackerman, 1998; Loorbach, 2022; Reed et al., 2W009). Analysing and addressing conflicts between actors and desired futures (e.g., conceptualised in visions) helps to develop innovations that address the critical conflicts that hinder or facilitate systems change (Tromp & Hekkert, 2018).

Activities undertaken: Due to COVID-19, this experiment was executed using the online video platform Zoom and the online collaboration platform Miro. Participants were divided into twelve groups representing different food system actors. Each group developed a vision of a future food system that caters to enough food for all and minimises food waste. This vision described the changes this may require in consumer behaviour and lifestyle, implications for production and supply, and other new aspects needed in the system to facilitate desired changes. Using these visions as a reference, participants completed a template to assess their actors' readiness to enter and move with the transition. This template asked for an analysis of various aspects of their actor, such as their decision-making structures, drivers of innovation and change, potential contributions to the transition, possible conflicts arising in the transition, and core driving values. Next, the groups were mixed to develop an actor map, positioning the actors based on their perceived power and interest in the transition in order to discuss and identify value conflicts that could serve as entry points for innovation. Afterward, the original groups reconvened to develop innovation proposals that their actor could implement in the present to foster the transition.

Key insights related to framing: While this experiment tried to connect future stakeholder values in the transition to their current values, the framing lacked directives for repositioning actors based on future dynamics. The absence of a shared vision during joint actor mapping led to a lack of shared understanding and no common reference to address conflicts and design innovations for intended systems change.

Experiment 2

Focus of framing: This experiment focused on how to bring value to all system levels (for citizens, organisations, and the system) over time in the framing (i.e., connect current values with future values).

Supporting Literature Insights: Engaging actors in creating shared visions supports building collective commitment and mobilising action in transitions (Loorbach, 2010; Mok & Hyysalo, 2018). To effectively drive systems change, designers need to adopt a societal perspective, understanding both the salient user and stakeholder concerns that exist and emerge in the current context, as well as the systems interdependencies and overarching societal concerns in the present and the future (Tromp & Hekkert, 2018). Recognising different levels of value—value for users, organisations, ecosystems, and society—is crucial in this context (den Ouden, 2012). This understanding can enable a strategic focus on leveraging

organisational strengths, shifting the focus from assessment to active engagement in joint innovation for systems change (Goss et al., 2021; Mason & Rychard, 2005; Nogueira et al., 2019).

Activities undertaken: Participants were divided into twelve groups representing different food system actors. They were provided with the FETE research group's vision of a future food system. This vision was developed by a design agency in collaboration with FETE partners and other food system actors. It presents a Dutch food system that minimises food waste while envisioning new roles between consumers, retailers, and producers. In this experiment, the vision was explained in terms of the new system's dynamics, focusing on food production, processing, purchasing, and consumption. After reviewing the vision, each group completed a template to assess their actors' position within the transition and their readiness to respond within the transition. The templates provided in Miro were divided into three abstraction levels (individual-, organisation-, and system level) that explored distinct aspects of the transition.

The analysis at the individual level focused on identifying practices that hinder the transition to less food waste and value conflicts in consumer behaviour, such as short-term versus long-term health goals. This level indicated current system trends and practices and, in light of the vision, anticipated future trends and practices, helping to contextualise actor behaviour. For instance, a food manufacturer might increase single-sized portion production due to a rise in single homeowners. At the organisational level, the focus was on identifying potential barriers for the actor to enter the transition towards a food system that caters to enough. This level reveals how actors currently operate and examines their dynamics and alignment with transition goals, highlighting potential conflicts and barriers. For example, it revealed how current innovation processes might need to evolve to support the transition. Lastly, the system-level analysis focused on understanding the competencies of each actor in relation to others within the system. Specifically, it involved mapping key relations between actors and identifying their potential capitals of power (human, structural, relational, financial, reputational, resource, and cultural), helping to anticipate which organisational qualities could be leveraged to accelerate the transition. By assessing the readiness of each actor and their respective capitals and conflicts, this level provided crucial input for strategies to accelerate the transition towards a food system that ensures sufficiency.

Key insights related to framing: While this experiment tried to make the investigation into the values offered to citizens, organisations, and the system in the transition more explicit and manageable, analysing the different levels independently overlooked their interconnectedness. This resulted in innovations that did not integrate insights from all levels of the system and led to incoherent design reasoning. For instance, innovations that conflicted with the future dynamics or innovations that failed to consider the potential consequences to business models and roles of actors if joint innovations were pursued.

Experiment 3

Focus of framing: This experiment focused on how the interactions within the meso-level (i.e., between organisations) can be better integrated into the framing, and how to utilise relationships at the meso-level to ensure actors remain relevant in the near and far future.

Supporting Literature Insights: Innovation strategies need to extend beyond an actor's individual network to consider the broader networked environment in which they operate (Planko et al., 2016). By collectively adapting the system, actors can create a fertile ground for innovation, developing new relationships that facilitate wider innovation adoption. This highlights the important role of collaboration in creating environments conducive to innovation. Establishing consensus on which behaviours to foster through innovation in the future is crucial for generating momentum and aligning innovation efforts within a network in a transition (Roorda et al., 2012).

Activities undertaken: Participants were assigned a food system actor and were shown a video of the FETE vision that explained how the envisioned future food system provides enough food for all while minimising food waste. The video highlighted the system's core values and dynamics, including 1) prioritising vitality and effectively governing illness prevention, 2) embracing and highlighting flexibility, 3) celebrating and valuing the food journey, and 4) utilising technology to gain insights about people both as individuals and as a society. Subsequently, each participant individually completed a template similar to that used in Experiment 2 to assess their actor's readiness to respond within the transition. However, the analysis at the individual level focused on linking the practices envisioned in the future system more explicitly to their respective actor. Participants were asked to articulate which consumer-level practices complement or hinder their actor's alignment and mobility in the transition. They also identified existing patterns of behaviour and system dynamics that hinder societal progress toward the envisioned future. Following this, participants were randomly paired with a peer representing a different actor. Together, they collaborated to develop an innovation that was attractive to both actors' networks in the present and aligned with the future system dynamics conceptualised in the vision.

Key insights related to framing: By explicating the future values for stakeholders through systems principles, this experiment facilitated participants in developing joint innovations that effectively addressed each actor's interests and expertise, making them relevant both now and in the future. However, the resulting innovations were reasoned only in terms of their contribution to reducing food waste. The framing lacked support for developing innovations that extended beyond merely addressing the current problematic behaviour of food waste to align with the necessary behavioural adaptations reflected in the future, such as fostering flexible behaviours to reduce food waste or promoting behaviours aligned with health and vitality to reduce food waste.

Experiment 4

Focus of framing: This experiment focused on how to onboard the meso-level to effectively engage stakeholder interests in the framing, ensuring that design innovations implemented by stakeholders align the everyday lives of people (micro-level) with the broader system aims (macro-level) over time.

Supporting Literature Insights: Different types of actors are reflected in societal systems and are also important in light of transitions. Some actors operate outside the dominant system constraints, driving radical innovations and pioneering disruptive changes. Others are embedded within the current system, which may be resistant to change, but their involvement is crucial for scaling up and integrating new practices within the existing system. Some actors shape the external pressures and opportunities for change, influencing the broader context in which the transition occurs (Geels & Schot, 2007).). By considering these different types of actors and their potential roles, designers can develop innovations that can be implemented within the existing system while driving it toward desired alternatives. Analysing how actors relate, depend on, and interact with one another (inter-actor analysis) and within their own organisations (intra-actor analysis) supports insights into system robustness and adaptability. This understanding enables designers to navigate and mitigate conflicts while leveraging synergies and maximising actor buy-in and participation (Jonas et al., 2018).

Activities undertaken: Participants were divided into three groups and provided with the same FETE vision as in Experiment 3 (Goss et al., 2024). Each group was asked to choose a different type of actor but one that they were familiar with: one group chose an actor that is outside the dominant food system, one group a dominant and established actor within the current food system, and one group an actor that influences the cultural norms and political environment of the food system. First, the groups applied Causal Loop Diagramming (Hirsch et al., 2007) to understand the system and identify and conceptualise innovation opportunities. Causal Loop Diagramming, originating from system dynamics, is a method that visually represents the feedback loops and interactions among variables within a system, helping to understand and analyse the system's behaviour over time (e.g., Hirsch et al., 2007). Next, participants completed four mini-analyses–vision, inter-actor, intra-actor, and transition readiness–to identify innovation opportunities for their chosen actor in the transition. For each aspect, they were provided with a guiding question and relevant keywords. In the vision analysis, they examined the key qualities of the vision, focusing on behaviour, practices, and value conflicts. The intra-actor analysis explored how the actor operates and innovates, using keywords such as the actor's function, driving forces, and capability to adapt. The inter-actor analysis investigated the actor's network and unique capabilities, emphasising capital of power, dependencies, and relationships. For the transition readiness analysis, they assessed the actor's preparedness for the transition, focusing on system barriers and conflicts, and system dependencies and relationships. They

were not required to follow a specific order in their analyses but were encouraged to deepen their understanding of each aspect as new insights emerged. After presenting their analyses, new groups were formed, including representatives of all three actor types. The new groups were tasked with conceptualising joint innovations toward the future system dynamics defined by the vision–i.e., embracing flexibility, putting vitality first, celebrating the food journey, and using technology to learn–in a way that was strategic for their actor and ensured they remained relevant in the future system.

Key insights related to framing: While this experiment supported participants in negotiating their actors' interests when discussing joint innovation directions, the framing was ineffective in supporting participants in reasoning toward more concrete innovation proposals. This was because the actors' position in the transition and their readiness to enter and accelerate the transition differed when considering the four principles of the vision (e.g., when discussing dynamics related to flexibility vs. vitality). These differences in barriers, relationships, and dependencies when relating to the systems principles both in the present and toward the future made it challenging to propose a single innovation that related to all future system dynamics, thereby complicating the design reasoning.

3.2.2. Experiment 5: The FETE innovation process and outcomes

Experiment 5 was the final experiment and presented the most refined framing from the study. The following describes the activities and supporting process artefacts used in the experiment. Figure 3-2 provides an overview.

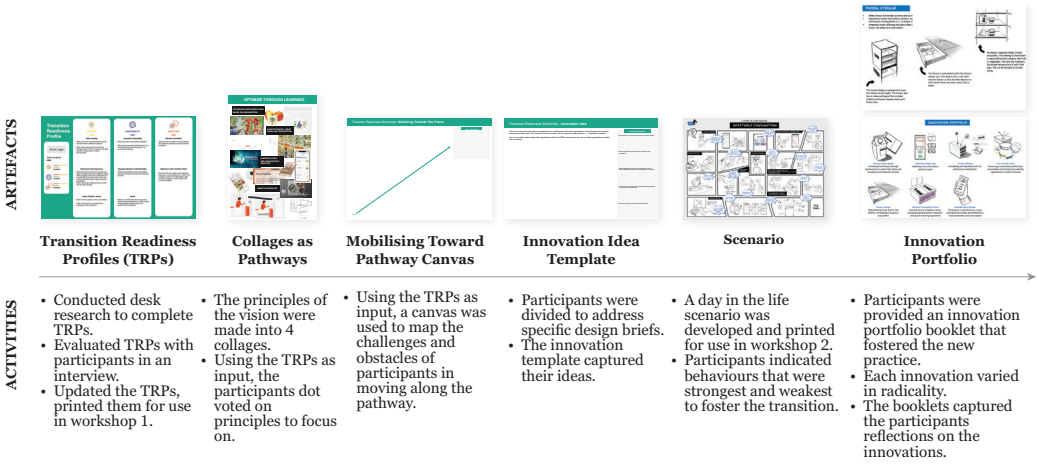


Figure 3-2 | Overview of activities and process artefacts used in experiment 5. © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

Preparation for 1st workshop

The first author performed desk research to create Transition Readiness Profiles (TRPs) (Figure 3-3) for each of the stakeholders participating in the experiment. These profiles describe how ready the stakeholder is to enact the transition given 1) its position and stake in the current system, 2) its adaptability and capacity to transform, and 3) its direction and alignment with the transition trajectory reflected in the vision. This included activities such as reviewing the organisation's website (including yearly reports), other professional profiles (e.g., LinkedIn), studies performed by the consortium partners, and social media presence (e.g., Instagram). After the TRPs were drafted, the first author presented them to the representative of the respective organisation. This was followed by a one-hour semi-structured interview to verify the TRPs' accuracy and make any adjustments based on the participant's feedback.

Workshop 1

In the first workshop, participants (i.e., the representatives of the organisations) selected one of the vision's systems principles to focus on and discussed how their innovation efforts aligned with it. To support this selection, collages were created that gave participants a visual representation of the impact the principles would have on people and the wider system. Through dot voting, the principle of Embracing Flexibility was chosen as the most crucial and relevant pathway for the transition

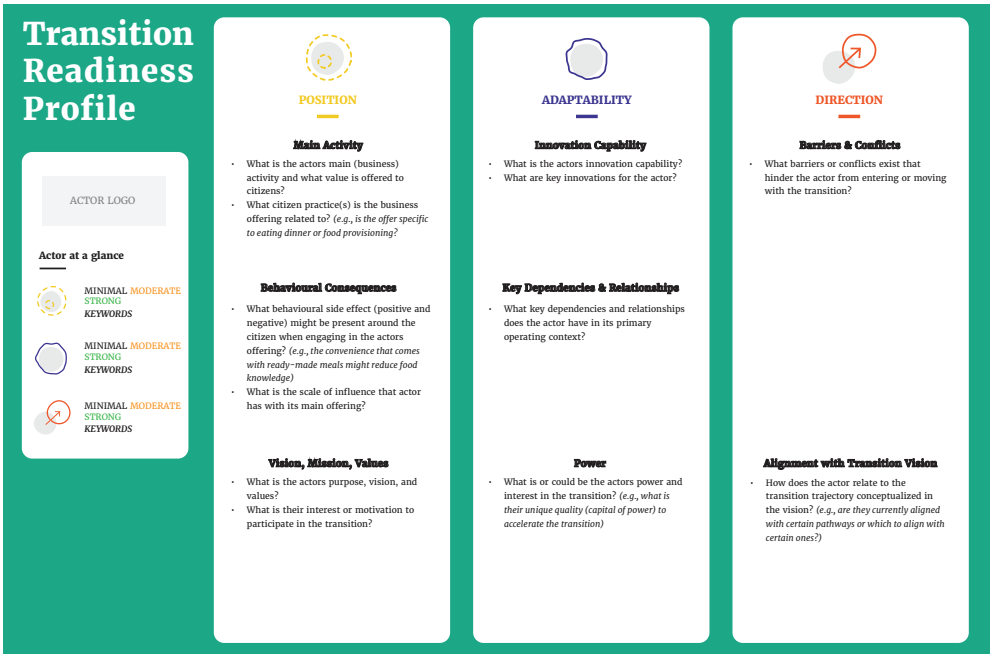


Figure 3-3 | Template of the Transition Readiness Profiles in Experiment 5. © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

given the contexts of the participating organisations. Using the TRPs, the participants identified challenges and opportunities their organisations might face moving along this pathway. In addition, they explored how their organisations could support each other in aligning with the pathway and overcoming shared challenges.

While exploring the pathway of Embracing Flexibility, participants reflected that the emphasis and prioritisation of food safety in the Netherlands is a key factor to address since it contributes highly to the amount of food being wasted and limits innovation opportunities for fostering the transition. The strict regulations to ensure the safety of food products are causing waste of still nutritious foods and restricting the space to experiment with sustainability measures. One participant reflected, "to really transition to a sustainable food system, we need to let go a bit of control". This highlighted the need for the Dutch food system to realign the values of food safety, food quality, and sustainability to foster the transition. A relatively higher prioritisation of sustainability in relation to food safety would allow more resilience and risk-taking in society. Based on this discussion, the participants were divided around two design challenges: one focusing on societal organisation and regulation of food, and one focusing on the household and their dealings with food. The first design brief brought together representatives of a national nutrition centre, a food waste foundation, and a waste collector. They discussed facilitating more risk-taking behaviours by removing labels from packaging to gauge acceptance of potential risks (e.g., health, taste inconsistencies, quality, and well-being). They also discussed stimulating such behaviours through personal waste management and incentives. The second design brief brought together representatives of a food manufacturer and a meal delivery service company. They discussed the facilitation of more flexibility in cooking through a Surprise Box intervention offering incomplete meals complemented by a monthly starter box to supplement the recipes with items with a long shelf-life, like pasta, beans, and frozen ingredients.

Preparation for the 2nd workshop

Building on the outcomes of the first workshop, the authors designed a new practice called Adaptable Consumption, focusing on embracing flexibility to cater to enough. When designing the practice, the authors looked into the far future to consider how adaptable consumption can become the norm. The designers reframed the original design challenge from fostering a food system that runs on enough to design a new practice that fosters flexible and waste-free behaviour in daily life while also driving systemic changes. To communicate the practice, the authors, in collaboration with a student assistant, developed a scenario depicting a consumer going through their week while engaging in the behaviours of the new practice (Figure 3-4). They also visualised an innovation portfolio consisting of seven innovation concepts (Figure 3-5), with each innovation being conceptualised in three variations ranging in radicality to illustrate how the practice could develop and evolves over time (Figure 3-6). This highlights the value of the behaviour (i.e., sub-practice) now and in the future.

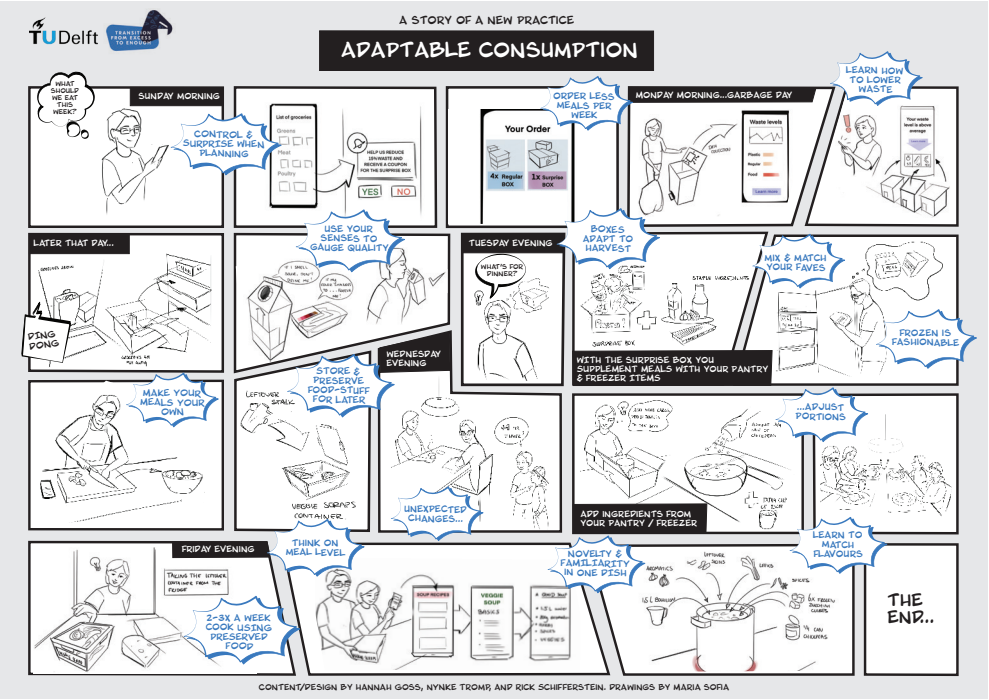


Figure 3-4 | Template of the Transition Readiness Profiles in Experiment 5. © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

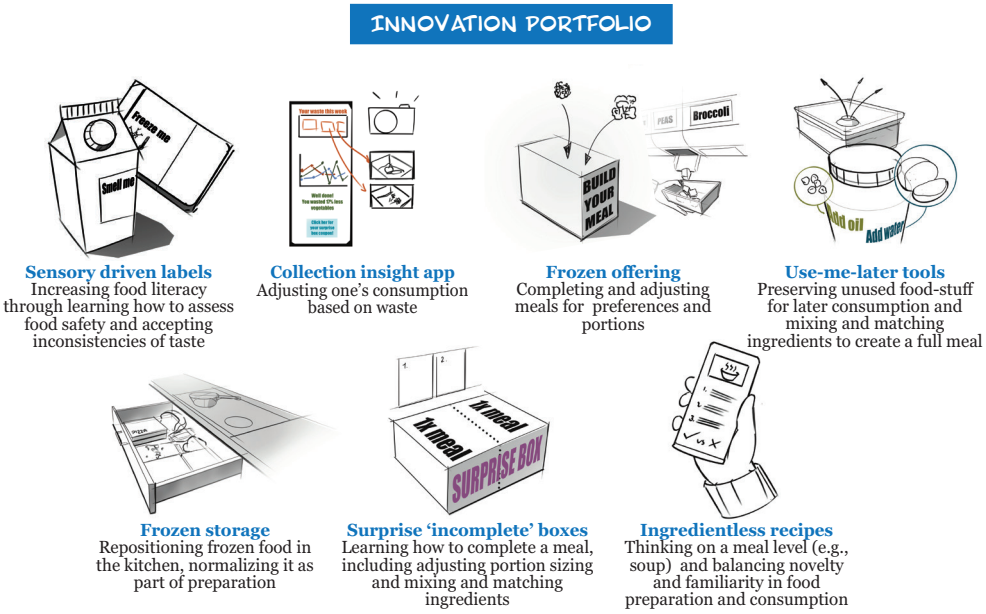


Figure 3-5 | A comic strip communicating how Adaptable Consumption manifests in daily life in the future (drawings by Maria Sofia). © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

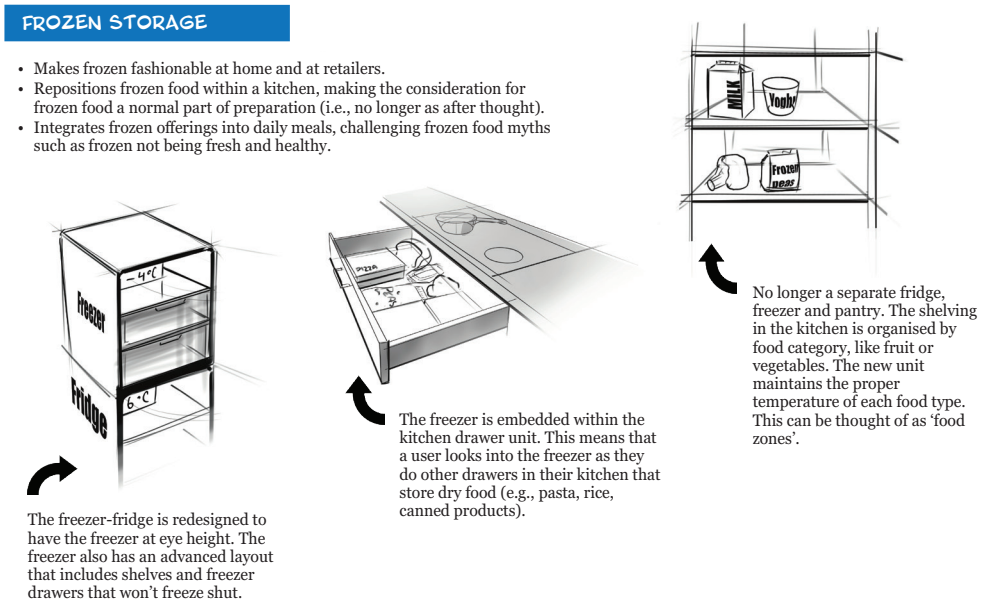


Figure 3-6 | Overview of the seven innovations that support the practice of Adaptable Consumption (drawings by Maria Sofia). © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

Workshop 2

The second workshop evaluated and further refined Adaptable Consumption from a societal and business perspective. First, participants were presented with the scenario (Figure 3-4) and reflected on which behaviours they considered strongest and weakest to support the transition through embracing flexibility towards less food waste. Next, participants were given a booklet outlining the innovation portfolio. After being presented with all innovations, the participants examined the innovations individually, reflecting on three questions: which innovation(s) they considered most interesting for their organisation; how they could improve the success of the innovation(s); and what role they could play in experimenting with the innovation(s) to assess the potential of the new practice. The session concluded with a collective discussion about the most promising innovations and how the consortium might proceed with experimentation.

3.3. Findings and discussion

Through a research-through-design approach, we wanted to understand how designers can use their framing expertise to navigate system dynamics when innovating in transitions and how to support this. By iteratively analysing and reshaping the design process, activities, and process artefacts and evaluating outcomes in relation to the proposed frame in the five experiments, we gained insights into the specifics of framing system complexity in transition contexts. These insights come together in a

conceptual framework that supports reasoning toward innovation opportunities that achieve desired impacts. This understanding is particularly relevant for supporting innovation across various system scales and timeframes.

3.3.1. Framework for framing system dynamics

From the literature, we saw that framing system dynamics for innovation in transition challenges is complex due to navigating across different system scales (micro, meso, macro) and timeframes (now, near future, far future). Although the literature showed insufficient conceptual and methodological support for understanding how to intervene in the lives of people in such a way that it fosters desired transition and system dynamics, researchers working in transitions point towards social practices and using language and visualisations that contextualise system changes in everyday life as promising directions. Yet, challenges remained in how to articulate the current system influence in light of a transition trajectory, as well as how to relate the meaning offered to people to the wider business context for organisations to act upon. In response to these challenges, we developed a design process supported by several artefacts:

- To relate to the future system, we used a vision and offered pathways for organisations to take in the transition and, at the same time, described what is meaningful to people. This came together in the systems principles.
- To relate to stakeholders, we used the Transition Readiness Profiles to onboard stakeholders into the transition in a way that repositioned them within a pathway and supported responses for new organisational roles.
- To relate to the daily lives of people, we used scenarios which presented new behaviours and capabilities for people supported by new products and services. We viewed the behaviours and capabilities beyond individual choices or actions and rather as part of a practice.

Our findings converge into a proposed conceptual framework (Figure 3-7), highlighting key concepts for designers to frame system dynamics in a way that supports innovating in transitions. The framework highlights that considering a future practice that is defined by new systems principles, new organisational roles that organisations take now, and new behaviour and capabilities people could adopt tomorrow, is a fruitful way to frame system dynamics in transitions. Through this framing, designers are supported in identifying short-term innovation efforts to foster longer-term systemic changes. It encourages thinking across different system scales (micro, meso, macro) and timeframes (now, near future, far future) to align innovations with transition goals. In the next section, we elaborate on our findings, presenting evidence from our research-through-design experiments. Although we developed and applied various design activities and process artefacts throughout the experiments, we focus the discussion on how they supported our investigation

into framing for transitions, rather than insights related to the specific form of the artefacts.

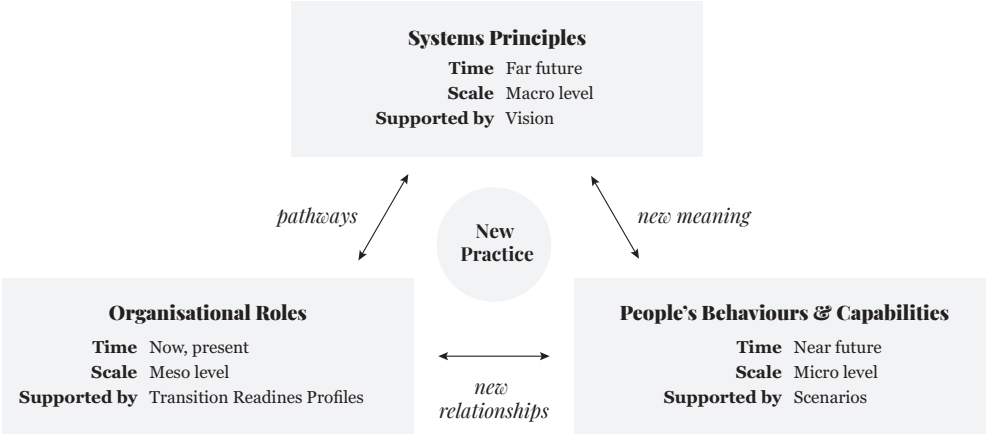


Figure 3-7 | Conceptual framework highlighting systems principles, organisational roles, and people's behaviour and capabilities as valuable concepts of a design frame. This frame supports designers in aligning short-term innovation efforts with long-term systemic changes. © 2025 Goss, H.M., Tromp, N., & Schifferstein, H.N.J. Published by International Journal of Design.

Relating to the future system

A key observation from our experiments is the importance of the handling of the vision—what to focus on in the vision and how this interacts with stakeholders in the current system. We found that the vision needs to describe dynamics that have implications for both stakeholders and people. This was challenging as focusing more on one or the other has downsides. If the vision does not indicate what meaning is offered to people in the future, it leads to innovations that lack, or superficially reflect, this meaning. While, if the vision presents concrete innovations for stakeholders, it leads to solutions that lack consideration for system dynamics.

- For instance, in Experiment 1, a group representing a catering company developed the following vision: "a future where catering promotes conscious eating habits by offering less variety and smaller portions while informing consumers about the current food waste situation and encouraging them to actively change their habits." In response, they proposed an enough day, where the caterer uses only their nearly expired food for meals at a reduced price once a week. The catering locations would display the amount of food wasted by customers and suggest how customers can consume differently. Although the concept allows the organisation to make better use of their ingredients, the reduced price might lead to a reduction in revenue, and the brand image would likely be negatively affected due to the blaming strategy employed, suggesting the consumers, not caterers, need to act differently.

- In Experiment 2, the vision used in the transition design process was developed through a multi-stakeholder process led by a design agency (Goss et al., 2024). The way in which the vision was communicated already depicted potential design solutions to illustrate innovation directions for stakeholders (e.g., a refrigerator box outside the house to receive groceries). However, such direct imaginations of elements of a future system did not support the more systemic discussions on the role stakeholders should play in (transitioning to) the new system. Therefore, while concrete design interventions support the imagination of possible future practices and, as such, may work to use as a reference for innovation, they run the risk of stakeholders selecting only a part of the system to focus on without considering the larger system dynamics that need to change for the transition.

Another key observation was the challenge of communicating the vision in a way that engaged stakeholders while also moving to the level of use. When the vision focused on components like food production, processing, and purchasing, innovations tended to superficially reflect stakeholders' business contexts with little deepening of what it meant for people or how they related to the new system dynamics. When the vision articulated principles that drive the system, it helped to define pathways to onboard stakeholders in the transition while at the same time understanding what the transition means for people in day-to-day life. Therefore, we found that the vision needs to provide a coherent and meaningful narrative for how potential innovation can foster the system dynamics reflected in the far future.

- In Experiment 2, one group representing an IT consultancy firm proposed implementing AI cameras in retail to analyse the quality of products and reduce prices on nearly expired food to increase sales. While this innovation reflects the stakeholder's expertise in data and technology, it does not align with the vision to shift away from traditional supermarkets or its goal to reduce overall food production and consumption. Experiment 3 represented a critical step in the process and use of the vision. The system's principles we defined were: 1) putting vitality first and governing the prevention of illness properly, 2) embracing flexibility and highlighting its benefits, 3) celebrating and valuing the food journey, and 4) using technology to learn about ourselves as individuals and as a society. These principles refer to dynamics between key stakeholders (in our case, producers, retailers, and consumers) and imply new actions from each. For example, putting vitality first involves implementing holistic health programs and repositioning food purchases into a larger set of vitality and wellbeing-focused lifestyle offerings (new stakeholder dynamics). Services are offered by sports facilities, municipalities, and retailers as part of their commitment to a vitality consortium. As such, it repositions retailers from food companies to care companies (new business models). This helps

consumers work towards a lifestyle that makes them feel balanced and strong by providing personalised meals, identity-exploring food experiences, and app-monitored consumption patterns reviewed by personal vitality coaches (meaning to people).

Relating to stakeholders

An important objective was to relate design innovation to organisational drivers in framing. Our experiments varied in how to support this reasoning, and we experienced various conflicts in trying to connect user value, organisational value, and system value over time. In this study, we found that relating to stakeholders and their wider business context and concerns needs to support speculating about what new roles they can play to move along a pathway. Additionally, it should redefine current and possible relationships within the system using this position to drive innovation opportunities. To incorporate their business concerns in a way that considers their potential in light of the transition, we developed the Transition Readiness Profiles (TRPs) (see Figure 3-3).

- In Experiments 1 to 3, the participants conducted desk research to complete the templates to reflect the business context. However, this knowledge was limited to what was publicly available and, in some cases, lacked an understanding of what was within the scope of the business. For instance, one group represented a food wholesaler and wanted to promote more seasonal consumption. Their innovation proposal involved retailers displaying produce based on whether they were in or out of season and focusing supply on seasonal food. While seasonal eating is something the wholesaler values and wants to promote, it remains unclear if they have the leverage to shape the retailer's in-store displays and offerings and what it would entail (e.g., financially and procedurally) to implement such an intervention.
- In Experiment 4, we decided to ask design researchers and practitioners to represent specific stakeholders in a group setting. While we were afraid that once the represented stakeholders were at the table they would respond conservatively, we found that by onboarding them through the template, they were able to speculate more about potential future roles. When innovating using causal loop diagramming, innovations remained close to the current system (e.g., a multinational retailer offering greater variation in package size to reduce food waste). However, when using the template, innovations were more systemic, and new roles and relationships were considered necessary to move in the transition trajectory. For instance, the participants explored how a multinational retailer might need an entirely new business model to align with a vision that does not focus on selling as much food as possible. They negotiated and reasoned from their stakeholder perspective, proposing that an initial step could be forming partnerships with sustainable

co-ops and using their retail space as pop-ups to begin this shift in focus and customer base.

- In Experiment 5, we prepared and verified the TRPs with the corresponding stakeholders before the co-creation sessions. The stakeholders were onboarded to relate their organisations with the transition trajectory and act from this potential future state rather than responding to the current business context. The TRPs helped the stakeholders and designers in assessing how far along the pathway each stakeholder could be positioned considering their relationship to the transition, their current direction, and their adaptability for change. By bringing the stakeholders together, the group could begin to envision new organisational roles within the collective, leveraging each other's opportunities, challenges, and knowledge. For instance, the national nutrition centre started to hypothesise how it might have a bigger role in steering the ministry's research agenda to promote the concept of the flexible consumer, such as setting up research focused on positive risk-taking with support from the food waste foundation. They began hypothesising how this would result in them needing to loosen up about how they currently think about and communicate health, safety, and sustainability-related information (e.g., what if there was less attention to the nutritional tools?).

Relating to people

A key observation from our experiments is the importance of relating to people's behaviours, identifying what behaviour to support in the present that builds the behavioural adaptation needed in the future. We found that if innovations focus on addressing narrow user problems, actions, or choices without sufficiently considering how the innovations empower consumers to adopt and sustain the lifestyles central to the envisioned future, they will fall short in supporting the adoption of new system dynamics. By discussing the user context in terms of multiple behaviours and new capabilities as part of a practice that can be adopted over time, we started to build a more complex view of behaviour change and opened up opportunities for joint innovation in light of the transition.

- In Experiment 2, participants developed innovation proposals by adopting the perspective of a single stakeholder, aimed at addressing a specific consumer behaviour that hinders the transition toward less food waste. One such innovation proposed the concept of a retailer shifting away from the traditional storefront model to offer a pre-portioned 7-day meal package that customers ordered online. While this idea diminishes food waste at the retail level, it might inadvertently lead to an increase in food waste within homes. It also removes the opportunity for consumers to develop skills in gauging their meal requirements due to the predefined nature of the meal

packages. As such, the concept conflicts with many aspects of the desired future system as conceptualised in the vision.

- Experiment 5 represented a critical step in the process and use of scenarios to depict user practices that yield joint innovation opportunities. This involved identifying and connecting several user behaviours that could reduce food waste as a practice, understanding how these behaviours influence the system along a pathway, conceptualising joint innovation that could mediate these, and depicting a person engaging in the practice in daily life (Figure 3-4 and Figure 3-5). For instance, by shifting consumer thinking from specific ingredients to overall meals, consumers can become more skilled at mixing various ingredients and flavours (user behaviour). This flexibility enhances their resilience to changes in food supply and promotes more efficient use of partially consumed food (system influence). Innovations like an ingredient-less recipe book can be implemented and supported by a national nutrition centre and a food waste foundation (joint innovation).

Exploring the innovations along varying degrees of practice radicality helped the designers better understand their potential impact. This also supported discussions around challenges stakeholders must overcome to make the innovations realistic for their organisation, proposing new collaborations among the stakeholders, and shaping possible experiments to test elements of the practice.

- In Experiment 5, innovations were developed within a limited time frame. Therefore, the emphasis was on highlighting the innovation's potential to shape the practice rather than its manifestation, like details around form or materiality (Figure 3-6). For example, one innovation aimed to enhance food literacy by enabling consumers to use their senses to determine food quality through the redesign of food packaging. One articulation of the innovation is to have packaging without any labels, suggesting a future where consumers are skilled enough at assessing food quality that standard 'use by' and 'best before' dates become obsolete. A less radical version suggests labels with sensory cues (e.g., if I smell like eggs, don't eat me) and dynamic suggestions (e.g., it's time to freeze me) to help consumers assess the food and act in alignment with this. A participant noted that the strength of this (sub)practice lies in its ability to reduce the cognitive burden currently placed on consumers and supports behaviours that reduce food waste while simultaneously improving food literacy. Whereas another participant voiced regulatory challenges in changing labels and current work being done to overcome these challenges in some product categories (e.g., some labels needing to be identical in Dutch and Belgian markets).

3.4. General discussion

This paper contributes to the understanding of how framing expertise is situated in transition design challenges, specifically in innovating to drive desired systems changes (Gaziulusoy & Ryan, 2017a, 2017b; Loorbach, 2022). Transitions are multi-stakeholder settings in which multiple and varied innovations implemented by numerous actors at different levels of the system are needed to drive systems changes. Discussions in design have emphasised the need for stakeholder participation and engagement when tackling complex societal challenges (Jones & Van Ael, 2022; Sangiorgi, 2011). It has been proposed that this engagement should move beyond mere involvement in design processes to also facilitate a deeper systemic understanding essential for designing innovations that foster systems changes (Carvalho & Goodyear, 2018; Jones & Van Ael, 2022). We demonstrate that engaging selected stakeholders in the innovation process supported the designers in navigating the business context and gaining a more nuanced understanding of the systemic context. However, it is key to support stakeholders in thinking about possibilities for the future rather than being focused on the restrictions of their current business activities, as we achieved through the Transition Readiness Profiles. The innovations developed in these experiments were not off-the-shelf solutions but intentionally designed for the specific transition challenge and actor network. They involved careful alignment with the transition pathway, the stakeholders' interest, and the value for people in their day-to-day lives.

In hindsight, we see that choosing one transition pathway to focus on and working with a smaller selection of stakeholders allowed us to temporarily simplify the system's complexity, making it manageable to design for. This simplification of selecting and limiting the number of system elements being considered at one time has been applied by other researchers working in transitions. For instance, Gaziulusoy and Ryan (2017a) and Hyysalo et al. (2019) focus on specific changes, such as technological or political, and specific system levels, such as a neighbourhood or city, to design innovation opportunities or transition pathways. This deliberate reduction in complexity allows designers to alleviate cognitive overload, freeing up mental space for imaginative exploration and exploring possibilities for new meaning (Dorst, 2019b; Gaziulusoy & Ryan, 2017a; Goss et al., 2023; McGrail et al., 2015).

Transitions result in mainstream practices becoming outdated and being replaced by new, ideally more sustainable alternatives. As such, this study contributes to discussions regarding the role of design and innovation in reshaping and reconfiguring current practices (Gaziulusoy, 2015; Gaziulusoy & Brezet, 2015). Shove (2010) describes practices as comprising three key elements: meanings (social expectations and symbolic interpretations), materials (tools and objects essential for practice), and competences (skills and knowledge required for practice). When the interaction between these elements persists, routines and habits are sustained, while disruptions can act as catalysts for change within established practices. In the field of Transition Management, four types of activities foster new practices: strategic

activities (cultivating a shared vision and potential pathways), tactical activities (building foundations for collaboration and common agendas), operational activities (engaging stakeholders to implement the vision), and reflexive activities (evaluating and reassessing practices, interactions, and discrepancies) (Loorbach & Rotmans, 2010). Therefore, when designing for transitions and explicitly framing system dynamics for innovation, we see that focusing on systems principles, organisational roles, and people's behaviours and capabilities hints toward new practices that serve as stepping stones toward sustainable alternatives. Systems principles establish norms and cultures (i.e., meaning, strategic, and reflexive activities), organisational roles direct new products and services (i.e., materials, tactical, and reflexive activities), and people's behaviours and capabilities reflect new skills and knowledge (i.e., competences, operational, and reflexive activities). By framing system dynamics through these concepts, we show that designers can reveal which current practices ought to be reinforced and which ought to be dismantled (Loorbach et al., 2017; Olstad & Kirkpatrick, 2021). While our study reports on findings that support the earlier proposed potential of practices to foster new systems, the application of social practice in design processes remains primarily descriptive (Fam & Mellick Lopes, 2015; Kuijer & de Jong, 2012; Shove et al., 2015; Watson & Meah, 2012). As such, more research is needed to understand how to intervene on the level of practices and how this can be supported.

The proposed conceptual framework (Figure 3-7) is valuable because it helps designers understand the complex system they are working within to align short-term innovation efforts with long-term systemic changes. It articulates important concepts to consider and explore when innovating in transition design contexts. In other words, it helps designers understand the system they wish to intervene in and reason from desired impacts to innovations to be designed (Dorst, 2015). While we acknowledge that this framework is not exhaustive and research is ongoing to understand how it relates to other concepts of complex systems and transitions, we offer reflections and speculations on its relevance to these concepts in its current state. Notably, the framework's inclusion of various time horizons facilitates a deeper understanding of learning loops, sensitivity to current conditions, and the mechanisms of emergence that can, might, or ideally will take place (Ladyman et al., 2013). This involves identifying promising practices for desired systems changes and exploring strategic design interventions to support and amplify these practices through mechanisms such as self-organisation or infrastructure (van der Bijl-Brouwer et al., 2024). Although the framework delineates boundaries within systems analysis–focusing on systems principles, organisational roles, and people's behaviours and capabilities–we recognise the interconnected and relational quality of these boundaries, highlighted by the two-way arrows in the framework that define potential pathways, new meanings, and new relationships.. These interactions suggest that through continuous feedback, designers can gain deeper insights into both specific system components and the system as a whole. However, to integrate these feedback loops effectively and to frame system dynamics without perpetuating unjust

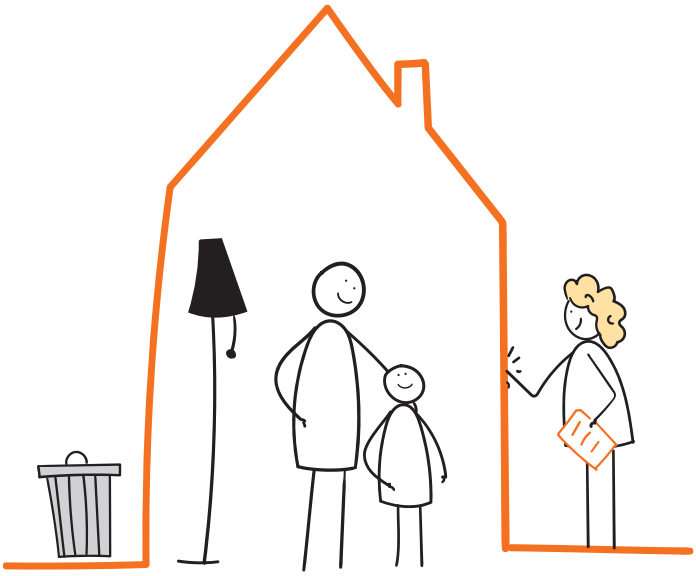
and unsustainable structures, cultures, and practices, designers must continuously employ a high degree of systems reflexivity (Fitzpatrick et al., 2024; Vink, 2023). Additionally, while the process artefacts outlined in the framework, such as using a vision, day-in-the-life scenarios, and Transition Readiness Profiles, offer valuable support for designers in framing system dynamics, they are not the only possible options. Other design activities or artefacts may support the exploration of the key concepts, such as speculative design (Dunne & Raby, 2013), role-playing (Vink & Koskela-Huotari, 2022), and giga-mapping (Sevaldson, 2011). Nevertheless, by highlighting the specific qualities needed for effective framing, we provide guidance and support for selecting or adapting the application of alternative ways to assist designers in navigating complex systems for innovation.

The specificity of our research context and approach has implications for our findings. This study, and notably the proposed final experiment, adopted a relatively top-down and sequential approach in applying the concepts within the conceptual framework: first adapting the vision into a workable form by identifying systems principles, then engaging stakeholders to secure interest and understand how they can contribute to the desired future through new organisational roles, and finally, integrating the user context to support the development of new behaviours and capabilities. While this was done pragmatically, we speculate that a simultaneous exploration of the conceptual framework among organisational stakeholders and user groups might also be possible and perhaps better resonate with the inherent nature of design since it allows integrating the user context earlier in the process. Future research should, therefore, investigate the implications of varying the integration of these concepts within the transition design process and if or how that affects the framing of the system dynamics. Similar to other transition design projects that take a pragmatic approach to stakeholder selection, either through accessible networks motivated in the transitions or predetermined consortia (Gaziulusoy & Ryan, 2017b; Hyysalo et al., 2019), our process was also top-down, in that it engaged a select group of stakeholders with an direct interest in reducing food waste. While stakeholder engagement is logical, given that they need to implement innovations into the system, we did not explicitly engage consumers in the experiments or co-creation sessions. While we believe this would not change the framework, we believe that involving consumers earlier in the process might have led to innovation conceptualisations that are more attuned to people's day-to-day lives and the needed skill adaptation for proposed practices.

3.5. Conclusion

This paper explores how framing expertise can be applied in transition design challenges to support designers in making design decisions and developing strong reasoning for what innovations to propose to foster desired transitions. Our findings indicate that considering a future practice that is defined by new system principles, new organisational roles that organisations can take now, and new behaviours and

capabilities people can adopt tomorrow is a fruitful way to frame system dynamics. By applying an iterative research-through-design approach, we show that this framing supports designers in thinking across different system scales and timeframes, helping them to reason from desired system dynamics in the far future to activities organisations can engage in in their current context to deliver new and meaningful concepts for people in the near future. Further research is needed to assess the proposed framing beyond the context of the experiments (i.e., the food system).



Design Step 4

exploring consumers and their user context

Chapter 04

Let's get flexible: exploring adaptable consumption toward reducing household food waste in The Netherlands

This chapter is previously published as:

Goss, H. M., de Koning, J. I. J. C., Tromp, N., & Schifferstein, H. N. J. (2025). Let's Get Flexible: Exploring adaptable consumption toward reducing household food waste in The Netherlands. Sustainable Production and Consumption. doi: https:// doi.org /10.1016 /j.spc.2025.01.005

Building on the framing of adaptable consumption in the previous chapter (which engaged system actors), this chapter focuses on exploring micro-level consumer behaviours and capabilities as an important aspects of framing new practices. It investigates adaptable consumption as a transformative strategy for reducing household food waste, emphasising its role in enhancing food system resilience. Adaptability of consumption empowers households to adjust food-related behaviours in response to changes in food availability, household needs, and other disruptions.

Through cultural probes and semi-structured interviews with 11 Dutch households (43 participants), this chapter identifies five actionable opportunities for supporting consumers in developing greater adaptability for reducing food waste: 1) supporting flexible meal moments, 2) reclaiming food edibility, 3) reintegrating food into routines, 4) integrating feedback loops, and 5) playing into life-changing moments. These opportunities represent critical moments in time, behavioural routines, or dynamics where food waste-reducing behaviours can be successfully introduced and fostered. Additionally, this chapter provides practical recommendations within each opportunity, including implementing sensory-driven food labels to guide safe consumption decisions, introducing storage tools to minimise waste, and leveraging digital tools to provide actionable feedback. By implementing such interventions, stakeholders can enable households to adopt sustainable practices that align with systemic goals for food waste reduction and resilience, effectively connecting individual behavior change to the broader transition objectives.

4.1. Introduction

Resilience in food systems relies heavily on the capacities for adaptability and flexibility, which enable responses to mounting pressures such as climate change, resource depletion, and socio-economic instability (UNEP, 2024). These challenges threaten food availability, affordability, and quality, making the need for resilient food systems more urgent than ever (Rotz & Fraser, 2015; Tendall et al., 2015). Resilience, as defined by Tendall et al. (2015), is the "capacity over time of a food system and its units at multiple levels to provide sufficient, appropriate, and accessible food to all, in the face of various and even unforeseen disturbances." This definition highlights that resilience goes beyond robustness; it requires the ability to adapt to evolving circumstances and remain flexible in the face of disruptions. Such capacities are essential for food systems to navigate both immediate and long-term challenges while avoiding undesirable outcomes like food insecurity or environmental degradation (Tendall et al., 2015). Resilience and sustainability are, therefore, deeply intertwined, as maintaining a food system's long-term functioning—a core principle of sustainability—is fundamental to achieving resilience (Rotz & Fraser, 2015; Tendall et al., 2015).

Adaptability and flexibility, though distinct, are complementary dimensions of resilience that operate across multiple levels of the food system, from global supply chains to individual households (Adger et al., 2005). Adaptability involves the capacity for long-term adjustments to meet changing conditions, such as adopting new dietary patterns or preservation techniques (Carpenter & Brock, 2008). In contrast, flexibility enables short-term responses to immediate disruptions without requiring structural change, such as substituting ingredients or modifying meal plans (Adger et al., 2005). While much of the adaptability and flexibility demonstrated in food systems has been reactive—addressing past or ongoing challenges—these capacities can also be anticipatory, allowing proactive measures to strengthen resilience (Adger et al., 2005).

To date, most research on adaptability and flexibility has focused on food production and supply chains, exploring strategies such as crop diversification (Darnhofer et al., 2010), and technological innovation for production and processing efficiency (Brenner et al., 2014; Van Wezel et al., 2006; Yu et al., 2024). However, there has been relatively little attention to how these concepts apply at the consumer level, where households play a crucial role in fostering resilience through their consumption practices (Beddington et al., 2012; Tendall et al., 2015). For a food system to be resilient, it must also support households in adapting consumption patterns over time while enabling flexible responses to situational challenges without compromising nutrition or well-being (Goss et al., 2023, 2025c).

A key area where consumer-level adaptability and flexibility could significantly enhance food system resilience is in reducing household food waste (Beddington et al., 2012). Globally, food waste accounts for approximately one-third of all food produced annually, with households responsible for 50% of this waste in

Europe (Tostivint et al., 2016). This food waste has severe consequences for society, placing pressure on production resources, the environment, and public health, and it poses significant economic costs across the food chain (UNEP, 2024). Recent studies have explored these concepts on the consumer level, such as in flexible meal planning (Cooper et al., 2023; Heidenstrøm & Hebrok, 2022; Pickering & Reynolds, 2023), and consumer flexibility in food purchases (Ghosh Chowdhury et al., 2018; van Herpen & Jaegers, 2022), but few have examined these as a central strategy for reducing food waste. Notably, Cooper et al. (2023) are among the first to place flexibility at the core of an intervention specifically aimed at minimising household waste, signalling an emerging research area with considerable potential.

In the literature and the present study, *adaptable consumption* is proposed as a practice for enhancing household resilience by enabling households to adjust their food provisioning activities towards food waste minimisation (Béné, 2020; Goss et al., 2023, 2025c). It integrates flexibility through short-term adjustments like substituting ingredients or modifying meal plans and adaptability through practices such as using suboptimal food and improving storage techniques in the long term. The present study delves deeply into the everyday practices and lived experiences of households, uncovering how adaptable consumption unfolds within their daily food provisioning and waste routines. It examines how Dutch households engage in adaptable consumption and identifies opportunities to foster both flexible and adaptive waste-reducing behaviours and practices. By positioning adaptability at the core of a household-level strategy for food waste reduction, this research provides insights into how changes in household practices can support resilient food system goals.

4.2. Literature review

4.2.1. Adaptability and flexibility in household food practices

Adaptability in household food practices encompasses longer-term, structural changes aimed at embedding sustainable and waste-reducing behaviours into daily life (Goss et al., 2023, 2025c). This includes the adoption of sustainable dietary patterns, such as integrating seasonal and locally sourced produce into meal planning or incorporating plant-based proteins to reduce environmental impact. Seasonal eating, for example, not only aligns household consumption with the natural availability of food but also reduces reliance on resource-intensive food production and storage practices (Boon & Schifferstein, 2022; Macdiarmid, 2014). A study by O'Neill et al. (2022) found that seasonal produce boxes encourage consumers to adopt more preservation techniques, embrace less familiar ingredients, and adjust their shopping routines based on the produce provided, thereby becoming more adaptable. Such practices foster a proactive approach to food management and enable preparation for future uncertainties.

Conversely, flexibility in household food practices refers to the ability of households to make short-term, situational adjustments to their food-related routines in response to daily challenges or immediate disruptions. These adjustments may include substituting unavailable ingredients, modifying recipes to accommodate what is on hand, or creatively using ingredients to avoid waste. For instance, "meal mutability"—the capacity to adapt recipes by replacing or omitting ingredients, tools, and preparation techniques—has been shown to align food preparation with the resources available in a household (Pickering & Reynolds, 2023). Similarly, Cooper et al. (2023) introduced the concept of "Use-up Days" as an intervention for flexible meal creation, where households are encouraged to prepare meals using a base ingredient, a vegetable, a protein, and seasonings. This approach stimulated households to be more creative and flexible in creating a meal by simplifying the meal-building process. It also encouraged them to consider fruit as a main ingredient in a dinner meal, which is often not considered in many countries, including the Netherlands (Dubbeldam, 2020). By reducing dependence on rigid recipes, these strategies encourage flexibility in cooking and support waste reduction by utilising perishable items before they spoil.

In addition to recipe adjustments, short-term changes in shopping behaviours also contribute to flexibility. Studies have shown that purchasing smaller quantities, shopping more frequently (Heidenstrøm & Hebrok, 2022), or opting for frozen alternatives (Schanes et al., 2018) can help households prevent over-purchasing and reduce waste. For example, shopping more in the frozen food aisles not only offers items with an extended shelf life but also provides a practical alternative for preserving nutritional value and reducing spoilage compared to the item's fresh counterparts (Janssen et al., 2017). Such behaviours are particularly relevant in contexts where food availability or household needs fluctuate, as they enable households to adapt without significant disruption to their consumption routines.

4.2.2. Social and material dimensions of Adaptable Consumption

The social context of food practices also plays a critical role in shaping household behaviours and their contribution to food waste (Warde, 2016). Social norms surrounding food freshness, abundance, and variety often result in over-purchasing, which in turn leads to food waste and can hinder adaptable and flexible behavioural adoption (Stangherlin & de Barcellos, 2018). These norms are embedded in cultural expectations and are further reinforced by external influences such as marketing campaigns, retail strategies, and societal perceptions of "perfect" food (Evans, 2014; Porpino et al., 2016). For example, advertisements promoting abundance as a symbol of prosperity may encourage consumers to buy more than needed, while the rejection of aesthetically imperfect produce by retailers contributes to the normalisation of waste at both individual and systems levels. However, reframing these norms to emphasise sufficiency—buying just enough—and the acceptance of

suboptimal foods, such as blemished or misshapen produce, can reduce food waste (Zhang, 2024). Educational campaigns and awareness-raising initiatives, such as those highlighting the environmental and economic benefits of choosing "ugly" fruits and vegetables, have been successful in challenging ingrained consumer biases and encouraging more sustainable behaviours (Aschemann-Witzel et al., 2015). However, research also indicates that campaigns alone are often not enough to change food waste behaviours, rather multiple strategies are needed that address the various social and cultural dimensions influencing food waste producing behaviours (Cappellini & Parsons, 2012; Richetin et al., 2012; Watson & Meah, 2012).

Material infrastructure, such as storage facilities, preservation tools, and kitchen design influence how households manage, store, and utilise food (Evans, 2014). For instance, large refrigerators and freezers affect not only storage practices of households but also shopping and cooking habits, such as buying in bulk and saving large quantities of leftovers. On the other hand, households with limited storage space or inadequate preservation methods may struggle to manage food effectively, leading to increased spoilage (Evans, 2014). The ease of acquiring food due to the high number of retailers, particularly in cities (Gojard & Véron, 2018), the prevalence of promotions, and the occurrence of bulk packaging encourage over-purchasing, further exacerbating waste when excess food goes unused (Graham-Rowe et al., 2015). Research suggests that visibility-enhancing storage solutions, such as transparent containers and well-organised shelving, can reduce waste by improving inventory management and preventing items from being forgotten or overlooked (Farr-Wharton et al., 2014).

4.2.3. Socio-demographic factors of Adaptable Consumption

The broader socio-demographic factors of households play a critical role in shaping adaptable consumption practices and their relationship to food waste (Schanes et al., 2018; Stangherlin & de Barcellos, 2018). Flexibility in employment, as discussed by Dixon et al. (2014), has significantly altered eating habits and food choices. The rise of flexible and unpredictable work schedules has disrupted traditional synchronised mealtime routines, leading to more irregular eating and provisioning patterns. These changes often increase reliance on convenience foods and unplanned or ad-lib eating and purchasing moments, behaviours that are associated with a higher likelihood of food waste (Dixon et al., 2014; Schanes et al., 2018). Explicitly supporting the need for the "just-in-time" nature of modern life has the potential to counter these wasteful practices. For instance, van Herpen and Jaegers (2022) show that consumers are willing to switch to buying frozen bread as an alternative to fresh, especially when faced with reduced fresh bread options when shopping late in the day, a switch that supports waste reduction efforts.

Household composition also plays a pivotal role in determining food waste behaviours. Households with children are particularly susceptible to higher levels of food waste (van Dooren & Mensink, 2018; van Geffen et al., 2020; Visschers et al.,

2016). Parents often face challenges in predicting children's consumption patterns which can lead to over-preparation or discarding uneaten meals. For instance, young children's preferences and appetites change frequently (Evans, 2011; Visschers et al., 2016), while older children might make last-minute decisions to eat out or bring friends home (Visschers et al., 2016), leading to poor portion management. Children may also be involved in different types of activities, like sports or music lessons, that disrupt meal plans (Evans, 2014). Additionally, feelings of guilt associated with serving leftovers to children, combined with the societal expectation of being a "good provider", further exacerbate food waste in family households (van Geffen et al., 2020; Visschers et al., 2016). These underscore the importance of developing interventions tailored to specific household compositions, particularly for families with children.

4.2.4. Reconfiguring household food practices for Adaptable Consumption

Food-related routines often become automated and are carried out with minimal cognitive effort, reinforcing wasteful practices (Evans, 2014; Jackson, 2005). These routines are often socially learned, passed down (e.g., parents teaching provisioning techniques to their children), and extend beyond individual behaviours to shape household behaviours (e.g., weekly shopping routines)(Warde, 2016). Because food waste behaviours are often unconscious, they emerge as a consequence of how daily routines are structured (Warde, 2016). According to Evans (2014), understanding how food waste-producing practices are embedded, socially shaped, and routinised within households is essential to shift toward food-saving practices. Yet reconfiguring food practices involves the deliberate disruption of established routines and the introduction of new materials (e.g., interventions), skills, and/or meanings to encourage behaviours that reduce food waste (Reckwitz, 2002). Such reconfigurations require households to adopt new ways of thinking about food planning, preparation, and storage.

Schuster et al. (2022) argue that meal boxes have disrupted traditional consumption practices by substituting individual decision-making and culinary skills with pre-selected recipes, pre-portioned ingredients, and detailed instructions. While meal boxes have the potential to enhance adaptability by allowing households to adjust to changing circumstances, such as switching meal options based on seasonal or locally available produce, they may simultaneously constrain flexibility due to their reliance on fixed recipes and pre-determined meal plans (Heidenstrøm & Hebrok, 2022). Similarly, the rise of online grocery shopping has disrupted food provisioning from in-person selection to a digital process, reducing spontaneous buying, altering social aspects of shopping, and enabling home delivery, which can affect meal planning, inventory management, and food waste practices (Heidenstrøm & Hebrok, 2022). Online grocery shopping allows consumers to be physically close to their household food inventory, such as what is in their fridges, freezers, and

cupboards, while making purchasing decisions. This proximity allows them to check what they already have at home, helping to avoid over-purchasing and better aligning their shopping with immediate and long-term needs. However, Ilyuk (2018) and Ananda et al. (2023) found that the convenience and reduced effort needed when making online grocery purchases reduce consumers' psychological ownership—responsibility for purchases and negative affect towards parting with purchases—over the food items purchased. This in turn, increases the likelihood that consumers throw away food items purchased online. Also, the quality of fresh products when purchased online cannot be assessed sensorially, which might lead to dissatisfaction with delivered goods, which can increase the risk of food being discarded once it arrives at the home (Abbott, 1999; Park et al., 2021; Schifferstein et al., 2019).

Beyond these provisioning interventions, reconfiguring food practices involves fostering new skills associated with food management. Ability and knowledge gaps, particularly regarding food safety and label interpretation, contribute significantly to waste behaviours. Studies by Watson and Meah (2012) and Wilson et al. (2017) show that individuals frequently discard edible food due to misunderstandings of "use-by" and "best-before" labels, which are often misinterpreted as indicators of food safety rather than quality. This lack of ability to assess food freshness and safety independently of labels reflects a gap in self-efficacy, or the belief in one's ability to manage food effectively (Bandura, 1986). Therefore, increasing food-related knowledge and skills can empower and support individuals in making informed consumption and disposal decisions and reducing unnecessary waste. Cooper et al. (2023) and Pickering and Reynolds (2023) exemplify this by showing that enhanced cooking skills support reducing food waste by improving inventory management and the use of unused ingredients. Similarly Stefan et al. (2013) show that improving planning skills can increase the efficient use of resources, thereby reducing waste.

4.3. Methods

This study employs a qualitative, designerly approach to explore adaptable consumption in households with children in the Netherlands. Three materials were specifically designed for this study: (1) a cultural probe booklet, (2) a visual scenario of adaptable consumption and (3) seven product or service innovation concepts for adaptable consumption. The cultural probe was presented at the start of the study and invited participants to actively engage with the topic (Gaver et al., 1999). Subsequently, semi-structured interviews were conducted, in which the scenario and the innovation concepts were presented, portraying potential ways to reduce food waste (Figure 4-1). The use of these materials, next to the interviews, aimed to elicit information not only on the attitudes, behaviours, and routines of households but also specifically on the physical household artefacts and service set-ups that make for people's food waste context, thereby generating rich, qualitative data encompassing both the explicit and unspoken aspects of their experiences (Sanders & Stappers,

2012). All the materials were available in Dutch and English to accommodate the language preferences of the participants.

The materials in the study use the Path of Expression to guide participants through the research activities (Sanders & Stappers, 2012). The Path of Expression, based on psychological theory about memory and creativity, refers to the process of steering participants through a process of observing present experiences, recalling and reflecting on good and bad memories of the past, and imagining their hopes and dreams for the future (Sanders & Stappers, 2012). In design research, guiding participants through this pathway is supported by "Do, Say, Make" activities (Sanders & Stappers, 2012). "Do activities" encourage participants to express themselves through actions and making; "Say activities" involve verbal expression; and "Make activities" involve creating something to express themselves. In this study, "Do and Make activities" were used in the cultural probe, whereas 'Say and Do activities' were primarily used in the interview—see Table 4-1 and Appendix B.

Additionally, participants were provided with four different food items to cook with during two of the activities described in the booklet (see Table 4-2). Including the food items introduced an additional unexpected event that participants would have to respond to in their consumption practice. The food items included 3 bell peppers and 4 apples (among the most wasted foods in The Netherlands), a bag of bulgur (chosen for its shelf life and lower familiarity as a grain in The Netherlands), and a pouch of chickpeas (selected for their versatility and shelf life) (van Dooren & Knüppe, 2020; van Dooren & Mensink, 2018).

4.3.1. Cultural probes

Cultural probes are a prominent method in design research and are particularly effective in settings where the presence of researchers might influence participant behaviour (Sanders & Stappers, 2008). A cultural probe often consists of a booklet with a number of relatively simple tasks that may involve practical activities or reporting

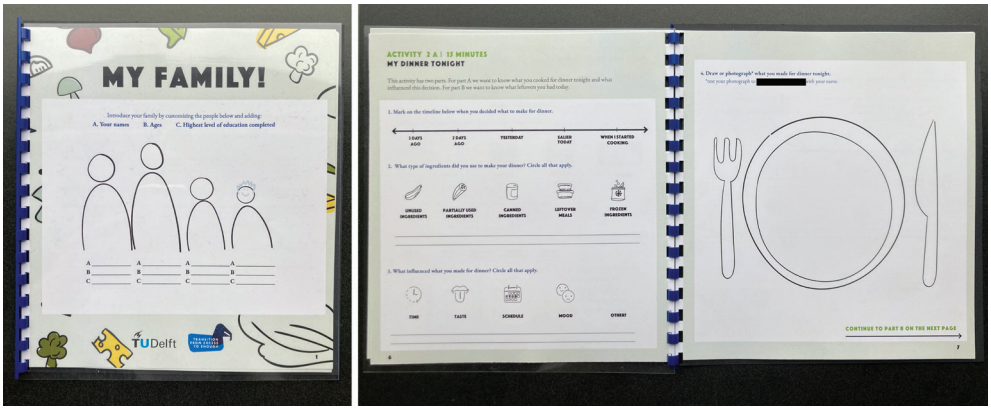


Figure 4-1 | Cover page (left) and part of Activity 2 (right) from the cultural probe booklet provided to each participating household. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J.

Table 4-1 | Cultural probe activities and theories behind them.

Cultural probe activities	Position in the path of expression	Type of 'do, say, make' activity
Activity 1 collected background information about the households, including names, ages, highest level of completed education, weekly grocery spending, distribution of grocery purchases across different outlets (e.g., in-store, online, market), and responses on a 5-point Likert scale regarding the frequency of engaging in flexible behaviours (e.g., cooking seasonally, using frozen ingredients).	Past to Present	Do
Activities 2 and 3, which were identical, asked families to draw or photograph their dinner and specify the time they decided on the meal. Participants noted the types of ingredients used (uncut whole, partially used, canned, leftover meals, and frozen), the factors influencing their decision (time, taste, schedule, mood, and other), and any preparation, cooking, or plate waste, along with how they handled these.	Past to Future	Do
Activity 4 asked households to prepare either a soup or curry dish for dinner, using two of the four provided ingredients. Participants were asked to draw or photograph their meal and specify which of the ingredients (chickpeas, bell peppers, apples, and bulgur) they used. They also described their likes, dislikes, and neutral experiences regarding the cooking activity.	Present	Make
Activity 5 was similar to Activity 4, except that it asked households to prepare any dish for dinner as long as it incorporated two of the four ingredients provided.	Present	Make

opinions, emotions, and behaviours. One of the aims is to prepare and sensitise the participants to the topic of the study, so that they can optimally engage with the topic (Mattelmäki, 2006). The cultural probe is delivered to the participants' home before the start of data collection, so that participants can register their behaviours, form their opinions, and reflect on these, without the interference of the researchers (Sanders & Stappers, 2008). It allows participants to generate their own visual and narrative data, in their own context, thus offering researchers rich, context-specific insights without the intrusiveness of traditional ethnographic methods that require prolonged researcher immersion.

Cultural probe studies are not intended to produce conclusive results; rather, they aim to provide a rich understanding and inspire design opportunities rooted in actual user experiences and needs (Sanders & Stappers, 2012). Cultural probes must be tailored to reflect the specific context of inquiry, ensuring that the probes not only gather relevant and rich data but also resonate with the participants' everyday experiences and the unique challenges of the research context. As cultural probes are developed for a specific context, they usually cannot be used in a different study that has a different goal. While it is essential that each probe is custom-made (Mattelmäki, 2005), the design of cultural probes adheres to several

guidelines—such as aligning tasks with research questions while also ensuring they are sufficiently open-ended to encourage creative and broad-ranging responses from participants and facilitating self-documentation through methods like photography or diary entries. However, this context specificity also limits the generalisability of cultural probe studies. Additionally, performing and reporting on the activities and analysing the rich information gathered in the booklets are labour-intensive both for the participant and researcher, often resulting in smaller sample sizes (Sleeswijk Visser et al., 2005).

Nevertheless, given that the current literature lacks insights into opportunities to support households in adopting adaptable consumption practices to reduce food waste, the cultural probe method is well-suited to identify such opportunities. It supports participants (i.e., households) in exploring and communicating their ideas about how they want to live, work, and be in the future (Sanders & Stappers, 2012), offering a contextual, nuanced, and opportunity-revealing understanding of participants' contexts. Cultural probes methodology has been utilised across food-related research to explore solo dining experiences and food choices (Bocanegra et al., 2022), uncover drivers of bread consumption (Pantidi et al., 2017), encourage sustainable eating habits (Cho et al., 2021), and investigate motivations and barriers to reducing food waste (de Bruin et al., 2019).

The cultural probe used in the present study was a small booklet of 5 activities, and each household was provided with its own. The booklet was designed to be playful, aesthetically pleasing and provoking, with minimal text. Each activity was designed to take between 5 and 20 minutes. The activities focused on dinnertime, which is the meal most often consumed together as a family (Cooper et al., 2023). The activities were selected and designed to capture a holistic view of households' food-related behaviours and routines related to adaptable consumption and food waste, while also respecting participants' time by balancing depth and ease in each task to make participation manageable. Therefore, the five activities, as described in Table 41, ask participants to photograph, draw, circle, and jot-note experiences rather than write paragraphs of text. The filled-in booklets informed and were used during the semi-structured interviews (Mattelmäki, 2005). See Figure 4-1 for an impression of the style and quality of the booklet, and see the Appendix C for all the booklet pages.

4.3.2 User scenarios

The second material designed for the present study was a visualised user scenario (i.e., comic strip) depicting a household engaging in a proposed practice of adaptable consumption. User scenarios are valuable methodologies in design as they enable the exploration, communication, and evaluation of future possibilities in participatory research. User scenarios, which can take forms such as written narratives or comic strips, are rich descriptions of how users interact with a design proposal, helping to identify user needs, contextual challenges, and areas for refinement (de Bont et al., 2013). Comic strips, in particular, use sequential visual storytelling to depict user

behaviour, emotions, and interactions in an engaging and accessible way, fostering empathy and understanding among users (Tversky, 2018). Scenarios, if validated by the users, provide a realistic and concrete use context which users themselves utilise to evaluate design concepts.

The behaviours depicted in the present scenario were the outcome of a study conducted as part of a research project called "From Excess To Enough" (FETE), a collaboration involving three Dutch universities and eight organisations within the food system (see Goss et al., 2023, 2025c). As a consortium, FETE is interested in how they can support households in realigning the values of food safety, food quality, and sustainability to foster the transition toward less food waste. The behaviours depicted in the user scenario include 1) mixing and matching ingredients and flavours, 2) assessing food quality with the senses, 3) adjusting recipes for different portions, 4) thinking on a meal level, 5) adjusting food purchasing based on how much food they waste, and 6) storing leftovers effectively to integrate them into meals (Figure 4-2). Throughout the scenario (i.e., comic strip), different innovations supported the household in engaging in these behaviours. The scenario was printed on an A3 sheet of paper for each household (Figure 4-2) and presented during the interview.

4.3.3. Innovation concepts

The third material used in this study was an overview of seven innovation concepts (Figure 4-3). Each of the innovations was designed to stimulate specific adaptable behaviours that could help reduce food waste. Innovation concept drawings complement scenario methods by making the concepts depicted in the scenarios more tangible and discussable with participants (van den Hende, 2010). Each concept drawing was accompanied by 2 - 4 lines of text explaining the operation of the innovation. These concepts were printed on an A3 sheet of paper for each household and presented during the interviews. The seven innovations were: 1) Collection Insight App, 2) Freezer Storage, 3) Use Me Later Tools, 4) Frozen Offering, 5) New Sensory-Driven Food Labels, 6) Ingredientless Recipes, and 7) Surprise 'Incomplete' Boxes. For a full account of the development of these innovations, see Goss et al. (2023); Goss et al. (2025c).

4.3.4. Participants

Data were collected from 43 participants, comprising of 20 adults and 23 children, across 11 different households living in the Netherlands with at least one child under 18 years old. Following Cooper et al. (2023), households with children were chosen because they have the highest absolute level of household food waste, also in the Netherlands (van Dooren & Knüppe, 2020). Participants were recruited through the networks of the first author and the research assistants. During recruitment, attention was paid to diversity across participating households, such as in the number of children, age(s) of children, geographical location within the Netherlands, and interest in sustainability-related behaviours.

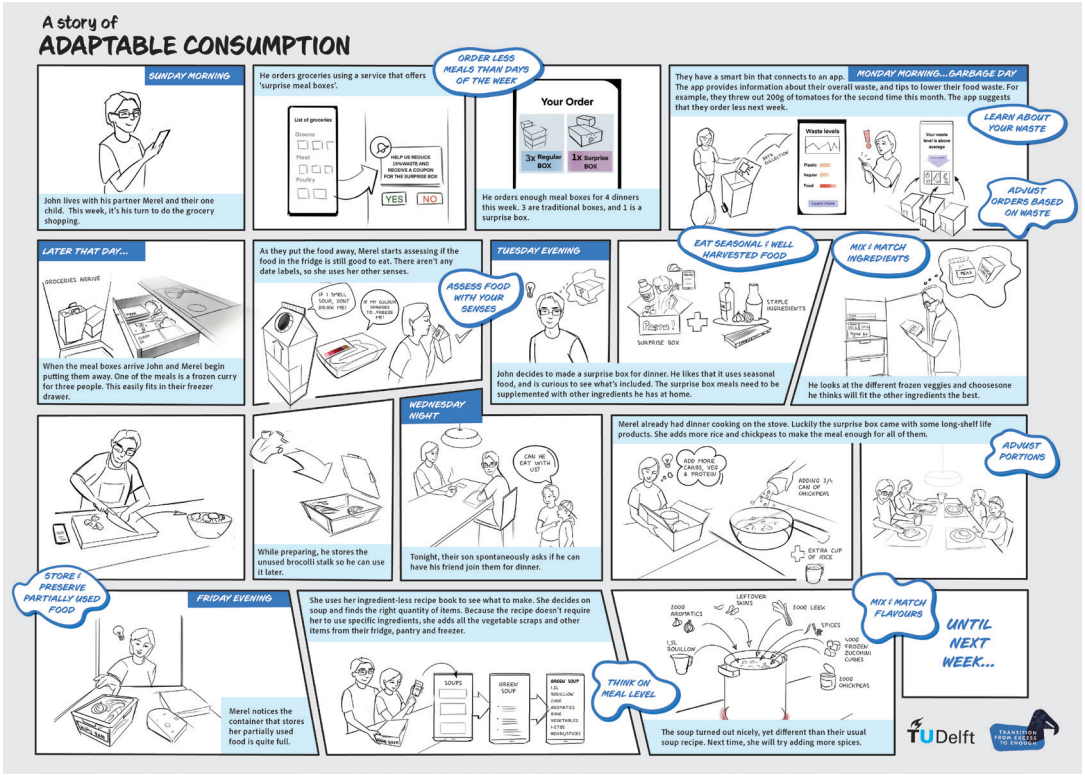


Figure 4-2 | User scenario depicting a household engaging in Adaptable Consumption. The drawings are by Maria Sofia. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J.

There were 2 households with one child, 6 households with two children, and 3 households with three children. The children's ages ranged from 3 to 15 years old. The highest level of education among the adults varied: 3 had PhD degrees, 6 had master's degrees, 6 had bachelor's degrees, 4 had college degrees, and 1 had vocational training. Therefore, the education level of the participants was higher than the national average in the Netherlands (CBS, 2024). See Appendix A for the participant demographics.

The first author developed the research materials, recruited most of the participants (8 out of 11 households), and analysed the data. To reduce bias, the first author did not collect any data, and the research assistants did not collect data from households they recruited or had previous contact with during recruitment. Ultimately, each research assistant collected and transcribed data from 3-5 households. Participants were informed about the purpose and structure of the study and signed an informed consent prior to data collection. Participants spent 1.5 hours with the research assistant across the 9-day data collection period (see Table 4-2). Each household was compensated with a €100 gift voucher and a food waste reduction tool package from the Netherlands National Nutrition Centre. Participants had the option to participate in English or Dutch.

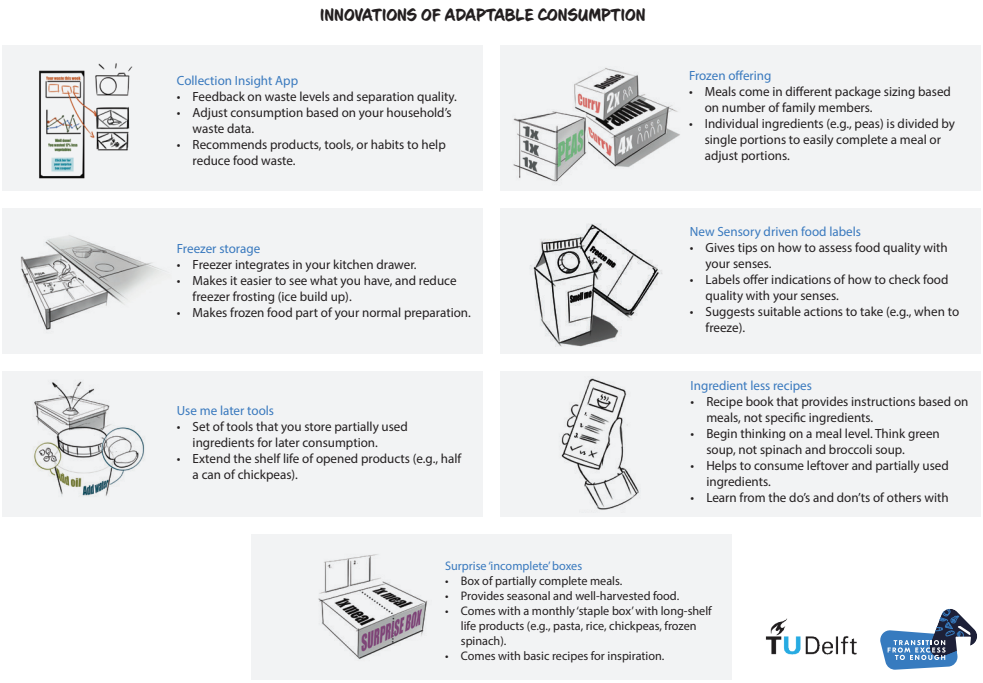


Figure 4-3 |Overview of the innovations designed to support Adaptable Consumption. The drawings are by Maria Sofia. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J.

4.3.5. Data collection

Data collection occurred between February and March 2024 by three research assistants who gathered and transcribed data from both the cultural probes and interviews. The research with the participants was set-up in three phases: 1) introduction and start of the study, 2) booklet activities, and 3) semi-structured interviews (Table 4-2).

Introduction session

The first interaction with the participants was through e-mail, inviting them to participate in the study. When people agreed to participate, a 30-min onboarding session conducted in participants' homes was planned. During this session, the research assistant distributed the cultural probe booklet, introduced its activities, and provided several products to be used in the cooking assignments. Additionally, food-related spaces (e.g., kitchen and refrigerator) were photographed to support contextualising the data (Gojard & Véron, 2018; Watson & Meah, 2012). At the introductory session, it was explicitly communicated verbally and in the informed consent that participant anonymity was guaranteed during data collection, analysis, and reporting.

Table 4-2 | Activities and materials of the study. The process is repeated for each participant.

	Phase 1	**Phase 2**	**Phase 3**
	Day 1: Introduction	*Days 2 – 8: Booklet Activities*	*Day 9: Interview*
Research activities	– Researcher introduces participant to the research at the participant's home – Researcher explains the booklet and its activities and takes photos of the participant's domestic food spaces.	– Do and Make activities. – Participant completes the booklet activities in their home, at a time of their choosing. The researcher is not present. – Interview preparation: – 48 hours before the interview participant sends photos of completed activities to the researcher. – Researcher reviews the completed activities.	– Do and Say activities. – Audio-recorded interview at participant's home. – Part 1 of interview goes through the booklet. – Part 2 of the interview goes through the behaviours of adaptable consumption (comic strip). – Part 3 of the interview goes through the innovation concepts.
Materials	– Booklet of 5 activities to be completed by participant. – Four different food items for the participant to use during activities 4 and 5.	– Booklet of 5 activities.	– Competed booklet of 5 activities. – User scenario notated by participant during the interview. – Overview of 7 innovation concepts notated by participant during the interview.
Researcher contact with participant	– 30 minutes for the introductory meeting.	– Minimal contact, only to clarify questions and send completed activities.	– 1 hour for the interview.

Filling out the cultural probe booklet

Over seven consecutive days, participants were asked to complete their booklet and perform five activities in their homes without the researcher present. The activities ranged from indicating what they had for dinner and the way they handled their leftovers and waste (e.g., activities 2 and 3), to cooking activities that required participants to integrate the ingredients provided to them and reflect on this experience (e.g., activities 4 and 5). Each activity explained, in text form, what the participant should do and what information needed to be recorded in the booklet. An overview of the activities is shown in Table 4-1, and each activity is detailed in the booklet as shown in Appendix C.

Interviews

1-hour interviews with participants were scheduled at their homes within 7 days of completing the booklet activities. When more than one adult from the household participated in the interview, both adults answered the interview questions

together. In preparation for the interviews, the participants were instructed to send photographs of their completed activities to their researcher. The interview format was semi-structured and divided into three parts, each with supporting material (see Appendix B for the interview setup).

The first part of the interview focused on the booklet results, with the photographs and text from the activities serving as supporting material. The second part focused on exploring and discussing behaviours of adaptable consumption toward less food waste. It used the 1-page user scenario depicting a consumer going through their week while engaging in the behaviours of Adaptable Consumption as supporting material (Figure 4-2). Participants evaluated the likelihood of adopting the behaviours and provided reasoning for their assessments. Coloured dot stickers were used to record their responses, with each colour representing different levels of likelihood and readiness of adoption (refer to Appendix B for the interview questions). The third part of the interview focused on evaluating the innovations that support adaptable consumption and used the 1-page overview of the 7 innovations (see Figure 4-3). The innovations presented did not exist and were only presented through drawings. Participants assessed the likelihood of incorporating these innovations into their daily lives and explained their reasoning. Similar to the above, coloured dot stickers were used to indicate preferences, with each colour representing a specific level of likelihood of adoption (refer to Appendix B for the interview questions).

4.3.6. Data analysis

All 11 households completed the cultural probe activities and participated in the interview. The data from the cultural probes and interviews were collected, transcribed, and translated into English as necessary. All collected data (Table 4-3) were entered into Atlas.ti, a qualitative analysis software. Thematic analysis, a common practice in qualitative research methods and previously used in studies on food waste (Filimonau et al., 2022), was undertaken following Braun and Clarke's (2006) guidelines. Specifically, an inductive thematic approach was chosen due to its suitability for exploratory studies that aim to identify patterns, themes, and meanings within the data, especially when relationships and structures are not predetermined.

Following Braun and Clarke (2006), the first step of analysis involved thoroughly reviewing the entire data set, including the transcripts, booklet activities, domestic photographs, and notated user scenarios and innovation overviews. Second, each data extract (e.g., quotes, photograph) was coded if it suggested adaptable or flexible behaviours related to food waste. This resulted in 25 codes such as "assessing food quality with the senses," "changes to routines," and "catering meals to available ingredients". Third, the codes were organised into themes, ensuring that the themes accurately represented both the coded extracts and the data set as a whole. This step also involved examining the data extracts to identify them as barriers or

opportunities for performing adaptable consumption behaviours toward reducing food waste within its theme.

During analysis, preliminary themes and their corresponding codes and supportive extracts (e.g., quotes) were independently discussed with the second and fourth authors. Following these reviews, the first author completed the rest of the analysis. The analytical process is depicted in Figure 4-4. The final themes induced by the thematic analysis are presented in Figure 4-5.

Table 4-3 | Data collected and analysed in this study

Data source	Description	Reason of collection
Cultural probe activities	11 complete booklets containing 5 activities.	Insights into actual food consumption behaviour.
Interview transcripts	11 semi-structured individual interviews with each participating family (audio recorded and transcribed).	Individual and in-depth reflections on adaptable consumption toward less food waste.
Domestic photos	139 photographs of domestic food-related spaces within each participant's home (e.g., kitchen, inside the fridge and freezer, garbage).	Support contextualising the data from the booklets and interviews.
User scenario with dot stickers	11 printed visualised user scenarios with different coloured dots indicating preferences.	Support participants in reflecting on their judgments of adaptable consumption.
Innovation overview with dot stickers	11 printed innovation overviews with different coloured dot indicating preferences.	Support participants in reflecting on their judgments of innovations that support adaptable consumption.

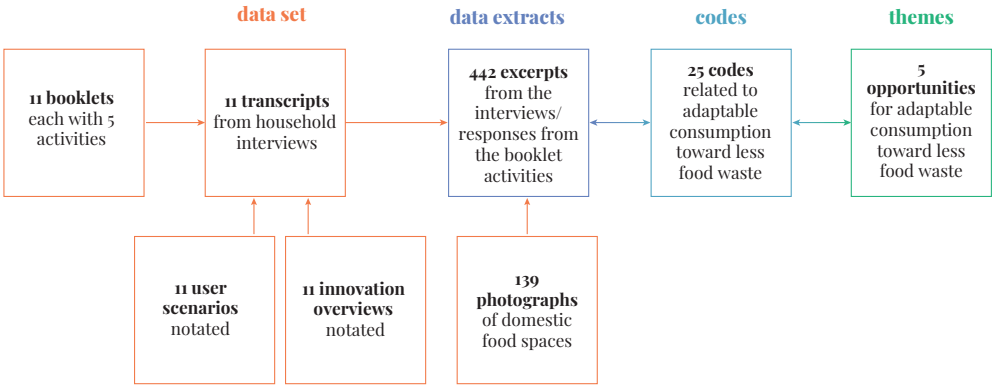


Figure 4-4 | Overview of the thematic analysis process undertaken in this study. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J.

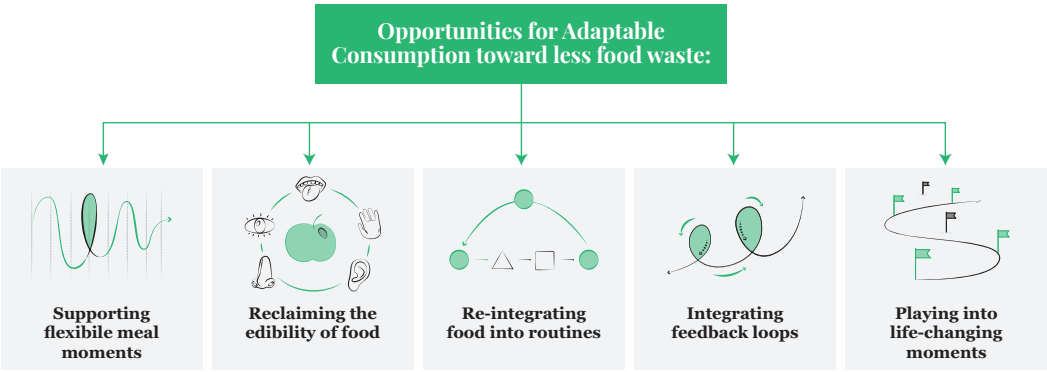


Figure 4-5 | Themes induced from the data that present opportunities for supporting adaptable consumption toward less food waste. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J.

4.4. Findings and discussion

In response to the pressing challenge of food waste, this study investigated how Dutch households engage in adaptable consumption to identify opportunities to foster both flexible and adaptive waste-reducing behaviours and practices. In this section, the findings, limitations, and directions for future research are discussed.

4.4.1. Opportunities for Adaptable Consumption towards waste reduction

Based on the thematic analysis, five themes were identified in the data that represent opportunities for supporting households in adopting adaptable consumption toward waste-reducing behaviours. These include 1) supporting flexible meal moments, 2) reclaiming the edibility of food, 3) reintegrating food into routines, 4) integrating feedback loops, and 5) playing into life-changing moments (Figure 4-5). Each theme is discussed below with representative quotes from the interview transcripts to add validity to the study's findings.

Supporting flexible meal moments

Participants indicated that experimentation and exploration in meal preparation occurred during less constrained times, such as weekends and holidays, when they felt they had more mental space. They also indicated that meal choices were shaped by the anticipated time available for preparation, eating, and cleaning. This finding supports Boulet et al. (2021a) and Watson and Meah (2012), who argue that time constraints are a finite and critical factor influencing meal planning and the resulting food waste. For instance, one participant noted:

> *"In the holidays, I can experiment more because then I have more peace of mind. In the weekdays, I am being lived, and then I quickly go after the standard meals."*
>
> – *Household 12*

This flexibility can support households in repurposing leftovers or using near-expiring ingredients that may not fit into weekday routines.

Participants exhibited diverse approaches to meal planning, balancing the need for predictability with moments of change. Some organised meals around weekly grocery shopping trips and assigned specific meals to days, while others shopped weekly but determined daily meals based on the freshness of ingredients and family preferences. Many participants highlighted the appeal of straightforward, family-approved recipes that were quick to prepare, ensuring the preparation efforts were justified. However, they also expressed a desire to break the monotony of routine meals, seeking ways to integrate variety without overhauling their entire meal plan. As one participant noted:

> *"If I've been working all day, I come home, then very quickly I make the same things, and I always think that's too bad. Of course, things can be similar and that's fine but if it's the same food, I find it boring."*
>
> – *Household 10*

> *"During COVID we ordered meal boxes. What appealed to me was the fact that they put a lot of thought into creating good flavour combinations. It allowed for much more variety and self-discovery in cooking. When left to our own devices, we fall back on standard combinations like cauliflower, potatoes, and meat or vegetarian options, but then we miss out on the exciting combinations."*
>
> – *Household 6*

By incorporating flexible moments, households can introduce new flavours and recipes without compromising their established routines. Current research has explored differences between online grocery shopping and in-store shopping (Zhang & Qi, 2024) and differences between preparing using meal boxes and conventional "loose" shopping as they relate to food waste generation (Schuster et al., 2022). However, examining the impact of controlled or fixed weekly meal planning versus flexible day-to-day choices on food waste outcomes could provide further insights into the balance of routine and flexibility in household consumption.

Research shows that introducing novelty into consumption reduces decision fatigue by providing new options without the burden of constant choice (Warde, 2016). Meanwhile, reliance on familiar recipes and ingredients helps households manage daily pressures through established routines (Torkkeli et al., 2021). In the present study, participant routines were intentionally disrupted by providing additional ingredients and requesting that households prepare specific meals using these ingredients. While many participants appreciated the change to their routine, they reported that these extra ingredients did not alter their provisioning habits.

Households continued with their regular grocery shopping, adding the study-provided ingredients to their meals. This finding suggests that introducing flexibility should be carefully managed to avoid inadvertently generating waste, as spontaneous routine disruptions could cause current food to displace existing ingredients (Evans, 2014). In line with this, participants in the study responded positively to the "Incomplete surprise boxes" and "Ingredientless recipes" innovations because they would offer meal structure while allowing for customisation, thereby introducing novelty without departing too far from comfort zones. This direction supports research by Cooper et al. (2023) and Pickering and Reynolds (2023), who suggest that interventions combining structure and flexibility can lead to more efficient resource use and reduced food waste. Nevertheless, the participant's willingness to adopt flexibility-supporting interventions is tempered by the strength of their existing routines and confidence in the kitchen. For instance, participants reflected,

> *"I'm in favour of flexibility, but not within a meal. Most of the time we stick to dishes and recipes we know are tasty."*
>
> – *Household 11*

> *"I had to laugh really hard when we had to cook a curry or soup for activity 4. Because you immediately see the difference between me and [my partner]. I just have a weekly menu, so I found this a hassle because I'm not such a good cook. So we did it on the weekends and [my partner] went wild."*
>
> – *Household 10*

In everyday practice, participants employed various strategies to adapt their meals, such as using frozen or long-shelf-life products, repurposing leftovers, and preparing meals in stages to meet family preferences (e.g., separating vegetarian and non-vegetarian meal variations). This adaptability allowed them to adjust portion sizes and ingredient use to match family needs, supporting waste reduction by preventing the preparation of excess or unwanted food.

The findings of this opportunity indicate that balancing flexibility with routine is crucial for maintaining sustainable food practices without overwhelming households. By introducing adaptable and flexible moments within their routines, households can explore new foods and recipes without compromising sustainability or family goals, ensuring that food provisioning remains efficient and waste-conscious. For instance, interventions encouraging households to try one new recipe each week alongside familiar meals can help them explore new foods and add variety to their routine. By explicitly integrating food items consumers already have at home within these new weekly recipes can also support waste reducing behaviours.

Reclaiming the edibility of food

Participants in this study demonstrated a flexible approach to assessing food usability,

often treating expiration dates as approximate rather than definitive indicators of food safety. Many participants described using sensory cues—such as smell, appearance, and texture—to determine whether the food was still edible, even when it had technically surpassed its labelled expiration date. This sensory-based approach reflects a growing trend, as seen with the "Look-Smell-Taste" labelling initiative by Too Good To Go, which encourages consumers to use their senses before discarding products (Too Good To Go, 2022). One participant explained,

> *"I don't really believe in expiration dates. I trust my senses more than the expiration label. You can often tell if something is still good just by giving it a sniff… while I understand the legal aspects of expiration dates, I also know that it's not always necessary to discard food once it reaches that date."*
>
> – *Household 6*

Consistent with other studies, participants did not apply sensory evaluations uniformly across all food categories (Patra et al., 2022; Watson & Meah, 2012). While they confidently used sensory checks for low-risk items, they were more cautious with high-risk foods like dairy, eggs, and meat, where perceived health risks were higher. Notably, sensory evaluations were often applied as items neared their labelled dates, but were less likely to be trusted once those dates had passed. One participant explained,

> *"If it is something that is a long-life product and it is approaching its date, then I [evaluate the product] by feel or sight. But I don't use anything after the expiration date. I trust my senses when it's approaching its sell-by date. And a "Sensory driven food label" as you propose is also not going to convince me to use afterwards."*
>
> – *Household 7*

This selective flexibility suggests an adaptability rooted in risk management, indicating that households might benefit from support to make context-specific decisions that reduce waste without compromising safety. For partially spoiled items without date labels, participants displayed mixed approaches: some salvaged edible portions by cutting away blemishes, while others discarded whole items as they no longer met their freshness standards. As one participant remarked:

> *"Well, there was a small spot in the pepper that we got [from you], so I exchanged it with our own bell pepper… yours was no longer good, and I was afraid it will make us sick."*
>
> – *Household 8*

This behaviour aligns with broader findings in the literature, suggesting that food is often discarded not due to complete spoilage but because it no longer meets household expectations (Aschemann-Witzel et al., 2015; Evans, 2014; Schifferstein, 2024). Risk aversion plays a significant role in these decisions, as risk perceptions significantly influence consumers' willingness to consume or discard sub-optimal food items. Tsiros and Heilman (2005) suggest that perceived health risks outweigh economic or environmental considerations, particularly as items near expiration. Educating consumers on the perishability of certain foods and promoting a moderate acceptance of sub-optimal items (such as bruised or soft produce) could foster cultural norms that support waste reduction without compromising safety.

A tension between "thrift" and "hygiene" was evident in participants' decision-making as described by Watson and Meah (2012). While the present study found that participants raised in households with thrift-oriented values were more inclined to salvage food to minimise waste, supporting findings by Aschemann-Witzel et al. (2015), it also identified an adaptability among participants who were not raised with thrift-oriented values. This adaptability reflects a gradual shift in attitudes, as environmental awareness encourages some households to embrace thrift as a waste-reducing practice. For instance, two participants reflected these contrasting backgrounds:

> *"Well, there was a small spot in the pepper that we got [from you], so I exchanged it with our own bell pepper… yours was no longer good, and I was afraid it will make us sick."*
>
> – *Household 8*

> *"Judging food with my senses, I actually always have done this. I inherited it from childhood. You begin to notice which activities actually lead to less food waste."*
>
> – *Household 10*

The study also highlighted a sense of agency among participants who preferred personal judgment over regulatory standards. One participant remarked,

> *"It's simply a sense of agency of not being dictated by label."*
>
> – *Household 4*

Watson and Meah (2012) describe date labels as technological interventions that shift responsibility for food safety away from sensory assessments to institutional guidelines, which contributes to consumer mistrust and a reliance on external standards over personal judgment. In the present study, when uncertain about food safety and edibility, some participants sought reassurance from household members or online resources, particularly for items that looked edible but raised doubts. One participant shared,

> *'We had mushrooms this week that were a bit brown. I said to my husband, is it still good? I really wanted to check it, so I googled it to see how you can determine if these are still OK. It said you should smell, and if they don't smell neutral then it's not OK. I smelled and it smelled really weird, so it wasn't good anymore. So, something like the 'sensory labels' innovation with added cues would be really handy because now I'm just googling."*
>
> – *Household 3*

This illustrates that consulting 'others' (human or non-human) can serve as a social risk mitigation strategy, providing an additional layer of reassurance and shifting the responsibility from an individual decision to a collaborative one. This behaviour reflects how households share responsibility in food-related decisions, a finding that aligns with Watson and Meah's (2012) observations on the social dimensions of domestic food management. It suggests that such risk mitigation resources can be explicitly introduced into households as a way of navigating uncertainty around food usability, supplementing traditional sensory evaluations.

This opportunity suggests that increasing a household's adaptability in assessing food quality and confidence in sensory-based evaluations, supporting decision-making, and communicating about perceived risks can prevent premature disposal of food items and promote the consumption of sub-optimal foods, thereby reducing waste. While this approach does not imply encouraging the consumption of food with a high risk of illness (e.g., meat past its expiry date), it can help consumers adapt to foods changing textures with diminished quality, which often remain safe to consume but are otherwise discarded.

Reintegrating food into routines

Participants frequently employed various strategies to reintegrate food into their routines with the dual goals of feeding the household and using existing food inventory. A common method was freezing leftovers and ingredients to extend their shelf life, aligning with literature highlighting freezing as an effective waste reduction strategy (Nikolaus et al., 2018; Schanes et al., 2018; van Dooren & Knüppe, 2020). However, a recurring challenge identified by participants was the tendency to forget about frozen items once stored, a limitation also noted by O'Neill et al. (2022). Without explicit plans for the reintegration of frozen foods into meal planning, their potential to reduce waste is often negated, as one participant reflected:

> *"Sometimes I freeze it when it is a whole meal. However, the risk is that if we do that, it will be in the freezer for 80 years and will never be used."*
>
> – *Household 2*

This highlights the need for adaptable strategies that support the reintegration of stored items into meal routines, rather than simply relying on storage as a solution. The study also found that visibility and accessibility of stored food are crucial for waste prevention, aligning with research suggesting that easily accessible items are less likely to be forgotten (Farr-Wharton et al., 2014; Schanes et al., 2018).

Participants expressed interest in innovations in this study like the "Use-me-later-tools" for its potential support in extending the open-shelf life of items, and the convenience of storing partially used food items for later use. At the same time, there was scepticism about incorporating new storage solutions into existing habits. This finding, together with the overwhelming variety of available storage options on the market today, highlights a significant behavioural gap between recognising the benefits of more visible and organised food spaces (e.g., fridge, cupboard, and freezer) and the actual adoption of new tools intended to extend food life and reduce food waste. For instance, one participant reflected that,

> *"Better storage containers would be handy. Like the 'use-me-later tools'. Now, when I have 1/2 tin of things, chickpeas or tomato sauce or so, it's always a bit difficult to store, or it falls over in the fridge. On the other hand, often I just use the package where it comes from, so I'm not sure I would actually use it."*
>
> – *Household 1*

Participants also discussed efforts to incorporate locally and seasonally sourced produce into their routines, reflecting an environmental awareness and a preference for low-carbon food options. However, participants' experiences in the present study aligned with those documented by Heidenstrøm and Hebrok (2022) and O'Neill et al. (2022), who noted that while there is significant enthusiasm for local and seasonal eating, practical challenges such as availability, flexibility, and convenience can hinder the consistent integration of these practices into everyday life, and may contribute to increased waste. Participants reflected,

> *"We started with the vegetable and fruit box, but now we only have the fruit box because the vegetables were a bit too difficult in the winter to eat it all."*
>
> – *Household 1*

These findings emphasise that sustainable procurement practices like seasonal eating require support, such as recipe suggestions and flexible preserving solutions, to help consumers adapt these practices without generating additional waste.

Another notable practice involved the intentional preparation of extra food for future meals, particularly as "meal-prep" for weekly dinners or lunches. Typically, participants saved preparation leftovers while discarding plate waste into the bin as

being unfit for later consumption, a finding also found by Nikolaus et al. (2018). Participants who saved preparation leftovers typically saw this as a time-saving measure, intentionally preparing larger portions reinforcing a sense of efficiency, while others just focused on using whatever was leftover for other meals, whether their leftovers were initially planned or just the outcome of inaccurate preparation. Three participants reflected,

> *"I cook big portions so I don't have to cook often during the working week."*
>
> – *Household 8*

> *"It's rarely that I don't have leftovers because I cook too much. And then my husband eats it the next day at lunch."*
>
> – *Household 3*

> *"Once a week I say,'Tonight is leftover day'."*
>
> – *Household 2*

This perception of leftovers as functional and time-saving efforts reflects Cappellini's (2009) findings that leftovers are often valued as both a convenience and a means to optimise household routines. Dedicating certain days for consuming leftovers, as shown by some participants in the present study, encourages routine integration of leftovers into planning and increases acceptance of leftovers within the household by reframing it to a positive ritual and family experience (Evans, 2014).

This opportunity illustrates that household strategies for reintegrating food leftovers into routines involve a complex interplay between intentions and practical constraints. The aspiration to reduce waste and embrace sustainability often confronts the realities of daily life, where time, convenience, skill, and habit play significant roles in effective adaptable and food saving behaviours.

Integrating feedback loops

The present study reveals that participants' food management habits relied on personal experience and long-standing family practices. Adjustments to portion sizes or strategies for extending product shelf life often resulted from knowledge gained through years of cooking and experimentation. This practical, experience-based approach to consumption and waste reduction aligns with Watson and Meah's (2012) observation that household food management strategies evolve over time, guided by intuitive understandings and family traditions. However, these adaptive strategies are not without challenges, as they sometimes lead to unintentional waste despite best efforts. As participants shared,

> *"When you've been cooking for your family for a long time, you*

> *start to develop a sense of how much food you need to prepare, which helps in minimising waste."*
>
> – *Household 6*

> *"You can't freeze everything. Once I froze leeks and that did not go well. My husband said I should have cooked them first."*
>
> – *Household 10*

While participants generally felt competent in managing household consumption needs and having minimal food waste, they also expressed an interest in additional feedback mechanisms to further support waste monitoring and reduction—like the "Collection Insight App" proposed in the present study. While this aligns with the broader trend of using technology to promote sustainable practices and reduce food waste (e.g., Manzocco et al., 2016; Martin-Rios et al., 2020), participants' enthusiasm for technological solutions was offset by concerns about privacy in digital waste monitoring. For instance, one participant expressed,

> *"I'm not sure how I would go about monitoring my waste with a digital system like you propose… I'm a bit concerned about where the data goes. On the other hand, it could help. It's nice that you can then adjust your orders. And it says, 'you have already bought this three times. Are you sure?'."*
>
> – *Household 1*

This receptiveness to feedback underscores an openness to integrating new information into daily practices, provided that privacy concerns are addressed. Meadows (2009) highlights the importance of feedback loops in fostering behavioural change through continuous reflection and adjustment, suggesting that feedback mechanisms can enhance waste awareness and encourage adaptable actions. In this context, the household waste bin plays a crucial role. As Chappells and Shove (1999) argue, bins often serve as a means to relinquish responsibility for waste, transferring the burden onto public waste management systems. Once food enters the bin, it becomes "invisible," allowing households to avoid confronting the implications of disposal (Evans, 2012). A participant reflected,

> *"We have this small container wherein we put food waste. And well, it's just nicely tucked away. So, we don't see it. So, we're actually not really aware of how much we throw away. Now there were three of these bags and I was like wow, three of these, how quick did this go?"*
>
> – *Household 3*

The findings from this opportunity suggest that feedback loops, whether through personal experience or material interventions (e.g., apps), can play a crucial role in fostering adaptable and food waste-reducing consumption practices. These loops can enable households to adapt their practices in favour of waste reduction by adjusting purchases, portion sizes, and storage techniques, thus capturing and reinforcing household traditions that minimise waste and increase resilience over time.

Playing into life-changing moments

Participants indicated that significant life events often catalyse changes in household consumption practices, providing natural opportunities for reassessing and modifying food provisioning behaviours. This finding aligns with Thompson et al. (2011), who observe that life transitions frequently prompt a re-evaluation of household roles, creating space for alternative practices that can support more adaptable and waste-reducing behaviours. For example, several participants noted shifts in consumption patterns after becoming parents, transitioning from experimental to more conservative practices to meet their children's dietary needs and preferences. Reflecting on these shifts, one participant shared,

> *"Before we had kids, we would take more time in cooking and we experimented a bit more… Now that the children are older, we're starting to introduce food like curries and using chickpeas, so it gets more interesting for all of us."*
>
> – *Household 1*

In this case, adaptability can allow the household to gradually incorporate diverse foods without risking excessive waste, as new ingredients are integrated thoughtfully over time.

Dietary transitions, such as adopting vegetarianism, also emerged as critical points for renewed culinary experimentation. Environmentally impactful patterns—such as reliance on animal products (Willett et al., 2019) or those that promote over-purchasing (e.g., "good provider" behaviours (Visschers et al., 2016))—tend to persist, even when households express dissatisfaction (Thompson et al., 2011). However, life changes oriented toward sustainability goals can disrupt these routines and encourage waste-conscious decisions. One participant exploring vegetarianism remarks:

> *"We are experimenting with how we can eat vegetarian and what we like. We also just got a vegetarian cookbook. So, this study was perfect timing because we're in an experimenting phase, otherwise we might not have dared to take on those chickpeas and bulgur [you provided us] so quickly."*
>
> – *Household 11*

Although experimenting with new foods can sometimes result in initial waste if ingredients are unfamiliar or disliked, over time, households become more adept at incorporating new foods due to increased familiarity with food taste and texture. Additionally, over time, their knowledge and ability to integrate these items into meals the household enjoys increases, which can lead to reduced food waste associated with dietary transitions. This supports and extends the work of Evans (2014) and van Geffen et al. (2020) on the positive, supportive, and disruptive role that informational resources like cookbooks and food material itself, can have in facilitating transitions toward sustainable food practices.

Changes in household roles, such as assuming new responsibilities for grocery shopping, were also noted by participants in the present study as reshaping household consumption practices, with potential implications for waste reduction. Those managing food provisioning tended to exert greater influence over household consumption patterns, sometimes aligning meals more closely with their values. One participant explained,

> *"I eat vegetarian and I struggle to cook with animal products because of the environmental impact. But my son finds meat very tasty. Now I have a lot more influence on what is being cooked because I took over the shopping and cooking when my partner started working full time. In the beginning, the resistance to vegetarianism was fiercer. It takes a bit of getting used to and that's okay."*
>
> – *Household 10*

This finding challenges the conventional "good provider" role described in the literature, which suggests that parents often prioritise children's preferences over their own (Aschemann-Witzel et al., 2020; Evans, 2014). In the present study, shifts in household roles enabled some parents to assert their own consumption values, even when family preferences initially resisted these changes. However, some participants also expressed adding more flexibility and effort into preparation to ensure all family members received food they enjoyed. One participant explained,

> *"I'm vegetarian, one of my daughters is vegetarian, and my husband is flexitarian. But what I do then, like for spaghetti, is I put two frying pans on the stove. I prepare one with the minced meat with the sauce, and the other the vegetarian sauce. Then I make it even more complicated, because I want extra vegetables, but my daughter who is also vegetarian doesn't want that, so when the vegetarian sauce is done, I take part out for my daughter, and I throw extra cups of peas through it for myself."*
>
> – *Household 2*

These findings suggest that certain lifestyle changes can open up opportunities for individuals to renegotiate household food practices in alignment with evolving personal beliefs, particularly around health and sustainability. Given the prevalence of waste as part of the "good provider" identity (Aschemann-Witzel et al., 2020), challenging this conventional role may also encourage waste-reducing practices. This reframing of household behaviour through individual norm changes aligns with broader food waste literature, suggesting that individual behaviours can reinforce household norms (Cappellini & Parsons, 2012; Evans, 2011). Additionally, it supports calls for comprehensive food waste prevention research that examines household-level dynamics alongside individual behaviours (Boulet et al., 2021b).

This opportunity suggests that significant life events provide natural opportunities to reassess and adjust food provisioning practices in ways that can support adaptable consumption. Research by Boulet et al. (2021b) and Evans (2014) underscores the potential of these moments to facilitate meaningful reductions in household food waste, especially when households are ready and willing to embrace new consumption practices. While waste-reducing intentions may sometimes be undermined by other household members' preferences (Cappellini & Parsons, 2012), effectively leveraging life-changing events can help to establish new, waste-reducing and adaptable routines. As reflected in the findings of this theme, intervening during life-changing events requires greater attention to the underlying power dynamics within households, such as parent-child or shopper-eater relationships. Hargreaves (2011) emphasises the importance of examining these dynamics, suggesting that this remains an underexplored area in understanding how consumption practices are reconfigured during life transitions.

4.4.2. Limitations and future research

While the present study provides rich insights, limitations remain. The study's sample size was limited, and the duration was relatively short. While smaller participant numbers are common in the study's methodology, a larger sample could have provided more robust conclusions. The participants were also primarily highly educated, and although they were spread across the Netherlands to provide differing regional differences in consumption, this study does not claim to be representative of all Dutch households. Additionally, the majority of households in this study (7 out of 11) participated in Dutch, necessitating the translation of their contributions to English. Although the researcher who conducted the interviews also performed the translations to preserve the participants' intended meanings rather than providing a verbatim translation, some nuances might have been lost in this process.

While the present study incorporates real-time reflection through the booklet to capture household behaviours and decision-making processes, it relies on self-reporting, which may be influenced by social desirability biases (van Herpen et al., 2019). To reduce socially desirable responses, the set-up ensured that the researcher collecting data and the participants did not know each other before data

collection began. In addition, the researcher communicated on multiple occasions that the focus was on participants' actual experiences and daily practices, rather than behaviours they might have assumed the researcher wanted to know. This step was intended to foster an open and honest dialogue, focusing on capturing genuine insights into adaptable consumption practices. Additionally, participants reported an important part of the data in the booklets when the researchers were not present. These booklets served as input for the discussions during the interviews. Hence, the time spent with each household was minimal, limiting the potential influence of the researcher's presence on participants' natural behaviours.

The absence of objective waste measurements in the present study prevents a direct assessment of waste reduction impacts through adaptable consumption practices. While measuring waste was not the intention, the study cannot confirm the impact of the areas of opportunities (themes) on actual waste reduction. Nonetheless, the identified opportunities lay a foundation for future studies, which could introduce interventions related to the opportunities and conduct weight-based waste tracking over longer periods of time and among varied household compositions.

Despite the limitations discussed, the findings of the present study contribute valuable, rich and context-specific insights into the opportunities and challenges surrounding adaptable consumption for reducing food waste and present interesting avenues for others to build on the work, using more extensive and diverse samples to further validate and extend these findings. The study shows the potential of food-reducing behaviours by targeting adaptable and flexible behaviours, such as by explicitly recalling past experiences of effective portioning or storage when preparing food. Therefore, future research could further investigate how interventions that focus on adaptable consumption behaviours—rather than explicitly targeting food waste reduction—can contribute to food system resilience, as such behaviours may lead to food waste reduction as a beneficial secondary effect.

4.5. Conclusions

The present study addressed the critical issue of household food waste by advancing the concept of adaptable consumption, defined as the ability of households to adjust their food planning, preparation, and storage practices in response to both immediate disruptions and long-term changes. The findings identify five key opportunities to foster adaptable consumption: supporting flexible meal moments, reclaiming food edibility, reintegrating food into routines, integrating feedback loops, and leveraging life-changing moments. Together, these opportunities highlight the interplay between behavioural, material, and social dimensions of food consumption, demonstrating how adaptable consumption can reduce waste and enhance household resilience.

Flexible meal moments allow households to break from rigid routines, encouraging creative use of ingredients, while reclaiming food edibility through sensory cues or obtaining second opinions prevents premature food disposal.

Reintegration of food into routines ensures leftovers and stored items are utilised, and feedback loops, enabled by digital tools or personal insights, encourage waste-conscious behaviours. Finally, life-changing moments, such as becoming parents or adopting new dietary habits, create natural entry points for embedding waste-reducing practices into daily life.

This work contributes to a growing understanding of how everyday practices can align with the broader goals of resilience and sustainability in food systems. By positioning households as active contributors to resilient food systems, the present study provides a pathway to reducing food waste while addressing food system goals. It offers practical insights for researchers and practitioners to design interventions that enable adaptable, resilient, and sustainable consumption practices. Future research should explore the scalability of these opportunities across diverse socio-economic and cultural contexts and examine how systemic factors, such as retail practices and policy frameworks, influence household adaptability.

Design Step 5

exploring designers and design reasoning

Chapter 05

Framing across system scales and timeframes: supporting designers in reasoning toward transition design interventions

This chapter is previously published as:

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Design is commonly characterised by abductive reasoning—a pattern of thinking that starts with a desired outcome and works backward to identify possible means of achieving it. In transition contexts, this reasoning becomes significantly more complex. Designers must navigate extended timeframes, multiple system levels and scales, and engage diverse actors. These complexities necessitate better support for designers in conceptualising systemic interventions.

To address this gap, and synthesise insights from system actors (Chapter 3) and consumers (Chapter 4) toward the vision of a future food system (Chapter 1), this chapter introduces a transition design rationale tailored to transition challenges. The rationale supports designers in making design decisions and constructing clear arguments for how proposed interventions can foster desired transitions. Through two studies, it investigates the development and application of a logical framework that reflects the aspects of the design rationale. The first study, a grounded theory study on design reasoning, involved developing interventions to reduce food waste in the Dutch food system (drawing from the previous chapter). The second study comprised two evaluative workshops where designers used the framework to develop interventions that can foster desired societal changes.

Findings from this chapter suggest the logical framework helps designers frame complex transition contexts in ways that make them more manageable to design for, while also increasing confidence in the efficacy of proposed interventions. A key challenge, however, remains in articulating the relationship between individual- and systems-level behavioural change. This chapter concludes by identifying opportunities for further methodological development and calling for continued collaboration within the transition design community to refine and expand a shared repertoire of behaviour change mechanisms capable of driving systemic transformation.

5.1. Introduction

Transitions are viewed as complex, long-term processes of systems change, evolving over decades and involving various actors and sectors to promote innovation at all systems levels (Loorbach, 2007). A core ambition of transitions research is to understand these processes and explore possibilities to advance and accelerate desired transitions (Loorbach et al., 2017). Transition management, a field within transitions research, is concerned with analysing transitions and formulating interventions and actions towards systems change (Loorbach, 2007). A key element of transition management processes is the practice and activity of creating a shared vision and formulating strategic pathways, as these are essential for building collective commitment and mobilising action towards shared and desirable futures (Loorbach, 2010; Mok & Hyysalo, 2018). As such, vision and pathway building are common first steps in transition design processes, reflecting the significant shifts needed in technological, social, organisational, and institutional structures (Gaziulusoy & Ryan, 2017b; Goss et al., 2024; Irwin, 2015).

Transitions result in mainstream practices becoming outdated and being replaced by new, ideally more sustainable alternatives (Gaziulusoy & Brezet, 2015; Scott et al., 2012). Practices are characterised as routinised behaviours performed in a large part of society (Reckwitz, 2002). They are made up of materials (objects and interventions), competences (necessary skills and knowledge), and meanings (social and symbolic values) (Shove et al., 2015). To disrupt entrenched practices and facilitate new ones, interventions must consider and address routines in daily life (e.g., food provisioning) and not isolated actions (e.g., occasionally choosing near-expired food). By designing interventions that (re)shape and (re)configure practices, designers can have lasting effects on the behaviours, practices, and lifestyles of people and society.

The reconceptualisation and reimagination of whole systems towards desirable alternatives make transitions suitable design challenges, with design contributing valuable expertise (Dorst, 2019b; Gaziulusoy & Ryan, 2017a; Irwin, 2015; Loorbach, 2022; Vervoort et al., 2024). For instance, human-centred design practice is particularly valued for its ability to make change meaningful for people and society (Tromp & Hekkert, 2018; van der Bijl-Brouwer & Dorst, 2017). Other design skills, such as imagining and depicting futures others want to act upon, reframing and challenging existing practices, integrating diverse perspectives, and developing artefacts that foster systemic changes, are also valued in transition design challenges (Dorst, 2019b; Gaziulusoy & Ryan, 2017a; Goss et al., 2024; Hyysalo et al., 2019; Mok & Hyysalo, 2018). As such, over time, more designers are engaging in complex societal issues and transitions, requiring them to make informed choices, exercise judgment, and take responsibility for their interventions' effectiveness in achieving desired outcomes (Dorst, 2019a; Hekkert & van Dijk, 2011; Tromp & Hekkert, 2018).

However, proposing interventions is a challenging task in transition design challenges due to complexities like multi-stakeholder involvement, diverse knowledge

fields, multiple problem owners, interconnected and dynamic problems, and the need to navigate multiple system scales (macro, meso, micro) and timeframes (now, near future, far future) simultaneously (Dorst, 2015; Goss et al., 2025c; Loorbach et al., 2017). While design tools and methods exist to support conceptualising system-shifting interventions (Drew et al., 2022), they often fall short of supporting designers in bridging system understanding and conceptualising new interventions (Goss et al., 2021; Goss et al., 2025c). Typically, they help in understanding the problem and context without supporting the conception of intervention proposals, or they focus on implementing, scaling, or optimising existing proposals for systemic change (Jones & Van Ael, 2022; Peeters et al., 2024). Although some studies have proposed concrete interventions within transition design challenges (Gaziulusoy & Ryan, 2017a; Goss et al., 2025c; Hyysalo et al., 2019), there is a need for further exploration of the reasoning and processes behind such proposals to support the conceptualisation of more effective interventions, especially as a strong transition design rationale can increase stakeholder alignment (Peeters et al., 2025).

While transition processes ultimately aim for desirable alternatives, the tremendous scope allows for a variety of interventions to move through such processes and (temporarily) establish more desirable alternatives. The added complexities of transitions require more nuanced reasoning for how a proposed intervention with intended effects will contribute to desired transition values. The current paper presents two studies that explore how a transition design rationale—a design rationale tailored to the complexities of transition challenges—supports designers in making design decisions and developing clear argumentations for how proposed interventions foster desired transitions. In the first study, we investigated design reasoning, the findings of which supported the development of the logical framework presented in this paper. In this first study, designers applied the framework to strengthen the reasoning behind design proposals. This was followed by a second study, where we conducted evaluative workshops—one with design practitioners and another with design students—where participants applied the proposed framework to design interventions for transitions. Based on these studies, we offer avenues for methodological development to understand better how designers can be supported in conceptualising transition interventions based on a strong transition design rationale.

In the next sections, we present our transition design logical framework and the reasoning behind it.

5.2. Design reasoning

Designers engage in a reasoning pattern known as design abduction, which involves hypothesising about how their design proposals will deliver specific value to users and/or stakeholders (Cross, 1982; Dorst, 2011; Schön, 1987). This process, depicted in Figure 5-1, comprises a 'what' (design) and a 'how' (mechanism/working principle)

that together achieve a desired 'value' (desired outcome) (Dorst, 2011). Typically, designers begin with the intended value they wish to achieve and work backwards to formulate the intervention and its mechanisms. However, this becomes challenging when there is no predetermined formulation of *what* new intervention(s) to propose and no known or chosen *how* to achieve the value. To navigate this uncertainty, designers employ 'framing'—a process of proposing if/then statements to predict how a mechanism will achieve desired values (Dorst & Cross, 2001). When filled in, the logical framework (Figure 5-1) reflects the reasoning, i.e., design rationale, behind a design proposal.

Framing is an essential design practice, occurring in the process of co-evolution between a frame and a solution (Dorst & Cross, 2001). To illustrate with an example: if a designer aims to create something to make people feel special (value) for a commercial internet provider, a birthday can be a frame to hypothesise what working principle might lead to this value, like receiving personal attention (how). This frame supports the ideation of interventions, for example, addressing people with their names in automated mailings (what). In simple design challenges, like in this example, evaluating a frame based on its ability to support the generation of a variety of new and original design ideas is likely sufficient. However, in the more complex transition design challenges, this quality is not sufficient as there are more considerations to take into account, such as multiple stakeholders, system scales (macro, meso, micro), and timeframes (now, near future, far future) (Dorst, 2015; Goss et al., 2023, 2025c; Loorbach et al., 2017).

WHAT + **HOW** *leads to* **VALUE**

FRAME

Figure 5-1 | Design reasoning framework adapted from Dorst (2011).

In a recent paper, van der Bijl-Brouwer et al. (2024) adapted Dorst's logical framework to support systemic design reasoning, adding the distinction between individual and stakeholder value, change mechanisms, and broader societal benefits (Figure 5-2). While this expanded framework accounts for multiple stakeholder values and relates to different system scales, it does not relate to different timeframes of systems change (Goss et al., 2025).

Within transitions, multiple frames—ranging from the individual (micro), group (meso), and societal (macro) levels—coexist and interact (Peeters et al., 2025). These frames also extend across timeframes, from immediate to long-term (Goss et al., 2025c). Yet the challenge for designers lies in linking these frames—connecting the understanding of a desired transition to specific pathways and concrete interventions. This requires translating a vision and pathway into actionable interventions by identifying behavioural mechanisms that offer value to

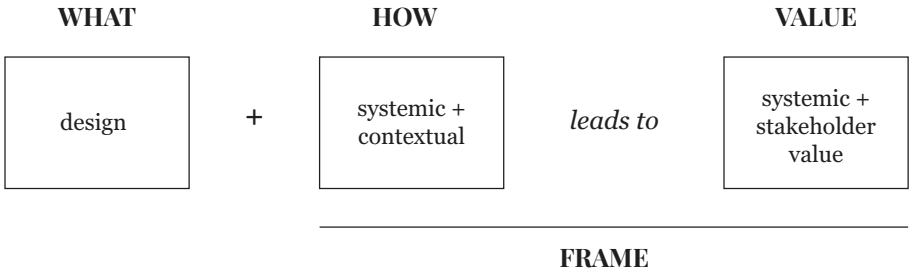


Figure 5-2 | Logical framework for societal challenges adapted from van der Bijl-Brouwer et al. (2024).

both individuals and the system. Building on the work of Dorst (2011) and van der Bijl-Brouwer et al. (2024), the next section introduces our proposed logical framework to support the practice of transition design reasoning toward interventions.

5.3. Transition design logical framework

Our proposed framework, illustrated in Figure 5-3, supports designers in reasoning toward transition design interventions by temporarily simplifying the complexity of the design challenge. It makes the transition context manageable to design for while keeping the broader context and goals in mind. A distinction made in the proposed framework is the focus on behaviour at both an individual and systems level. This focus stems from the fact that transitions result in the adoption of new practices that offer new meaning, competences, and materials to people and society. As such, transition interventions should yield individual and system behaviour changes that offer value(s) to both.

In design projects, the desired values are often the only known variable. In transition design, the ultimate values or ambitions guiding the transition are usually conceptualised through a vision and pathway(s) toward a desired future. As such, our framework becomes applicable once the ultimate values (and perhaps also the pathways) are initially defined. Following, it helps the designers define the pathways and conceptualise interventions aligning behaviours and values in a way that contributes to the transition.

5.3.1. Framework elements

The ultimate value(s) and pathway

Our framework asks designers to articulate the ultimate societal and planetary values aimed for in the transition, along with defining a promising direction or pathway to achieve these values, thereby setting boundaries within the design context. Ideally, this process is supported by a vision of the desirable future. For example, in the

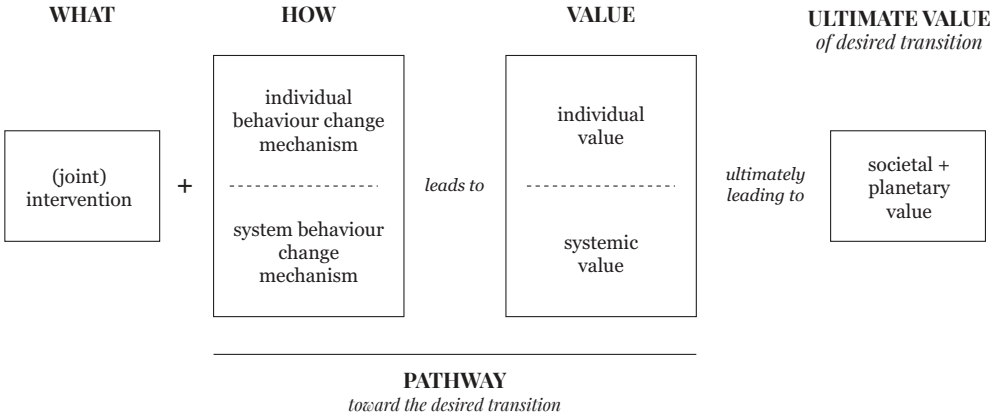


Figure 5-3 | Logical framework for transition design challenges. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J. Published by Systemic Design Association.

Dutch food waste transition, if a designer adopts a future vision with enough food for all with minimal waste, they might prioritise food security and reducing the food systems greenhouse gas emissions as key values. A potential pathway like 'celebrating the food journey' could be defined to enhance appreciation and value of food, thus reducing food waste and achieving desired systems change (Goss et al., 2024).

The how(s) and value(s)

Transitions aim to reconfigure and evolve practices toward sustainable alternatives, requiring a deep understanding of how individual behaviours and broader systemic actions are interlinked. Daily behaviours shape practices, and thus, changes at the individual level can affect and be affected by system-level changes (Kuijer & de Jong, 2012; Liu & McCarthy, 2023). As such, designers using our framework are tasked with identifying mechanisms that can change behaviours at both individual and system levels, evaluating how each contributes value in light of the ultimate transition values and pathway. For instance, if a designer identifies 'celebrating the food journey' to increase appreciation and value of food as promising toward the food waste transition, the challenge is defining what this means for individuals and the system and determining how it can facilitate desired behaviour changes.

The what(s)

Addressing complex systems change requires more than isolated one-time interventions within organisational silos. It requires a collaborative approach involving various stakeholders and organisations to create diverse, coordinated, and continuous strategies for change (Loorbach, 2007; van der Bijl-Brouwer & Malcolm, 2020). This involves viewing interventions as parts of a larger and interconnected ecosystem, enabling the development of an intervention portfolio that can address

the several behaviours and values relevant to transitions (Loorbach, 2007; van der Bijl-Brouwer & Malcolm, 2020). Therefore, a portfolio approach allows for several interventions to be explored, selected, and amplified based on their impact. The type of interventions can vary—ranging from policies, products, services, campaigns, and proposing new actors—depending on who is implementing them and their location in the system. Diversifying the type of interventions supports onboarding diverse stakeholders and positioning them as drivers of the transition (van den Bosch, 2010). Additionally, diversifying interventions across a portfolio increases the likelihood of achieving desired outcomes and resilience of the future system, even if some of the interventions face challenges or do not facilitate desired changes. Given these qualities, our proposed framework promotes the design of joint interventions within a portfolio, positioning stakeholders and organisations as central drivers of transition.

5.4. General methodology

We conducted two studies to assess the efficacy of the proposed logical framework (Figure 5-3) in supporting designers in making informed design decisions and developing clear argumentations for how a proposed intervention will contribute to a desired transition. The first study was a grounded theory study on design reasoning. In this study, designers in a consortium working on transitioning the Dutch food system toward sufficiency developed interventions to reduce food waste in Dutch households. These designers applied the resulting framework to strengthen the design reasoning for intervention proposals (Study 1). In the second study, we applied the framework in two workshops. The first workshop involved design practitioners addressing a societal challenge, and the second workshop included design students tackling a transition case (Study 2). Below, we describe each study and its outcomes.

5.4.1. Study 1: grounded theory study within a research consortium

This study was executed as part of the FETE research project ("From Excess To Enough"), involving three Dutch universities and eight organisations from the food system. FETE is focused on reducing food waste by transitioning from a system offering abundant (and unnecessary) choices to one offering sufficient choices. The study, which helped develop the transition design logical framework, consisted of two stakeholder sessions and design ideation held over two weeks. Below, we focus on the activities undertaken by the designers in this process.

Study 1, set-up and procedure

In a first stakeholder session, five of the eight FETE partners—including a national nutrition centre, a food waste foundation, a food manufacturer, a waste collector, and a meal delivery service—explored their roles in the transition, identified innovation pathways, and developed two intervention concepts. The session built on a vision

previously developed with input from all FETE partners, so participants were already aligned with the transition goals (Goss et al., 2024). The vision presented a future Dutch food system that provided enough food for all while minimising food waste by supporting new roles and relationships between the actors—consumers, producers, and retailers—and through developing new skills and behaviours.

Building on the session outcomes, the designers involved in FETE (first and third authors) conceptualised a new practice called adaptable consumption over three meetings. Adaptable consumption refers to a new practice where households have the ability to modify their food acquisition, preparation, and usage practices based on changing circumstances and available resources and sustain these practices over time as conditions evolve (Goss et al., 2025). In this process, the designers used the framework to strengthen the design reasoning for each intervention proposal. To communicate the practice, the designers developed a scenario depicting a consumer engaging in the new practice in multiple situations over a one-week period and visualised seven interventions to support the consumer.

A second stakeholder session evaluated adaptable consumption from societal and business perspectives to enhance its effectiveness and feasibility. During the session, the same five FETE partners reviewed which behaviours and interventions were strongest and weakest to foster the transition. The session concluded with a collective discussion about the most promising interventions for FETE (Goss et al., 2025). Following the session, the FETE designers applied the framework to each intervention proposal again to strengthen the design reasoning, thereby increasing each proposal's (potential) contribution to the transition.

5.4.2. Study 1, findings and discussion

This section presents findings related to the design reasoning applied to the proposals by the FETE designers. The findings are organised around how the designers applied the framework and its elements. For a detailed overview of this study and the stakeholder sessions, see Goss et al. (2025).

The ultimate value(s) and pathway

The vision developed for FETE indicated the goal of the transition as "having enough food for all with minimal waste". Additionally, it defined four potential pathways to this goal: 1) prioritising vitality and governing illness prevention, 2) embracing and highlighting flexibility, 3) celebrating and valuing the food journey, and 4) utilising technology to learn about ourselves as individuals and society. In the first session, FETE partners selected "Embracing Flexibility" as the preferred pathway, thereby focusing on realigning food safety, quality, and sustainability.

The how(s) and value(s)

With the embracing flexibility pathway defined, the designers decided to intervene in

consumption behaviours to support food waste-free and flexible behaviours in daily life while also driving wider systemic change. They began conceptualising interventions by defining what behavioural changes at the individual and system levels might mean while considering the values these changes contributed. For example, individual behaviours, such as storing leftovers effectively, assessing food quality with the senses, and mixing and matching ingredients, were identified. Navigating between the individual and system level behaviours and values and the ideas for interventions was done simultaneously. Once the framework was initially filled in, each aspect was refined for coherence and persuasiveness. To explore and articulate the impact of the behaviours, the designers developed a scenario in the form of a comic strip depicting a consumer going through their week while engaging in the behaviours that supported flexibility toward less food waste.

The what(s)

The designers conceptualised a portfolio of interventions as part of adaptable consumption that addressed different moments in the consumer's food management journey, from planning to disposal, and different stakeholder contributions such as providing ingredients, composing recipes, waste collection, and education. All the interventions were household-focused, being sensitive to the FETE partners who focused on the household context rather than agricultural production or retailing. To communicate the interventions, the designers visualised an innovation portfolio of seven concepts (Figure 5-4). The interventions were designed to have synergy and work together to enhance the overall effectiveness of adaptable consumption by offering complementary skills and meanings. For example, to learn to mix and match ingredients, the use of the ingredient-less recipe book (intervention) can be supported by storing partially used food effectively (intervention).

When presenting the interventions to the FETE partners, some stakeholders suggested adjustments to better align with their organisational context. For example, one proposal was an app and a smart bin to offer insight into food waste data (Figure 5-5). The national nutrition centre noted that the intervention was 'high-tech', excluding some households. They advocated for re-evaluating the intervention's format (such as a physical bin insert) to maintain inclusivity without compromising the design reasoning which was evaluated positively.

5.4.3. Study 2: evaluative workshop with designers

In Study 2, we conducted two workshops in which participants applied the logical framework to develop design proposals. The workshops were held at the Faculty of Industrial Design Engineering at TU Delft and focused on different participant groups and design challenges. For both workshops, participants provided oral consent for the audio recording of presentations and discussions and for photographing completed frameworks.

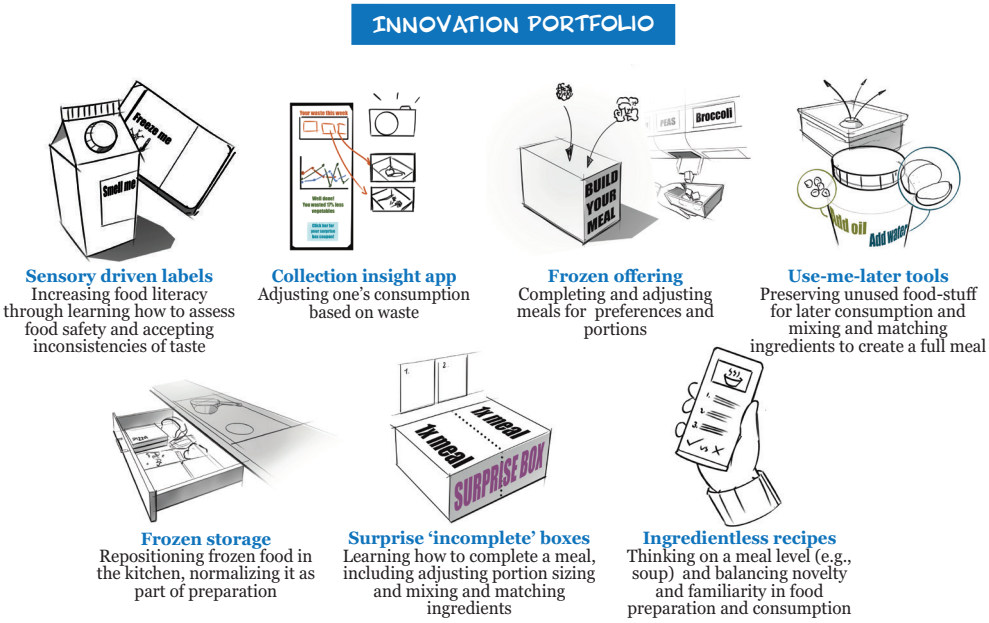


Figure 5-4 | Intervention portfolio supporting Adaptable Consumption (drawings by Maria Sofia). © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J. Published by Systemic Design Association.

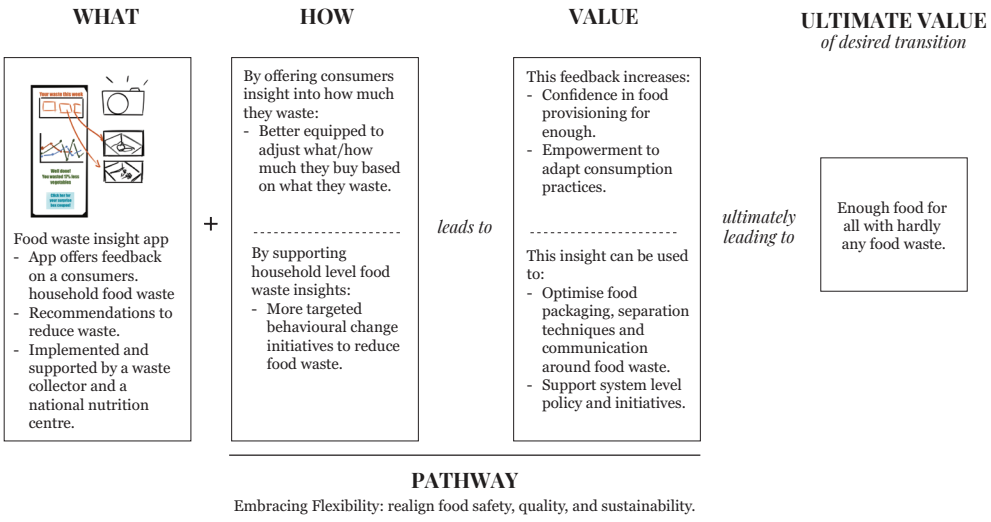


Figure 5-5 | Framework for a food waste insight App. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J. Published by Systemic Design Association.

5.4.4. Study 2, set-up and procedure

Workshop 1 design practitioners

The first workshop involved 18 design practitioners during a two-day Systemic Design Masterclass at TU Delft. On the first day of the masterclass, participants developed systems maps of a complex challenge they were working on. This included developing a giga-map (Sevaldson, 2011) and an iceberg model (Stroh, 2015). Our workshop was held on the second day of the masterclass and lasted approximately 90 minutes. This workshop began with an introduction covering transition design concepts, focusing on challenges related to time and scales, and introducing the logical framework.

Next, participants were divided into four groups of four to five people. They applied an empty framework (Figure 5-6) to the case they were working on. Two groups focused on designing for youth public participation in Europe, and two on youth eco-anxiety in the Netherlands. After applying the framework, the groups presented their interventions, describing how their design contributed to the societal challenge, their navigation through the framework, and any challenges.

Workshop 2 design students

Workshop 2, which lasted approximately six hours, involved 11 design students as part of a master's course at TU Delft. It began with an introduction, covering the concepts of transition design, focusing on challenges related to time and scales, and introducing the logical framework. Participants were briefed on two cases: designing for net-zero households in the Dutch energy transition and designing for food waste reduction in the Dutch food system transition. Each case provided visions, pathways, barriers, and key stakeholders. Students were grouped into five pairs or trios and chose one case to focus on.

Next, participants received partially filled-in templates based on design reasoning from Study 1 (Figure 5-7) to help them understand the framework and design reasoning. Following this exercise, they applied the empty framework (Figure 5-6) to their selected case. After applying the framework, the groups presented their interventions, describing how their design contributed to the transition, their navigation through the framework, and any challenges.

5.3.5. Study 2, findings and discussion

This section presents findings from both the design practitioners' and design students' workshops. In each workshop, groups applied the framework to develop design proposals for the case they were working on. The findings are organised around how the groups applied the framework and its elements.

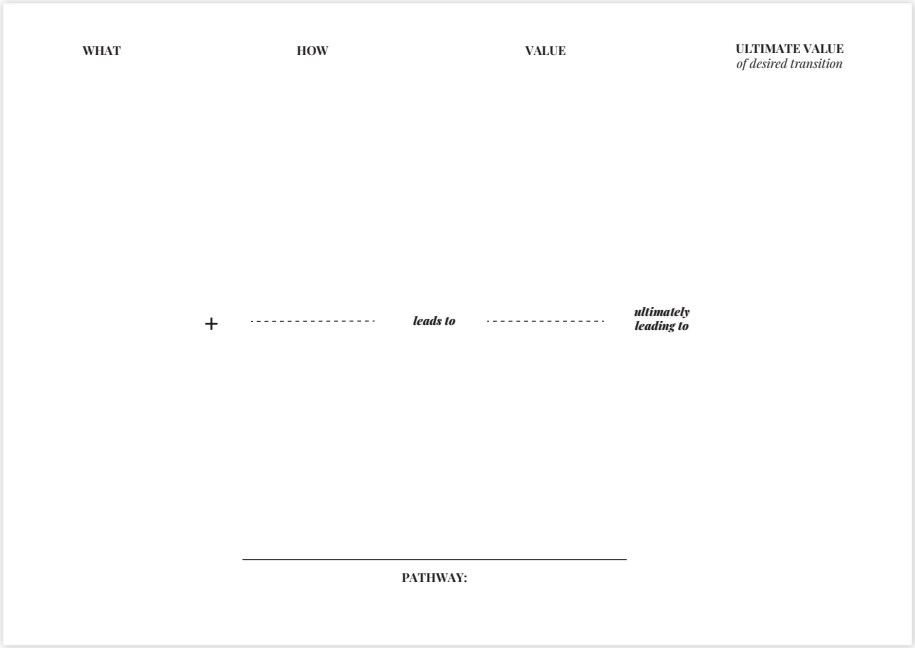


Figure 5-6 | Empty framework applied in workshops. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J. Published by Systemic Design Association.

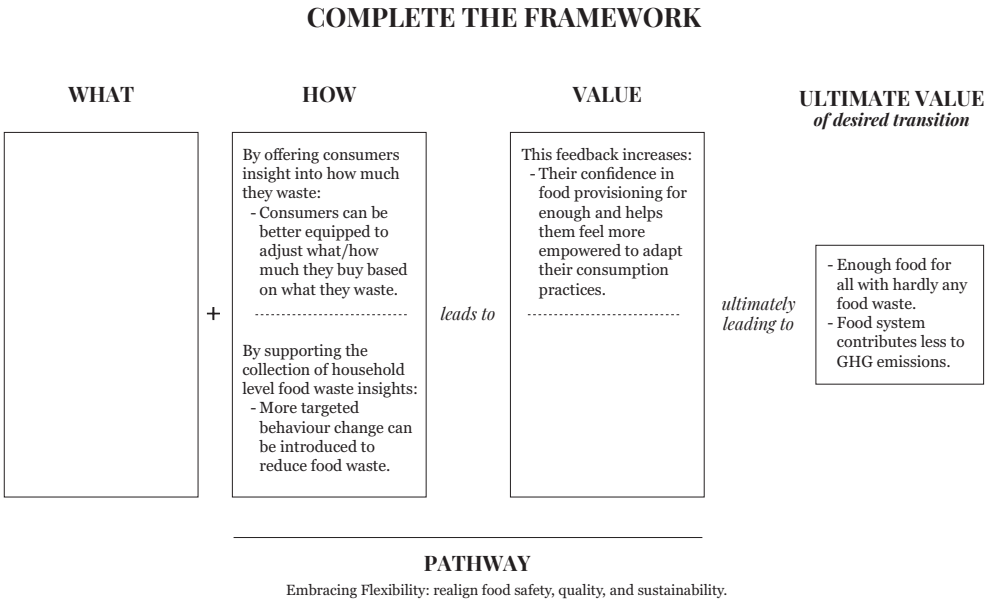


Figure 5-7 | One of the partially filled-in templates to be completed by the students. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J. Published by Systemic Design Association.

Navigating through the framework

All groups began by articulating the ultimate values of their challenge—yet their progression through the framework varied from that point onwards. Around half the groups, after defining the ultimate values and then defining the statement for the pathway, immediately brainstormed interventions. However, without articulating the values and behaviours (i.e., HOW) underlying that pathway, the design space remained too open, leading to several proposals with uncertainty about their contribution to the transition. One participant noted, *"as designers, coming to a 'HOW' and 'VALUE' of an intervention happens subconsciously. Yet when making this explicit by labelling it on the framework, it becomes less clear how [we came to] the conclusions about the 'VALUE' and 'HOW', and how [these actually] related to the transition"*. In this way, making the reasoning explicit highlighted the gaps in their rationale. In contrast, two practitioner groups in Workshop 1 defined their ultimate values and pathway, then determined, either explicitly or roughly, the values and behaviour change mechanisms. These groups reflected that moving through the framework in this way meant that each step focused the design space until they came to an intervention proposal, either intuitively or through refinement (Figure 5-8).

The ultimate value(s) and pathway

Defining ultimate values proved challenging. In both workshops, groups struggled with the scope at which ultimate values should be articulated, such as envisioning a more 'democratic society' or totally 'reimagining citizenship'. In Workshop 1, some practitioners found that outlining ultimate values and defining pathways simultaneously helped to scope the design space and understand the intended

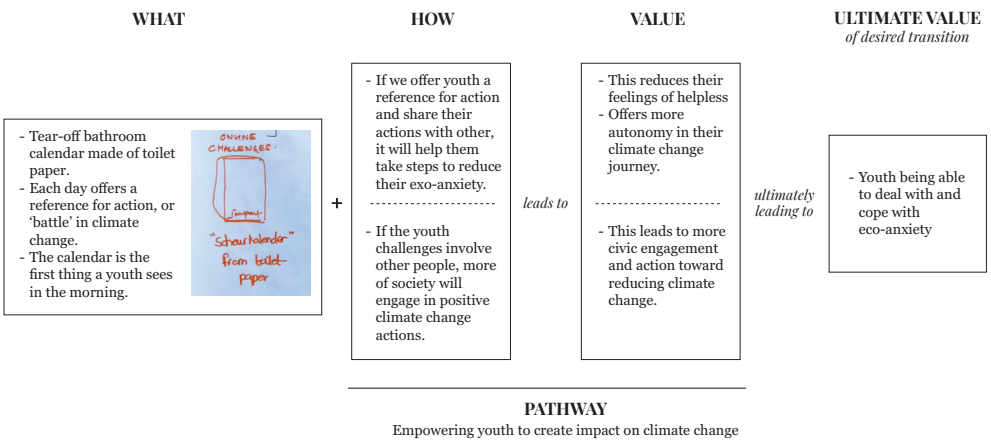


Figure 5-8 | Completed framework of a group from Workshop 1. © 2025 Goss, H.M., de Koning, J.I.J.C., Tromp, N., & Schifferstein, H.N.J. Published by Systemic Design Association.

changes over time. One participant noted, *"thinking from the individual to the system, through the pathways, helps to understand how changes on a wider scale can be achieved over time"*. Several practitioner groups noted that their previously developed systems maps helped them identify which pathway to focus on, clarifying the design context. One participant reflected, *"the giga-map helped because we could relate what we discovered to certain pathways experienced in reality that we could design for."*

In Workshop 2, despite being provided with a vision expressing transition goals and potential pathways, the student groups struggled more than the practitioners to define these elements in the framework. While this might have resulted from less experience with complex problems compared to the practitioners, it might also have resulted from the lack of time for the students to understand how and why the specific future was envisioned. In the case of the practitioners, the participants previously explored the challenges they were addressing and developed systems maps. Additionally, we observed that the students wanted to align goals and pathways with their personal or design interests rather than drawing them from the provided content.

Several student groups in Workshop 2 only defined a statement for the pathway at the end of their design process, as discussions on the ultimate values inspired intervention proposals. As such, the pathway did not inform or support the framing of their design context and was included as an afterthought in the design rationale, leading to poor coherence. Additionally, student groups that signalled new system dynamics within their pathways, such as through new roles, were better able to adopt a generative mindset, allowing these dynamics to be unpacked and explored in terms of their implications for people and society. For instance, within groups addressing the energy transition, framing the pathway as "households actively engaging in the energy transition" guided the design exploration while maintaining openness to various solution directions, unlike the framing of "by offering sustainable heat pumps," which provides a solution direction.

The how(s) and value(s)

Both workshops revealed difficulties in articulating behaviours and values. In Workshop 1, practitioner groups found defining the HOWS and VALUES on both individual and system scales the most challenging part of the framework to define. This was due to difficulty in determining what constitutes appropriate values and behaviours for systems change and that they considered these elements in interaction rather than isolation. This perspective differed from the student groups, which focused on the individual and system levels in isolation—first addressing the individual level and then the system level—without considering their interaction. We observed that practitioner groups that referred to their systems map were able to define the values and behaviours at the systems level more easily because problematic behaviours were already outlined that they then used to inform their

design reasoning. One group, who did not reference their systems map, reflected that they assumed they already had the necessary systems knowledge which was why they did not look at their giga-map for their reasoning. However, this assumption was incorrect and impaired their ability to decide on values and behavioural change mechanisms that effectively link their interventions to desired system changes.

In contrast, student groups in Workshop 2 showed confidence in identifying behaviours and values on the individual level yet faced challenges in articulating systems-level behavioural mechanisms. Additionally, when they began completing the framework, all student groups confused system behaviours with systemic values. For example, one group initially described the systemic value of an intervention in supporting the transition to less food waste as 'retailers choosing to offer products based on sufficiency rather than excess.' This reflects a system behaviour rather than a value, as it does not express the underlying drivers of this action.

A common strategy used by many groups in both workshops was to postpone detailing the HOW until after drafting interventions. This approach, arguably typical for designers, allowed for better articulation of behaviour change mechanisms by understanding the interplay between the design and desired outcomes.

The what(s)

In both workshops, the formulation of the proposals remained conceptual, with no groups clearly defining who should implement the intervention and why—likely influenced by the limited time. Nevertheless, we found that groups focusing on fewer, clearly defined values were more successful in developing intervention proposals with strong reasoning for how they contributed to the transition. In general, groups that articulated more than two values struggled to integrate them into a coherent intervention proposal, as more values did not support narrowing the design space, making it harder to articulate behaviours that could be supported through a single intervention. Additionally, groups that made the intervention proposal more tangible, such as by drawing or sketching the interaction, were better able to move back and forth between the different elements of the framework more easily than groups that only used words to define the intervention.

In Workshop 2, many student groups, although filling-in the framework elements (i.e., ultimate values, pathway, how, and value), failed to use these elements to inform their design proposals. This led to groups either becoming paralysed by the complexity of the framework elements and unable to translate these higher levels of abstraction into proposals, or they produced proposals with partial rationales only aligning with the ultimate values and not the other elements of the framework.

Form of the framework

Participants expressed that the framework, at times, restricted their analytical and creative processes. Half the practitioner groups in Workshop 1 reported that the

labels WHAT and HOW did not align with their interpretations, complicating their analytical thinking. Some perceived the WHAT as the behaviour they aimed to support and the HOW as the method for implementing it. Student groups in Workshop 2 felt the framework's rigid structure forced them to narrow their focus to fewer values and did not support exploring conflicts between individual and system levels, resulting in overly optimistic rationales. Yet when tensions in the design reasoning surfaced, the student groups did not actively iterate upon the frameworks to develop stronger rationales or improve upon their proposals. Nevertheless, participants in both workshops found the framework supportive in contextualising interventions within broader transition aims. They expressed that with more time, they would engage the framework iteratively, refining behaviours and values for greater coherence.

Workshop 1 participants appreciated how the framework facilitated abstraction across system scales and timeframes, linking planetary considerations to human-centred design. They felt the framework's tangibility "allowed us to make some quick decisions, keep the ball rolling, and tweak it afterwards. Otherwise, you stay in this state of discussion instead of having a more tangible thing to extend your knowledge and further refine the intervention." Workshop 2 participants noted how completing the framework gave them more confidence in the potential impact of the design proposals but expressed a need for clearer guidance on iterating and refining the design rationales.

5.5. General discussion

In this discussion, we reflect on avenues for methodological development informed by the insights gained from the two studies in the present paper. Our focus is on identifying opportunities related to transition design reasoning, particularly in the context of conceptualising interventions that facilitate desired transitions. Additionally, we examine the application of the proposed logical framework, detailed in Figure 5-3.

5.5.1. Mechanisms for systemic change

Designers' ability to effectively navigate and integrate individual and systemic behaviour changes is crucial for ensuring coherence and alignment within transition design contexts. Moving beyond reductionist approaches that focus on isolated behavioural levels within interventions (Maier & Cash, 2020), our transition design logical framework advocates for an integrative approach that addresses the interconnections between values and behaviours at multiple levels of the system. Adopting a complex, multi-level understanding of behaviour change extends human-centred design knowledge to incorporate strategic and systemic viewpoints. This, in turn, adds complexity to articulating even individual behaviour change (e.g., Goss et al., 2024; van der Bijl-Brouwer & Dorst, 2017). While designers experienced in systemic design processes are better equipped to iteratively navigate between

intervention proposals and their broader implications across behavioural levels, they still lack adequate support for addressing these interactions. Transition designers must situate individual behaviour change within its systemic context to design new practices that align with desired transitions, emphasising the need for cultivating an integral behaviour change capability within systemic and transition design education and practice (Goss et al., 2025c; Irwin, 2015).

While individual behaviour change has a rich repertoire in design (Maier & Cash, 2020), the lack of systemic behaviour change mechanisms limits designers' ability to ground interventions in robust rationales reflective of complex design contexts (van der Bijl-Brouwer et al., 2024). Given that transition design processes are intensive learning experiences requiring designers to challenge entrenched practices and devise solutions for complex, interconnected problems (Irwin et al., 2022), the development of a shared repertoire of systemic behaviour change mechanisms is imperative. This repertoire should be built through transparent articulation, documentation, and reporting of both effective and ineffective transition design interventions. These reports must explicitly detail the behaviour change mechanisms and design rationales underpinning each intervention. Such transparency would enhance the collective understanding of transition design reasoning and foster the iterative learning and adaptation processes necessary to steer complex systems change effectively. By addressing this gap, transition designers will be better equipped to navigate the complexities of systemic behaviour change and contribute to the broader goals of sustainable transitions.

5.5.2. Defining pathways of change

The integration and interpretation of transition values and pathways are central to supporting a generative position in transition design processes (Sevaldson, 2022). Findings from the present studies reveal that while specifying transition pathways provides necessary boundaries to the design space, the articulation of these pathways is crucial. Pathways that foster a generative mindset successfully narrow the design space while preserving openness to diverse solution directions. For instance, articulating new roles and relationships within pathways that signal future system dynamics support creativity but also ensures pathways remain adaptive to evolving systemic needs (Gaziulusoy & Ryan, 2017b; Goss et al., 2025c). Nonetheless, further exploration into the qualities of effective transition design pathways is necessary. Identifying the attributes that enable pathways to frame and guide design processes effectively would significantly enhance their role in transition design. This includes understanding how pathways can integrate future-oriented dynamics while maintaining coherence with current systemic contexts. By addressing these gaps, transition design research can strengthen the critical role that pathways play in framing, ultimately supporting designers in navigating the complexities of systemic change more effectively.

5.4.3. Portfolio-level design rationales

The interventions from the studies in the present paper remain purely conceptual. Nevertheless, the proposals highlight how multiple values relevant to individuals and the system (e.g., stakeholders) may require different behavioural mechanisms to achieve desired outcomes. By developing multiple interventions for the same transition challenge, as in Study 1, transition designers can address various behaviours and values and align with organisational contexts needed for implementation (Goss et al., 2025c). While Study 2 lacked the time for this, it is conceivable that the next step could involve bringing together the groups addressing the same challenge to explore how their proposals might be iterated upon to reinforce each other. This portfolio approach challenges design reasoning from focusing on single intervention rationales to developing a rationale across multiple interventions. The development of this overarching design rationale encourages a deeper understanding of the interplay between design proposals and their broader societal impacts. It also allows designers to narrow the scope of individual proposals while maintaining an overview of how they support wider change processes (Goss et al., 2025c). This approach is essential for addressing the multidimensional nature of transition challenges (Gaziulusoy & Ryan, 2017a; Geels, 2002; Goss et al., 2025c). Therefore, transition design education must teach students to conceptualise not one but a portfolio of interventions based on strong rationales that lead to synergy, reinforcement, and complementarity between interventions in pursuit of desired systems change (van den Bosch, 2010).

5.5.4. Limitations of the framework

The current study has several limitations that may inspire further research. First, the framework was applied in two ways, influencing how the designers engaged with it. Study 1 used the framework in a more reflective design practice, where designers drafted rationales for intervention proposals and applied the framework to evaluate and enhance these rationales. Conversely, Study 2 used it within a generative design practice to develop new intervention proposals, necessitating formulating all the framework elements from scratch. Additionally, we recognise that the framework operates between a canvas, tool, and method. Future research should explore how the form and interaction with the framework can be adapted to suit various design practices (e.g., generative or reflective), applications (e.g., workshops, projects), and formats (e.g., canvas, tool, method). For instance, if used as a canvas, adding descriptive subtitles that offer cues for each element, such as adding *"WHAT is designed", "HOW it influences change",* and *"what VALUE is gained"* would help clarify the focus of the different elements. Moreover, the study suggests that projects applying the framework should allocate ample time and resources for designers to comprehend system dynamics in order to develop transition design interventions with sound design reasoning and the potential to contribute to the transition.

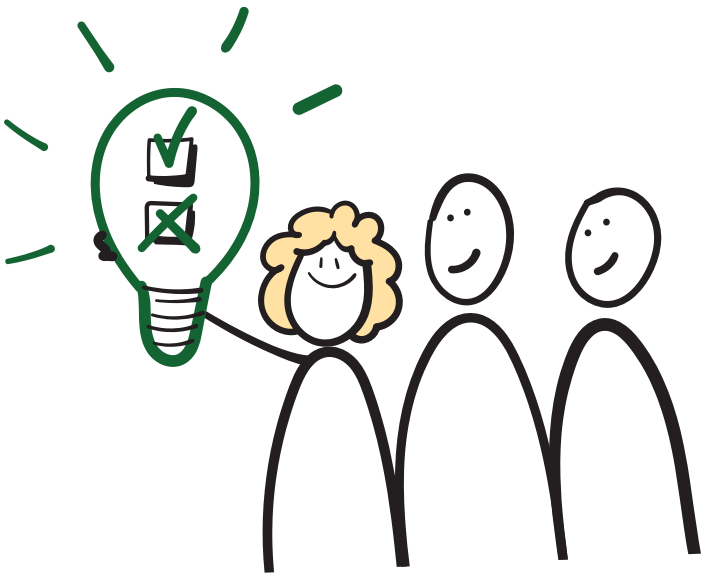
In its current state, the framework facilitated designers in reasoning toward interventions that promote short-term changes with the potential for long-term systemic impact. Although its distinctions—the What(s), How(s), Value(s), Pathway, and Ultimate Value(s)—facilitate abstraction across system scales and timeframes, it should not be considered a standalone method. Effective application requires designers to propose, reflect, iterate, and critically examine the consequences of proposed interventions and the tensions between individual and system scales. We underpin what Fitzpatrick et al. (2024) and Vink (2023) found: designing for transitions necessitates strong systems reflexivity and requires sensitivity to the systemic context. To support designers intervening in complex societal transitions, we must deepen our understanding and application of transition design reasoning, enabling designers to envision and navigate meaningful change across different scales and times.

part three

Evaluating

Transition designers aim to shift systems toward more desirable alternatives through the design of systemic interventions. However, in transition contexts, the impact of interventions, which span multiple timeframes and target behaviours like resilience or flexibility, can be challenging to observe and measure. Therefore, despite growing interest in transition design practice, there remains a gap in understanding the effectiveness of its resulting outcomes in fostering systemic change.

Part 3 of this dissertation, Evaluating, consists of a single chapter (Chapter 6) that examines how transition designers can assess the impact of interventions as output of their process. While this single study may not fully capture the breadth of evaluation as a reflexive design expertise, it provides insights into how evaluation can be staged within transition design processes.



Design Step 6

understanding the potential effectiveness of designed interventions

Chapter 06.

The proof of the pudding: introducing quantitative testing in transition design reasoning.

This chapter is under review for journal publication as:

Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., and Tromp, N.,. The proof of the pudding: Introducing quantitative testing in transition design reasoning. Contexts—The Systemic Design Journal.

Following the development of a future food system vision in Part 1 and the design of adaptable consumption and its intervention portfolio in Part 2, this chapter examines how the interventions can be evaluated for their potential to foster desired systemic change. Within transition design processes, designers must assess how interventions align with envisioned futures, respond to evolving system dynamics, and connect actions across actors and scales. This evaluative practice demands continuous experimentation, learning, and adaptation, alongside critical reflection on how interventions unfold within complex systems and how they may reinforce, alter, or disrupt existing trajectories.

This chapter proposes a conceptual framework connecting five essential transition design activities—navigating scales, considering temporality, engaging and repositioning actors, framing and designing, and practising reflexivity—to three qualities of its outcomes: desirability, plausibility, and networkedness. Using this framework, we assessed a portfolio of the 21 proposed interventions designed to transition the Dutch food system toward reduced waste.

The interventions were evaluated by consumers, companies, and experts (n = 312) through an embedded mixed-methods approach in which primarily quantitative research was complemented by qualitative insights. Each intervention was presented as a drawing of a product-service system accompanied by a user narrative. Our findings reveal that while consumers and companies tend to favour near-future interventions that adapt existing food consumption practices, experts prefer long-term interventions that disrupt existing practices. Additionally, the results indicate that primarily quantitative evaluations may not sufficiently capture the complex, systemic qualities of transition design interventions, suggesting a need for a more balanced approach incorporating context-sensitive insights. This chapter concludes by reflecting on avenues for further methodological development to strengthen evaluation as a transition design practice.

6.1. Introduction

Today's societies are increasingly confronted with crises, like climate change, racial injustice, and socioeconomic inequality, that reveal systemic vulnerabilities and require transformative responses (Avelino et al., 2024; Geels et al., 2023). As these challenges are complex and interwoven, approaches integrating technical, political, and creative expertise are gaining attention as effective strategies for fostering desired societal changes (Gaziulusoy & Ryan, 2017a; Kossoff & Irwin, 2021). Transition design, a specialised field of design research and practice, offers an approach for facilitating and accelerating societal change towards more desirable alternatives through systemic interventions (Irwin, 2015). Situated at the intersection of design, sustainability science, and transition studies, transition design seeks to align short-term innovation efforts with long-term systemic changes (Goss et al., 2025d). Its potential to support deliberate societal transitions has stimulated growing interest in its processes and methodologies. However, there remains a gap in understanding and evaluating the outcomes of transition design, particularly in assessing the effectiveness of the resulting interventions. Therefore, the present study aims to answer the question: what is the perceived effectiveness of interventions resulting from a transition design process?

Once interventions for transitions have been designed, efforts to assess their impact within complex systems are inherently challenging, requiring approaches that reflect the dynamic and evolving nature of the context (Avelino et al., 2024; Sevaldson, 2022). As transition design is a relatively young field (Irwin, 2015), standard methods for its evaluation have yet to emerge, leaving it as an understudied area within the field. These considerations motivated us to develop a conceptual framework for transition design to 1) understand how transition design processes contribute to systemic changes and 2) provide qualities by which to evaluate its outcomes. The proposed framework connects five essential activities in transition design practice with three core qualities of transition design outcomes. In the study presented in this paper, we formulated hypotheses to apply our framework in evaluating a portfolio of 21 proposed interventions resulting from a transition design process aimed reducing food waste in the Dutch food system. While we acknowledge that the effects of a transition design process cannot be assessed solely through its outcomes, examining these outcomes provides valuable insights into how such processes may contribute to systemic change. Through a mixed-methods approach, where quantitative research was complemented by qualitative insights, the 21 interventions were evaluated by three distinct actor groups—consumers, companies, and experts. Although we employed hypothesis testing, these hypotheses functioned not as traditional theory-testing tools, but rather as structured evaluative criteria to guide and support our assessment.

This paper brings together both conceptual development and empirical application, providing a comprehensive contribution to transition design. Readers

primarily interested in the conceptual foundations can focus on Sections 6.2-6.4, while those seeking empirical insights can find intervention development and evaluation in Sections 6.5-6.8. In the next section, we discuss how the concepts adopted in the framework are represented within the literature (Sections 6.2-6.4). This is followed by an overview of the transition design process that led to 21 proposed interventions (Section 6.5). We then present our hypotheses (Section 6.6), which are tested in a narrative-based study (Section 6.7), and present the results (Section 8). Finally, we conclude by reflecting on the practical and methodological implications for conceptualising transition design interventions and highlight areas for future research by which to strengthen transition design practice and evaluation (Section 6.9).

6.2. Transition design activities

We focused on five essential activities for transition designers that emerged from the literature and from experiences from practice. These activities include: 1) navigating scales from micro to macro-level systems; 2) considering temporality from present to the far future; 3) engaging and repositioning actors from individuals and groups to networks; 4) framing and designing from single solutions to portfolios; and 5) practising continuous reflexivity within and across activities and outcomes. These activities are reflected in our final framework (Figure 6-1).

6.2.1. Navigating scales from micro- to macro-level systems

Transition design operates across multiple scales: the micro level, where individual behaviours, skills, and knowledge shape systemic change; the meso level, where organisations establish roles, relationships, and strategic directions for products and services; and the macro level, where policies, cultural values, and societal norms influence structural shifts (Geels, 2002; Rip & Kemp, 1998). Navigating these interconnected scales is fundamental, as change at one level can reinforce, constrain, or redirect shifts at another (Geels, 2002; Kossoff & Irwin, 2021; Overdiek et al., 2024; Rip & Kemp, 1998). For instance, organisational support at the meso level can amplify behavioural changes at the micro level, potentially influencing macro-level policies and cultural narratives (Fischer & Riechers, 2019; Smith et al., 2005).

To effectively interpret these cross-scale dynamics, transition designers have drawn on frameworks such as the Multi-Level Perspective (MLP) (Geels, 2002) and Social Practice Theory (SPT) (Reckwitz, 2002). The MLP explicitly conceptualises socio-technical transitions through interrelated levels: niches (where innovations emerge), regimes (dominant structures and practices), and landscapes (broad external forces like climate change or economic trends) (Geels, 2002). Meanwhile, SPT focuses on how everyday practices evolve through interactions between materials, skills, and meanings (Reckwitz, 2002; Shove et al., 2015). Together, these theories offer transition designers conceptual tools for understanding and

strategically intervening across multiple scales, linking local actions to broader systemic transformations (Goss et al., 2025a; Irwin et al., 2022; van der Bijl-Brouwer et al., 2024).

However, designing across multiple scales presents challenges, particularly due to potential misalignments and resistance at different systemic scales and levels. Misalignments arise from differences in the speed, scope, or structural constraints inherent to each scale (Smith et al., 2005). For example, macro-level policy changes typically unfold slowly, often over decades, while micro-level behaviours may adapt more rapidly in response to targeted interventions. Resistance, on the other hand, emerges from political, economic, or social barriers that inhibit the implementation or acceptance of interventions (Smith et al., 2005). For instance, macro-level policy lock-ins or entrenched cultural values may hinder transformative shifts, meso-level organisational structures may find radical changes too disruptive, and individuals at the micro level might resist interventions that significantly alter established practices (Geels, 2002). If these multi-scalar and level dynamics are overlooked, transition design interventions risk failing to achieve sustained systemic impacts. Therefore, transition designers must strategically position interventions, carefully balancing sensitivity towards existing structures with the ambition to drive systemic transformations.

6.2.2. Considering temporality from present to far-future

Transitions inherently unfold gradually, often spanning decades and requiring sustained, coordinated efforts to be planned across extended timeframes (Loorbach & Rotmans, 2010). Consequently, transition designers must adopt a long-term perspective, recognising that while future outcomes cannot be entirely predicted or controlled, present actions can shape evolving system dynamics (Irwin, 2018; Kossoff & Irwin, 2021; Murphy, 2022). Therefore, designing for transitions often begins with an understanding of both the envisioned future system and the current conditions in which designers wish to intervene. By understanding how current and future system dynamics interact, designers can develop interventions within existing structures that foster desired long-term transformations (Dorst, 2015; Goss et al., 2025a; Goss et al., 2025d).

To navigate these temporal dimensions, transition designers use methods such as visioning (e.g., Boehnert & Alexander, 2025; Goss et al., 2024), scenario development (e.g., Gaziulusoy & Ryan, 2017b), and pathway mapping (e.g., Hyysalo et al., 2019). These approaches enable designers to articulate clear transition pathways—also referred to as trajectories or directions— that guide interventions from present conditions towards envisioned futures. By adopting a long-term view, designers can overcome existing systemic constraints and imagine radically alternative practices that generate new meanings for individuals, organisations, and societies (Geels & Schot, 2007; Verganti & Öberg, 2013). This long-term orientation also situates new practices within evolving systemic contexts, helping designers

anticipate obstacles, identify necessary resources, and establish milestones critical to the gradual introduction and adaptation of transition design processes.

However, transition design inherently involves navigating tensions and trade-offs across varying temporalities. For example, the urgency to mitigate climate change may conflict with the slower processes needed to ensure equitable and just decision-making (Ciplet & Harrison, 2020). Similarly, intentional systemic changes, guided by stakeholder interests, governance structures, and organisational capacities, might move at different paces than broader systemic shifts such as technological developments, political instability, or climate crises. Transition efforts, therefore, exist within dynamic systems, requiring continual reassessment of risks, opportunities, and emerging conditions as circumstances evolve. Without recognition or sensitivity of these temporal complexities, transition design processes risk misaligning short-term interventions with long-term objectives, thereby undermining sustainable and just outcomes (Gibson, 2006).

6.2.3. Engaging and repositioning actors from individuals and groups to networks

Transition design requires more than mobilising individual actors or isolated stakeholder groups to intentionally foster collaboration within and between actor networks (Kossoff & Irwin, 2021). These networks—coalitions of stakeholders operating at localised, sectoral, and cross-sectoral scales –collectively drive systemic change by leveraging diverse resources, knowledge, and influence (Löhr et al., 2022; Loorbach, 2007; Wittmayer et al., 2021). For example, in the context of food systems, actor networks may include organic farmers, local food distributors, community-supported agriculture initiatives, consumer groups, research institutions, and municipal policymakers. Understanding and effectively engaging with actor networks enhances the coordination and coherence of interventions across different scales and sectors (Joore & Brezet, 2015; Wittmayer et al., 2017).

However, collaboration within actor networks is rarely smooth or linear. As transitions inherently challenge established systems, tensions and conflicts among stakeholders are inevitable (Geenen et al., 2022; Nedaei & Jacoby, 2023; Shaw & Solsø, 2024). Actors are often embedded in existing power relations, roles, and interests, which can lead to resistance when systemic shifts threaten their position. Additionally, transition processes may require actors to reposition themselves, adopt new roles, reshape services, or dissolve outdated organisational forms (Geels & Schot, 2007; Goss et al., 2025d). Recognising conflict as a source of systemic learning, rather than as a barrier, is critical for transition designers seeking to foster transformative change. Yet working with these tensions requires more than ad hoc participatory activities; it demands intentional efforts to sustain collaboration over time (Boztepe et al., 2024; de Koning & van der Bijl-Brouwer, 2024).

Sustaining active actor networks involves building resilient partnerships that support continuous knowledge-sharing, establishing governance structures that

support joint decision-making, and designing adaptive processes that accommodate evolving stakeholder roles (Wittmayer et al., 2017). While many participatory design approaches, such as workshops or co-creation sessions (e.g., de Koning et al., 2018; Gaziulusoy & Ryan, 2017b; Goss et al., 2025d), successfully convene stakeholders to generate outcomes, their long-term effectiveness is limited unless there are structures in place to support ongoing collaboration.

Thus, transition designers must move beyond short-term engagement strategies toward a more embedded, long-term presence within transition contexts. By proactively cultivating actor networks, facilitating role renegotiations, and safeguarding the values that underpin just transitions, designers can help foster adaptive, future-oriented coalitions capable of sustaining systemic transformations over time (Avelino et al., 2024; Goss et al., 2024; Hyysalo et al., 2019). This requires a commitment to remaining engagement across the unfolding phases of transitions, ensuring that efforts are not only initiated but also meaningfully embedded within the evolving dynamics of actor networks.

6.2.4. Framing and designing from single solutions to portfolios

While transitions aim to facilitate sustainable and just societies, the vast scope and complexity of related challenges call for a diverse range of interventions to foster desirable alternatives. Transition design recognises that systemic changes cannot be achieved by singular interventions, rather, it requires multiple interconnected solutions, each addressing aspects of a system while supporting broader transition dynamics (Gaziulusoy & Ryan, 2017a). Adopting a portfolio-based approach is, therefore, essential in transition design, as it enables designers to engage with systemic complexity from multiple perspectives and create varied entry points that collectively increase the resilience and efficacy of transition efforts.

A portfolio of interventions can span multiple system levels (e.g., household, community, city) and engage different domains of systemic activity (e.g., consumption, production, distribution). Such portfolios can intentionally introduce new practices, through new skills, meanings, and materials, designed to evolve over different time in response to shifting contexts (Kossoff & Irwin, 2021; Kuijer, 2014). Rather than pursuing a singular, definitive solution, transition design thus embraces what Kossoff and Irwin (2021) call "solutioning over time". This recognises that transitions unfold through continuous experimentation, adaptation, and recalibration. By fostering an iterative and evolving approach, portfolios aim not only to introduce alternatives but to strategically disrupt entrenched structures and cultivate pathways toward more sustainable and just futures.

Crucially, portfolios also redistribute agency within transition processes. They create opportunities for a wide range of actors to participate as active drivers of change, rather than passive recipients of predefined solutions (van den Bosch, 2010). By pursuing multiple interventions, transition design efforts become less vulnerable. For instance, if some interventions face challenges or fail to achieve desired changes,

alternative interventions within the portfolio are still being explored and continue to sustain momentum. Furthermore, portfolios facilitate collective reflection among designers and stakeholders, enabling critical evaluation of the coherence, complementarity, strengths and gaps, and evolving relevance of transition efforts (Si et al., 2022)(Whyte et al., 2022).

6.2.5. Practising reflexivity from activities to outcomes

Reflexivity is fundamental to transition design and is increasingly recognised as a critical skill for navigating complex systems change (Fitzpatrick et al., 2024; Vink & Koskela-Huotari, 2022). In this context, reflexivity is not simply an individual reflective practice, but a deliberate process embedded in transition design processes. It requires designers to critically examine the assumptions, power structures, and decision-making processes that shape both the design process and its systemic outcomes (Fitzpatrick et al., 2024; Vink & Koskela-Huotari, 2022). Reflexivity ensures that design does not unintentionally reinforce dominant institutional logics or inequities, but challenge entrenched structures to enable just transformation (Pel et al., 2023). In multi-stakeholder transitions, where diverse actors hold competing values, interests, and power positions, reflexivity helps designers navigate external pressures that may distort systemic intent. Rather than viewing transition design as a linear or purely technical process, reflexivity highlights its relational nature, where knowledge, values, and lived experiences continuously shape transition efforts (Bateson, 2017).

Additionally, embedding reflexivity into transition design processes enhances the adaptability and resilience of efforts, ensuring they remain responsive to shifting socio-political and environmental conditions (Fitzpatrick et al., 2024; Gibson, 2006). Although there is growing consensus on the importance of reflexivity, researchers continue to call for more practical tools—especially for supporting systems-level reflexivity—and for more empirical work to complement the field's largely conceptual discourse (de Koning, 2019; Fitzpatrick et al., 2024; Lu & Sangiorgi, 2021; Vink & Koskela-Huotari, 2022).

6.3. Transition design outcomes

The preceding discussion highlights that transition design is an iterative process, guided by five key activities that inform decisions about which interventions to propose, when to implement them, and how they should be combined. The outcomes of this ongoing process should reflect and embody these activities, producing a portfolio of interventions capable of driving systemic change. We define these outcomes as needing to demonstrate: 1) desirability across different actor groups to enable uptake; 2) plausibility in fostering micro- (individual), meso- (organisational), and macro-level (systems) transformations over time; and 3) networkedness, reflecting the interrelation of multiple interventions within a portfolio. This section discusses

the literature on these three qualities (desirability, plausibility, networkedness) of transition design outcomes, which are also reflected in our final framework (Figure 6-1). Although all five transition design activities contribute to shaping outcomes, these three qualities are particularly essential for ensuring that interventions are critically evaluated and continuously aligned with transition aims.

6.3.1. Desirability

In transition design, desirability concerns the extent to which interventions align with the diverse needs, values, and expectations of different actor groups (e.g., citizens, organisations, and institutions). The literature discussed below highlights two key dimensions of desirability: 1) value, referring to the perceived benefits and relevance of an intervention for different actors, and 2) innovativeness, reflecting an intervention's novelty and capacity to inspire engagement and adoption. Together, these dimensions shape whether an intervention resonates across varied interests of actors, thereby influencing its uptake, and, ultimately, its potential for impact.

Offering value for diverse actors

Understanding the perceived value of transition design interventions is crucial for their implementation, adoption, and sustained use (Ceschin & Gaziulusoy, 2016). Value is not an inherent property of an intervention; rather, it is context-dependent and shaped by actors' desires and anticipated outcomes (Harris, 2017). Because transition design interventions are embedded in everyday life, their perceived value depends on how well they align with the interests and expectations of diverse actor groups (de Koning, 2019; den Ouden, 2012). This embeddedness introduces complexity, as different actors apply different evaluative criteria to interventions.

Consumers tend to prioritise personal relevance and experience, seeking interventions that improve daily life or offer emotional and symbolic meaning (Fokkinga et al., 2020). Companies, in contrast, assess interventions based on strategic fit, profitability, and competitive positioning, considering long-term business potential (den Ouden, 2012; Loorbach et al., 2010; Loorbach & Wijsman, 2013). Academic experts evaluate interventions based on their (systemic) impacts, conceptual robustness, and potential to shift problematic paradigms (Smith & Stirling, 2010). Meanwhile, the public sector emphasises societal impact, alignment with policy priorities (e.g., public welfare), and regulatory compatibility, often focusing on shorter-term benefits (Loorbach & Wijsman, 2013; Meadowcroft, 2009). Moreover, certain interventions, such as infrastructural projects or policy measures, operate at a systemic level, where value is less connect to direct user experience and more concerned with structural change, regulatory stability, or long-term societal benefits.

These differing perspectives highlight a central challenge in transition design: interventions must align with the specific values of distinct actor groups while

maintaining broader relevance to support collective innovation efforts. Without this cross-actor appeal, even technically robust and socially-sound innovations will likely face resistance and limited adoption (Gaziulusoy & Ryan, 2017a, 2017b; Geels, 2002; Goss et al., 2024). Addressing this requires a values-based design approach that explicitly considers and negotiates diverse actor perspectives. For transition designers, such an approach is critical not only for building initial momentum, but also for sustaining engagement across the evolving dynamics of systemic change (Mok & Hyysalo, 2018; Ozkaramanli, 2021).

Providing innovative solutions

Innovativeness enhances desirability by introducing novel proposals that challenge conventional thinking and inspire new ways of acting (Irwin, 2015). Within transition design, innovativeness extends beyond simply developing new products or services; it entails reimagining system structures, behaviours, and social practices to support lasting systemic change. This process of reimagining is crucial, as innovative interventions must evoke curiosity, stimulate engagement, and offer a compelling sense of possibility to encourage their adoption and sustained impacts (Verganti, 2009). However, as with perceived value, perceptions of innovativeness vary across actor groups, creating complexity in how an intervention is assessed and prioritised.

For consumers, innovativeness is often associated with two dimensions of newness: form and function. Newness in form refers to aesthetic, symbolic, and experiential aspects, such as novel product designs, materials, and visual appeal. In contrast, newness in function relates to technological advancements, enhanced usability, and novel features that improve product performance and/or interaction (Lee et al., 2018; Mugge & Schoormans, 2012). Both aspects contribute to desirability by shaping how consumers perceive and engage with innovations in their daily lives. Academic experts typically assess innovativeness based on an intervention's ability to disrupt dominant paradigms and propose meaningful alternative practices (Irwin, 2018; Tromp & Hekkert, 2018). For these actors, innovative interventions provoke reflection, open up new imaginaries, and shift perspectives towards systemic changes (Dunne & Raby, 2013; Irwin, 2018; Tromp & Hekkert, 2018). Alternatively, companies typically prioritise innovativeness in terms of market differentiation, scalability, and competitive advantage, focusing on how new ideas can translate into profitable business models (den Ouden, 2012; Teece, 2010). Finally, the public sector tends to favour incremental innovation that aligns with policy priorities and cycles, as well as existing infrastructures, seeking solutions that can be integrated without major disruptions while still offering long-term benefits (Meadowcroft, 2009).

Moreover, innovativeness in transition design must be understood as unfolding across different time horizons. Innovations focused on the present tend to be incremental, improving current systems within existing constraints and thus result in minimal disruption (Norman & Verganti, 2014). In contrast, near- and far-future innovations introduce greater novelty and speculative possibilities,

potentially repositioning actors toward long-term transition aims (Dunne & Raby, 2013; Geels, 2002; Goss et al., 2025d). Far-future interventions, in particular, are often the most inspirational, as they challenge existing paradigms and envision new cultural traditions, social practices, and institutional structures (Tromp & Hekkert, 2018; Verganti & Öberg, 2013). However, realising such transformations requires time for regulatory adaptation, infrastructural shifts, and societal acceptance (Irwin, 2015; Vezzoli et al., 2015). By supporting actors to imagine compelling alternative futures, transition design interventions not only introduce novelty but also inspire shifts in mindsets and behaviours, enhancing the desirability of long-term transition processes.

6.3.2. Plausibility

In transition design, plausibility concerns the perceived achievability of interventions within current and envisioned societal systems. The literature discussed below highlights two key dimensions of plausibility: 1) an interventions capacity to foster behavioural changes, and 2) its contribution to addressing societal challenges along a transition pathway. As such, transition designers must evaluate interventions based on the intervention-level attributes (e.g., aims, behavioural mechanisms, form, function), their alignment with transition pathways, and the likelihood of achieving intended systemic shifts (Wiek et al., 2013). This ensures that interventions are not merely visionary but are "occurrable" (Wiek et al., 2013), meaning they can realistically trigger behavioural changes within the systemic context where they are implemented (Ceschin & Gaziulusoy, 2016).

Fostering desired behavioural changes

Addressing behavioural changes is paramount for transition design interventions because transitions fundamentally involve altering established patterns of consumption and production to more sustainable alternatives (Gaziulusoy & Brezet, 2015; Scott et al., 2012). As such, transition design interventions that overlook behavioural dimensions risk being ineffective, as technological or policy changes alone cannot guarantee the adoption of sustainable practices (Shove, 2010). To drive transformative changes, interventions must consider the underlying values, habits, and social norms that shape individual and collective behaviour (Jackson, 2005). By focusing on intended behavioural changes, interventions can facilitate the development of new routines and lifestyles and create the social conditions necessary for sustainable and equitable futures (Geels, 2011; Kuijer, 2014).

Designing for behaviour change requires sensitivity to contextual factors, such as cultural norms, economic conditions, and local infrastructures, which shape how behaviours emerge, adapt, and become embedded over time (Mok & Hyysalo, 2018; Verbeek, 2005). These contextual aspects act as the 'materials' of design, influencing the adoption and maintenance of new behaviours (Vink & Koskela-Huotari, 2022). While individual behaviour change is well-studied in design

(Maier & Cash, 2020), systemic behaviour change is still developing (van der Bijl-Brouwer et al., 2024). To be effective, interventions must address both individual and systemic changes simultaneously, as focusing on only one aspect, such as only individual change without supporting systemic changes, or vice versa, is unlikely to drive societal transitions (Goss et al., 2025a).

Contributing to societal challenge along a pathway

For transition design interventions to be effective, they must directly address a clearly defined societal challenge (Loorbach, 2007). Since transitions fundamentally seek to shift complex societal systems in response to persistent challenges like climate change, inequality, or resource depletion (Geels, 2011), interventions disconnected from these challenges risk being perceived as superficial or peripheral, undermining their potential to drive lasting changes (Gaziulusoy & Brezet, 2015; Irwin, 2018; Rotmans et al., 2001). Grounding interventions in a clearly articulated societal issue strengthens their ability to mobilise stakeholders, leverage existing momentum, and create a shared sense of urgency and collective action and transformation (Loorbach, 2007; Meadowcroft, 2009).

Beyond issue identification, aligning interventions with strategic transition pathways is crucial for achieving desired transformation because pathways provide a frame for navigating intended societal shifts (Rotmans et al., 2001). For instance, pathways articulate the desired trajectory of change and anticipate key milestones and obstacles, enabling interventions to be strategically aligned and targeted in ways that contribute to broader transition goals through a coherent and coordinated approach (Geels, 2011; Goss et al., 2025a; Hyysalo et al., 2019; Smith et al., 2005). Interventions that lack alignment risk becoming fragmented efforts, limiting their capacity to contribute meaningfully to broader transition goals. Therefore, aligning with a recognised societal issue along a pathway enhances the legitimacy and relevance of interventions, increasing stakeholder buy-in and facilitating long-term desired changes (Loorbach, 2007; Meadowcroft, 2009).

6.3.3. Networkedness

A portfolio is a collection of networked interventions designed to address multiple dimensions of a complex societal challenge. A diverse portfolio, with interventions of varying types and degrees of disruption, increases the chances of engaging a variety of actors at different system levels, improving adoption and implementation (Klingebiel & Rammer, 2014; Si et al., 2022). It ensures that even if some interventions encounter obstacles, the overall system remains capable of progressing towards desired outcomes (Klingebiel & Rammer, 2014; Si et al., 2022). Additionally, a diverse portfolio of interventions enables actors to contribute to immediate improvements while also laying the groundwork for transformative changes, balancing incremental and radical interventions (Loorbach et al., 2010).

Effective transition design portfolios must also be complementary, synergistic, and reinforcing. *Complementarity* ensures that interventions target different actors, behaviours, and system levels, collectively addressing various aspects of the challenge (Geels & Schot, 2007; Markard et al., 2012). For instance, one intervention might focus on encouraging consumers to use leftovers more effectively, while another targets legislation to improve food labelling practices to reduce confusion regarding expiry dates. *Synergy* emerges when interventions interact to amplify their combined impacts (Irwin, 2015; van den Bosch, 2010). Continuing the same example, educating consumers on leftover use alongside clearer expiration date labels would likely have a greater effect together than either intervention would have alone. *Reinforcement* strengthens this further, ensuring that one intervention supports the success of another (Smith & Stirling, 2010). For instance, if government policies promote food waste labelling while simultaneously incentivising businesses to adopt waste-reducing packaging, these interventions reinforce each other, creating a more cumulative shift.

Finally, *coherence* in the portfolio ensures that interventions work within a unified strategic vision, whereby each intervention addresses a different aspect of the challenge—e.g., from consumer practices to business models to legislation (Dorst, 2011; Nguyen et al., 2018).

6.4. The transition design framework

We introduce a conceptual framework (Figure 6-1), linking five essential activities of transition design in the outer ring with three evaluative qualities of its outcomes in the inner ring. Building on the literature reviewed, we argue that these five activities – navigating scales, considering temporality, engaging and repositioning actors, framing and designing portfolios, and practising reflexivity – are essential for conceptualising and practicing transition design as it responds to complex societal challenges . These activities, rather than being linear steps, are integrated throughout the transition design process, influencing decisions and shaping interventions to address systemic complexity. Ultimately, they contribute to the design of interventions that are desirable for various actors in the transition, plausible for transforming behaviour over time in response to a societal issue, and, in combination with a networked portfolio, reflect a strategy for systems change.

Section 5 presents the transition design process used to develop proposed interventions, showing how the five activities were integrated across different design phases. Each intervention was then conceptualised as a drawing of a product-service system and accompanied by a narrative of a user engaging with the intervention. To evaluate the interventions, the three qualities (desirability, plausibility, networkedness) were translated in hypotheses and survey questions, and evaluated by consumers, companies, and experts through a mixed-methods approach.

Figure 6-1 | Framework representing 5 key transition design activities, connected to 3 key evaluative criteria of transition design interventions. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

6.5. The FETE transition design process

6.5.1. Project setting

The Netherlands, a leading producer and exporter of agricultural products, significantly shapes global food systems (Berkhout et al., 2018). Despite its influential role, the Dutch food system faces challenges similar to those of other developed nations, notably driven by societal expectations of abundance, convenience, and continuous availability (Evans, 2011, 2014). While prioritising excess and variety may satisfy consumer demands, it leads to considerable societal costs due to inefficient resource use (FAO, 2020). A major consequence of this is food waste, defined as

unnecessarily discarded food that remains suitable for human consumption (van Dooren & Knüppe, 2020).

Approximately one-third of food produced globally is wasted annually (UNEP, 2024). This level of waste strains resources, exacerbates food insecurity, and results in considerable economic and environmental costs (UNEP, 2024). Notably, food waste generates unnecessary greenhouse gas emissions from food production, distribution, and disposal, further intensifying pressure on ecosystems and contributing to climate change. As such, reducing food waste is widely recognised as one of the most effective strategies for addressing climate change (Bajželj et al., 2020; Beddington et al., 2012; Drawdown, n.d.; Stuart, 2009). In affluent countries like the Netherlands, food waste predominantly takes place at the consumer and retail levels (Beddington et al., 2012). In 2020 in the Netherlands, consumers generated the largest share of food waste, approximately 161 kilograms per capita, accounting for 36% of total national food waste (Soethoudt & Vollebregt, 2023). With the Netherlands' intention to halve food waste by 2030, in accordance with Sustainable Development Goal (target) 12.3, the country faces critical challenges in achieving this goal due to entrenched consumption and production practices (Lieshout & Knüppe, 2022).

This research is part of the "From Excess to Enough" (FETE) project, a collaborative initiative established in 2020 in response to the urgent challenges of food waste in the Netherlands. FETE brings together three Dutch universities and eight commercial and non-profit food system partners. The industry partners represent various roles and perspectives within the food system, including a national nutrition centre, a food waste foundation, an IT consultancy, a frozen food manufacturer, a waste collector, a food-focused business school, and a meal delivery service company. Together, the consortium explores how innovative consumer and retail practices, supported by novel business models, can facilitate a transition towards a food system based on "enough" rather than excess.

The transition design process followed in this research was iterative, moving between pragmatism and theory— which is typical of transdisciplinary research— while navigating the activities outlined in our framework to ensure interventions met the identified qualities (Figure 6-1). Throughout the design process, actors across multiple levels of the food system, both within and outside of the FETE consortium, were actively engaged. Given that the FETE partners focused on the household context rather than agricultural production, the design process focused on conceptualising micro-level interventions while linking these to meso- and macro-level systemic changes. For instance, enhancing food literacy through new product labels implies changes to organisational communication and wider packaging legislation. Moreover, the design process explored how interventions evolve temporally, aligning short-term adaptations with a long-term food system transition. The resulting portfolio consists of seven intervention sets, each with three variations, amounting to a total of 21 proposed interventions. All the interventions were designed to foster flexible and adaptable food consumption behaviours to reduce waste (Figure 6-5).

The transition design process toward these interventions followed five phases:

1. Developing a vision of a future food system
2. Aligning actor innovation efforts around a new food consumption practice (i.e., Adaptable consumption)
3. Exploring how to embed this practice within daily life through an intervention portfolio
4. Iterating on the proposed interventions to strengthen their transition design reasoning
5. Evaluating the interventions' effectiveness for systemic changes

An overview of the process is shown in Figure 6-2 and briefly described below. The present study focuses on the final phase: evaluating the proposed portfolio to assess intervention potential and reflect on the transition design process. While outcomes cannot fully capture the effects of a transition design process, they offer valuable insights into its contribution to systemic change.

6.5.2. Design phases

The **first phase** established a shared vision of a future food system in the Netherlands through a participatory process led by a design agency (Figure 6-3). This phase engaged actors from within and beyond FETE to co-create a desirable future scenario for 2030 focusing on "future food practices". The designers used the Vision in Design method (Hekkert and van Dijk (2011)) to support them in developing proposals grounded in the intended societal and behavioural impacts they aimed to facilitate in the future. The designers conceptualised this effect in reference to an anticipated future context, including both positive and negative developments, to avoid fixation on problems in the current food context and to work with the opportunities the future brings. While the description of the future food context was as neutral as possible—reflecting plausible and possible futures—the innovations as a response to the future were deliberately normative, transforming toward preferable futures. The resulting vision emphasised a future food system that prioritises vitality, embraces flexibility, celebrates the food journey, and leverages technology for learning. By linking individual food behaviours (micro) to organisational practices (meso) and societal norm changes (macro), and by considering how food practices might evolve over time, this phase laid the foundation for identifying systemic opportunities and barriers that informed subsequent phases. For more details, see Goss et al. (2024).

Building on this shared vision, the **second phase** introduced Adaptable Consumption—a proposed practice enabling households to adjust their food provisioning to minimise waste (Goss et al., 2025b; Goss et al., 2023, 2025d). The practice integrates flexibility (e.g., ingredient substitution, meal plan adjustments) and adaptability (e.g., using suboptimal food, optimising storage) to facilitate waste-

	 **1** **Developing a shared vision**	 **2** **Aligning toward a transition pathway**	 **3** **Embeddin change in everyday life**	 **4** **Refining transition design reasoning**	 **5** **Evaluating intervention proposals**
APPROACH	Participatory visioning led by a design agency that engaged 18 food system actors and experts in interviews, as well as FETE partners in 5 co-creation sessions.	2 innovation workshops together with FETE industry partners.	Diary and interview study that engaged 11 Dutch households.	Design sessions that synthesised feedback from industry actors and consumers to iterate upon the interventions.	Mixed-methods evaluation with 312 consumer, company, and expert participants.
PROCESS OUTCOME	Vision of a future food system that provides enough food for all with minimal waste based on four systems principles.	New consumption practice for the pathway of Embracing Flexibility. The pathway is supported by a proposed portfolio.	Insights on embedding adaptable consumption and its proposed interventions in everyday life.	Visual overview of feedback from phase 2 and 3, and an updated portfolio with explicit transition design reasoning.	Insights into the effectiveness of the proposed interventions in fostering the transition from excess to enough along the pathway of embracing flexibility.
DESIGN OUTCOME	Animated video and vision report.	User scenario and innovation portfolio.	5 opportunities for supporting household in adopting adaptable consumption.	Updated visualisations of 21 proposed interventions along with 21 narratives communicating each intervention.	
ACTIVITY PRACTISED	***Navigating scales:*** aligning micro-meso-macro changes. ***Considering temporality:*** projecting future changes. ***Engaging actors:*** co-developing a desired future vision. ***Framing & designing:*** translating possible systems into tangible principles.	***Engaging actors:*** co-developing shared strategies and pathways to "enough". ***Considering temporality:*** extrapolating behavioural changes over time. ***Framing & designing:*** designing interventions within a portfolio.	***Engaging actors:*** engaging consumers as experts of their own experiences. ***Framing & designing:*** integrating interventions into lived experiences.	***Practising reflexivity:*** evaluating and adjusting portfolio rationale. ***Framing & designing:*** explicating transition design reasoning for interventions. ***Navigating scales:*** aligning interventions across micro-meso-macro levels. ***Considering temporality:*** explicating anticipated influence of interventions over time.	***Practising reflexivity:*** assessing design process and outcomes. ***Navigating scales:*** evaluating systemic relevance. ***Considering temporality:*** assessing influence of interventions over time. ***Engaging actors:*** assessing interventions with three key actors groups.
INTERVENTION QUALITY	***Desirability:*** aligning long-term aspirations with actors' values. ***Plausibility:*** grounding the vision in realistic future developments. ***Networkedness:*** engaging diverse system actors in co-creating solutions.	***Desirability:*** ensuring alignment between future vision and actor contexts. ***Plausibility:*** mapping possible routes for change. ***Networkedness:*** developing a portfolio of joint interventions.	***Desirability:*** ensuring interventions resonate with consumers. ***Plausibility:*** embedding interventions within daily practices.	***Desirability:*** refining interventions based on multi-actor input. ***Plausibility:*** evaluating theory of change for each intervention. ***Networkedness:*** enhancing coherence across interventions in the portfolio.	Reporting findings on ***desirability, plausibility, and networkedness*** of proposed interventions.

Figure 6-2 | Overview of the transition design process, activities, and outcomes undertaken. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

free and flexible behaviours in daily life while contributing to broader systemic changes. Adaptable consumption was developed through two workshops with FETE industry partners, who identified Embracing Flexibility as a key strategic pathway for reducing food waste. They highlighted that existing Dutch food safety regulations highly prioritise safety over sustainability, limiting opportunities to experiment with new innovations. Discussions emphasised the need to realign values, balancing safety, quality, and sustainability. For more details, see Goss et al. (2023, 2025c).
To translate adaptable consumption into tangible design directions, we developed a user scenario depicting a family engaging in the proposed practice and an innovation portfolio with seven intervention concepts, each presented in three variations (Figure 6-4). The user scenario illustrated six key behaviours for the new practice: mixing and matching ingredients and flavours, assessing food quality with the senses, adjusting recipes for different portions, thinking on a meal level, adjusting food purchasing based on how much food they waste, and storing leftovers effectively to integrate them into meals. By framing adaptable consumption as an evolving practice over time, this phase developed intervention sets that also reflected a behavioural evolution over time. The proposed interventions emerged through an iterative designerly process, balancing conceptual exploration with practical considerations for what might evolve in the present, near-future, and far-future, and how flexible and waste-reducing behaviours might be supported at home. For more details, see Goss et al. (2025b).

The **third phase** examined how adaptable consumption could integrate into consumers' daily routines in ways that reflected their lived experiences. Through diaries and interviews with 11 Dutch households, we identified five key opportunities for adaptable consumption in homes: supporting flexible meal moments, reclaiming the edibility of food, reintegrating food into routines, integrating feedback loops, and playing into life-changing moments. These highlight how behavioural, material, and social dimensions shape food consumption, revealing ways to reduce waste and enhance household flexibility. For instance, flexible meal moments allow households to break from rigid routines, encouraging creative use of ingredients, while reclaiming food edibility through evaluating sensory cues or obtaining second opinions can prevent premature food disposal. For more details, see Goss et al. (2025b).

The **fourth phase** focused on refining the intervention portfolio based on insights from both the FETE actors (phase 2) and consumers (phase 6-3). Through a structured synthesis of feedback, each of the 21 interventions was assessed for its intended behavioural impacts on flexibility and waste reduction, reinforcing its role in fostering adaptable consumption (see Appendix F for all interventions and their design rationales). For instance, one design rationale for a new food waste bin is as follows: by offering consumers insight into how much, and what food they waste, they will have better visibility into their waste situation and be better equipped at adjusting what they buy based on what they waste (individual behaviour). This feedback increases their confidence in food provisioning for enough and helps them

feel more empowered to adapt their consumption practices (individual value). By introducing information flows about food waste on the household level, more targeted behavioural change can be introduced to reduce food waste (system behaviour). This information can be used to optimise food packaging, separation techniques, communication around food waste and to support various system policies and initiatives (e.g., province, municipality, neighbourhood) (systemic value). In this phase, we also revisited how interventions functioned as a portfolio, ensuring they targeted distinct yet complementary behaviours (see Figure 6-5). For more details, see Goss et al. (2025a).

Figure 6-3 | Impression of the formgiving of the video and report. Video by Freek Trimbach. Drawings and report by Reframing Studio. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

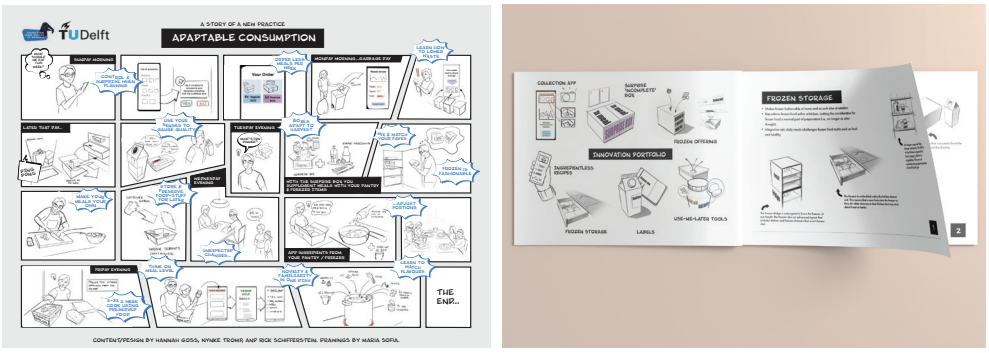


Figure 6-4 | Comic strip and proposed interventions, with three variants for different timeframes. Drawings by Maria Sofia. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

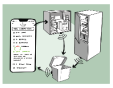
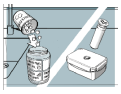
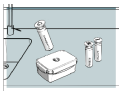
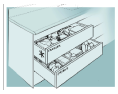
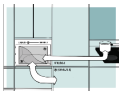
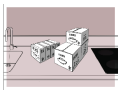
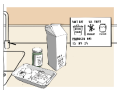
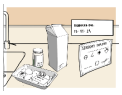
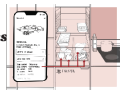
Set	Time variation 1 *(present)*	Time variation 2 *(near-future)*	Time variation 3 *(far-future)*
Waste Bin Insights	 **PSS 1 Countertop waste bin** Indicates the number of wasted food portions.	 **PSS 2 Smart food waste bin** Tracks food waste levels and types, provoding data and tips for consumption practices.	 **PSS 3 Smart kitchen system** Uses a grocery app to optimise shopping based on food consumption, stock, and waste patterns.
Use-me-later Tools	 **PSS 4 Preservation duo** Containers that extend ingredient shelf life and provide preservation tips.	 **PSS 5 Food life-extending tools** Includes dehydrator, freezer, and vacuum storage for optimal preservation.	 **PSS 6 Preservation pods** Equipped with sensors to monitor and maintain food freshness.
Freezer Integration	 **PSS 7 Fridge-freezer drawers** Keeps food organised, visible, and in optimal condition.	 **PSS 8 Quick-freeze and defrost device** Maintains ingredient quality and simplifies meal preparation.	 **PSS 9 Speed freeze bags** Improves frozen ingredient visibility, nutrient preservation, and enables quick defrosting.
Frozen Ingredients	 **PSS 10 Frozen meal packages** Tailored to dietary needs for better meal integration.	 **PSS 11 Personalised frozen meals** Optimises portion sizes and ingredient selection.	 **PSS 12 Dissolvable packaging** Enhances visibility, preservation, and portioning of frozen ingredients.
Consumption Boxes	 **PSS 13 Consumption boxes** Mix of fresh and long-shelf-life ingredients to simplify meal	 **PSS 14 Integrated boxes** Syncs with household schedules to adjust meal plans and preferences.	 **PSS 15 Growth boxes** Adapts ingredients and portions based on evolving needs.
Assessment Labels	 **PSS 16 Freshness labels** Helps determine ingredient freshness and safety.	 **PSS 17 Sensory labels** Guides food evaluation through smell, texture, and other sensory inputs.	 **PSS 18 Minimalist labels** Displays production date for consumers to assess food quality using existing food knowledge.
Ingredientless Recipes	 **PSS 19 Ingredientless recipes** Encourages improvisation with available, local, and seasonal ingredients.	 **PSS 20 Ingredientless menus** Supports meal planning around seasonal, local menus instead of specific ingredients.	 **PSS 21 Ingredientless eating** Promotes cooking based on techniques, styles, and flavors rather than fixed ingredients.

Figure 6-5 | Overview of the 21 product service systems designed and tested in this study, as well as which intervention set they belong to. See Appendix F for more detailed explanations of the interventions. Drawings by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

6

The **final phase** of the process, reported in this paper, focused on evaluating the proposed interventions to assess their desirability, plausibility, and networkedness as outlined in our framework. This large-scale study, conducted with consumers, food system companies, and experts, provides insights into the perceived effectiveness of the proposed interventions and their potential to contribute to a transition toward a food system with minimal waste.

6.6. Hypotheses

Based on our conceptual framework, we formulated a series of hypotheses to examine the perceived desirability, plausibility, and networkedness of the proposed interventions. By investigating these qualities, we aim to determine the potential effectiveness of the interventions in fostering desired systemic change, i.e. supporting adaptable consumption as a strategy to reduce food waste. The hypotheses (detailed below) address three hierarchical levels: the portfolio, the intervention sets, and the individual product-service systems (proposed interventions). Rather than serving as

traditional theory-testing tools, these hypotheses function as structured evaluative instruments, enabling us to assess both the characteristics of the interventions and, indirectly, the effectiveness of the transition design process that created them

6.6.1. Desirability

Given that the transition design process engaged diverse actors and that the interventions were designed to support a new practice of consumption that aligns across timeframes, we hypothesise that:

H1—There is a positive perceived desirability reported across all groups

H1 is tested using:

H1a—There is a positive perceived value across all actor groups

H1b—There is a positive perceived innovativeness across all actor groups

H2— The perceived innovativeness increases with time (Time 1 < Time 2 <Time 3)

H3—The time to market increases from Time 1 to Time 3 (Time 1 < Time 2 < Time 3)

6.6.2. Plausibility

Given that the interventions were designed along a pathway toward the transition in a multiple-actor setting, we hypothesise that:

H4—There is a positive perceived plausibility reported across all groups

H4 is tested using:

H4a—There is a positive perceived likelihood to contribute positively to the systemic pathway (i.e., minimise food waste and support flexibility)

H4b—There is a positive perceived likelihood to lead to the intended behavioural effects

H5—Far away interventions are equally plausible to near interventions, as the design process was created for that (Time 3 = Time 2 = Time 1)

H6—The effects of the interventions on food waste reduction are mediated by increasing flexibility (i.e., the interventions contribute to the societal challenge of food waste through the pathway of embracing flexibility)

6.6.3. Networkedness

Given that a portfolio of interventions was designed to support an envisioned practice, we hypothesise that:

H7a—There is perceived diversity among intervention sets within the portfolio

H7b—There is perceived complementarity between the intervention sets

H7c—There is perceived synergy among the intervention sets

H7d—There is perceived reinforcement among the intervention sets

H7e—There is perceived coherence among the intervention sets

6.7. Method

This study employed an embedded mixed-methods design, in which a primarily quantitative research survey approach was complemented by qualitative insights from open-ended survey responses (Almeida, 2018). In this type of design, both forms of data are collected and analysed concurrently, but the qualitative component plays a secondary, supportive role within the broader quantitative framework. We used this approach to examine how different actor groups evaluated 21 proposed interventions aimed at supporting systemic changes in the food system. The evaluation was informed by a literature review that shaped the conceptual framework, which we subsequently tested through narrative-based interventions and a structured, multi-factorial design. To gather these evaluations, participants assessed each intervention using a questionnaire that combined structured response scales with open-ended questions. Each intervention was introduced through an illustrated drawing accompanied by a narrative describing how a person would interact with the intervention in everyday life.

Narratives, widely used in design, were chosen for this study given their effectiveness in allowing individuals to imagine hypothetical situations and assess the behavioural impacts of prospective products (Tromp & Hekkert, 2016; van der Maden, 2024). They have been recognised as effective tools for evaluating speculative interventions, particularly when aiming to understand behavioural implications in imagined or speculative contexts (Candy & Dunagan, 2017; van den Hende, 2010). Rather than evaluating real-world effectiveness, narratives enable participants to assess whether interventions are desirable for various actors in the transition, whether they are plausible for transforming behaviour over time in response to a societal issue and pathway, and – when considered as part of a networked portfolio - reflect a strategy for systems change. A crucial aspect of narrative studies is the believability of the narratives themselves, as deeper engagement in stories enhances participants' ability to provide realistic evaluations (Green & Brock, 2000; Shapiro et al., 2010). While this narrative approach enables rich, future-oriented engagement with systemic change concepts, we acknowledge that participants' evaluations are interpretive and based on imagined scenarios, rather than real-world trials.

The study involved three distinct participant groups: consumers, companies, and experts (e.g., designers, food scientists, and behavioural change researchers). These groups were selected to reflect the need for transition design interventions to align with individual behaviours and organisational contexts to foster desired changes. Participants evaluated seven product-service-system (PSS), one from each of the seven sets (see Figure 6-5). The PSS variation and the order in which they were presented were randomised. This setup allowed us to mitigate order effects, avoid a systematic difference in the distribution of participants across the three time variations between the seven sets, and minimise participant fatigue by limiting the amount of information being processed.

The study was conducted between July and October 2024, and it obtained ethics approval (approval number 1332) from the University's Human Research Ethics Committee.

6.7.1. Participants

The study included three distinct participant groups—consumers, companies, and experts— selected to provide diverse perspectives on the research topics. Appendix G provides an overview of the demographic and background characteristics of these groups. Due to time and resource constraints, the study was conducted in English, and all participants were fluent in the language. Care was taken to avoid overly complex wording in the study materials, and Dutch translations were provided for less familiar terms where necessary. Additionally, participants could respond to open-ended questions in Dutch, which were later translated for analysis.

The consumer group consisted of 220 participants, recruited through the online platform Prolific, all of whom resided in the Netherlands. From an initial sample of 242 respondents, 22 were excluded due to failed screening questions or exceeding the time limit for survey completion. The consumer group was largely composed of Dutch nationals (65%). Participants belonging to the consumer group generally completed the questionnaire within 18 minutes. They received financial compensation according to Prolific standards.

The company and expert groups included 92 participants, retained after removing incomplete responses from an initial 121 recruited. The final company sample included 33 participants with an average of 14 years of professional experience. The final expert sample included 59 participants with an average of 12 years of professional experience. Both company and expert participants were recruited through the authors' networks and were contacted using direct mail, social media (e.g., LinkedIn), and mailing lists. We invited participants with expertise in the food domain (e.g., food technology, nutrition, food product development, food design, food policy, food marketing), consumer behaviour, or design (e.g., social design, systemic design). Potential participants received an invitation that contained a link to the Qualtrics questionnaire. They did not receive financial compensation.

Both company and expert participants represented expertise primarily in design (58%), consumer behaviour (56%), (food) product development (54), and food technology and nutrition (48%). The company representatives were mainly involved in food production (39%), processing and manufacturing (33%), and marketing (27%). The company and expert group participants were generally older and included slightly higher female representation than the consumer group. Additionally, they spent approximately twice as long to complete the questionnaire than consumers (41 to 42 minutes).

6.7.2. Interventions

In this study, participants evaluated design interventions described in drawings and

a narrative story, which served as the stimuli for hypothesis testing. Seven sets of proposed transition design interventions were evaluated, each consisting of three variations of product-service-systems (PSSs), planned for phased implementation over time (Figure 6-5)—the present (Time 1), near-future (Time 2), or far-future (Time 3). These intervention sets were designed by the authors (three with a background in design, and the fourth with a background in sensory food experience) and visualised by a research assistant (a graduate student in Integrated Product Design at TU Delft). Illustrations of the 21 proposed interventions were accompanied by short narratives, on average 206 words long (word range 137 – 306), describing a person using the intervention and encountering its attributes and benefits by taking different actions in a specific context of use. The narratives provide a sequence of events in chronological order, which enhances the degree of realism of the described situation, allowing participants to imagine their own prospective engagement (Green & Brock, 2000; Shapiro et al., 2010). The 21 narratives were developed by the authors, who carefully considered factors influencing perceived realism, such as the inclusion of concrete details, familiar settings, and the logical flow of events. The first author is a native English speaker, and the other co-authors are fluent in Dutch and English, ensuring that the narratives would be comprehensible to non-native English-speaking participants (i.e., international and Dutch people living in the Netherlands). See Appendix D for an example of one narrative used in the study with its corresponding intervention. Full materials of all sets are available at Goss et al. (2025c).

6.7.3. Procedure and measures

The questionnaire was developed using Qualtrics and administered to the three participant groups. These three groups followed two procedures: one designed for consumer participants and one for company and expert participants. The procedure was largely similar for both groups, with some variations in background questions and evaluation questions for the interventions, and some additional questions for the portfolio.

After providing informed consent, all participants were asked if they were comfortable reading and understanding English, and those who answered negatively were excluded from the study. Additionally, participants in the consumer group were asked whether they currently lived in the Netherlands, and those who responded negatively were removed from the study. For the consumer group, the questionnaire proceeded directly to the main survey. Participants in the company and expert groups were first asked to provide additional information regarding their professional backgrounds. They selected from various options, such as working in the food supply chain, conducting research and education, or developing government policy. Participants were asked about their area of expertise, years of experience, and the geographic region in which their activities were related. Company participants also indicated the role of their company in the food system (see Appendix G).

Subsequent questions were rated on a 7-point response scale (1=strongly disagree, 2= disagree, 3= somewhat disagree, 4=neither agree nor disagree, 5= somewhat agree, 6= agree, 7=strongly agree) unless otherwise specified. All participants were then instructed to read seven stories, each describing one of the PSS variations within the intervention sets. Each story included a drawing of the intervention described. For the consumer group, participants answered ten questions after reading each story. Eight of these questions were rated on the response scale described above (i.e., "I can see myself using this innovation," "It would be attractive for a company to develop an innovation like this," "This innovation is a new and creative solution to the problem of food waste," "This innovation will contribute to minimising food waste," "This innovation will contribute to making consumption patterns more flexible," "This innovation stimulates [individual behaviour A]," "This innovation stimulates [individual behaviour B]," "This story is believable"). See Appendix E, Table E1, for the individual behaviours outlined for each intervention set. The ninth question was a categorical response (yes/no/maybe) ("Do you think this innovation will (eventually) be available to consumers?"), and the tenth question was rated on a linear visual analogue scale running from 0 to 20 years ("How many years before this innovation will be available to consumers?").

The company and expert participants answered similar questions but focused on their professional perspectives. Most of the questions were identical, with the first two items being rephrased as "The innovation is something I can see consumers using" and "It would be attractive for a company to contribute to developing an innovation like this." The question items were always presented in the same order as indicated above. After evaluating each intervention, participants were provided with an open question to add any additional comments. For consumers, an attention check was randomly inserted between the intervention evaluations in the questionnaire.

After evaluating all seven innovations, the company and expert participants were asked to rate the extent to which the portfolio of innovations demonstrated five specific qualities (i.e., diversity, coherence, complementarity, reinforcement and synergy) on a 7-point scale response scale (1 = far too little, 2 = moderately too little, 3 = slightly too little, 4 = neither too much nor too little, 5 = slightly too much, 6 = moderately too much, 7 = far too much). These additional questions were not posed to consumers because evaluating portfolio dynamics requires a systemic perspective and specialised domain knowledge that is typically more aligned with the expertise of companies and domain experts. Finally, both groups were asked to report their gender and age.

6.7.4. Data analysis

To examine how participants evaluated the interventions in terms of desirability, plausibility, and networkedness, we conducted a mixed-factorial analysis of variance (ANOVA) of the quantitative survey responses. The analysis focused on comparing

mean responses across participant groups to assess how the proposed interventions were perceived in relation to their potential contributions to systemic change. To complement this, we reviewed open-ended responses to explore how participants' reasoning could help interpret the quantitative results.

The mixed-factorial design included both between- and within-subjects factors. The between-subject factor was Participant group (three levels: consumer, company, expert), and the within-subjects factors were Intervention Set (seven levels: waste bins, use-me-later tools, freezer integration, frozen ingredients, consumption boxes, assessment labels, ingredientless recipes), and Time (three levels: now, near future, far future). Descriptive statistics (means and standard deviations) were calculated for all conditions. Inferential analyses were conducted using ANOVA to examine the main and interaction effects of Participant Group, Intervention Set, and Time on perceived intervention effectiveness. Tests among the three product–service–systems (PSSs) variants within a single set always involved between-subjects comparisons. Tests across different sets involved both within- and between-subjects elements, since interventions from multiple sets were randomly assigned to each participant. Consequently, the experimental structure did not permit isolation of repeated-measures effects from between-subjects variance. Therefore, all comparisons were treated as between-subjects in the statistical analysis.

All quantitative analyses were performed using SPSS (version 28). Reported results include F-values, p-values, and partial η^2 as a measure of effect size. Where significant effects were observed, Bonferroni-corrected pairwise comparisons of means were used to account for multiple testing. In comparisons of means for separate PSSs in the different participant groups we used observed means and standard errors rather than marginal means with pooled error estimates. A detailed mapping of survey questions to their corresponding dependent variables is provided in Appendix E, Table E2.

In addition to the quantitative analysis, we reviewed open-ended responses to identify recurring themes that contextualised participants' evaluations. While this qualitative data was not systematically coded, all open response were exported into Excel, organised by Set and PSS, and coloured coded into common themes. This revealed patterns such as perceived effort, convenience, personalisation, and ethical considerations. These insights supported interpretation of the quantitative findings and offered a deeper understanding of how different actor groups perceived the interventions.

6.8. Results

To structure the presentation of our results, we follow the sequence of the hypotheses formulated in Section 6.6 concerning desirability, plausibility, and networkedness. Prior to this, however, we assessed whether participants perceived the narratives as believable, to ensure that the use of narratives was meaningful and comprehensible from the participants' perspective.

6.8.1. Manipulation check

On average, participants across all groups rated the believability of the stories above the neutral midpoint of the 7-point scale (M = 5.05), indicating general agreement that the scenarios were plausible. This pattern held consistently across participant groups, with group mean ratings ranging from 4.89 to 5.11. Believability scores (item 1 in Table E1) for the 21 individual PSSs ranged more widely (from 3.73 to 5.92), but all were at or above the midpoint. Therefore, participants rated the PSSs at least close to 4 (=do not agree nor disagree) up to almost 6 (=agree) on the believability item, suggesting that no intervention was broadly rejected as implausible. These results confirm that the narrative stimuli were sufficiently credible to serve as the basis for further analysis.

6.8.2. Desirability

To assess the overall desirability of the interventions, we combined participants' ratings of Value (item 2 and 3) and Innovativeness (item 4) into a single composite score. These two dimensions were both conceptually aligned and statistically correlated, with the three-item scale demonstrating satisfactory internal consistency (Cronbach's $\alpha = 0.746$; see Table 6-1). Across all actor groups, mean desirability ratings were above the midpoint of the 7-point scale, with an overall portfolio mean of 4.88. No statistically significant differences were found in ratings between consumers (M=4.91), companies (M=4.90), and experts (M=4.75), indicating a broad agreement that the interventions were desirable. These findings support hypothesis 1.

Similar patterns emerged when examining Value and Innovativeness as separate dimensions (Table 6-1). All mean ratings for value were consistently high across groups, and although innovativeness scores were slightly lower, all remained significantly above the neutral midpoint (based on mean ± 2SE). This reinforces the conclusion that participants viewed the interventions not only as valuable but also as innovative.

When looking at the 21 PSSs, mean desirability ratings showed similar variation but followed a consistent pattern across the different actor groups. Consumer mean ratings ranging from 4.10 to 5.59, companies from 3.94 to 5.80, and experts from 4.10 to 5.59 (see Appendix H). Only 2% of the PSSs received means below 4, providing further support for the conclusion that the interventions were broadly desirable. Therefore, these results also generally confirm H1.

While desirability was generally high across the portfolio, some interventions stood out as notably more or less appealing to different actor groups. The 'Countertop Waste Bin' (PSS 1) consistently received the lowest mean ratings, particularly among experts (3.51), while the 'Fridge-Freezer Drawers' (PSS 7) also scored relatively low, especially among companies (M = 4.22) and consumers (M = 4.35). On the other hand, 'Food Life Extending Tools' (PSS 5) was considered to be most desirable,

particularly by companies (5.80), while consumers (5.34) and experts (4.81) assessed it as moderately desirable. 'Preservation pods' (PSS 6) also received high ratings from consumers (5.59), with companies (5.10) and experts (4.91) indicating moderate desirability (see Appendix H). One PSS—'Minimalist Labels' (PSS 18)—elicited the most divergent responses. Experts rated it relatively high (M=4.96), while companies (3.94) and consumers (4.38), were less enthusiastic.

Innovativeness

Participants perceptions of innovativeness generally increased across the three time points (from Time 1 to Time 2) and remained high at Time 3. To test this pattern (hypothesis H2), we conducted an analysis of variance (ANOVA) to compare mean innovativeness ratings (item 4) over time with Set, Time and Participant group as between-subjects factors. As expected, the results indicated a significant main effect of Time at the portfolio level [$F(2, 2121) = 22.77$, $p < 0.001$, $\eta^2 = 0.021$], showing that ratings increased from Time 1 (M=4.26) to Time 2 (M=4.95), then slightly decreased at Time 3 (M=4.83), though no significant difference was observed between Time 2 and Time 3 ($p > 0.20$). These results indicate that participants viewed future-oriented interventions as more innovative, though perceptions levelled off between the near and far future.

Table 6-1 | Observed mean ratings and standard errors (SE) for Believability, Desirability, and Plausibility for the different groups at the portfolio level.

Constructs	**Item (see Table E2)**	**Cronbach's Alpha**	**Consumers** *(n=220)*		**Companies** *(n=33)*		**Experts** *(n=59)*	
			Mean	***SE***	***Mean***	***SE***	***Mean***	***SE***
Believable	1	-	5.11	0.04	5.00	0.10	4.89	0.08
Desirability	2 - 4	0.75	4.91	0.03	4.90	0.09	4.75	0.06
Value	2, 3	0.76	4.98	0.04	5.00	0.09	4.87	0.07
Innovativeness	4	-	4.77	0.04	4.71	0.12	4.53	0.08
Plausibility	5 - 8	0.84	5.26	0.03	5.31	0.08	5.03	0.06
Systemic change	5, 6	0.76	5.00	0.03	5.00	0.09	4.78	0.06
Behavioural change	7, 8	0.82	5.52	0.03	5.61	0.08	5.28	0.06

We also examined differences in perceived innovativeness across actor groups. A small but statistically significant main effect of Participant Group was found [$F(2, 2121) = 5.36$, $p = 0.005$, $\eta^2 = 0.005$]. Experts found the 21 PSSs to be less innovative (4.52) than companies (4.73) and consumers (4.77). No two-way interaction effect between Group and Time was observed [$p = 0.485$] (see Table 6-2), suggesting that while experts were generally more cautious in their assessments, the overall trend of increasing innovativeness over time was consistent across all groups.

Perceptions of innovativeness over time varied by intervention set (Figure 6-6). While most sets followed the general trend of increasing ratings from Time 1 to Time 3, some deviated from this pattern. While ratings increased with time for most sets, the 'Ingredientless Recipes' showed little change with time, while the 'Assessment Labels' saw ratings drop over time. A two-way ANOVA revealed a significant main effect of intervention Set [$F(6, 2121) = 7.36$, $p < 0.001$, $\eta^2 = 0.020$], as well as a significant Set x Time interaction [$F(12, 2121) = 4.38$, $p < 0.001$, $\eta^2 = 0.024$]. This two-way interaction indicates that the Time effect is different for the different intervention sets (Figure 6-6). To explore these differences, we conducted separate two-way ANOVAs (Time × Participant Group) for each set. Most sets showed the expected pattern: lower innovativeness at Time 1, rising at Time 2, and remaining steady or slightly declining for Time 3. However, for the 'Ingredientless Recipes' set, the time effect just missed statistical significance [$F(2, 303) = 2.99$, $p = 0.052$, $\eta^2 = 0.019$], with means varying from 4.15 (Time 3) to 4.85 (Time 2). Additionally, a notable deviation was found in the 'Assessment Labels' set, where perceived innovativeness significantly decreased over time [$F(2, 303) = 4.03$, $p = 0.019$, $\eta^2 = 0.026$] from 5.10 at Time 1, to 4.88 at Time 2, to 4.34 at Time 3. Pairwise comparisons with Bonferroni correction revealed that the difference detected between Time 1 and Time 3 was significant ($p = 0.018$) while the difference between Time 1 and Time 2 was not ($p = 1.000$).

Intervention availability

To assess expectations about whether the proposed interventions would eventually become available to consumers, we asked participants to indicate both the likelihood of availability ('yes', 'maybe', 'no') (item 9 in Table E2), and their estimated time frame on a scale of 0-20 years (item 10 in Table E2), thereby addressing hypothesis 3. Overall, we found that consumers expressed greater confidence in the future availability of the interventions compared to companies and experts. Specifically, the proportion of 'yes' responses were as follows: 57% of consumers believed the interventions would become available, while this belief was shared by only 49% of company representatives and 50% of experts. In contrast, the 'maybe' responses were more common among companies (37%), and experts (36%) than consumers (30%). The percentages of people who indicated that a PSS would not become available were similar for the three participant groups (12% for consumers, 14% for companies, and 14% for experts). A Kruskal-Wallis test for independent samples revealed that

these differences in response distributions among the three groups were statistically significant [H(2) = 9.36, p = 0.009]. Additionally, post-hoc pairwise comparisons showed that consumers differed significantly from both companies and experts [p < 0.05]. These findings highlight differing perceptions across actor groups, with consumers more inclined to see the interventions as achievable, while professionals in the field expressed greater uncertainty.

If participants answered *no* for item 9, they were not prompted to enter an estimate for the number of years before the intervention would be introduced (item 10). Since the percentages were similar in the three groups, we decided to continue our analyses for item 10 without any need for further corrections. Overall, participants anticipated a longer wait for interventions to reach the market the further they were positioned in the future (see Table H1). An ANOVA of item 10 confirmed a significant main Time effect [$F(2, 1844) = 41.66$, $p < 0.001$, $\eta^2 = 0.043$], alongside a significant main Set effect [$F(8, 1844) = 28.77$, $p < 0.001$, $\eta^2 = 0.086$] and a significant Time x Set interaction [$F(12, 1844) = 6.91$, $p < 0.001$, $\eta^2 = 0.043$]. Average time estimates increased across the three time points from 2.57 years for Time 1 to 3.92 for Time 2, and 4.73 for Time 3. These differences were statistically significant in pairwise comparisons using Bonferroni corrections [$p < 0.01$]. No main effects of Participant group [$p > 0.20$] were found, suggesting consistent expectations across consumers, companies, and experts.

To explore the interaction between time and intervention type, we analysed each intervention set separately using two-way ANOVAs. For the first five sets (Figure 6-1), participants consistently estimated longer timeframes as the interventions moved from present-day (Time 1) to far-future (Time 3), with significant time effects in all cases [p <0.01; 0.037, η^2, 0.163]. In paired comparisons with Bonferroni correction, Time 1 differed significantly from Time 3 in all five sets ($p < 0.01$), and in three cases also from Time 2 (p<0.01). Only one set showed a significant difference between Time 2 and Time 3 ($p < 0.01$). For the final two intervention sets, no significant time effects were found [$p > 0.10$; η^2 , 0.016], indicating stable expectations across time frames.

Qualitative feedback on desirability

To further explore participants' perceptions of desirability, we analysed their open-ended responses to the interventions. Overall, participants perceptions of desirability were shaped not only by perceived benefits, but also by anticipated barriers related to effort, trust, and relevance. Many participants highlighted convenience and personalisation as important qualities that made interventions desirable. At the same time, concerns emerged about data privacy, particularly in relation to the 'Waste Bins' and 'Consumption Boxes' sets, which were perceived to involve data collection and sharing . Additionally, intervention sets, such as the 'Ingredientless Recipes' or 'Assessment Labels', were described as cognitively demanding, requiring planning, decision-making, and interaction with new technologies. Participants found these factors off-putting. Practical concerns also influenced perceived desirability. The

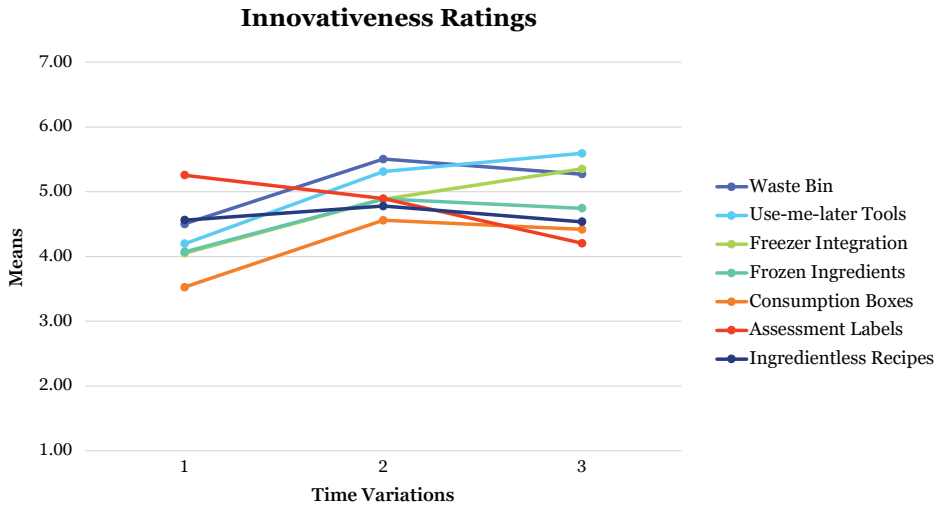


Figure 6-6 | Mean innovativeness ratings over time for the 7 Sets and 21 PSS. Responses varied from 1 = strongly disagree to 7 = strongly agree. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Table 6-2 | Observed mean ratings, standard errors, and p-values for each participant group over time for Value, Innovativeness, and Plausibility. Responses varied from 1 = strongly disagree to 7 = strongly agree.

Construct	**Time 1**		**Time 2**		**Time 3**		**F Test**
	Means	***SE***	***Means***	***SE***	***Means***	***SE***	***p-value***
Value							
Consumers (n=220)	4.90	0.06	5.03	0.06	5.00	0.06	0.334
Companies (n=33)	4.90	0.18	5.13	0.15	4.99	0.16	0.610
Experts (n=59)	4.97	0.12	4.66	0.12	4.99	0.10	0.067
Innovativeness							
Consumers (n=220)	4.36	0.07	5.05	0.07	4.92	0.07	< 0.001
Companies (n=33)	4.25	0.21	5.14	0.18	4.82	0.20	0.005
Experts (n=59)	4.18	0.15	4.65	0.12	4.75	0.12	0.006
Plausibility							
Consumers (n=220)	5.03	0.05	5.44	0.05	5.31	0.05	< 0.001
Companies (n=33)	5.08	0.14	5.53	0.12	5.35	0.14	0.057
Experts (n=59)	4.93	0.11	4.91	0.09	5.26	0.09	0.020

'Fridge-Freezer Drawers' (PSS 7) was viewed as energy-intensive, while 'Dissolvable Packaging' (PSS 9) raised concerns about food safety. Additionally, some participants felt that intervention sets like the 'Consumption Boxes' and 'Frozen Ingredients' lacked novelty, noting their similarity to other products on the market.

6.8.3. Plausibility

Overall, participants generally viewed the interventions as plausible, supporting hypothesis H4. We assessed this using the means of items 5 to 8 ($\alpha = 0.845$). At the portfolio level, average plausibility ratings were relatively high (M = 5.22). Additionally, a significant main effect of Participant group emerged [$F(2, 2121) = 6.16$, $p = 0.002$, $\eta^2 = 0.006$], with consumers (M = 5.26) and companies (M = 5.28) rating the portfolio as more plausible than experts (M = 5.05). A paired comparisons with Bonferroni correction confirmed these differences to be statistically significant ($p < 0.05$). Across the 21 PSSs, the mean ratings for each group followed a similar pattern: consumer ratings ranging from 4.62 to 5.83, companies from 4.36 to 5.89, and experts from 4.06 to 5.69 (see Table H1).

Some interventions were consistently seen as more plausible than others. The 'Fridge-Freezer Drawers' (PSS 7) received the lowest mean ratings from companies (M = 4.36) and consumers (M = 4.62), while experts rated it slightly more plausible (M = 4.79). The 'Countertop Waste Bin' (PSS 1) was rated as least plausible by experts (M = 4.06) and moderately plausible by companies (M = 4.77) and consumers (M = 4.77). On the other hand, the Food Life Extending Tools' (PSS 5) was rated most plausible by companies (M = 5.80) and consumers (M = 5.67), though experts gave it a slightly lower rating (M = 4.95). Other PSSs with high overall ratings were the 'Ingredientless Recipes' (PSS 19) and the 'Ingredientless Menus' (PSS 20) (see Appendix H). Overall, these findings support the general conclusion that, while ratings varied by actor group, the proposed interventions were broadly considered plausible, thereby confirming hypothesis H4.

Further analysis distinguished between two related aspects of plausibility: 1) the contribution to the systemic challenge to reduce food waste, and 2) the intended behavioural effects on individual and systems-level flexibility (Table 6-1). Although these aspects were highly correlated and were combined into a single indicator of perceived plausibility for hypothesis testing, the mean values diverged. Participants rated the contribution to systemic change (items 4 and 5) as less plausible than the intended behavioural effects (items 7 and 8) (mean difference 0.525, $p < 0.001$). This suggests that participants found the interventions' potential to change individual behaviour more plausible than their ability to drive large-scale systemic change. See Appendix H for the means and standard errors (SE) for all 21 PSSs for each participant group.

Plausibility over time

We explored whether participants' perceptions of plausibility changed depending on how far into the future an intervention was positioned (hypothesis 5). We found that perceived plausibility increased from Time 1 to Time 3 for all groups, indicating an increase in expected impact for the more futuristic interventions.

Plausibility was measured using items 5 to 8 ($\alpha = 0.846$) and mean scores were compared across three time points. A significant main Time effect emerged [$F(2, 2121) = 8.52$, $p < 0.001$, $\eta^2 = 0.008$], indicating that, overall, participants rated interventions sets further into the future as more plausible. However, this trend differed across groups, as indicated by a significant Time x Participant group interaction [$F(4, 2121) = 3.01$, $p = 0.017$, $\eta^2 = 0.006$] (see Table 6-2). For consumers, plausibility ratings increased significantly over time [$F(2,1519) = 17.72$, $p < 0.001$, $\eta^2 = 0.023$], with the lowest ratings at Time 1 (5.04) compared to Time 2 (5.49) and Time 3 (5.32).[2] The differences between Time 2 and Time 3 ($p > 0.20$) were not statistically significant, suggesting a plateau in perceived plausibility beyond the near future (Time 2). A similar trend was observed for companies. Company mean ratings also increased from Time 1 (M = 5.04) to Time 2 (M = 5.48) and Time 3 (M = 5.32), but this effect just failed to reach statistical significance [$F(2,210) = 2.75$, $p = 0.066$, $\eta^2 = 0.026$]. Among experts, plausibility scores rose more gradually. No significant difference was observed between Time 1 (M = 4.95) and Time 2 (M = 4.93), but ratings significantly increased at Time 3 (M = 5.26), [$F(2, 392) = 3.95$, $p = 0.020$, $\eta^2 = 0.020$], with an increase from Time 2 to Time 3 reaching statistical significance ($p < 0.05$).

Taken together, these results suggest that participants in all groups perceived far future interventions (Time 3, M= 5.26 - 5.32) as more plausible that present day ones (Time 1, M = 4.95 - 5.04). This difference was statistically significant for consumers and experts, and just failed to reach significance for the companies, possibly due to the smaller sample size. This suggests that plausibility increased for all groups between Time 1 and Time 3. However, groups differed in how they evaluated near-future (Time 2) interventions, with experts generally less convinced by their plausibility than consumers and company representatives.

Mediation of plausibility

We examined whether participants' belief that interventions could reduce food waste was partly explained by how much those interventions were expected to increase behavioural flexibility (hypothesis 6). Using the Hayes PROCESS macro version 4.2 in SPSS (Model 4) we conducted a mediation analysis to investigate the interrelationships among the components of plausibility: We tested whether the specific behavioural effects of the different interventions led to more flexibility, and

2 The marginal means from the ANOVA for plausibility over time are reported in the text and may differ slightly from the observed means presented in the tables.

whether this flexibility increase was responsible for the expected decrease of food waste, or whether there was another path, independent of the effect of flexibility on food waste.

For all three actor groups—consumers, companies, and experts—the analysis confirmed that behavioural flexibility partly mediated the relationship between an intervention's behavioural effects and its perceived ability to reduce food waste. For the consumer data at the portfolio level (Figure 6-7), all paths in the mediation model were statistically significant ($p < .001$), supporting the role of flexibility as a mediator between behavioural effects and expected reductions in food waste. The indirect effect through flexibility was significant, with a bootstrap coefficient of 0.24 (SE = 0.02, 95% CI [0.2053, 0.2841]). As shown in Table 6-5, similar analyses conducted for companies and experts yielded comparable results: all path coefficients, including the indirect effects, were significant. These findings indicate a consistent pattern across actor groups. Because both the direct and indirect effects were significant in each case, we interpret this as partial mediation—suggesting that increased behavioural flexibility partly explains why participants believe the interventions could help reduce food waste, while also recognising that other mechanisms are likely at play.

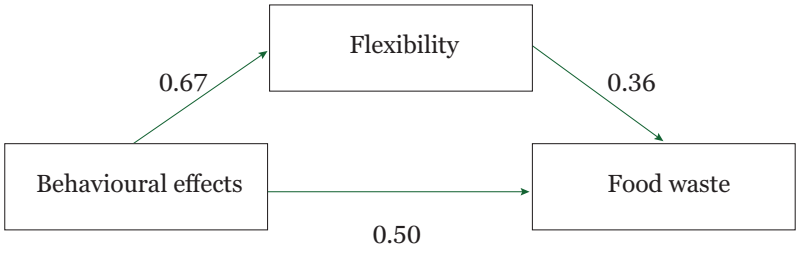


Figure 6-7 | Mediation analysis for the effect of flexibility on reducing food waste on the portfolio level for consumer responses. Based on Hayes Process Model 4. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Table 6-5 | Mediation analyses for the portfolio level for the different participant groups. Based on Hayes Process Model 4.

	Behavioural effects - Food waste		**Behavioural effects - Flexibility**		**Flexibility – Food Waste**		**Combined indirect effect**	
	Coefficient	*SE*	*Coefficient*	*SE*	*Coefficient*	*SE*	*Coefficient*	*Bootstrap SE*
Consumers	0.50	0.02	0.67	0.03	0.36	0.02	0.24	0.02
Companies	0.39	0.07	0.73	0.07	0.35	0.05	0.26	0.05
Experts	0.39	0.05	0.65	0.05	0.36	0.04	0.24	0.03

Qualitative feedback on plausibility

To deepen our understanding of how participants perceived the plausibility of the interventions, we reviewed their open-ended responses. Overall, participants' perceptions of plausibility were shaped not only by technological feasibility, but also by broader concerns around implementation, unintended consequences, and the readiness of existing systems to adopt such interventions.

We found that interventions based on familiar or existing technologies, likethe "Preservation Duo" (PSS 4), and 'Frozen Meals' (PSS 10), were generally seen as technically feasible and market-ready with minor adjustments. In contrast, interventions involving advanced automation, AI integration, and novel materials like the 'Dissolvable Packaging' (PSS 12) and 'Smart Kitchen System' (PSS 3) elicited more caution. Participants questioned the technical readiness of these interventions and pointed to long development timelines, high costs, and implementation challenges as barriers. Several participants also raised concerns about unintended consequences, such as increased food waste due to automation reliance or potential declines in food literacy. These doubts were especially pronounced for far-future interventions (Time 3), where participants reported scepticism about whether current systems could realistically support such innovations.

6.8.4. Networkedness of interventions

To evaluate how well the interventions worked together as a portfolio (hypothesis H7), company representatives and experts rated the overall networkedness of the portfolio across five dimensions: diversity, complementarity, synergy, reinforcement, and coherence (items 11 to 15 in Table E2). On average, the mean responses across all dimensions hovered around the midpoint of the scale (=4), which represented the optimum balance of the scale (neither too much nor too little). As there were no significant differences between the companies and experts [$p > 0.20$], we aggregated the data and only present the overall means here.

Rating for all dimensions were as follows: *diversity* (item 10)(M = 3.82, SE = 0.08), *complementarity* (item 11)(M = 3.80, SE = 0.11), *synergy* (item 12)(M = 3.89, SE = 0.15), *reinforcement* (item 13)(M = 3.75, SE = 0.09), and *coherence* (item 14)(M = 3.95, SE = 0.08). This suggests that the intervention portfolio was generally perceived as networked. However, in their comments some participants expressed difficulty in distinguishing between closely related dimensions, such as synergy versus complementarity. Additionally, they noted that having the interventions displayed on-screen during the portfolio assessment and briefly explaining how they could work together would have been beneficial.

6.9. Discussion

Assessing the effectiveness of interventions remains an understudied activity in transition design research and practice. This is perhaps not completely surprising,

given the field's relative youth and the nature of the challenges it engages with—challenges that span multiple scales and timeframes, involve diverse actor networks, and require reflexivity and portfolio-based thinking (Dorst, 2015; Goss et al., 2025d). Moreover, transition design addresses societal issues whose outcomes are inherently uncertain and cannot be fully predicted or controlled. Impacts tend to emerge over time, which calls for evaluative approaches that support learning and adaptation (Patton, 2010; van den Bosch, 2010). The present study addresses this gap in the transition design field by proposing a conceptual framework that connects five essential transition design activities—navigating scales from micro to macro-level systems; considering temporality from present to far future; engaging and repositioning actors from individuals to networks; framing and designing from single solutions to portfolios; and practising reflexivity across activities and outcomes—to three qualities of its outcomes: desirability, plausibility, and networkedness (see Figure 6-1).

To empirically investigate this framework, we developed specific hypotheses examining these three qualities and conducted a mixed-methods study evaluating a portfolio of seven proposed intervention sets, comprising 21 product-service systems (PSSs). The PSSs resulted from a transition design process to reduce food waste in the Netherlands. Our evaluation engaged 312 participants across key actor groups (consumers, companies, and experts), with each participant assessing seven innovations varying in degree of innovativeness and how they evoke behavioural changes. Through a questionnaire combining quantitative scales with open-ended qualitative questions, we gathered rich insights into actor perceptions. In what follows, we reflect upon the approach in the transition design process and the evaluations of the outcomes, discussing its relevance for transition design methodology and practice.

6.9.1. The transition design process and outcomes

Our results affirm that our transition design process successfully yielded proposed interventions that meet the needs of various actors (consumers, companies, experts) and are likely to drive both individual and systemic behavioural changes towards food waste reduction. Following their evaluation, the proposed interventions were found to be desirable (M = 4.88) and plausible (M = 5.22), with 19 out of 21 PSSs scoring 4.00 or higher on a 7-point scale for these metrics. These results affirm hypotheses H1 and H4 related to intervention desirability and plausibility. The interventions also demonstrated a substantial degree of networkedness, as their mean ratings for diversity, complementarity, synergy, reinforcement, and coherence were close to a mean of 4, suggesting almost optimal interconnectedness within the portfolio and affirming hypothesis H7. Additionally, the interventions were perceived to prospectively lead to a reduction of food waste to some extent by supporting flexible behaviours (H6), a finding which further supports their potential for systemic impact. This is a first confirmation that engaging in the five activities as described

in our transition design framework can lead to desirable, plausible and networked outcomes.

Temporal dynamics in desirability and plausibility

As expected, innovativeness (H2) was rated lowest for most of the intervention sets at Time 1. Differences between the Time 2 and Time 3 interventions were not significant (Table 6-2). This indicates that participants perceived present-day interventions (Time 1) as clearly less innovative than those for the near future (Time 2) and far future (Time 3). Participants reported smaller differences between Time 2 and Time 3, and in several cases, the mean scores for Time 2 were higher than those for Time 3. We did not specify any expectation for time effects for the value dimension of desirability, and indeed, Table 6-2 shows that the perceived values of the PSSs are not linked to a time horizon.

Contrary to innovativeness, we hypothesised plausibility ratings to be equal at all moments in time (H5). This was because the variations of PSSs within each set were designed to reflect its evolution over time, meaning that all three PSS within the set should be equally plausible in the context in which they would be implemented. However, the plausibility ratings followed a similar pattern to the innovativeness ratings, with all participants giving the lowest plausibility ratings to present-day interventions (Time 1). Plausibility means at Time 1 were consistently lower than those at Time 3, with the means at Time 2 being similar to Time 3 for consumers and companies, and means at Time 2 being similar to Time 1 for experts (Table 6-2). This indicates that plausibility ratings largely followed the same pattern as those for innovativeness.

While the differences in mean innovativeness ratings between Time 1 and Time 3 were approximately 0.6 on the 7-point scale, the differences in plausibility ratings were about 0.3. As plausibility reflects the participants' confidence that the proposed interventions will result in the desired behavioural changes—in other words transforming the system through increasing flexibility and reducing food waste—the perceived increase in plausibility with time reflects the designers' success in proposing effective interventions. The attenuated increase in rating possibly shows participants' awareness of the practical limitations associated with the more innovative concepts. While participants acknowledged an increase in innovativeness of proposed interventions at Time 3, they may have tempered their plausibility ratings due to scepticism with respect to their possible implementation. Alternatively, participants possibly expect that not all interventions and associated behaviours are effective in reducing food waste and thus contribute only partially to the desired changes. Therefore, we might assume that compromises arise between innovativeness and plausibility over time. Nevertheless, these results generally indicate a higher confidence for interventions that offer new ways of performing daily practices (Time 2 and 3 interventions) rather than simply optimising current practices (Time 1 interventions).

The temporal distinctions observed in the ratings highlight several research opportunities, particularly concerning the timing of which to engage different actors in transition design processes. Interestingly, our experts appear to have more confidence in the effects of the more radical futuristic interventions (Time 3), while they consider present-time and near-future interventions to be equally (and less) plausible to lead to transformation. Hence, experts are more likely to contribute their knowledge and expertise most effectively during the early conceptualisation phases, where their preference for bold, systemic changes through interventions can be strategised. Conversely, securing company buy-in and attracting consumer interest may require interventions that move only slightly beyond incremental innovation (Time 2), as the uncertainty of implementation and adoption over longer timeframes become harder to imagine.

When considering the time effects for the seven sets, the perceived innovativeness and expected time to market did not increase from Time 1 to Time 3 for the sets 'Assessment labels' and 'Ingredientless recipes'. Interestingly, these sets provided interventions that were relatively low-tech compared to the others. This suggests that participants tended to equate innovativeness with technical challenge or sophistication. In that respect their perception deviated from the designers' intended timeframe categorisations, which also considered the challenge to educate consumers on, for example, food quality (PSS 18) and cooking techniques (PSS 21).

Individual versus systemic behavioural perceptions

The intervention sets were designed to stimulate waste-free and flexible behaviour in daily life while driving broader systemic changes (see Section 6.5). The results, however, showed a statistically higher perceived likelihood that the intended individual behavioural changes would occur compared to the systemic behavioural change i.e., flexibility and food waste reduction (Table 6-1). This disparity may be due to several factors. First, designers' human-centred expertise, which prioritises people's needs, aspirations, and daily routines, likely makes participants feel more confident in the interventions' potential for immediate behavioural impact, while the potential systemic outcomes remain less apparent (van der Bijl-Brouwer & Dorst, 2017). Second, systemic outcomes such as 'flexibility' and 'food waste reduction' may seem more abstract and distant compared to individual behavioural change, such as keeping partially used food for later use, which shows more immediacy and personal relevance. According to psychological distance theory, distant concepts are inherently more challenging to assess, potentially explaining these differences in ratings (Trope & Liberman, 2010). Communicating systemic impacts requires greater depth than what a single concept drawing or short narrative of a user practice can offer (Goss et al., 2024; Sevaldson, 2022). Although designers are exploring various methods to integrally communicate different systemic effects—such as through scenarios (e.g., Boehnert and Alexander (2025)), giga-mapping (Sevaldson, 2022), and role-playing (e.g., Formo Hay et al. (2024))— further exploration is needed into

how these methods can inform decision-making within transition design processes and effectively engage and communicate with diverse actors.

6.9.2. Assessing individual PSSs

In the present study, data was collected on all 21 PSSs. However, our primary interest was in the results of the portfolio, which comprised all seven sets of interventions relating to different aspects of the proposed practice. This focus aligned with our research question, and the fact that the portfolio development was a main outcome of the transition design process undertaken (see Section 6.5). Consequently, the analysis prioritised how the individual PSSs integrated within their respective intervention sets and how these sets collectively formed a networked portfolio rather than examining individual PSSs in isolation. Future analyses could explore the data at the level of individual PSSs to identify significant differences within and between sets or among actor groups.

Integrating feasibility and viability in transition design processes

In developing the portfolio of 21 interventions through the transition design process outlined in Section 6.5 and evaluated in the present study, technological feasibility and financial viability were intentionally deprioritised by the designers. This choice was made to avoid constraining the reimagining of new practices and systems and to generate a diverse portfolio of interventions (Gaziulusoy & Ryan, 2017b; Goss et al., 2024; Kazakci et al., 2015). However, the written comments indicated that participants assigning lower scores to specific sets raised concerns about technical feasibility and financial viability, particularly regarding data privacy and the originality of certain PSSs. For instance, participants noted that some PSSs (e.g., the three comprising the 'Consumption box' set) lacked new business opportunities given their similarity to existing solutions. This concern about originality, however, overlooks that replicating effective interventions is essential in transitions as it enables the amplification of proven strategies across the system, a crucial factor in achieving systemic changes (Quaggiotto, 2024).

Although feasibility and viability were intentionally deprioritised in the evaluation, participants' feedback suggests that these practical considerations nevertheless shaped their perceptions of plausibility and desirability. This indicates that future evaluations might benefit from more explicitly integrating assessments of feasibility and viability into study designs, while also ensuring that participants are sufficiently informed to evaluate these aspects accurately. While our evaluative framework shares surface similarities with established innovation evaluation models, such as IDEO's emphasis on desirability, feasibility, and viability, it introduces a crucial distinction. In our approach, plausibility is defined in terms of an intervention's potential to foster individual and systemic behavioural changes, rather than its immediate practical feasibility. This distinction reflects the specific aims of transition design, which seeks not merely to develop new products or services, but to

reimagine and shift entire systems. As such, future research should carefully consider how and when feasibility and viability assessments are incorporated, ensuring they support, rather than constrain, systemic ambitions.

While evaluation is not new to design, few studies have explored how structured, hypothesis-driven methods might complement more interpretive and participatory forms of assessment within systemic and transition design. This study responds to that gap by demonstrating how design proposals—conceptual in nature and speculative in time—can be meaningfully evaluated through a narrative-based, mixed-methods approach. By surfacing patterns in actors' perceptions of desirability, plausibility, and networkedness, our approach not only offers a way to evaluate early-stage interventions but also contributes to ongoing discourse on the role of empirical evaluation in design research. Rather than displacing qualitative or embedded approaches, this work invites a richer conversation about how diverse evaluative logics can coexist and support the advancement of societal transitions.

The role of qualitative insights in PSSs prioritisation

While the interventions were generally perceived as being desirable, plausible, and networked, the study's quantitative evaluation exhibited limitations for assessing the unique qualities of the individual PSSs. Although some interventions obtained lower or higher mean responses, most of the means were quite similar and thus provided limited guidance on how to prioritise interventions for further development (see Appendix H). As such, these results were probably insufficient for effectively narrowing down the selection of interventions. Transition design necessitates not only the development of multiple interventions but also an approach for prioritising and deciding between them to facilitate resource mobilisation and implementation (Irwin, 2018; van den Bosch, 2010). The results of this study suggest that a predominantly quantitative approach may be too prescriptive and normative for evaluation in transition design, as this may result in overlooking factors critical to prioritisation, such as localised barriers, actor motivations, and interdependencies between interventions. The addition of open questions in the study survey was widely used, especially among companies and experts, and supported further understanding of the quantitative ratings. Integrating qualitative insights through a stronger mixed-method evaluation approach could offer a more context-sensitive basis for decision-making, guiding transition designers in prioritising and iterating upon interventions while also understanding the conditions necessary for their effective implementation and adoption. A next step for working with the data collected from the present study could be to analyse the qualitative data from the open questions more thoroughly per each PSS to provide more direction for pathways to take but also to guide further studies that investigate the potential of each of the 21 PSSs in more detail, for instance for feasibility and viability.

6.9.3. Limitations of study method for evaluations

The present study evaluated a portfolio consisting of seven sets of interventions across three different timeframes: present-day (Time 1), near-future (Time 2), and far-future (Time 3). However, participants only assessed one timeframe variation within each set, meaning they did not experience the intended evolution of the practice ('adaptable consumption' as outlined in Section 6.5). Although evaluating all timeframe variations sequentially within each intervention set was not feasible given constraints in time and cognitive load, this limitation likely affected our results, as more comprehensive evaluation across all timeframe variations might have revealed a greater divergence between interventions.

Our results validate that the transition design process engaging in the five core activities led to a portfolio of networked interventions. Despite this, challenges emerged in evaluating the portfolio, with participants struggling to understand concepts such as complementarity and synergy. Additionally, the lack of prioritisation in our study setup prevented clear decisions on which interventions to advance first. Future evaluations would benefit from a more structured prioritisation method to discern which interventions within the portfolio to pursue, such as ranking. This could also include mapping the interventions to better understand the reinforcing mechanisms between them (Sevaldson, 2022) and/or identifying those that present the greatest learning opportunities (van den Bosch, 2010) to guide decision-making.

The setup faced limitations in recruiting and retaining company representatives and experts due to their busy schedules and competing demands, thus reducing participant diversity. This study relied on social networks to recruit participants without financial incentives, possibly leading to selection bias, as only those with a strong interest in food waste or connections to the authors participated. Additionally, the length and cognitive demands of the study posed further constraints, with company and expert participants engaging in the content for approximately twice as long as consumers. This difference in time investment occurred because experts and company actors invested more time in providing qualitative feedback than consumers, as shown by the number and lengths of their comments. This time commitment may have influenced participant engagement levels, leading to reduced participation and a high rate of incomplete responses.

Furthermore, the decision to conduct this study in English and recruit participants via Prolific and the authors' networks was informed primarily by practical considerations, including the working language of the primary researcher, time constraints, and the prevalent use of English in the Netherlands and of targeted expert participants. Since food waste is a universally experienced phenomenon, language was not anticipated to significantly influence participants' conceptual understanding or responses. Nevertheless, while this approach facilitated the recruitment of a diverse range of participants in terms of age and nationality, it may have excluded non-English speakers and/or individuals less comfortable with digital research platforms. This limitation potentially impacts the representativeness and,

thus the generalisability of the findings. Future research could enhance participant inclusivity by administering questionnaires in multiple languages, thereby reaching a broader demographic and further improving the robustness and applicability of the results.

Finally, a limitation of this study lies in the fact that participants did not assess actual innovations, but instead evaluated conceptual representations conveyed through illustrations and written narratives. While we made considerable effort to immerse participants in the storyline of a user engaging with the PSS, this remains different from the experience of interacting with a fully developed system. On one hand, our presentation method allows for greater imaginative engagement and creative interpretation, which can enhance the perceived potential of the concept and generate valuable suggestions for improvement. It also enabled the exploration of ideas that are not yet technically or practically feasible. On the other hand, evaluating a more tangible and realistic version of the PSSs could yield more concrete insights into their feasibility and viability. Future research could address this by adopting more immersive techniques, such as virtual reality, to increase the realism of the innovation experience during the test. Furthermore, while the use of questionnaires provides valuable information about participants' perceptions, considerations, and intentions, it does not capture actual behaviour. For innovations that may not become available for several years, predicting acceptance is inherently challenging due to uncertainties about the future context of use. In the absence of direct behavioural data, participants' responses offer informed estimations that may, therefore, be the most reliable insights currently attainable.

6.10. Conclusion

As transition design continues to develop as a field, there is increasing need for approaches that support both its exploratory and systemic ambitions. Through this study, we contribute to that development by offering conceptual and methodological contributions to transition design discourse. Conceptually, we introduce a framework that connects five key transition design activities with three evaluative qualities of its outcomes: 1) desirability among different actors to ensure uptake, (2) plausibility in contributing to transformative changes at multiple system levels over time, and (3) networkedness of interventions within a portfolio. Through the development of this framework, we provide support in structuring transition design processes and its intervention evaluation. This is particularly valuable in emerging fields like transition design, where research and practice are still maturing. By linking transition design activities to outcome qualities, the framework can foster dialogue and collaboration within transdisciplinary teams while establishing a shared language by which to engage external actors. This is crucial for securing support for intervention development, implementation, and scaling.

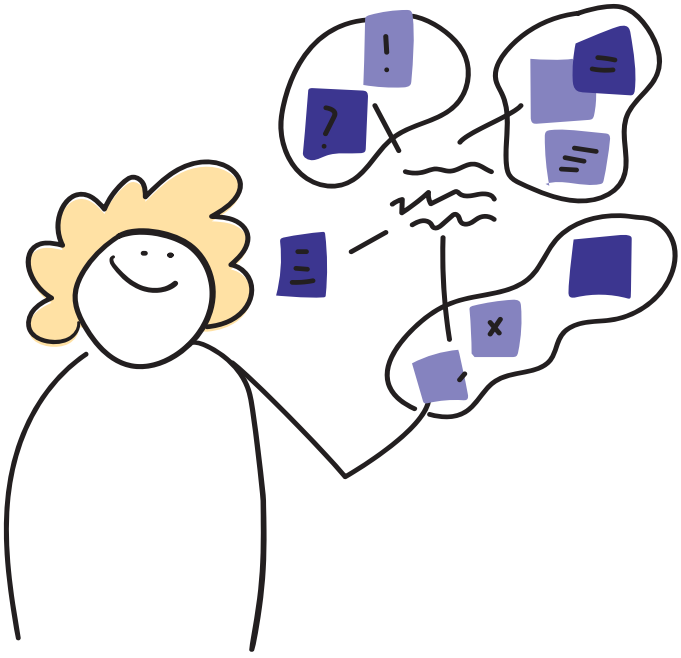
Methodologically, this study demonstrates how introducing quantitative testing within intervention evaluation can strengthen transition design as a reflexive and evidence-based practice. Our findings suggest that desirability, plausibility, and networkedness are critical for assessing the potential of interventions to drive systemic change. However, the study also highlights that overlooking feasibility and viability may hinder implementation and limit actor commitment. Future research should, therefore, explore how feasibility and viability can be integrated into evaluative frameworks to offer a more comprehensive basis for intervention assessment.

Further work is also needed to support decision-making around portfolio prioritisation, to improve the communication of intervention reasoning across both individual (experiential) and systemic levels, and to refine methodological approaches. In particular, greater attention should be given to how quantitative, qualitative, or mixed-methods can be applied across different phases of transition design, from conceptualisation through to implementation. Advancing these evaluative practices will be essential for building more credible, systemic, and impactful transition design processes capable of addressing complex societal challenges.

part four

General discussion & conclusions

This final part of the dissertation comprises one concluding chapter (Chapter 7) that revisits the aim of this doctoral research and addresses the research questions. It reflects on the implications of the findings for research, practice, and education, discusses the limitations, and proposes directions for future research and development.



Chapter 07

Discussion and conclusions

7.1. Recalling the aim

This dissertation set out to deepen the understanding of design expertise crucial to both the design discipline and transition designers working towards systemic change. It investigates how designers can apply their expertise in visioning, framing, and evaluating within transition design challenges. These areas represent fundamental aspects of design expertise that hold particular significance for transition processes. Additionally, they form a sequential process that provides sufficient depth and diversity to investigate transition design practice: *visioning* articulates long-term desirable futures that provide direction for change, *framing* connects systemic understanding to actionable interventions, and *evaluating* assesses the effectiveness of interventions in contributing to desired systemic change.

This research was conducted as part of the project "From Excess to Enough" (FETE), which focused on reducing food waste in the Dutch food system now, and supporting the transition to a food system that has enough food for all with minimal food waste. By exploring design expertise through practical application rather than studying it at a distance, this work ensures that insights are refined through direct experience. This approach allows for the identification of design-specific knowledge gaps and generates valuable contributions to transition design research and practice.

This dissertation is structured into three parts, each addressing an area of expertise explored through the transition design process:

- **Part one** (Chapter 2) explores **visioning** expertise through a case study that developed a future vision of the Dutch food system, examining the tensions designers encounter when applying visioning in a transition context.
- **Part two** (Chapters 3–5) focuses on **framing** expertise, introducing a new practice—adaptable consumption—as a frame for developing an intervention portfolio. This part also examines how framing can support the alignment of interventions across actors, timeframes, and system scales.
- **Part three** (Chapter 6) addresses **evaluative** expertise by developing a framework connecting five essential transition design activities with three qualities of its outcomes. This framework was then applied to evaluate 21 interventions involving diverse actor groups.

7.2. Answering the research questions

In this section, the research questions are restated and the main findings are presented. Following this, we discuss the contribution of these findings to research, practice, and the development of transition design expertise.

7.2.1. Part one: visioning

Study 1—Research questions 1a and 1b: What is design-led visioning in a transition context? What challenges and successes do designers encounter when visioning within a transition context?

Designers apply their expertise to develop long-term visions, making the future tangible and engaging diverse actors through participatory processes. However, when working in different contexts, such as transitions, designers must adapt this expertise to the demands of the new context. Currently, little is known about how this adaption occurs or what tensions may arise when designers develop visions for transitions. By following a design agency tasked with conceptualising a future food system for the Netherlands, we identified three tensions in this adaption that show where development of visioning expertise is needed for transitions.

First, central to designers' expertise in visioning is making the future tangible and reflecting the experiential everyday qualities of the future system. This enhances actors' ability to 'step into the future'. However, transition contexts require designers to depict the experiential qualities of a system in a way that also reflects the dynamic relationships between these and the broader system characteristics. These additional dynamics and associated complexity can create tension for design as it requires more aspects to visualise, take into account, and combine into future visions. This means that the expertise of design visioning must develop into a more sophisticated practice with different techniques to capture these additional dynamics.

Second, designers working on transition visions must simultaneously develop a deep understanding of current systems while also constructively challenging these systems. This requires additional attention to balancing radical provocations with the practical realities of current actors' perspectives, ensuring they can still see their role in envisioned futures.

Third, while designers aim to turn current situations into preferable ones, transition contexts introduce heightened moral and ethical demands. This requires designers not only to participate in, but also, initiate normative debates about the desirability of the future. This expanded role requires additional support to equip designers with the skills needed to navigate and facilitate these complex value-driven discussions.

These tensions suggest that while designers possess valuable expertise in envisioning desirable futures that can mobilise action, even in complex transition contexts, their integration into transition visioning processes must be thoughtfully positioned and supported. Our findings provide a detailed account of a transition design visioning process and advocate for methodological developments that help designers navigate these specific tensions.

7.2.2. Part two: framing

Study 2—Research question 2: How can designers frame system dynamics to support innovation proposals that foster desired transitions?

A key challenge in transition design lies not only in developing a compelling vision, but also in determining where and how to intervene in the present to foster long-term envisioned changes. Currently, designers lack adequate conceptual and methodological support for understanding existing system dynamics in relation to desired future dynamics. This gap affects the reasoning process that connects values outlined in a vision to specific innovations that are still to be designed. Therefore, this study aimed to better understand how designers can identify intervention opportunities within existing systems and conceptualise innovations that can foster the long-term changes depicted in a vision.

Over the course of five experiments conducted over 2.5 years, we applied a specific transition design process supported by several process artefacts. First, we identified systems principles within the future vision that articulated pathways to pursue in the transition and the meanings these changes could offer. Next, we developed Transition Readiness Profiles to onboard actors by connecting the transition to their broader business contexts and enabling speculation about the roles they could adopt now in light of the transition. Finally, we linked these strategic efforts to everyday life by developing a scenario that illustrated behaviours and supportive innovations that people can adopt in the near future to build the capabilities needed for the transition. These efforts produced two key outcomes: 1) a conceptual framework, and 2) a new consumption practice supported by an intervention portfolio.

The conceptual framework (Figure 3-7, page 75) shows that defining a future practice by connecting systems principles that drive the future system, organisational roles that stakeholders can play in the transition, and changes in people's behaviour and capabilities that are required for the transition, are key to identifying what future practice(s) to design for. Through this framing, designers are supported in conceptualising innovations across system scales and timeframes, enabling them to identify short-term innovation efforts that can drive long-term systemic change. This approach led to the conceptualisation of *adaptable consumption*, a new practice designed together with the FETE consortium to realign food safety, quality, and sustainability within the Dutch food system. This practice, supported by a intervention portfolio, promotes flexible and waste-free behaviours in daily life while driving wider systems change.

Study 3—Research questions 3a and b: How do households engage with adaptable consumption, including their barriers and motivations to do so? And what opportunities exist to support households in adopting adaptable consumption behaviours towards less food waste?

In response to the pressing challenge of food waste, this reserach question investigates how the practice of adaptable consumption, and its supporting innovations, can become meaningful in people's daily lives as a strategy for food waste reduction. It deepens the exploration of the third component of the framework introduced in Study 2—people's behaviours and capabilities—by linking micro-level consumer practices to broader transition goals. Adaptable consumption builds food system resilience by empowering households to adjust to changing conditions (e.g., adopting new dietary patterns) and remain flexible in the face of disruptions (e.g., substituting ingredients). Reducing household food waste represents a key opportunity for strengthening resilience through adaptable consumption.

This study identified five opportunities for supporting consumers in adopting adaptable consumption practices to minimise food waste: 1) supporting flexible meal moments, 2) reclaiming food edibility, 3) reintegrating food into routines, 4) integrating feedback loops, and 5) playing into life-changing moments. Our findings reveal that households possess a foundational readiness to adopt these adaptable behaviours when given the appropriate skills, tools, and enabling systems.

These opportunities illustrate the complex interplay between behavioural, material, and social dimensions of food consumption. Additionally, they demonstrate how adaptable consumption can simultaneously reduce waste and enhance household resilience. Effective implementation, however, requires a nuanced understanding of diverse household dynamics and interventions that address everyday practical challenges—not just food waste in isolation. By positioning adaptability as a household strategy, this study provides actionable insights that can contribute to building a more resilient food system.

Study 4—Research question 4: How can designers reason toward interventions that foster societal transitions, and how can a logical framework support this reasoning?

Once designers identify where and how to intervene in a system, the reasoning process toward design proposals remains a challenging and underexplored activity. To address this, we developed and applied a transition design logical framework. This framework reflects a design rationale tailored to the complexities of transition challenges. It supports designers in making design decisions and developing clear argumentations for how proposed interventions will contribute to desired systemic change.

The framework organises design reasoning around several interconnected aspects: the Ultimate Value(s), the Pathway, the How(s) on different system levels, the Value(s) on different system levels, and the What(s). The *Ultimate Value(s)* define the societal and planetary aims for a desired transition. The *Pathway* provides a strategic trajectory toward these ultimate aims, reflecting new roles and dynamics within systems. Together, these Ultimate Value(s) and Pathway serve as a frame for further design reasoning. The *How(s)* specify the behavioural changes needed at

both individual and system levels in relation to the pathway. The *Value(s)* describe the individual and systemic value generated through these behavioural changes. Finally, the *What(s)* define the interventions—such as new products, services, or policies—that can drive the desired transition through the behaviours, values, and pathway dynamics identified.

The findings indicate that the framework (Figure 5-3, page 123) temporarily simplifies the complexity of the design challenge, making the transition context manageable to design for, while keeping the broader transition context and aims in mind. Through its application, the framework helped designers articulate their decisions and connect them to systemic outcomes. The framework's structured approach also facilitated clearer communication of intervention rationales to other stakeholders, enhancing both credibility and strategic alignment.

Effective use of the framework relied on dynamic engagement across its different aspects, enabling iterative refinement of both intervention proposals and their underlying systemic reasoning (Figure 7-1). Through repeated applications, the framework supported the development of intervention portfolios by encouraging designers to reflect on how multiple interventions collectively contribute to desired transitions. These findings highlight that a key value of the framework lies in making transition design reasoning explicit, thereby supporting better alignment between proposed interventions and their intended systemic effects.

7.2.3. Part three: evaluating

Study 5—Research question 5: What is the perceived effectiveness of transition design interventions resulting from a transition design process?

Despite growing interest in transition design processes, gaps remain in understanding the effectiveness of its outcomes in fostering desired systemic change. To address this research question, we evaluated a portfolio of 21 intervention proposals designed throughout our transition design process. This evaluation was guided by a framework (Figure 6-1, page 154) developed that connects five essential transition design activities with three qualities of its outcomes. The transition design activities include: 1) navigating scales from micro to macro-levels, 2) considering temporality from present to far-future, 3) engaging and repositioning actors from individuals and groups to actor networks, 4) framing and designing from single solutions to portfolios, and 5) practising reflexivity from activities to outcomes.

By navigating these activities, transition designers can determine which intervention proposals to implement, when, and in which combinations. The outcomes of such an ongoing process should demonstrate: 1) desirability for different actors to ensure uptake, 2) plausibility to foster transformative changes at micro (individual), meso (organisational), and macro (system) scales over time, and 3) function as part of a networked portfolio of multiple interventions.

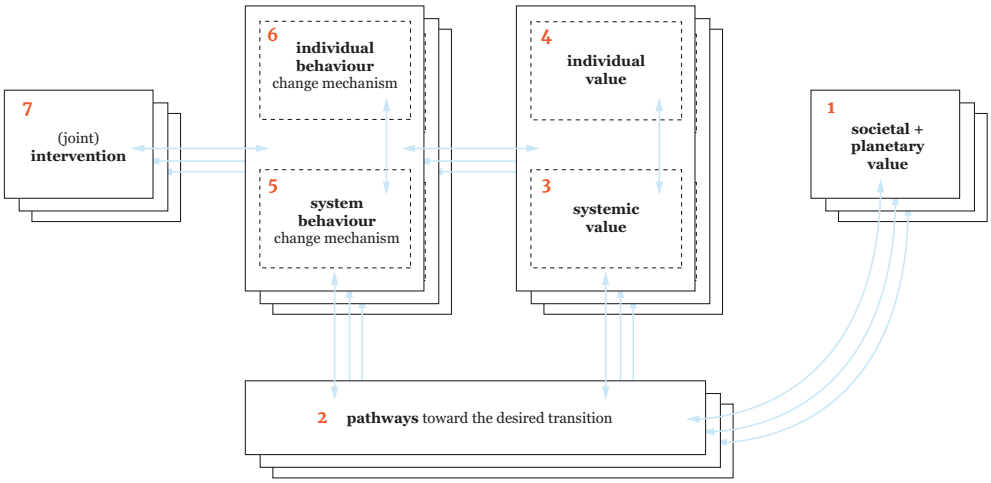


Figure 7-1 | Aspects of the transition design logical framework. © 2025 Goss, H., de Koning, J.I.J.C., Tromp, N., & Schifferstien, H.N.J.

Our results confirm that our transition design process successfully yielded proposed interventions that meet the needs of various actors and are likely to drive both individual and systemic behavioural changes towards food waste reduction. Specifically, the interventions were found have mean ratings of 4.88 for desirability and 5.22 for plausibility on a 7-point scale. The interventions also demonstrated a substantial degree of networkedness, with their mean ratings for diversity, complementarity, synergy, reinforcement, and coherence being close to a mean of 4, suggesting almost optimal interconnectedness within the portfolio. Additionally, the interventions were perceived to lead to a reduction of food waste to some extent by supporting flexible behaviours. This provides an initial confirmation that applying the five activities of the framework can lead to desirable, plausible, and networked outcomes that support the desired transition.

7.3. Implications and future work

This section examines the broader contributions of this dissertation, by building on the exploration of visioning, framing, and evaluating expertise within transition design processes. It demonstrates how design expertise can be staged to drive systemic change while contributing to a deeper understanding of design's evolving role in addressing complex societal challenges. As transition design continues to mature as a field, this research strengthens its theoretical foundations and expands its methodological approaches. This section concludes by outlining promising directions for future research and practice, with specific emphasis on applications to food system transitions and waste reduction initiatives.

7.3.1. Visioning for desirable micro-meso-macro changes

Visioning is both a key design competency and an essential output of transition design processes. Visions of possible futures help designers and stakeholders question, debate, and imagine desirable systemic changes, serving as a reference for guiding innovation and decision-making (Dunne & Raby, 2013; Hekkert & van Dijk, 2011). Designers' human-centred, integrative, and participatory knowledge makes them well-suited for visioning processes as they are able to create visions that mobilise action and foster collectivity around shared futures. When reflecting on the transition design process undertaken in this dissertation, we see that transition design visioning asks that designers 1) take *moral agency* over the process and outcomes, 2) *articulate pathways* that bridge macro-meso-micro level behavioural changes, 3) explicitly align *intent, method and participation strategy, and outcomes* of the visioning process, and 4) balance complexity and concreteness in *systemic formgiving*.

First, transition design visioning requires designers to assume moral agency over both the process and its outcomes. This means navigating tensions between stakeholder interests and systemic goals, while carefully integrating their own values and supporting stakeholders in reflecting on their roles in sustaining unsustainable systems. Without confidence in this role, critical transition questions risk being overlooked or only superficially explored. In this dissertation, vision development marked the first transition design activity. The designers involved in this process—including myself—were not experts in the domain, which, combined with emerging trust issues among partners, limited opportunities to explicitly challenge existing structures. These constraints were not solely due to individual expertise but were also shaped by the project's boundaries and expectations, which defined the scope, length of time, and depth of engagement. Looking back, I recognise that as a design researcher new to both food systems and transition design, I initially lacked the situational and relational knowledge needed to confidently engage with the normative, ecological, and political dimensions of the transition. Over time, however, I gained more confidence to initiate such discussions, illustrating how a designer's moral agency can develop through sustained practice and reflection. My experience echoes insights in the literature that trust, relational understanding, and ethical capacity emerge through prolonged engagement in situated, value-laden contexts (Irwin, 2015; Manzini, 2015). This highlights the importance of designers being embedded in transition contexts over extended periods—not only to build contextual knowledge, but also to develop the ethical maturity needed to navigate the normative dimensions of systemic change.

Second, designers engaging in visioning within transitions need the ability to translate abstract visions into actionable pathways that reflect shifts across micro, meso, and macro levels. These pathways serve as trajectories that highlight changes in behaviours, roles, and relationships essential for desired systemic change. Our research revealed that translating the vision into pathways that illustrate how desired

futures might be realised is a critical design step. A key aspect of developing these pathways is recognising the role of behaviours in bridging systemic ambitions with everyday practices. Focusing on behaviours not only help stakeholders understand how their actions contribute to systemic change but also clarify for designers what they are aiming to contribute to through their interventions. In this way, transition design pathways differ from those described in transition studies (i.e., transformation, de-alignment and re-alignment, substitution, and reconfiguration), which serve as abstract models of how systemic change occurs (Geels & Schot, 2007). While our pathways share similarities with "transition images" from Transition Management by outlining possible trajectories (Loorbach, 2007), they are uniquely positioned to inspire action among both stakeholders and designers themselves. However, further research is needed to explore how pathways can be effectively framed, communicated, and applied within transition design processes, as well as what qualities make a promising pathway. Addressing these questions will enhance the capacity of pathways to inspire meaningful change, guide transitions, and serve as actionable tools for bridging behavioural changes across system scales and timeframes.

Third, the purpose of visioning processes in transition design may vary, influencing both the form and process of engagement. While visioning processes orients and mobilises actors around long-term systemic goals (Loorbach, 2007; Wiek & Iwaniec, 2014), visions themselves may serve diverse functions—for instance, to provoke debate or to align strategies. In our process, a singular shared vision was developed from four envisioned systems to anchor the design process and foster a shared sense of purpose and ownership among the FETE consortium. However, this is not to suggest that a single vision is necessary, or even desirable, in all transition design processes. Other approaches may prioritise the development of multiple or evolving visions, particularly when aiming to foster pluralistic engagement (Pereira et al., 2021). Decisions around visioning are closely linked to choices about participation. Our process, based on the Vision in Design method (Hekkert & van Dijk, 2011), was expert-driven within the consortium—similar to transition management practices where broad public participation is often limited during visioning activities (Loorbach, 2007). The Vision in Design approach distinguishes itself by explicitly considering what must change, and also what should endure in the future. In this way, it recognises that some societal elements remain stable even through transitions. It also requires designers to take a stance on desirable futures, encouraging them to articulate and defend their positions rather than act as neutral facilitators. However, in this research we recognise that while expert-led visioning can offer strategic coherence and support more radical innovation, it may also limit inclusivity, legitimacy, and responsiveness of the process and outcomes. Future research should explore how different forms of participation (e.g., bottom-up versus top-down) and different types and functions of visions can be strategically employed in transition design to support both visionary direction and societal legitimacy.

Finally, visioning for transitions involves making systemic complexities tangible and understandable for diverse audiences. Designers use their visualisation and formgiving skills to translate abstract visions into accessible, experiential formats—such as drawings, scenarios, and videos—that foster engagement, co-creation, and dialogue with system actors. These outputs not only engage stakeholders, but also play a crucial role in supporting designers' own understanding by enabling exploration of envisioned futures and transition dynamics. In our process, we experimented with different ways of communicating the vision and its underlying dynamics. A key challenge was balancing the need for concrete, actionable visualisations with the desire to preserve the nuance and complexity of systemic relationships, and support a possibility-oriented mindset. We see this as an area where future research could provide valuable insights. In particular, research could explore how designers engage in systemic formgiving to express dynamics across multiple system levels. Advancing this understanding could strengthen visioning processes by enhancing both stakeholder engagement and designers' systemic insight.

7.3.2. Framing new practices and intended changes

In transition design, framing plays a critical role in shifting existing practices towards more desirable alternatives. This dissertation demonstrates how linking micro-level individual behaviours, meso-level organisational roles, and macro-level systemic principles enables designers to conceptualise new practices and develop interventions supporting their adoption. Conceptually, our findings align with Social Practice Theory (SPT) (Shove, 2010; Kuijer, 2014) by relating systemic principles to new meanings, organisational roles to materials, and individual behaviours to competences. However, we extend SPT—which typically focuses on micro-level dynamics or offers retrospective analyses of practice evolution across scales—by explicitly connecting these elements to actionable roles and interventions at the system level. Yet, further research is needed to examine the implications of different framing strategies, including the sequence of exploring systems principles, organisational roles, and individual behaviours, particularly regarding how various approaches shape design processes and influence the implementation and evolution of practices over time.

The design reasoning presented in the transition design logical framework (Figure 7-1) further supports the development of new practices. It positions individual behavioural change as a key driver of transitions, recognising that shifts in everyday practices are crucial for systemic transformation. While the framework acknowledges the importance of supportive mechanisms at the meso-level, their role in enabling and amplifying individual change remains relatively implicit—addressed only in part through the concept of joint innovation and the underlying assumptions about how change occurs. Yet this ambiguity raises important questions about how the meso-level is conceptually situated within the overall reasoning.

Transitions inherently rely on a reciprocal relationship between individual behaviours and supportive organisational and system-level conditions: widespread adoption is needed for systemic change, while enabling structures are essential to sustain new behaviours. Over time, this interplay can transform isolated actions into established social practices, potentially reaching a tipping point that reshapes existing systems—consistent with the concept of niche dynamics (Geels & Raven, 2006; Geels, 2002). Our logical framework seeks to reflect this reciprocity by placing individual and system levels in conversation through meso-level interventions. However, further refinement is needed to make these dynamics more explicit—particularly how micro- and macro-level changes can be intentionally aligned, and how the meso-level functions conceptually within the design reasoning. Effectively engaging the meso-level requires a deep understanding of stakeholder contexts and organisational dynamics. Without such contextual knowledge, proposed innovations risk being too abstract, misaligned with actors' realities, or insufficiently actionable to enable broader adoption. While this research focused on consumers as key individual-level actors, future work could explore how the reasoning shifts when other types of actors are positioned at this level.

7.3.3. Evaluating systemic impacts

This dissertation advances the underexplored domain of evaluation within transition design by proposing and empirically testing a set of evaluative qualities—desirability, plausibility, and networkedness—as meaningful heuristics for assessing the transformative potential of systemic interventions. These qualities enable designers to engage with the diffuse, indirect, and emergent nature of systemic change—for example, nuanced shifts in behaviours, well-being, or resilience that characterise systemic interventions (CLICKNL, 2024; de Koning & van der Bijl-Brouwer, 2024). In this way, this work frames evaluation as an anticipatory and reflective practice, foregrounding the role of designerly judgement in the absence of real-world measurable effects.

Importantly, the work surfaces limitations and future directions. First, while the proposed qualities offer a promising foundation, the dissertation acknowledges the need to integrate feasibility and viability more explicitly—especially as interventions move from speculative concept to implementation. Second, the role of prioritisation within intervention portfolios remains methodologically underdeveloped. Understanding how to weigh and sequence interventions based on evaluation is a critical next step for transition design. Third, the research surfaces tensions between novelty and scalability, inviting greater attention to the interplay between innovation, exnovation, and the diffusion of systemic practices.

Finally, throughout this research, we engaged in reflexivity both in the design of the studies and in the transition design process in which we were engaged. While we connect evaluation to reflexivity—particularly in assessing the impact of interventions by critically examining the processes and assumptions that shape

them—reflexivity as a distinct design skill was not explicitly studied. This presents an opportunity for future research to explore how transition designers can more explicitly incorporate reflexive practices into their work and use reflexivity to support and enhance their design processes. By embedding evaluation within the epistemic and temporal realities of transition design, this dissertation contributes to building a more responsive, grounded, and actionable approach to assessing the transformative potential of design interventions.

7.3.4. Showing detail in the transition design process

A key contribution of this research is the thorough documentation of transition design activities in practice. Each chapter details specific design actions, decision rationales, and outcomes, addressing a common gap in design disciplines where processes often remain implicit or poorly recorded (see Table 7-1). By making these processes explicit, this dissertation offers a comprehensive case study of transition design in practice—tracing the journey from envisioning desirable futures to framing interventions and evaluating their systemic impacts. It advances disciplinary understanding by showing how transition designers operate in real-world contexts.

This work builds on Irwin's (2015) call for design to engage across disciplines and with diverse actors, and it elaborates on the roles outlined by Gaziulusoy and Ryan (2017a)—namely inquiry, process, and output—by offering situated examples from the food system context. Similarly, it extends the UK Design Council's (2021) description of systemic design roles (e.g., system thinker, leader and storyteller, designer and maker, connector and convener) by demonstrating how these roles unfold within transition design.

Beyond the design discipline, this research contributes to adjacent fields. For sustainability transitions, it offers concrete examples of how design expertise can support researchers and practitioners—bridging the gap between the theoretical potential of design and its practical application (Coops et al., 2022). For the fields of consumer behaviour and food waste, it illustrates how design can address urgent societal challenges by generating actionable strategies to strengthen food system resilience. Ultimately, this dissertation not only clarifies the roles and value of designers in transition contexts but also provides foundational insights to support more deliberate and effective integration of design within broader transition efforts.

7.3.5. Formgiving in transition processes to facilitate actionable dialogue

This dissertation highlights the role of meaningful formgiving as a core practice for enabling systemic engagement and cross-boundary dialogue in transition design. By working across disciplines and with diverse actors both within and beyond the FETE consortium, the research demonstrates how the material and visual expertise of design fosters collaboration, reflexivity, and reframing. Translating abstract system-level reasoning into concrete situated outputs proved central to building

shared understanding and alignment in the transition design process. Throughout the research, various design outputs were developed and applied (see Table 7-1 and Figure 7-2), including the Vision Video, Transition Readiness Profiles, and the Comic Strip with the Innovation Portfolio. These outputs not only communicated ideas but also actively shaped the transition design process.

First, the Vision Video helped convey envisioned future dynamics to a wider audience in a more tangible way than the corresponding report. The video, approximately three minutes long, combined narrated storytelling with visualisations of systemic change, offering a concise yet layered depiction of the envisioned future. However, its brevity also proved limiting—some nuances and interdependencies within the vision required additional explanation to be fully understood and meaningfully applied by designers and actors. In developing the vision, we realised how transition design visions must strike a balance between providing concrete examples of abstract system principles to make the vision accessible, while avoiding overly archetypical or literal representations that can diminish imagination. What this balance entails and how to methodologically support it remains a promising area for further exploration.

Second, the Transition Readiness Profiles served as tools to reposition actors within the transition, fostering a possibility-oriented mindset and helping designers and actors reimagine their roles to achieve systemic impacts. While the content of the Profiles themselves played a critical role, the format—a single sheet of paper—allowed them to be easily shared, reviewed, and used flexibly in both one-on-one and co-creation settings. Additionally, the format enabled comparisons between actor profiles, allowed us to easily add new profiles to explore the transition dynamics without needing extensive reworking, and offered a digestible representation of each actor's readiness for transition. When presenting this doctoral research at Dutch Design Week 2024, food system actors outside of the research project expressed a desire to adopt the approach in their own contexts. Given its promise, further development into the specific questions and themes covered within the Profiles could be beneficial.

Third, the Comic Strip with Innovation Portfolio were used in several studies to communicate the practice of adaptable consumption and allow participants to engage with the design proposals, surface contextual challenges, and suggest refinements. Following van den Hende (2010), we chose drawn stories and sketches to allow participants to interact with the material at their own pace and annotate their thoughts, such as with post-its. Based on our earlier experience with the Vision Video, we avoided using videos for these proposals. Additionally, we found that presenting interventions in terms of how they could enable the evolution of everyday practices over time—rather than presenting fully resolved design solutions—encouraged more productive discussion about their systemic potential.

Taken together, these outputs show that formgiving functioned not only as a mode of communication but also as a generative and interpretive design practice. It shaped how systemic challenges were surfaced, understood, and explored. Yet,

Table 7-1 | Overview of expert design activities performed as part of the research undertaken in this dissertation, as well as the material supporting these activities.

Area of expertise	Expert design activities performed	Material designed and used in this dissertation (see Figure 7-2)
Visioning	– Articulate systems principles underlying the envisioned future – Depict and communicate systemic and experiential characteristics of desirable futures through visual and narrative means – Facilitate participatory visioning – Conduct expert interviews to explore potential future developments – Stimulate critical reflection of futures through speculative innovation proposals	– Vision report – Future system sketches – Day-in-the-life scenarios – Animated vision video – Innovation directions
Framing	– Engage diverse actors in collaborative innovation workshops – Assess actor readiness and organisational positioning within a transition context – Define emerging roles and responsibilities for actors involved in systemic change – Conceptualise new social practices integrating competencies, meanings, and material elements aligned with transition goals – Enable consumers to reflect on present experiences, past memories, and imagined futures – Design interventions that integrate into everyday life, enhancing the perceived relevance of transition efforts – Tailor interventions to align with local and cultural contexts to improve acceptance – Integrate feedback from diverse sources, like actors, consumers, and desk research, into design proposals – Make explicit the rationale behind design decisions for both expert and lay audiences – Anticipate how interventions may influence behaviours and practices over time – Develop a portfolio of networked solutions that are coherent, synergistic, complementary, diverse, and reinforcing – Ensure proposed interventions are desirable for diverse actors – Ensure proposed interventions will plausibly contribute to a desired transition	– Transition Readiness Profiles – Vision collages – Innovation template – Pathway canvas – Booklet of a portfolio of interventions that evolve over time – Bulleted overview of intervention portfolio – Comic strip depicting a household scenario – Cultural probe booklet – Conceptual framework for designing for new practices – Transition design logical framework
Evaluating	– Use visual and narrative methods to illustrate how interventions may be experienced in daily life and the values they support – Assess the anticipated or observed impact of transition interventions on systems and behaviours through mixed-methods approaches	– Short narratives describing intervention interactions – Refined portfolio of interventions – Transition design framework of activities and outcomes

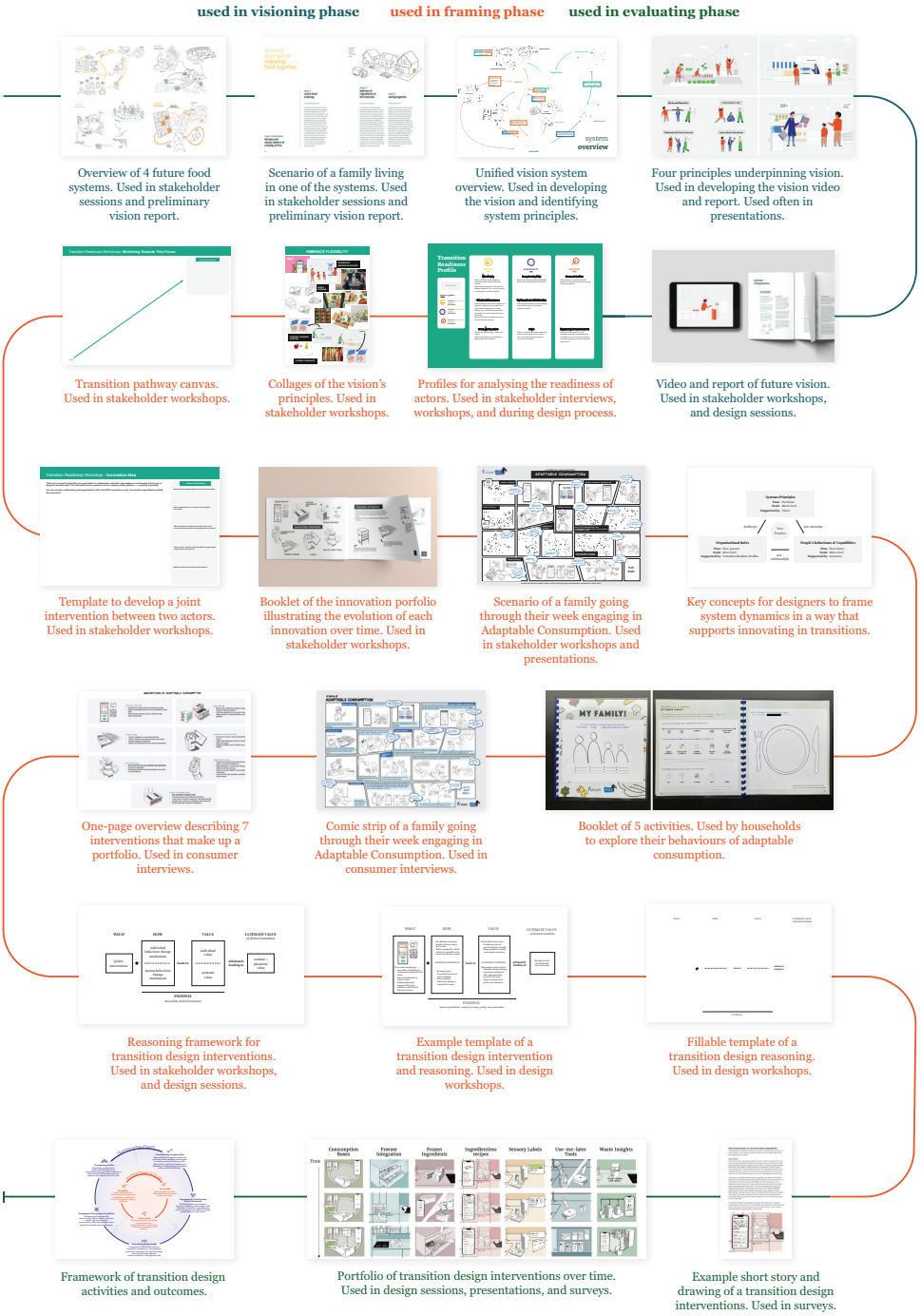


Figure 7-2 | Overview of material used throughout the transition design process undertaken in this dissertation as part of FETE. Materials also developed by Reframing Studio (vision), Freek Trimbach (vision video), Maria Sofia (first interventions and comic strip drawings), and Sterre Witlox (final intervention drawings). © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

despite its central role, formgiving was not systematically investigated as a knowledge practice in its own right. This presents a valuable direction for future research to examine formgiving as both a methodological and epistemological practice within transition design.

7.3.6. Adaptable consumption as a new approach to addressing food waste

While this dissertation primarily advances academic understanding of transition design, its application within the Dutch food system contributes meaningfully to addressing one of the sector's most pressing challenges: reducing food waste in a system shaped by overproduction and excess consumption. Through a systemic approach, this work demonstrates how design expertise can help envision alternative food system futures, reframe food waste to identify new reduction strategies, and evaluate interventions that drive systemic shifts toward resilient and sustainable food production, distribution, and consumption.

The research identified four guiding principles to facilitate a transition toward a food system predicated on "enough": (1) embracing flexibility and highlighting its benefits, (2) prioritising vitality and governing the prevention of illness, (3) celebrating and valuing the food journey, and (4) using technology to learn about ourselves as individuals and as a society (Goss et al., 2022; Hoope et al., 2021). While this research primarily explored the first principle through the concept of adaptable consumption, all four principles offer valuable foundations for future research consortia and practitioners working toward sustainable food systems. Furthermore, there are likely additional practices beyond adaptable consumption that align with these principles. We encourage future research to explore alternative entry points, such as sustainable food production or citizen-led initiatives, to broaden the scope and potential of this framework.

This research also emphasises that interventions supporting adaptable consumption must be grounded in an understanding of the concerns that shape household behaviour. Concerns—defined as the values, needs, and goals individuals prioritise—explain why households may engage in wasteful practices like over-purchasing or discarding food (Evans, 2014; Tromp & Hekkert, 2018). When concerns conflict—such as the desire for variety versus the need for efficiency—interventions must help households navigate these tensions. Taking a step back, we start to see design principles emerge that can support the further development of interventions aimed at fostering adaptable consumption: the need to balance novelty and familiarity, to provide both agency and support, and to maximise impact through minimal means. For instance, meal planning tools that introduce modest novelty within, otherwise, familiar routines can stimulate creativity and reduce decision fatigue. Similarly, promoting versatile ingredients and efficient cooking strategies can enhance a sense of control while reducing costs, effort, and waste. At a societal level, reshaping the identity of a 'good provider' from one who offers abundance to one who models pro-environmental behaviour, like reducing waste, may help

shift deeply ingrained consumption norms hindering the transition to "enough". Recognising and designing for these concerns in intervention strategies can provide a strong starting point for further research into fostering sustainable and adaptable consumption within households.

7.3.7. Developing expertise for transition design

The findings of this doctoral research offer valuable insights into how current and future designers might develop transition design capabilities. By examining the activities involved in our transition design process, this research highlights opportunities to enhance curricula, foster experiential learning, and promote collaboration across educational institutions. These insights are particularly relevant for design students, educators, and practitioners specialising in transition design, as well as design agencies seeking the expertise needed to tackle transition design challenges.

Integrating transition design activities into curricula

The Transition Design Framework, detailed in Chapter 6 and shown in Figure 7-3, highlights five essential activities when designing for transitions. It is important to note that we recognise that addressing transition design challenges may require assembling diverse teams with complementary skills across the five key activities identified. Nevertheless, educational programmes can utilise this framework to develop their curricula and educational activities, guided by the following suggestions:

1. **Navigating scales:** Future transition designers can benefit from the ability to integrate multiple levels of systems change within design processes. This suggests that designers might explore how individual behaviours and capabilties at the micro-level interact with organisational roles and relationships at the meso-level, and how these, in turn, can influence and be influenced by macro-level norms, policies, and cultural values (Geels, 2002). Techniques such as multi-scalar mapping, stakeholder network analysis, and zoom-in zoom-out exercises can enable students to analyse these dynamics. Making these dynamics visible through role-playing (e.g., Formo Hay et al., 2024; Gaziulusoy & Ryan, 2017a) or visualisation such as drawings or collages (e.g., Boehnert & Alexander, 2025; Mok & Hyysalo, 2018; Sevaldson, 2022) can help make these interactions more tangible. This tangibility allows students to explore the systemic impacts of their interventions and investigate opportunities for reinforcing change across scales.
2. **Considering temporality:** Since transitions are inherently gradual, unfolding over decades and requiring sustained efforts, building temporal capacity involves encouraging designers to bridge long-term visions with

Figure 7-3 | Framework representing 5 key transition design activities, connected to 3 key evaluative qualities of transition design interventions. Reprinted from Chapter 6. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

actionable present strategies. Gaining experience in using future-oriented methods such as vision building, backcasting, and pathway mapping can help articulate desirable futures and bridge the temporal dimensions of transitions (Gaziulusoy & Ryan, 2017b; Hyysalo et al., 2019; UK Design Council, 2021). Visioning exercises might focus on the skills required to make futures both aspirational and grounded (Wiek & Iwaniec, 2014). For instance, by asking students to articulate long-term systemic visions that reflect desired values and dynamics, while at the same time identifying concrete, pragmatic steps to achieve these outcomes.

3. **Engaging and repositioning actor networks:** Cultivating collaboration and co-creation skills is essential for students to engage effectively with diverse actor networks. Transition design relies on engaging these networks to amplify systemic change by leveraging shared resources, knowledge, and influence (Löhr et al., 2022; Wittmayer et al., 2021). To move beyond

superficial actor participation (Marques et al., 2020), designers can develop the skills to actively reposition actors within transition contexts. As shown in this dissertation, this involves fostering an understanding of actors' positioning, adaptability, and directionality, encouraging the exploration of new possibilities rather than being constrained by current business limitations. Additionally, design education can strengthen designer's relational skills to address tensions constructively within co-creation efforts. Rather than resolving or dismissing tensions prematurely, designers might learn to sit with them and navigate them thoughtfully, thereby fostering deeper understanding to advance systemic learning (Shaw & Solsø, 2024).

4. **Framing and designing portfolios:** Transition design education can play a crucial role in shifting designers away from isolated solutionism toward the development of intervention portfolios. Designers can learn to apply design reasoning to individual interventions, while extending this reasoning capacity across multiple interventions within a portfolio. This can involve supporting students in reasoning strategically, systemically, and contextually. As demonstrated in this dissertation, encouraging designers to design beyond single outputs enables them to recognise synergies and complementarities between interventions, thereby enhancing their overall transformative potential. Integrating collaborative evaluation activities, including peer and stakeholder reflection, can further strengthen designers' capacity to align interventions, assess their systemic impact, and prioritise implementation strategies within portfolios in complex design contexts.

5. **Practising reflexivity:** Reflexivity is essential for developing evaluative expertise, enabling designers to critically assess their design processes, assumptions, and outcomes (Fitzpatrick et al., 2024). In design education, reflexivity can be embedded through activities like iterative evaluations, reflective journaling, and critical design reviews (Pel et al., 2023). Developing more nuanced reflexivity skills will support designers in taking responsibility for the choices and contributions of their design practice. It can help them engage more in normative discussions, debate the ethical considerations of envisioned futures and intervention outcomes, be explicit about the power dynamics influenced in the transition, and more consciously map potential unintended consequences (Avelino et al., 2024; Wittmayer et al., 2021). To support this practice it is adventageous to allow students to engage with certain domains for longer periods of time.

By structuring transition design education around these five activities, designers can develop the competencies required for today's complex design contexts (CLICKNL, 2024; UK Design Council, 2021; Voûte et al., 2020). However, educational programs must also consider how these activities can be tailored to designers at different skill levels—ranging from bachelor to master programs and

practitioners—as each group is able to engage with complexity to varying degrees (Cross, 2004; Lawson & Dorst, 2013).

7.3.8. Practical learning and the use of tools, canvases, and frameworks

Educating designers capable of addressing complex societal challenges requires sustained investment in practical learning. The design profession has evolved significantly, moving beyond the creation of products to the design of systemic change—work that demands transdisciplinary approaches and new competencies. Design education must therefore prepare students to navigate these complexities, fostering both critical and applied skills that enable them to contribute to multi-dimensional, long-term, and multi-stakeholder transitions. This includes providing both theoretical grounding and practical guidance.

This doctoral research underscores the importance of effectively integrating theory with practical application in transition design education. The complexity of transition challenges cannot be fully understood through theoretical study alone; it requires the development of heuristics that emerge through experience. Actively engaging in a transition design process profoundly deepened our understanding of how to apply design expertise to real-world challenges. Throughout this research, practical tools and frameworks—such as the Transition Readiness Profiles (Chapter 3, Figure 3-3, page 70) and the Transition Design Logical Framework (Chapter 5, Figure 5-3, page 123)—were pragmatically developed and refined to bridge theoretical concepts with the realities of transition design practice. These tools and frameworks were applied both within the FETE consortium and in educational courses to test and demonstrate their relevance. In developing these tools, we deliberately used language aimed at fostering shared understanding across disciplines, such as transition studies and organisational change.

Overall, we found that these tools and frameworks were crucial in helping both design and non-design engage with the complexities of transitions and apply their knowledge to conceptualise interventions. However, this process was not without challenges. Students often struggled to move from understanding system dynamics to designing interventions that actively engaged with those dynamics. Additionally, while existing methods like actor mapping were initially considered sufficient for framing the food system, limitations became apparent in practice. In particular, these methods failed to link current dynamics to desired future states or to integrate everyday perspectives into broader system views—both of which are important when designing interventions for transitions. These challenges led to the development of the Transition Readiness Profiles (Chapter 3), which were applied with greater success. Moving forward, some of these tools and frameworks will be integrated into three Bachelor's and Master's courses at TU Delft, further demonstrating the significant contributions of this research to education.

While these tools and frameworks proved valuable, the increasing proliferation of tools, canvases, and frameworks in design education raises critical

questions about their value and role. A key question is whether the tool, canvas, or framework genuinely helps students to envision, understand, and foster futures in ways that integrate with and enhance their design process. Effective tools must go beyond enabling understanding—they must actively facilitate the integration of systemic insights into actionable designs (i.e., bridging analysis and synthesis). While the inputs (e.g., tools, canvases, and frameworks) and outputs (e.g., scenarios, innovation sketches) of this research were specifically designed to support the transition design process, we should remain critical of what we, as educators, provide to, and ask of, students. The tools developed through this research were often insufficient when treated as stand-alone artefacts, applied within short timeframes, or used without a critical mindset, as these conditions made it difficult to fully abstract and apply their value. Therefore, they should be viewed as starting points that may need to be adapted when used in new and different contexts, as each project may have its own peculiarities that require attention.

7.3.9. Universities' role in collaborative efforts

The long-term nature of societal transitions underscores the need for educational and academic research structures that enable sustained engagement. Universities, as key actors within the quintuple helix, have a critical role to play in fostering societal transitions. To take this role seriously, universities must articulate their position in supporting transitions at the institutional level, rather than limiting such efforts to individual PhD projects. This calls for a deeper exploration of how universities can collaborate with other stakeholders to build structures that ensure continuous and meaningful engagement in transition processes. Understanding and shaping this role requires further study.

One promising example of how such structures can take shape is found within the emerging field of systemic design. Although still relatively small, systemic design is a growing international community passionate about fostering collaboration and exchanging knowledge across institutions and between research and practice. The significant participation of over 1000 attendees at the 2024 Relating Systems and Design Conference underscores the increasing global interest and momentum within this field (May, 2024). Fortunately, TU Delft hosts a diverse Systemic Design Lab, with over 15 researchers working across topics such as the circular economy, systemic design in the public sector, and transitions in the food, health, and energy sectors (Systemic Design Lab, n.d). Members of the lab have lectured at other institutions, sharing the systemic design methodologies and approaches developed at TU Delft. Similarly, guest lecturers from other institutions have contributed to the lab's Systemic Design Talks, further enriching the exchange of knowledge. These interactions not only bridge institutional boundaries but also introduce new perspectives, as each institution brings its own approaches to systemic design. While these initiatives have already made an impact on systemic design thinking within the design community, further efforts could strengthen collaborations and expand

opportunities for knowledge sharing. As a relatively young field, systemic design benefits greatly from such diversity and exchange of methodologies. These exchanges enrich education, broaden the repertoire of systemic design tools and strategies, and contribute to the field's maturity.

Throughout this doctoral research, we have had the opportunity to contribute to this knowledge-sharing by presenting our work at international research conferences, participating in sessions with other systemic and social design labs in the Netherlands and Belgium, and engaging students and practitioners through educational workshops. Such knowledge-sharing platforms are crucial for enriching systemic design educational landscapes and connecting research with practice.

7.4. Limitations

Despite the valuable contributions of this doctoral research, the findings must be viewed within the context of certain limitations, particularly those related to the context, the engaged actors and designers, and the limited timeframe of the research.

7.4.1. Food system context

A limitation of this doctoral research is that, apart from design workshops (Chapter 5), all the empirical work was conducted within the context of the Dutch food system transition toward reducing food waste, as part of the "From Excess to Enough" (FETE) research project. While this focus and practical application provided a rich foundation for exploring transition design expertise, as well as for developing and applying the findings and frameworks detailed across the empirical chapters, it introduces a limitation. The contributions may be less generalisable to other transition design contexts, such as the energy or mobility sectors. For instance, transitions in energy are often focused on less frequent purchasing decisions (e.g., to purchase a heat pump) or individual emotions related to things like price and comfort (e.g., lower temperature in homes or showering less) (Burger et al., 2015), while mobility transitions are typically technology-driven (Zhang et al., 2024). These sectoral differences may influence how transition designers approach a transition challenge in research and practice. While the doctoral supervisors bring expertise in energy and healthcare transitions, providing valuable cross-domain perspectives, the findings of this dissertation were not empirically tested in other sectors, and as a result, the findings and outcomes primarily reflect the experience of design expertise in navigating a certain transition (i.e., food waste) within the food system. Future work should apply the outcomes and process across diverse transition design contexts to evaluate their relevance, efficacy, and effectiveness.

7.4.2. Actors and designers engaged

The selection of actors engaged in this research was shaped by its context within

the FETE project, which prioritised mobilising consortium actors to drive systemic change towards transitioning the food system from excess to enough. While FETE included a diverse group of actors with different perspectives and roles within the food system—including a national nutrition centre, a food waste foundation, an IT consultancy, a frozen food manufacturer, a preservation and processing food manufacturer, a waste collector, a food-focused business school, and a meal delivery service company—it does not represent all actor types in the food system. For instance, traditional retailers (e.g., Albert Heijn in The Netherlands) and food growers (e.g., organic and/or intensive farmers) were not represented within the consortium. Although perspectives beyond the consortium were included when developing the transition design vision (Chapter 2), through role-playing and desk research (Chapter 3), and in evaluationg (Chapter 6), the majority of the empirical work relied on direct engagement of consortium partners.

While expanding the actor network to include a broader range of actor types was considered, particularly during the research-through-design experiments, it was not pursued due to practical constraints and the strategic decision to focus on consortium members who were already committed to transitioning the food system. However, this decision also meant that we may not have captured the wider range of perspectives necessary to navigate systemic barriers and opportunities across the wider food system. A critical point of reflection for transition design, warranting future research, is the impact of engaging actors who are actively interested in and working towards a desired transition, such as those in FETE, versus actors who may be resistant to change as they benefit from maintaining the current system but hold significant influence over systemic inertia. While the former is likely more interesting for designers to engage, future research should explore how transition design processes may differ depending on the actors informing the processes.

In addition to the food system actors engaged in this research, the designers involved introduce a limitation. The majority of the designers conducting and participating in the empirical work were based in Europe, with many situated in the Netherlands. This geographic and cultural concentration inherently brings a Western European perspective to the transition design approach and framing of the phenomena. Furthermore, the author of this dissertation, while initially trained in Canada, completed her master's and doctoral research at Delft University of Technology. The supervisory committee also comprises two designers fully trained within the Delft design tradition. This collective background reflects a particular understanding and approach to design that may not fully account for alternative perspectives, methodologies, or approaches.

These biases potentially limit the applicability of the findings across different cultural or socio-political contexts, where systemic inertia and stakeholder dynamics operate under different norms and power structures. To help mitigate these biases, all empirical chapters were submitted to international journals and conferences and revised based on feedback from international experts. Therefore, while the findings of this research provide valuable insights into

transition design practice and expertise, future work should explore more diverse perspectives by engaging designers and researchers from varied cultural and educational backgrounds. Such efforts would contribute to a more context-sensitive understanding of transition design and its applications across global contexts.

7.4.3. *Research timeframe of 4 years*

The timeframe of this doctoral research, constrained to four years, represents a limitation given that transitions typically unfold over decades. This mismatch between in timeframes raises questions about the ability to capture the long-term impacts of proposed interventions on the intended food system transition. While the research evaluated the transition design interventions and proposed practice of adaptable consumption in various ways (e.g., workshops (Chapter 2), interviews (Chapter 3), and narratives (Chapter 6)), it was unable to physically prototype and test the real-world impact of the interventions. Although future research could include prototyping interventions for user studies, controlled experiments, or longitudinal studies to assess the behavioural impacts of the most promising ideas, such activities require extended time frames and resources that were beyond the scope of this dissertation.

The limited timeframe also constrained the depth of exploration into the three areas of transition design expertise—visioning, framing, and evaluating—investigated in this research. Each of these areas could, in itself, warrant a standalone PhD research. As a result, it was not possible to fully investigate all theoretical underpinnings, methodological applications, and practical implications of each area. Nevertheless, their integration within this research provided valuable insights into how designers can apply their expertise to foster desired systemic change, laying the groundwork for deeper future investigations.

Another critical challenge that arose from the limited timeframe was bridging the gap between generating innovative ideas and moving toward their development and implementation. While the research made significant progress in setting up transition design processes that led to promising ideas, a persistent gap remains between ideation and action. This reflects a broader issue within the design discipline, where greater understanding is needed of how to select the most promising ideas for implementation (Baldassarre et al., 2020), and how to address the barriers to practical development, adoption, and scaling—especially in transition contexts where no single actor owns the process. An interesting next step for us could have been to investigate how to bring together the right stakeholders around a specific innovation idea and secure their buy-in to further develop and implement the concept. This includes exploring the conditions and mechanisms that enable stakeholders to take collective ownership of the process and shift from ideas to implementation within transition design challenges.

Addressing these temporal and implementation challenges not only requires more time but also a stronger focus on sustained actor engagement and commitment

throughout the transition design process. The consortium model adopted in this research highlighted both the value and the challenges of transdisciplinary collaboration. The consortium's diversity enriched the design process by supporting problem reframing and the co-creation of interventions tailored to systemic challenges. However, it also revealed difficulties in maintaining continuous alignment and shared understanding over time. Participation fluctuated as individuals entered and exited the process, and some organisations faced periods of reduced involvement due to internal pressures and structural constraints. Such dynamics are common in long-term transition processes, but present significant barriers to cultivating champions within organisations and sustaining momentum toward implementation. Future research should explore strategies not only for mobilising actors at the outset of transition design processes but also for maintaining engagement throughout implementation and scaling phases. Insights from transitions research—particularly concerning how transition managers onboard and facilitate transition arenas—could inform design practices seeking to bridge the design-implementation gap and enable longer-term, systemic impacts.

7.5. Concluding remarks

Despite these limitations, this doctoral research offers a meaningful contribution to the evolving field of transition design by demonstrating how designers can engage with complex societal transitions through visioning, framing, and evaluating. It shows how design expertise can be applied not only to make sense of systemic challenges, but also to co-create interventions that are actionable and situated within context. The tools, frameworks, and reflections developed throughout this research provide a foundation for future academic inquiry, educational practice, and design work at the intersection of design and sustainability transitions.

This research also reinforces the importance of situating design within ongoing, long-term transition processes, rather than treating it as a standalone activity. It highlights the need for deeper collaboration across disciplines, sustained engagement with diverse actors, and thoughtful consideration of how design outputs can move from ideation toward implementation and scaling. While the scope of this dissertation was necessarily bounded, the work has laid a foundation for future research that can expand and refine these ideas across different transition contexts.

Epilogue

The completion of this doctoral research marks the close of a profoundly rewarding and intellectually challenging journey. It is a moment not only of synthesis that brings together years of inquiry, but also of reflection and looking forward. At its core, this dissertation was grounded in a central commitment: to explore how design can meaningfully contribute to societal transitions. By investigating three areas of design expertise it examined how designers can foster systems change by envisioning desirable futures, exploring transformative pathways, and developing interventions that align short-term and long-term impacts.

Focusing on the Dutch food system—an exemplary case of a system in urgent need of transformation—this research has revealed both the potential and limitations of design when operating across scales and timeframes. It offers tools and frameworks for integrating transition design into practice, while acknowledges that design alone is not enough. Its effectiveness depends on its entanglement with other forms of knowledge, actors, and structures.

This research required personal transformation. One of the most significant challenges I encountered was taking on the role of a design researcher. As a designer, I am trained to act—to build, imagine, and move forward. But as a researcher, I had to take things apart, wait, and resist the urge to jump to conclusions. At times, it felt uncomfortable to keep deconstructing and remain in a mode of analysis when my instinct was to synthesise. Yet through it, I came to see that inhabiting the space the moves between analysis and synthesis is a critical part of the design research process. It is in this space that understanding deepens and more grounded forms of action can emerge. I continue to explore and define my identity as a design researcher.

Throughout this journey I came to appreciate how essential adaptability and resilience are. Adaptability allowed me to shift my methods and expectations in response to emergent insights and changing conditions. While resilience enabled me to persist through complexity, setbacks, and uncertainty while maintaining focus on long-term aims. They have shaped how I navigate my own life as I began to adopt more adaptable practices at home. Amidst the hypercomplex crises of our time, I believe such capacities are essential.

As this doctorate ends, many questions remain open. *How can we give form to the dynamic, relational nature of transitions? How might we mobilise actors around shared visions and ensure sustained commitment from implementation and scaling? How can designers prioritise interventions in a way that enables strategic, systemic impact?* These questions reflect an unfinished conversation—one I hope others will join, expand, and challenge.

As I move forward, I carry these learnings, experiences, and questions with me, excited to continue exploring the role of design in shaping a more equitable, sustainable, and just present and future.

I began this dissertation with a Dr. Seuss-inspired poem.
It feels fitting to conclude in the same way:

You reached the end of this book, so do you agree?
That design and transitions is a promising intersection to see

Some questions have been answered,
while some new ones appeared.
Luckily that is nothing to be feared

For transitions take time, step by step, year by year,
Together we shape the futures we hold dear.

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Appendices

Appendix A: Demographics of participants

Table A1 | Details of the households that participated.

Household	Household composition		Location in the Netherlands
	Adults	Children	
1	F42* M56	F13 M9	West
2	F42* M 44	F9 F11 F14	Central-East
3	F40* M44	F5 M8	Central
4	F35* M34*	F3	West
5	F39 * M30	F6 M8 M11	Central
6	F38* M40	M9 M8	Central
7	F40 *	F9 M13	South
8	F38* M39	F5 M7 M9	East
9	F45*	F9	West
10	F41* M46	M13 F15	East
11	F38* M40	F5 M7	East

F=female, M=male, number=age
*The person(s) who participated in the interview.

Appendix B: Overview of interview procedure and theories behind it

Table B1 | Overview of interview procedure and theories behind it.

Interview Division	Supported by	Content	Path of expression	Do Say Make
Part 1: **Cultural Probe Booklet**	Booklet Activity 1	– Have you always bought your groceries in this way? When did this start and why? – Is there one action that you wish you were able to do more often? Why, and what is stopping you?	Past to Present	Say
	Booklet Activity 2/3	– Reflecting on your meal, how well did it align with your expectations in terms of portion sizes and flavours? Why? – Why did you handle the leftovers in the way you did?		
	Booklet Activity 4	– Did you find it necessary to modify your grocery purchases because of the ingredients we gave you? Why? How?		
	Booklet Activity 5	– How did you decide whether to prepare curry or soup? Why? – The ingredients we gave you came with date labels. Did these labels affect how you used these ingredients in your cooking? How? Why? – How do you handle food that is expired or nearing expiration?		
Part 2: **Behaviours of Adaptable Consumption**	1-page visualised user scenario and dot stickers	– Using the green stickers, can you identify up to three activities shown in the comic that you recognise doing yourself? Why these, for how long, and how did you start? – Do you notice that these activities lead to less food waste? Why and how? – Using the yellow stickers, mark up to three activities that you have previously tried but did not make routine? When did you try them and why did they not become routine? – Are there any activities you can never see yourself doing? Why not? Mark up to three activities with red stickers. – With the blue stickers, can you indicate up to three activities that you would want to adopt in the future? Why those, and what needs to change for you to start doing them?	Past to Future	Say and Do

Table B1 Continued

Interview Division	Supported by	Content	Path of expression	Do Say Make
Part 3: Innovations supporting Adaptable Consumption	1-page innovation overview and dot stickers	– Are there any innovations that are similar to ones you currently use, mark these with the green stickers? What are they? When and why did you start using it/them? – Are there any innovations that you would be interested in using if they were to become available within the next year? Mark these with the blue stickers. – Why do they interest you, and how would they fit into your lifestyle? – Are there any innovations that would never fit your daily life? Why do they not fit your daily life? What would need to change for them to fit? Mark these with the red stickers. – Can you think of any innovation (i.e., product or service), not in our list, that would help your family reduce food waste and be more flexible in what and how they eat? Why and how would it help?	Past to Future	Say and Do
Wrap up	All materials	– What do you think about adaptable consumption as a consumption practice? – Do you feel that it would contribute to a reduction of your food waste in your home? Why or why not?	Future	Say

Appendix C: Cultural Probe Booklet

The contextmapping booklet contained five activities and was provided to each household. It was printed in a 21cm by 24cm format and spiral-bound, with a clear plastic cover and a black back page for durability and protection during kitchen use. Images of the booklet activities are shown below, with certain information removed for anonymity.

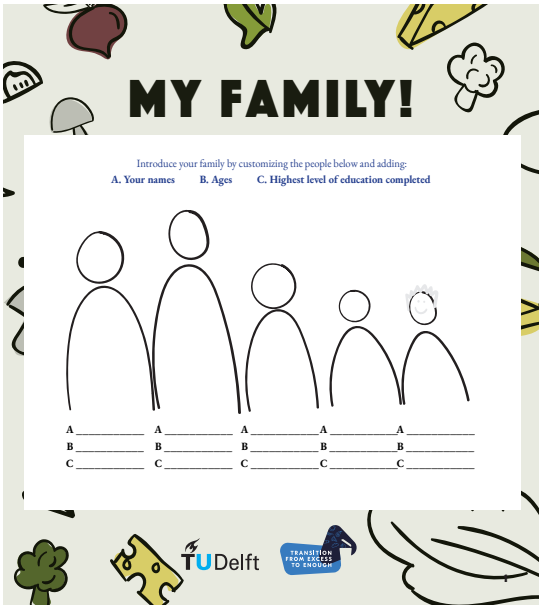


Figure C1| Cover of the booklet. © 2025 Goss, H.M.

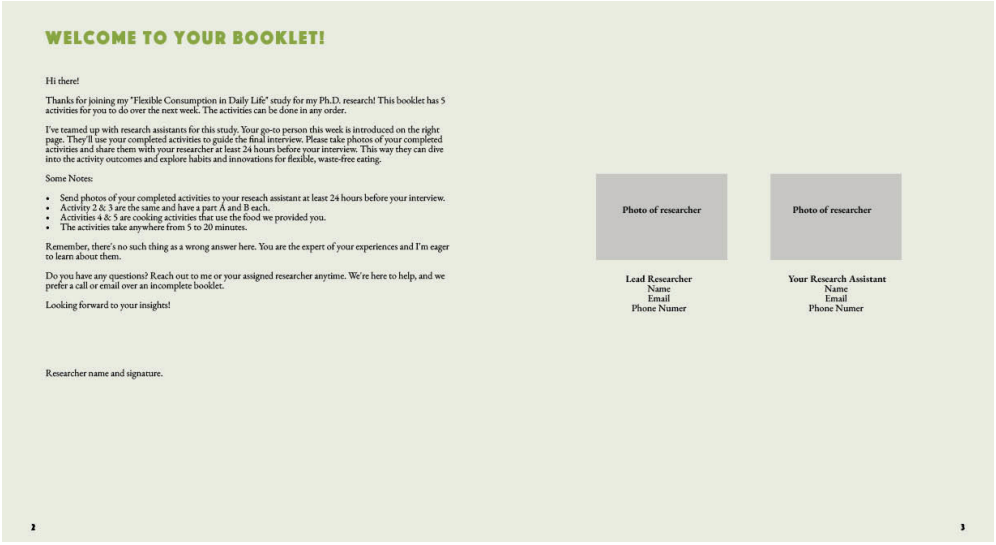


Figure C2 | Introduction to the booklet. © 2025 Goss, H.M.

ACTIVITY 1 | 5 MINUTES

FOOD AND YOUR FAMILY

This activity gives us information about your food purchasing and habits.

1. On average our family spends _____ euros per week on groceries.

2. Where do you usually buy your groceries? Indicate below with a percentage. The total should add up to 100%. (e.g., 80% Online store, and 20% in a food market).

ONLINE %

IN STORE %

MARKET %

OTHER %

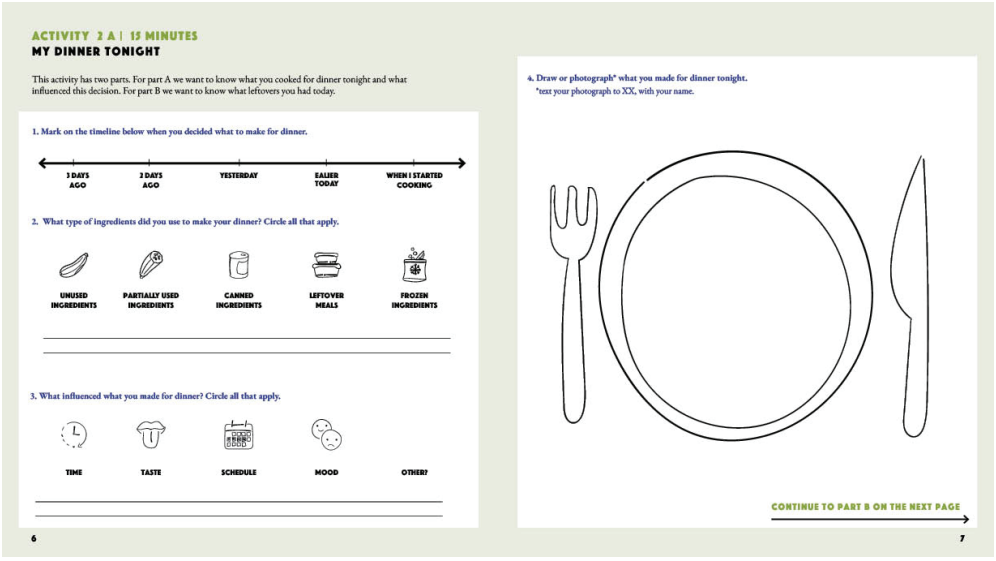
3. How often do you do the following:

	NEVER (0 days a week)	RARELY (1-2 days a month)	SOMETIMES (1-2 days a week)	OFTEN (3-5 days a week)	ALWAYS (6-7 days a week)
I use animal products in my dinners.					
I use frozen food in my dinners .					
I use canned food in my dinners.					
I use seasonal food in my dinner.					
I use recipes when preparing dinner.					

4

5

Figure C3 | Activity 1 in the booklet. © 2025 Goss, H.M.



ACTIVITY 2 A | 15 MINUTES

MY DINNER TONIGHT

This activity has two parts. For part A we want to know what you cooked for dinner tonight and what influenced this decision. For part B we want to know what leftovers you had today.

1. Mark on the timeline below when you decided what to make for dinner.

3 DAYS AGO | 2 DAYS AGO | YESTERDAY | EALIER TODAY | WHEN I STARTED COOKING

2. What type of ingredients did you use to make your dinner? Circle all that apply.

UNUSED INGREDIENTS | PARTIALLY USED INGREDIENTS | CANNED INGREDIENTS | LEFTOVER MEALS | FROZEN INGREDIENTS

3. What influenced what you made for dinner? Circle all that apply.

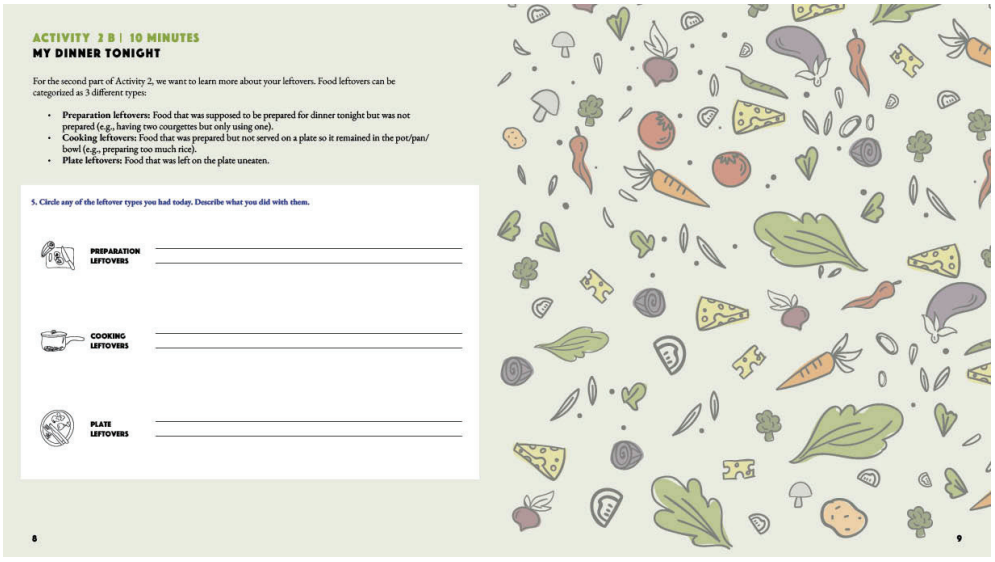
TIME | TASTE | SCHEDULE | MOOD | OTHER?

6

4. Draw or photograph* what you made for dinner tonight.
*text your photograph to XX, with your name.

CONTINUE TO PART B ON THE NEXT PAGE

7



ACTIVITY 2 B | 10 MINUTES

MY DINNER TONIGHT

For the second part of Activity 2, we want to learn more about your leftovers. Food leftovers can be categorized as 3 different types:

- **Preparation leftovers:** Food that was supposed to be prepared for dinner tonight but was not prepared (e.g., having two courgettes but only using one).
- **Cooking leftovers:** Food that was prepared but not served on a plate so it remained in the pot/pan/bowl (e.g., preparing too much rice).
- **Plate leftovers:** Food that was left on the plate uneaten.

5. Circle any of the leftover types you had today. Describe what you did with them.

PREPARATION LEFTOVERS

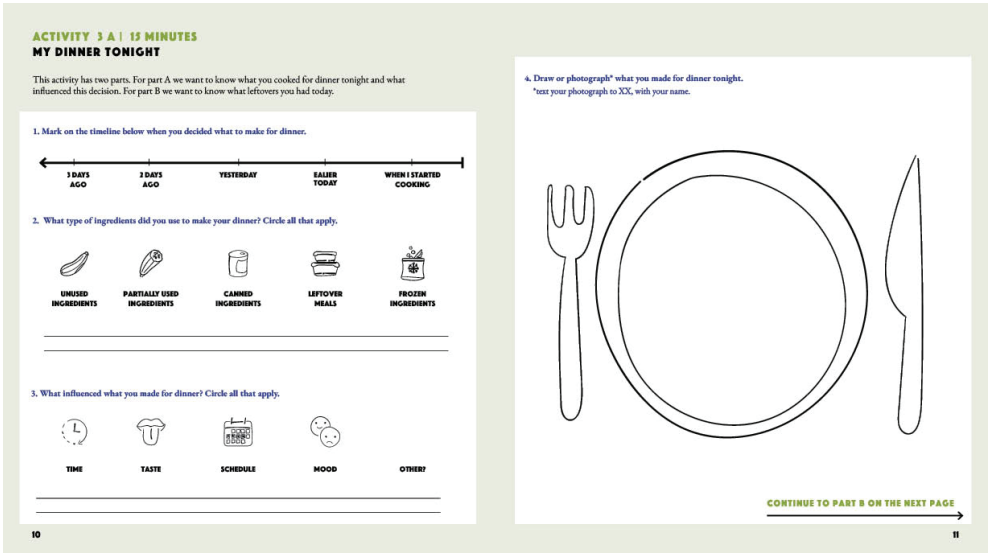
COOKING LEFTOVERS

PLATE LEFTOVERS

8

9

Figure C4 | Activity 2 in the booklet. © 2025 Goss, H.M.



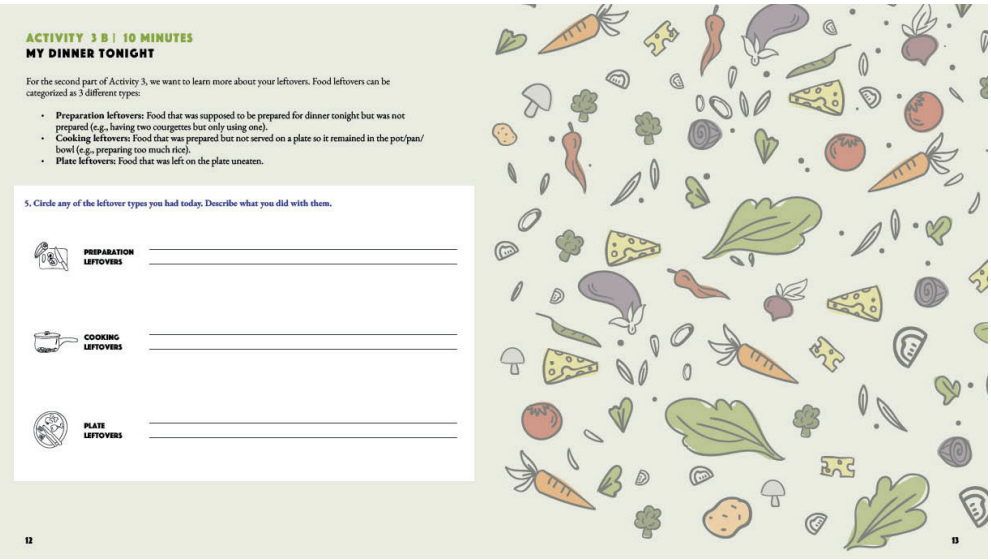


Figure C5 | Activity 3 in the booklet. Activity 2 and 3 are the same. © 2025 Goss, H.M.

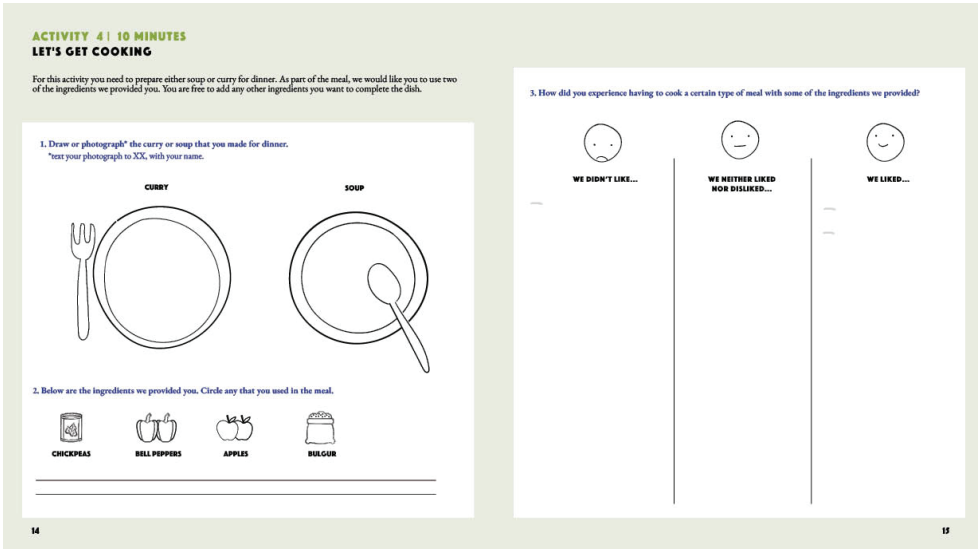


Figure C6 | Activity 4 in the booklet. © 2025 Goss, H.M.

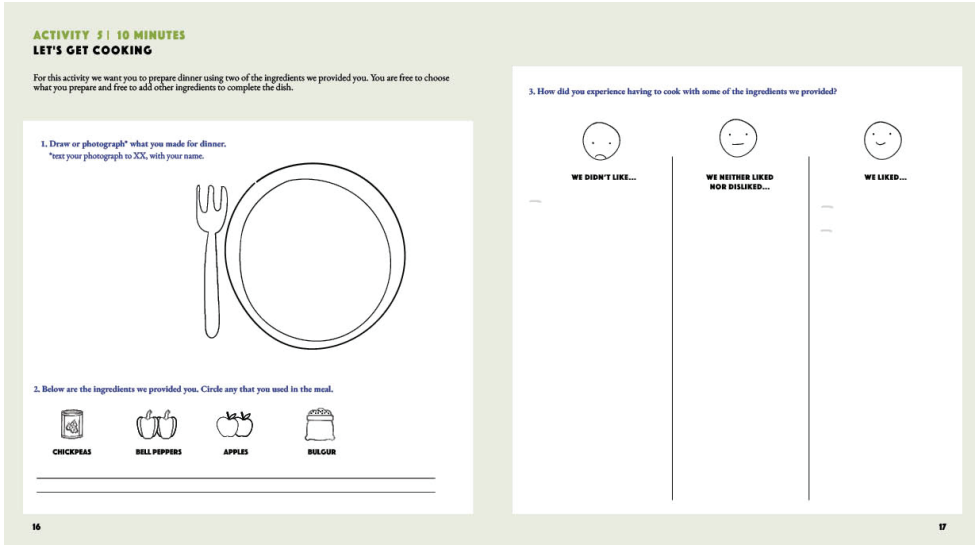


Figure C7 | Activity 5 in the booklet. © 2025 Goss, H.M.

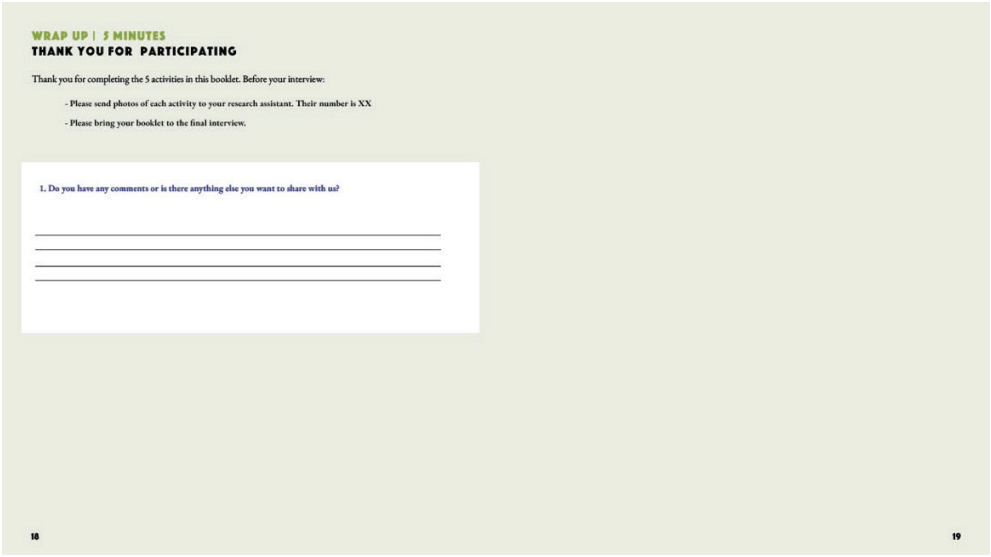


Figure C8 | Final pages of the booklet for participant remarks. © 2025 Goss, H.M.

Appendix D: Example Narrative

How Laura learns to mix and match ingredients

The following story describes the behaviour of Laura, a Dutch woman living alone in a small apartment. Laura uses an innovation to help her mix and match seasonal and local ingredients in her meals.

Laura's Story:

One Friday evening, Laura begins planning what she will serve her parents for dinner tomorrow night. She opens the Ingredient-Less Menus app on her phone and scrolls through the different menus, ranging from the number of courses to specific holidays and moods. Laura selects a 'Feel the Sunshine 3-course Menu' which is meant to evoke a bright, fresh, and vibrant theme for dinner. The menu advises that she select ingredients that are in season in her region to get the best flavours, but it leaves the choices to her. It also stimulates her to try and use the ingredients she has at home.

Laura looks in her fridge and finds zucchini *(courgette)* and tomatoes; knowing that these items are seasonal and local, she decides to shape the menu around them. For the appetiser, she reads that she should prepare 100 grams per person, so she decides on zucchini carpaccio. The menu says she should add a touch of sourness and natural fat after slicing the zucchini. *"I can use the leftover lemon I saw in the fridge and some olive oil,"* Laura thinks. For the main course, the app suggests a pasta-based dish that is about 200 grams per person. Laura decides on simple tomato pasta—she notes that she will go to the store tomorrow morning to buy pasta and cheese. For dessert, she reads that she can transform any remaining zucchini into a sweet dish by baking it with a natural sweetener. *"I can use some of my honey for this"* Laura thinks.

As she plans each dish, the Ingredient-Less Menu app supports her in creatively using whatever she has at home. This has helped Laura expand her cooking skills and focus on seasonal and local innovations. As she closes the app, Laura is excited to serve her parents this special dinner tomorrow night.

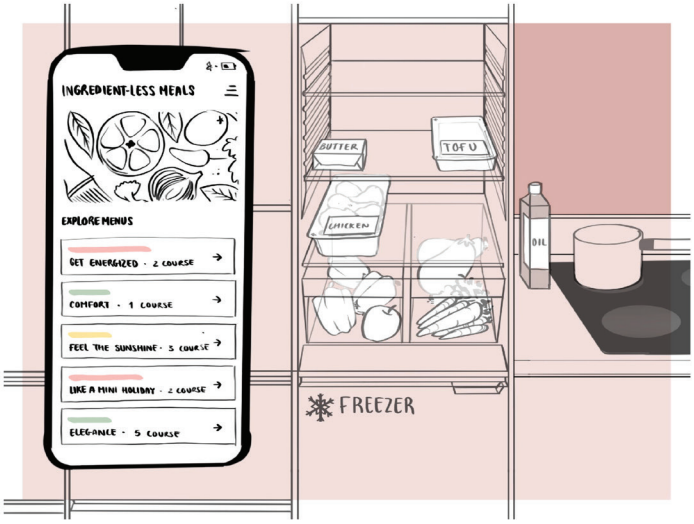


Figure D1 | Example of how participants were presented the narratives and the product-service-systems in Qualtrics. This example narrative is for PSS 20 ('Ingredientless Menus'). Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J. J.I.J.C., & Tromp, N.

Appendix E: Survey questions and items

Table E1 | Overview of intended behaviour supported by each intervention set.

Set	Behaviour A	Behaviour B
Waste bin insights	Careful consideration of how much food is bought.	Careful consideration of how much food is thrown away
Use-me-later tools	The efficient storage of partially used food.	The use of stored food in meal preparation.
Freezer integration	The effective storage of frozen items.	The integration of frozen items into meals.
Frozen ingredients	The use of frozen food in meals.	The mixing and matching of ingredients in meal patterns.
Consumption boxes	Completing and changing meals with ingredients in stock.	The mixing and matching of different ingredient types.
Assessment labels	Assessing food quality with the senses.	Taking appropriate actions based on sensory evaluation.
Ingredientless recipes	The mixing and matching of different ingredient types.	The use of ingredients that are in stock at home.

Table E2 | Overview of the full list of questionnaire items used in the analysis.

Item	Statement	Consumers	Experts/ Companies
1	'This story is believable'	✓	✓
2a	'I can see myself using this innovation'	✓	
2b	'I can see consumers using this innovation'		✓
3a	'It would be attractive for a company to develop an innovation like this'	✓	
3b	'It would be attractive for a company to contribute to developing an innovation like this'		✓
4	'This innovation is a new and creative solution to the problem of food waste'	✓	✓
5	'This innovation will contribute to minimising food waste'	✓	✓
6	'This innovation will contribute to making consumption patterns more flexible'	✓	✓
7	'This innovation stimulates [individual behaviour A*]'	✓	✓
8	'This innovation stimulates [individual behaviour B*]'	✓	✓
9	'Do you think this innovation will (eventually) be available to consumers?'	✓	✓
10	'How many years before this innovation will be available to consumers?'	✓	✓
11	'The innovations in the portfolio show diversity (e.g., there is range of innovation types)'		✓
12	'The innovations in the portfolio show complementarity (e.g., the innovations bring something unique)'		✓
13	'The innovations in the portfolio show synergy (e.g., the innovations work together to have more impact)'		✓
14	'The innovations in the portfolio show reinforcement (e.g., the innovations boost the effectiveness of the other innovations)'		✓
15	'The innovations in the portfolio show coherence (e.g., the innovations fit well together)'		✓

*See Table E1 for specific behaviours

Appendix F: Portfolio of interventions and Narratives

Set 1: Food waste feedback

Rationale for set

- By offering consumers insight into how much and what food they waste, they will have better visibility into their waste situation, equipping them better to adjust what they buy based on what they waste (individual behaviour).
- This feedback increases their confidence in food provisioning for enough and helps them feel more empowered to adapt their consumption practices (individual value).
- By introducing information flows about food waste on the household level, more targeted behaviour change can be introduced to reduce food waste (system behaviour).
- This information can be used to optimise food packaging, separation techniques, communication around food waste and support various system policies and initiatives (e.g., province, municipality, neighbourhood) (systemic value)
- An innovation that offers this can be supported and implemented by municipalities in collaboration with FETE partners: a food waste foundation, a national nutrition centre, and a waste collector.

Intervention Narratives: How Sascha gains insight into her food waste

The following three stories describe the behaviour of Sascha, a Dutch woman who lives in a small home with her family. Sascha uses different innovations to understand more about her food waste.

Sascha's Story 1:

It's 18:00, and Sascha just arrived home from work and starts to prepare dinner for her family. She decides to make soup and gathers the different vegetables she will use: onion, garlic, broccoli, carrots, and leek (prei). On her countertop, she has a waste bin. The bin is divided for avoidable food waste, like parts of fruit and vegetables that are still edible, and unavoidable food waste, such as peels and coffee grounds.

As Sascha throws the unused broccoli stalk into the avoidable waste section, she frowns. She notices an indicator showing they've already wasted four portions of edible food this week. This makes her think about how her family can reduce food waste and make better use of the ingredients. Sascha decides to save the broccoli stalk and other vegetable scraps for a soup she can make next week.

As Sascha continues cooking, she places unavoidable waste, like onion skins and garlic peels, into the bin. The bin helps her to see what could have been eaten and what couldn't. When dinner is ready, Sascha calls her family to the table to enjoy her homemade soup.

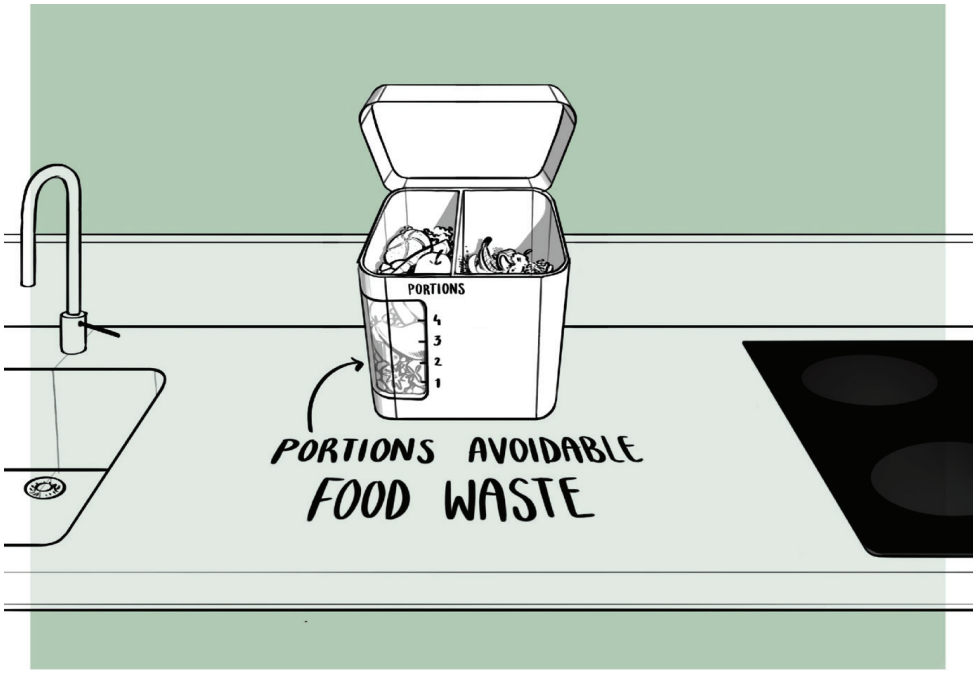


Figure F1 | Countertop waste bin. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Sascha's Story 2:

It's a May morning, and today in Sascha's neighbourhood the municipality collects the food waste bins. Before she goes to work, Sascha brings her food waste bin on wheels to the road for collection. Sascha has Smart Waste Bins. Her bins have sensors which capture data on the amount and type of waste discarded. This data is sent to a waste App on Sascha's phone.

As she sits in the train on her way to work, Sascha opens the waste App to check this week's waste data and neighbourhood comparisons. A few weeks ago, the app indicated that her household often discards apples. The app provided personalised tips like: "You threw away many apples; try ordering fewer next week" and "Frozen apples are tasty to use in pies." Since then, Sascha has been buying individual apples instead of large bags. Today the waste App shows that her family wasted less food and didn't discard any apples. Sascha can't help but smile.

Checking the neighbourhood comparisons, she sees that her family wasted a bit less than her neighbours. Sascha also reads about a new pilot program starting in a few weeks. The municipality will launch a new food waste initiative in her neighbourhood to address the increase in fruit and vegetable waste during the summer. As she looks out the train window, Sascha wonders what new tips she might learn from the upcoming initiative.

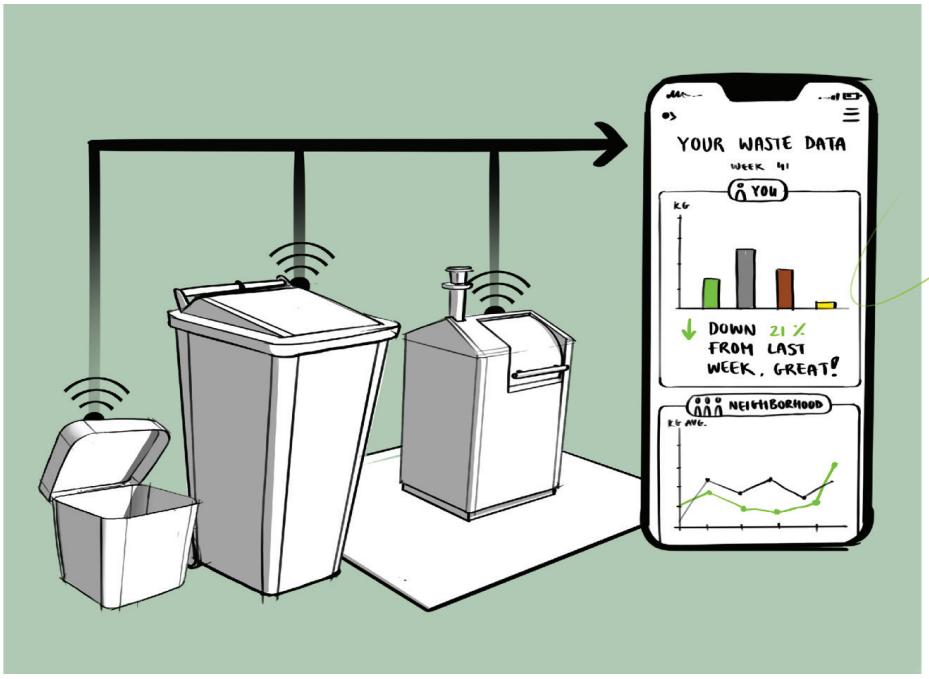


Figure F2 | Smart food waste bin. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Sascha's Story 3:

Sascha sits on her couch with a cup of tea. It's a weekday evening, and she's ready to order groceries for the upcoming week. She picks up her phone and opens her grocery app. The grocery app is connected to her Smart Kitchen System, which includes a smart food waste bin, smart fridge, and smart cupboards. As Sascha adds items to her shopping cart, like carrots, rice, and tofu, the grocery list automatically adjusts each quantity.

The adjustments are based on data about what food Sascha has at home and what food her family discards. For example, the grocery app shows they have a surplus of carrots in the fridge and suggests she skips buying more this week. It also knows that she often over-prepares rice, based on the data from the food waste bin. Therefore, the app recommends buying a smaller package and offers tips for preparing the right amount of rice for different recipes.

Sascha is happy that the app keeps track of the items in her storage and considers her habits, so that she always orders the right amount of food. With her groceries ordered, Sascha gets ready for bed.

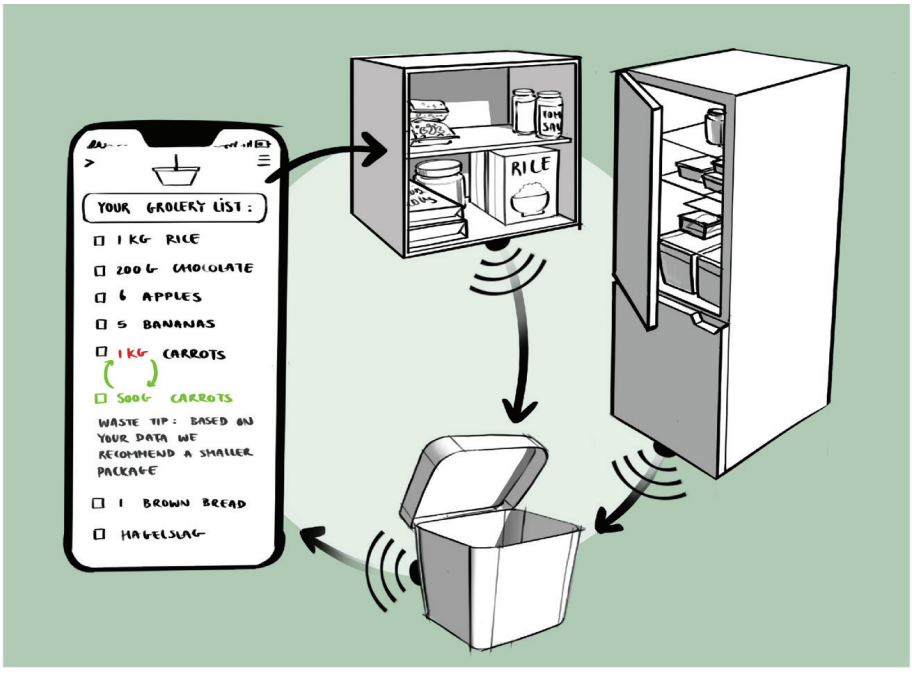


Figure F3 | Smart kitchen system. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Set 2: Use-me-later tools

Rationale for set

- By supporting consumers in storing and preserving unused food for later consumption effectively, consumers can be more skilled at assessing when food is still edible and be better equipped to repurpose food in different ways (individual behaviour).
- This flexibility increases their acceptance of inconsistencies in flavour and texture, and promotes more efficient use of partially consumed food (individual value).
- If preserving and repurposing partially used food becomes common practice, growers can focus more on sustainable farming practices rather than purely cosmetic standards, and growers can diversify their product offerings by selling not only fresh produce but also products made from surplus or imperfect items (system behaviour).
- If consumers appreciate the value of using the whole product, including parts that are usually discarded, it fosters a stronger connection between farmers and consumers, allowing farmers to sell more of what they grown regardless of cosmetic variations, and reduces the overall amount of food needing to be produced in the first place (systemic value).
- An innovation that offers this can be supported and implemented by FETE partners: a foundation against food waste, a national nutrition centre, and a preservation and processing food manufacturer.

Intervention Narratives: How Jorn extends the life of his food

The following three stories describe the behaviour of Jorn, a recently graduated Dutch male who lives alone. Jorn uses different innovations to extend the life of his food items.

Jorn's Story 1:

Jorn is sitting on the balcony of his apartment, having a drink. A few months ago, he started living on his own. While he enjoys the freedom of cooking what he wants, he struggles with the package sizes at the grocery store. After finishing his drink, he goes inside to make a sweet potato curry for dinner.

Jorn takes out one of his Preservation Duo food storage containers from the fridge. The container has leftover chopped sweet potato. His parents gave him these containers as a housewarming gift to help him store leftovers and extend the life of partially used food keeping them fresher for longer. Jorn releases the air-lock of the container before taking off the lid. He notices the sweet potato is slightly softer and less orange than last week. He shrugs and adds them to the pan on the stove anyway.

As the sweet potato cooks, he reaches for a can of chickpeas (kikkererwten) in the cupboard. He opens the can, pours out the liquid into the sink, and adds half of the can to his curry. He likes chickpeas, but adding the full can would make too much food for just him. Instead of throwing the rest out, he puts the unused half into the other Preservation Duo jar. Jorn reads the instructional labels on this jar and finds tips for storing chickpeas. Following the tips, he adds 1 tablespoon of oil to keep the chickpeas from drying out while they are stored in the fridge. Once the curry is ready, Jorn sits down to enjoy his meal.

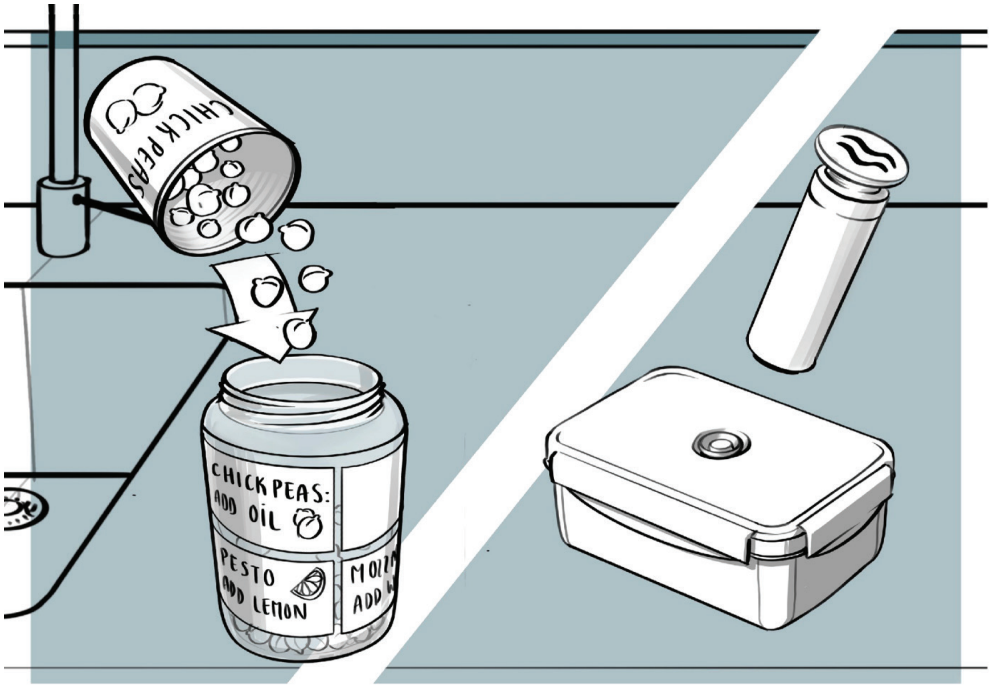


Figure F4 | Preservation duo. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Jorn's Story 2:

It's Saturday night and Jorn is having friends over for dinner. He wants to prepare his favourite pasta recipe. He gathers all the ingredients for the sauce: garlic, onion, unopened fresh mushrooms, and leftover cherry tomatoes. He puts a pan on the stove, adds some oil, and starts chopping garlic and onion adding them to the oil. He opens the mushroom container, takes out half, slices them, and adds them to the pan. Next, he releases the air-lock of the container of cherry tomatoes. The tomatoes are from two weeks ago and are a little bit soft, but he decides they will be fine when cooked in the sauce.

As the sauce cooks, Jorn starts cleaning up. He inspects the unused mushrooms, checks his meal calendar, and realises he won't be eating them this week. Jorn considers which of his Life-Extending Tools to use to preserve them: his dehydrator, quick freezer, or vacuum which removes the air. He chooses the dehydrator. He cuts the unused mushrooms into slices, places them in a container, and makes sure the mushrooms are dried well, so that they can be used later for soup or risotto.

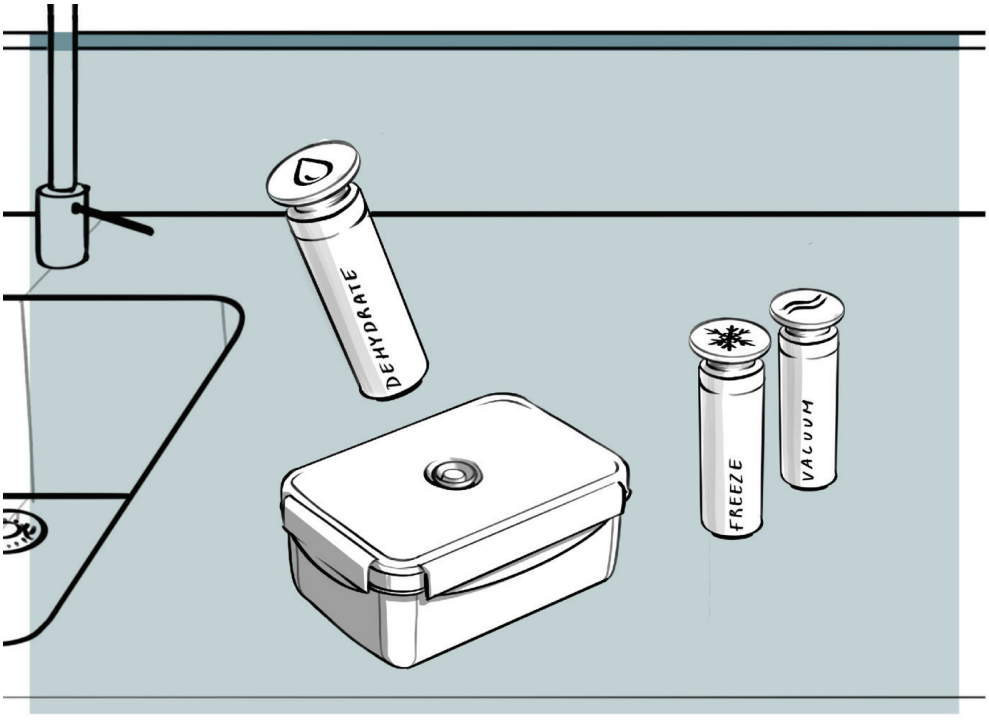


Figure F5 | Food life extending tools. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Jorn's Story 3:

Jorn is in his kitchen thinking about what to make for dinner. He looks in his fridge and cupboards and sees several Preservation Pods with food leftovers. The Preservation Pods have sensors that monitor the freshness of the food inside, automatically adjusting the internal conditions to slow down the decaying process and keep the food at its optimal quality. This is done by the Pods automatically removing the moisture, removing air, or cooling the contents to ensure prolonged freshness.

Some Pods have been in the fridge or cupboard for days, weeks, or even months, so he isn't sure what's inside anymore. Feeling low on energy, he decides to make a quick stir-fry. He opens a Pod with leftover roasted vegetables and another one with a piece of grilled chicken. He heats a pan on the stove, chops the vegetables and slices the chicken. As he cooks, Jorn notices how the Pods kept the vegetables crispy and the chicken juicy and tender. When the stir-fry is ready, he eats most of it and places the last few bites in a Preservation Pod, which cools the contents so he can enjoy it later.

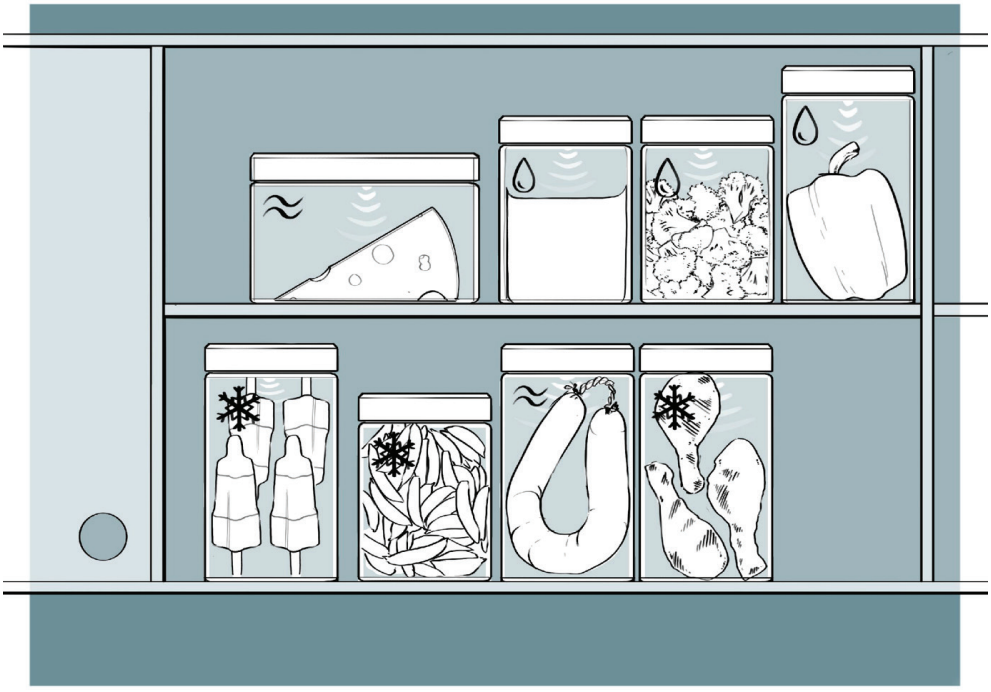


Figure F6 | Preservation Pods. Drawing by Sterre Witlox.

Set 3: Freezer integration

Rationale for set

- By making frozen products and leftovers more visible and accessible in consumers' homes, consumers will be better supported in integrating these items into their meal patterns, as well as mixing frozen products with fresh products when cooking (individual behaviour).
- This integration into the kitchen increases consumers' confidence that they have enough food in the house to adapt to unexpected events and supplement meals when necessary (individual value).
- By better integrating frozen products and leftovers into consumption patterns, more variety of frozen ingredients, meals, and package sizing can be developed and sold (system behaviour).
- This allows for more sourcing flexibility based on season and harvest, and increases the production and sale of frozen items, thereby using more of what is grown in different ways while retaining nutritional value (systemic value).
- An innovation that offers this can be supported and implemented by FETE partners: a frozen food manufacturers in collaboration with a kitchen appliances company like Phillips or IKEA.

Intervention Narratives: How Anna transforms her freezer

The following three stories describe the behaviour of Anna, a Dutch woman living with her husband. Anna transforms her freezer using different innovations.

Anna's Story 1:
It's 17.30, and Anna arrives home from work. She has a workout class at 19.00, so she wants to start preparing dinner. Anna walks into her kitchen and slides open her Freezer Drawer. The wide opening gives her a good overview of what she has in stock. Anna sees some burger patties and buns neatly organised without any sign of freezer burn or deterioration. She decides she will make these for dinner. As she closes the Freezer Drawer, she spots a bag of frozen peas, which will go nicely with her meal.

Sliding open the other drawer, the Fridge Drawer, Anna looks to see what else she can add to her dinner. She sees some lettuce and tomatoes for the burgers and some potatoes she can make into fries. As she cooks, Anna thinks about how much simpler meal preparation has become with their Fridge-Freezer Drawers. She no longer forgets about items hidden away or finds freezer-burned food she has to discard. The Drawers help to keep all ingredients at their best. With all her ingredients on the counter, Anna begins to prepare her meal.

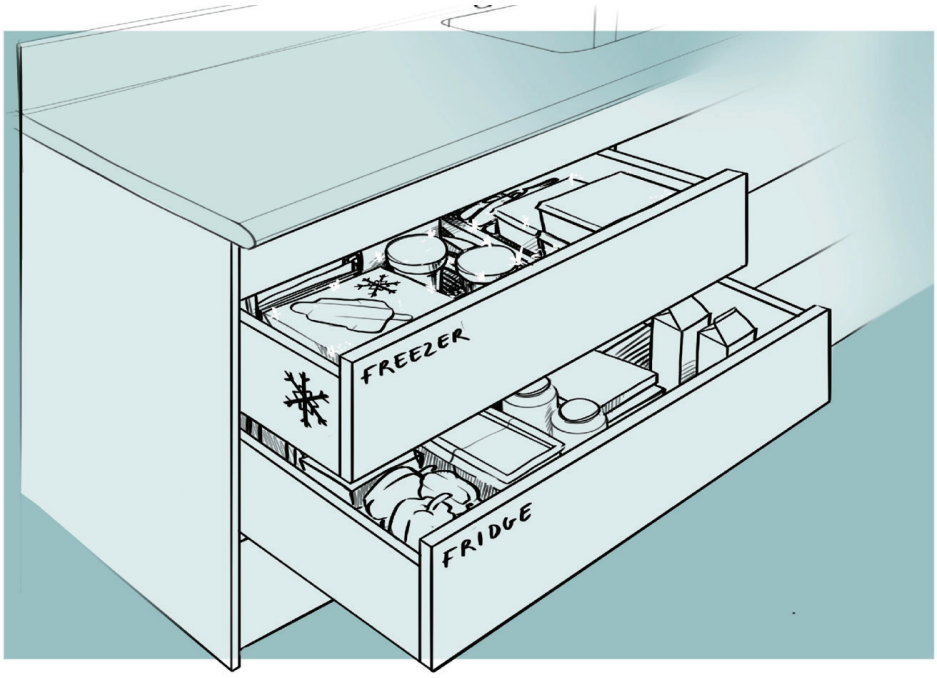


Figure F7 | Fridge-Freezer Drawers. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Anna's Story 2:

Tonight, Anna decides to make a quiche for dinner. She opens her freezer and takes out a bag of pre-chopped vegetables that she Quick-Froze last week. The red bell peppers (paprika's), broccoli, and asparagus are still brightly coloured. She uses her Quick-Defrost Device to get the vegetables ready to cook. While they defrost, Anna mixes some eggs and grates some cheese. She notices that the defrosted vegetables remain crunchy and colourful as she mixes them into the eggs. Anna pours the mixture onto the dough in a springform pie pan and puts it in the oven.

Once the quiche is ready, she calls her husband to the table to eat. After dinner, three slices of quiche remain. She puts the leftovers in a container, Quick-Freezes them and places them in the freezer for another time. When cleaning the table, Anna thinks about how her Quick-Freeze and Defrost Device has changed her preparation and cooking routine. It allows her to defrost items at the time of preparation, and also quickly freeze leftovers after dinner before storing them away. Plus, the Quick-Freeze and Defrost Device keeps food fresher and tastier, just like if things were professionally frozen.

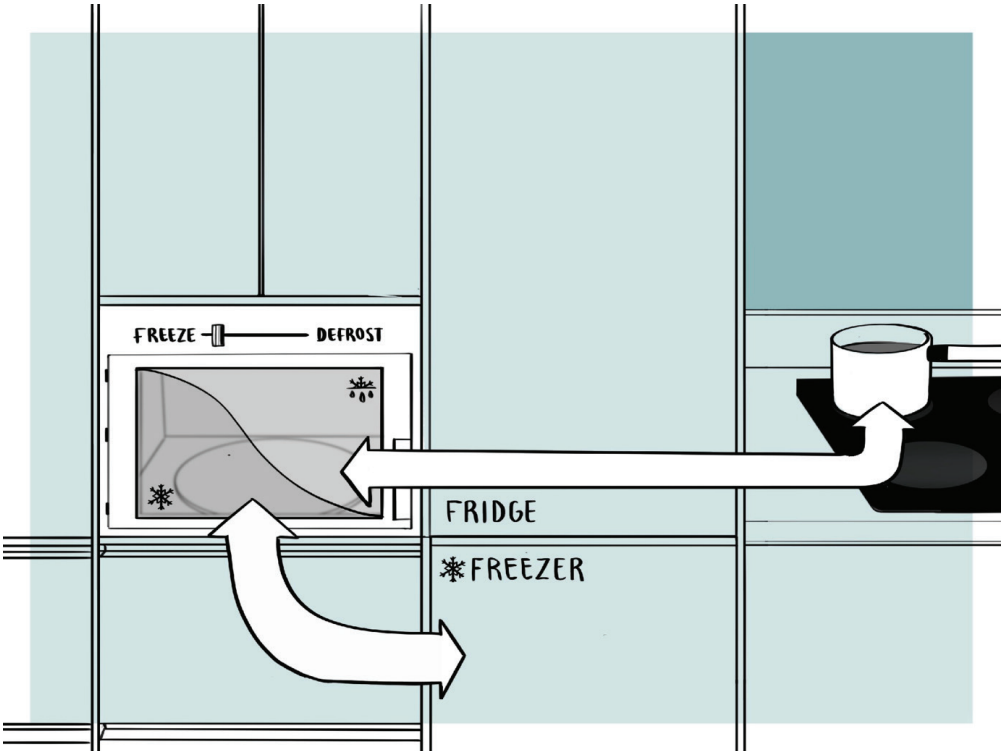


Figure F8 | Quick-Freeze and Defrost Device. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Anna's Story 3:

Tonight is curry night at Anna's house. Anna opens the cupboard and takes out a Speed Freeze Bag with vegetables that she prepared earlier this month. When she opens it, a quick defrosting process begins automatically. In minutes, her bell peppers (paprika's), zucchini (courgette), and spinach are ready to use, still crisp and nutritious. Anna heats a pan on the stove, adds oil, and tosses in the defrosted vegetables. Next, Anna grabs another bag from a shelf with a homemade curry sauce. The sauce defrosts quickly, and she pours the sauce into the pan with the vegetables, stirring until combined.

When the curry is ready, Anna calls her husband to the table. Even though they liked the curry, they couldn't finish all of it, so after dinner Anna scoops the remaining curry into a Speed Freeze Bag, sealing it properly. Within moments the bag automatically speed-freezes the curry, locking in its flavour, texture, and nutrients. She places the Speed Freeze Bag on the cupboard shelf alongside her other fresh and canned ingredients. By keeping the Speed Freeze Bags together with her other ingredients, she can see all her options clearly when planning and preparing meals.

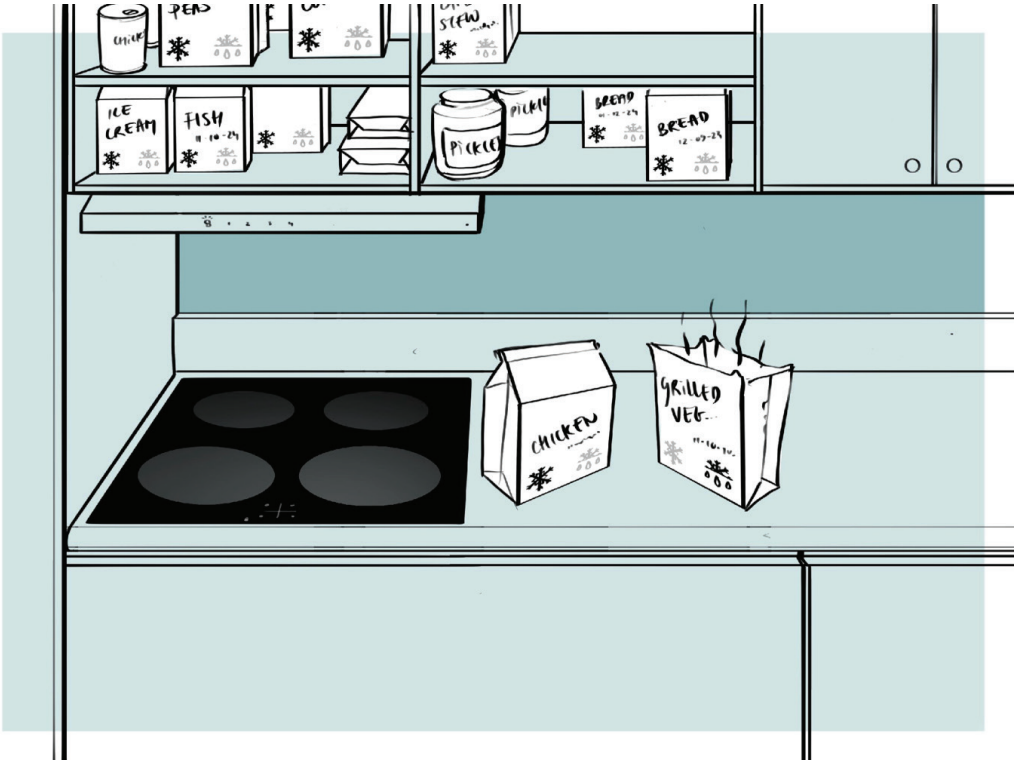


Figure F9 | Speed Freeze Bags. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Set 4: Frozen offering

Rationale for set

- By shifting consumer perception to view frozen food as a staple ingredient in meals, consumers can become more equipped to adjust portion sizing, feel confident in responding to unexpected events, and be skilled at mixing ingredients and flavours (individual behaviour).
- This flexibility promotes more efficient use of partially used ingredients, increases their confidence in food provisioning for enough, and allows for a degree of control and surprise for finding new flavour combinations (individual value).
- By shifting perceptions to see frozen as part of a normal meal pattern, more variety of frozen ingredients, meals, and package sizing can be developed and sold (system behaviour).
- This would allow for more sourcing flexibility in that food that is not 'perfect' can be used in other forms, such as frozen meals, or frozen ingredients, and increases food security by providing stocks that can be relied upon during times of supply chain disruption (systemic value).
- An innovation that offers this can be supported and implemented by FETE partners: a frozen food manufacturer, a foundation against food waste, and a national nutrition centre.

Intervention Narratives: How Paul enjoys frozen ingredients

The following three stories describe the behaviour of Paul, a Dutch man with a wife and two kids. Paul uses different innovations to help him integrate and enjoy frozen ingredients into his meal routine.

Paul's Story 1:

Paul stands in his kitchen preparing dinner for his family. He opens the freezer and takes out a Frozen Meal designed for families with different dietary needs. He chose a curry meal package that offers both vegetarian and meat options. The Frozen Meal shows the nutritional details of the vegetarian and meat variations. Paul follows the instructions, starting with the vegetarian curry for his wife and son. He cooks the vegetables with creamy tomato sauce. For Paul and his daughter, he takes some of the vegetarian sauce and puts it in a separate pan and adds the chicken from the package.

The package suggests adding two handfuls of peas for a hungry eater. He grabs his box of individually portioned frozen peas from the freezer and easily adds one portion, making sure the meal is filling and nutritious, also for his daughter who trains as an athlete. When dinner is ready, Paul calls his family to the table. They gather around, each eating the pasta variation that fits their needs.

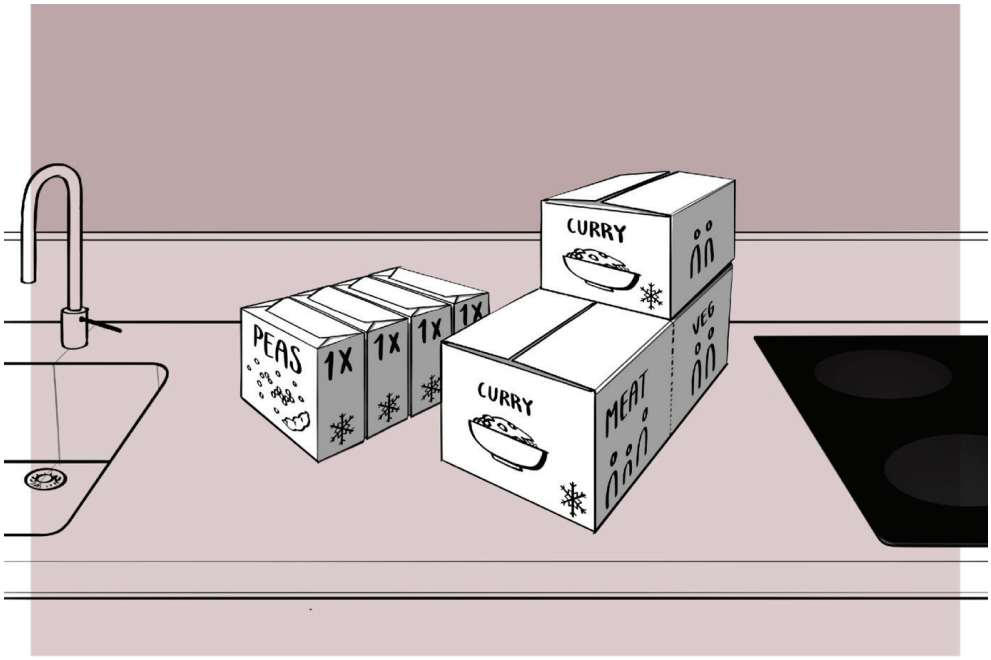


Figure F10 | Frozen meal. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Paul's Story 2:

On a winter evening, Paul sits at his kitchen table with a cup of tea. He is ready to order his family's groceries. He opens his grocery app and starts building his Personalised Frozen Meal. He decides to make a frozen vegetable lasagna. The Personalised Frozen Meal lets him adjust the ingredients and portions to suit his four-person household. He adds four portions of frozen pre-chopped carrots, zucchini (courgette), and spinach. Next, he adds the frozen cheese portions, including an extra portion to make it extra cheesy. Next, he adds frozen marinara sauce, adding only three portions because his daughter doesn't like lasagna too saucy.

As he finishes building his Personalised Frozen Meal, Paul decides to swap the zucchini for pumpkin, because it is currently in season. He also adds an extra portion of pumpkin so that there are leftovers he can eat for lunch at work.

After choosing the ingredients in the app, he could take his shopping list to the store and compose his meal. However, he decides to have everything delivered at his house. The ingredients in the meal will arrive with his other groceries frozen and perfectly portioned, keeping their texture and nutrients, making it easy to assemble. Having a few of these Personalised Frozen Meals in his freezer allows Paul to be ready for unexpected events during the month.

Figure F11 | Personalised frozen meals. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Paul's Story 3:

Tonight Paul decides to make a stir-fry. He opens the freezer and easily sees what ingredients he has in stock to cook with. He takes out peas, broccoli, and carrots. The vegetables are wrapped in a food-safe Dissolvable Packaging. This packaging eliminates the need for cardboard, and the clear film lets Paul see exactly what he has. The vegetables are colourful and don't appear to have any freezer burn or deterioration. He breaks off the amount of peas, broccoli, and carrots he needs, putting the rest back in the freezer. He grabs the remaining frozen tempeh and a few portions of frozen teriyaki sauce wrapped in the Dissolving Packaging.

Paul heats up a pan, cooks the tempeh, and adds the vegetables and teriyaki sauce. As they cook, the Dissolving Packaging disappears completely, leaving no trace. When dinner is ready, Paul calls his family to the table. They gather and enjoy the stir-fry.

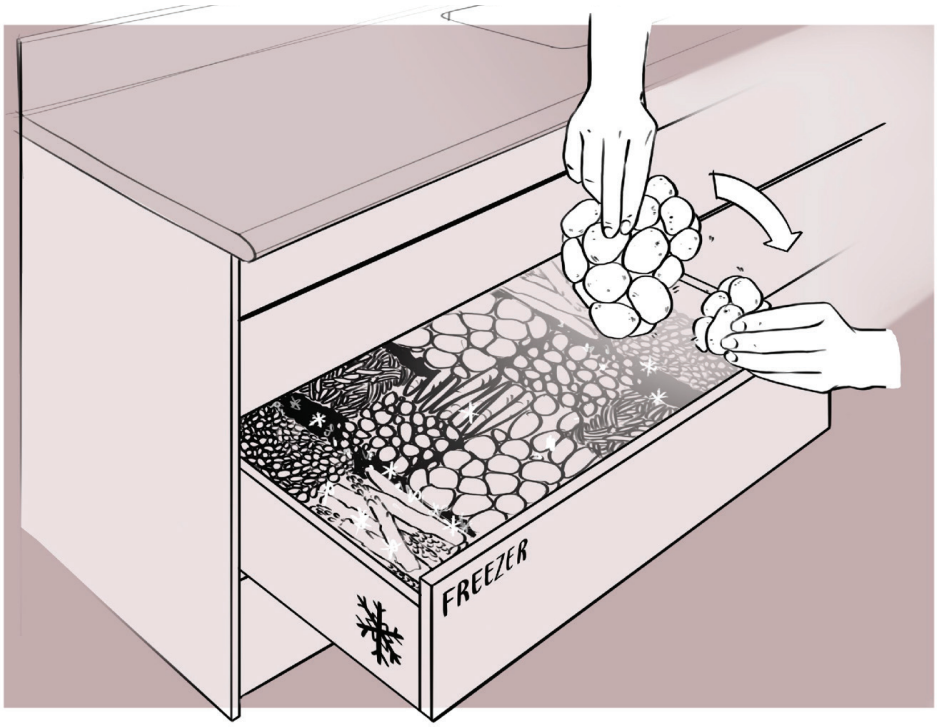


Figure F12 | Dissolvable packaging. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Set 5: Consumption boxes

Rationale for set

- By supporting consumers in completing and adapting meals on the fly, consumers can become more skilled at adjusting portion sizing and mixing various ingredients and flavours (individual behaviour).
- This flexibility enhances their resilience to supply changes, brings meals with customization, offers confidence to respond to unexpected events, and promotes the use of items consumers have at home (individual value).
- By offering meals that need to be supplemented by consumers, retailers and food manufacturers can default to smaller portions, use less fresh and vulnerable food items, and adjust offering based on season and harvest (system behaviour).
- This flexibility would allow for more sourcing flexibility based on harvest and season, incorporate more unique ingredients to diversify crops, handle supply-demand mismatches, and increase the production and sale of long shelf-life items, thereby selling 'all' that is grown (systemic value).
- An innovation that offers this can be supported and implemented by FETE partners: a frozen food manufacturer, a preservation and processing food manufacturer, a meal delivery service.

Intervention Narratives: How Puck uses a weekly consumption box

The following three stories describe the behaviour of Puck, a Dutch single mom with three kids. Puck uses different innovations to help her complete and adapt meals in her weekly routine.

Puck's Story 1:

It's late afternoon on a Monday in summer. Puck is sitting in her living room while her kids play with a puzzle on the floor. The doorbell rings, and she opens the door to a delivery man holding the Consumption Box she ordered. Opening the box, she finds items with a long shelf life, like rice, chickpeas (kikkererwten), and lentils (linzen), along with fresh seasonal produce, like tomatoes and coriander. The Consumption Box provides almost enough food for two dinners for her family.

Puck wants to use the Consumption Box tonight, so she looks through the included recipes. The recipes offer various ways to prepare the ingredients into a complete meal, depending on Puck's mood, time, and skill level. She decides to make a lentil curry. She uses the fresh tomatoes and onions, along with the lentils and rice. She has frozen spinach from a previous Consumption Box, adding that to the recipe to make enough food. The Consumption Boxes come with both long-shelf-life and fresh ingredients so that she always has enough varied ingredients to make a good meal, without the stress of daily meal planning. Once dinner is ready, Puck calls her children to the table, and they enjoy their lentil curry.

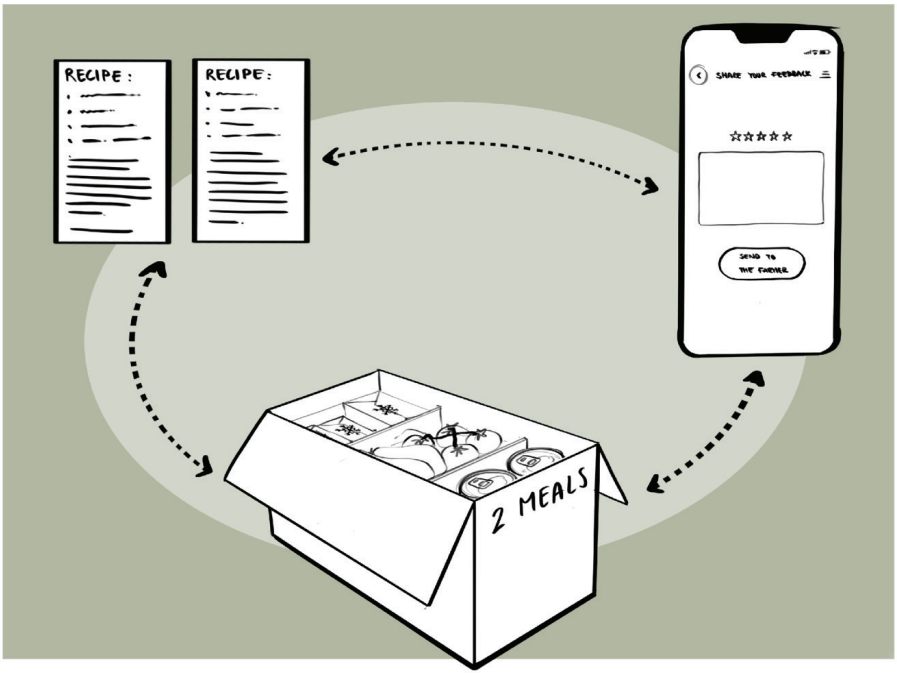


Figure F13 | Consumption boxes. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Puck's Story 2:

It's late in the evening, and Puck sits on her couch, ready to order her Integrated Box for the upcoming week. With a busy schedule, she often orders Integrated Boxes to simplify meal planning. The Boxes contain enough food for 3-4 lunch and dinner meals, with a mix of long-shelf-life innovations and fresh seasonal produce from local farmers.

She goes to the website of the Integrated Box and selects the plant-based variation without choosing specific recipes, meals, or ingredients. The service connects to her household calendar. On busy days and weeks, quick and easy recipes and ingredients are automatically provided. When Puck has more time, more complex ingredients and recipes are provided.

As Puck places the order, she sees a notification saying, "This is your first order of the month. You will get a few more long-life items to help you stock up and complete your meals this week in accordance with your momentary needs!". Puck also goes to the feedback section of the website to share her thoughts on tonight's dinner and ask for suggestions: "I made tacos tonight with the Box's ingredients. I used a soya variation I've never cooked before. That was a great tip! I'm open to more exploration with this innovation". This information will be used when composing future orders. Puck then closes the app and turns on her television to enjoy her favourite show.

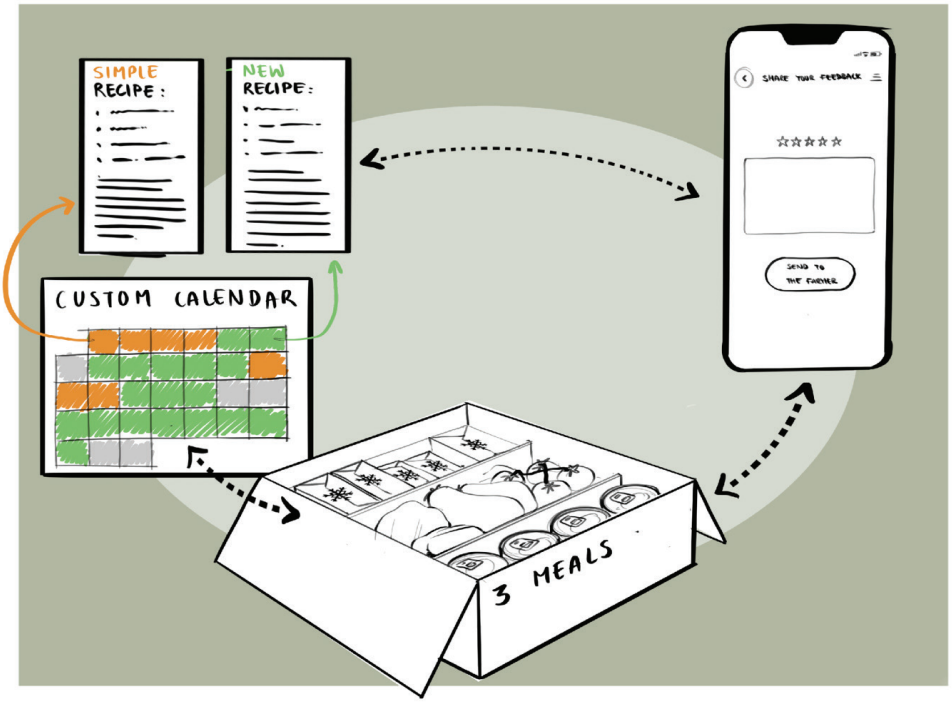


Figure F14 | Integrated boxes. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Puck's Story 3:

On a Sunday afternoon, Puck's doorbell rings. She opens the door and sees her Growth Box on her outdoor bench. As she unpacks her Growth Box, she finds enough food for 5-6 days of lunch and dinner. She also sees a mix of long-shelf-life innovations and fresh seasonal items from local farmers. As she puts away the contents, she's curious about how she will combine these ingredients into nice meals. She has a busy week ahead, but luckily the Growth Box service is connected to her household calendar, so the service did not provide any unfamiliar ingredients this week.

Puck picks up the eggplant (aubergine) from the Box, noticing it is quite small and somewhat odd in shape. This doesn't bother her because she knows that the quality is good. When she started using the Box service, she added details about her family, like their dietary preferences, ages, and health information. She knows from experience that the Growth Boxes adjust to her family needs, meaning that it provides more and bigger ingredients as her children grow and eat more. So, any worried feeling she may have had is replaced with confidence, knowing that, along with the other ingredients at home, she has enough high-quality food to meet her family's needs with little waste and hassle. Once all the ingredients are unpacked, Puck goes outside in her garden to play with her children.

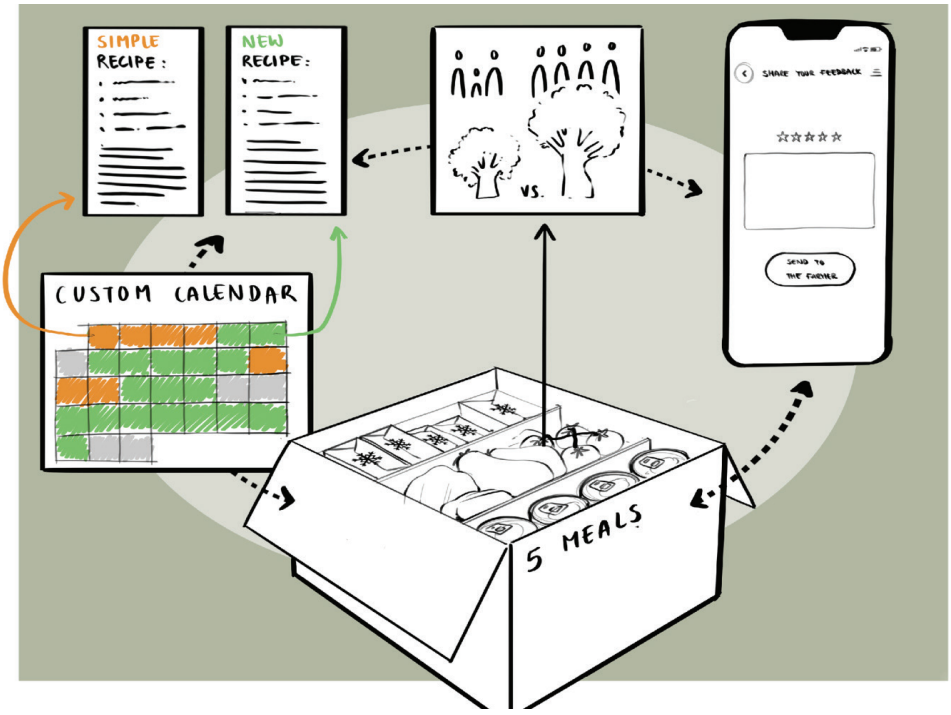


Figure F15 | Growth boxes. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Set 6: Food literacy labels

Rationale for set

- By supporting consumers in assessing food quality with their senses and taking appropriate actions based on their assessment they can increase their food literacy and be less reliant on/guided by date labels (individual behaviour).
- This flexibility increases their acceptance of inconsistencies in ingredients and meal flavours and textures, and allows them to use more of what they have and reduce overpurchasing (individual value).
- By changing how food safety is evaluated, less produce is needed as there can be less strict labelling for products that are safe for consumption past date labels, and producers can sell more of what they grow (system behaviour).
- This flexibility would allow for more produce in retailers being consumed, and less produce needing to be produced in the first place (systemic value).
- An innovation that offers this can be supported and implemented by FETE partners: a national nutrition centre, a foundation against food waste, and a meal delivery service.

Intervention Narratives: How Jordi assesses his food

The following three stories describe the behaviour of Jordi, a Dutch man living alone. Jordi uses different innovations to help him assess the food safety and quality of the food he has at home.

Jordi's Story 1:

Jordi walks into his kitchen to prepare dinner. He plans to make his favourite pesto pasta with mushrooms and spinach. He pulls out a package of mushrooms from his fridge. The Fresh Label is yellow, meaning the mushrooms are still good but should be eaten soon.

Next, he grabs a bag of spinach and notices the Fresh label has turned brown. He looks in the bag, picks out the leaves that look okay and adds them to his pan. The leaves that look withered end up in the waste bin. Lastly, he reaches for a jar of pesto in his cupboard. As soon as he opens it, the Fresh Label turns from white to green, indicating it's freshly opened. As Jordi sits down to eat his pasta, he doesn't taste that the spinach was past its best.

Figure F16 | Freshness labels. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Jordi's Story 2:

It's a Sunday afternoon, and Jordi is putting away his groceries. Before starting, he checks the items that are already in the fridge. Jordi relies on Sensory Labels to determine if the food is still good and safe to eat. The Labels offer tips on how he can use his senses to check if the food is still good to eat, and what actions he can take if he won't eat the food soon.

Jordi picks up a carton of milk in the fridge. The Sensory Label states it was produced two weeks ago and suggests throwing it away if the milk smells sour or is thick. It also mentions that milk can be frozen. He shakes the carton and notices it's half full, smells okay, and tastes okay. He takes the new carton from his grocery bag and puts it in the freezer for later. Next, he reaches for a container of mushrooms, pinches one mushroom, and notices they aren't as firm as they were earlier this week. The Sensory Label indicates that mushrooms are great for pickling or dehydrating, so he sets them aside to pickle them later. Once all his groceries are unpacked, Jordi goes to his couch to relax and opens a book.

Figure F17 | Sensory labels. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Jordi's Story 3:

On a quiet Saturday afternoon, Jordi decides to reorganise his fridge. He picks up a package of mushrooms and reads the Minimalist Label that shows it was produced last week. He presses the top of a few mushrooms, finds them firm, and decides it's still good to eat. He is happy that he was able to follow a special program that allowed him to obtain knowledge on how different foods deteriorate over time, how they can be kept best, and how to evaluate if they are still good to eat.

Then, he sees an open jar of fresh pesto at the back of his fridge. The label shows that it was produced 60 days ago, but he knows that he only opened it two weeks ago, so it might still be okay. He opens the jar and sees that the colour is still normal. He stirs and tastes a small amount and finds it still flavourful. The jar is half empty, so he scoops some of the pesto into a container to store in the freezer, keeping the remainder for dinner tonight. After reorganising the fridge, he sits down for a cup of tea.

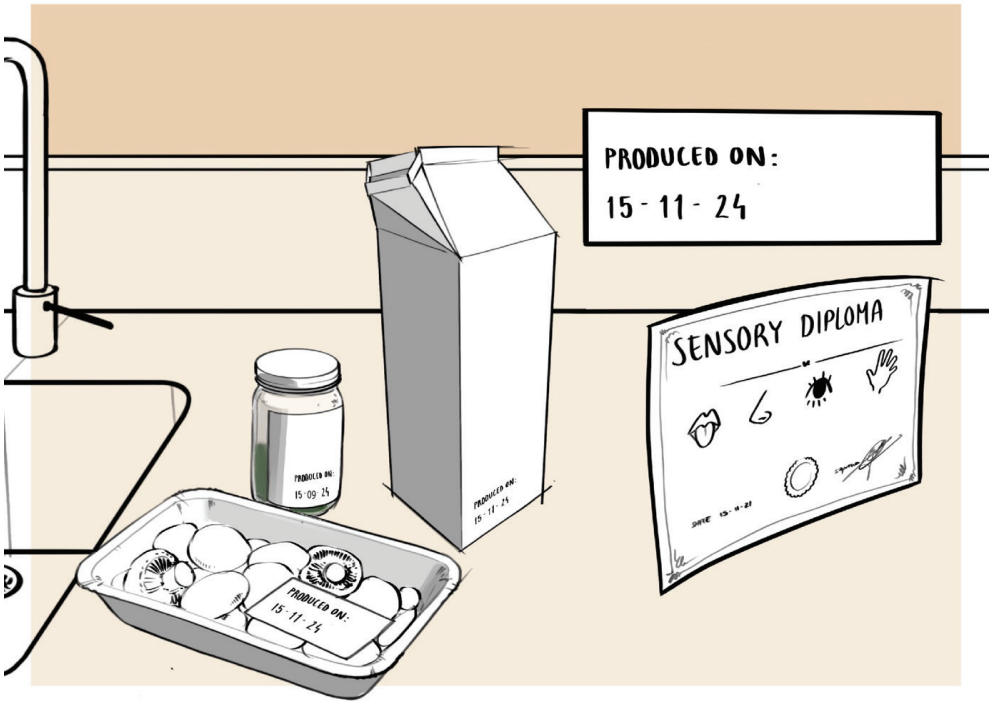


Figure F18 | Minimalist labels. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Set 7: Ingredient-less recipes

Rationale for set

- By shifting consumer thinking from specific ingredients to overall meals, consumers can become more skilled at mixing various (seasonal) ingredients and flavours, which allows them to use what they have (individual behaviour).
- This skill enhances their resilience to changes in food supply, promotes more efficient use of partially consumed fresh, frozen, and preserved foods, and brings novelty yet familiarity in consumption (individual value).
- By changing how consumption is framed from ingredients to meals, growers can adapt to the seasons and be less reliant on harvest uniformity (system behaviour).
- This flexibility increases the resilience of the food system by supporting growers to use all they grow, diversify their crops to offer more variety, and reduces the pressure of retailers to keep high stock levels of specific ingredients all year round, allowing for better inventory rotation and reduced spoilage across all ingredients (systemic value).
- An innovation that offers this can be supported and implemented by FETE partners: a foundation against food waste and a national nutrition centre.

Intervention Narratives: How Laura learns to mix and match ingredients

The following three stories describe the behaviour of Laura, a Dutch woman living alone in a small apartment. Laura uses different innovations to help her mix and match seasonal and local ingredients in her meals.

Laura's Story 1:

On a chilly evening, Laura is ready to make dinner. She opens her Ingredient-Less Recipes app to find something to cook. As she scrolls the recipes she sees different options, like Green Soup, Ratatouille, or Red Thai Curry. The app suggests Laura to first check her kitchen to see what ingredients she already has that she can use. Laura finds carrots, pumpkin, leek (prei), onion, garlic, and tomatoes.

Looking in the Ingredient-Less Recipes she learns that these vegetables are in season in her region and can be used to make a ratatouille. As Laura begins cooking, the app provides general cooking advice, such as the order to follow when preparing different types of vegetables and how to balance the flavours using different herbs, spices, and sauces. After dinner, she opens the Ingredient-Less Recipes again and leaves a comment on the recipe to avoid any future mistakes: "the balance of herbs was good but I should use less salt next time—maybe 1 teaspoon during cooking.". Closing the app, Laura is happy she can find this information next time she cooks a ratatouille.

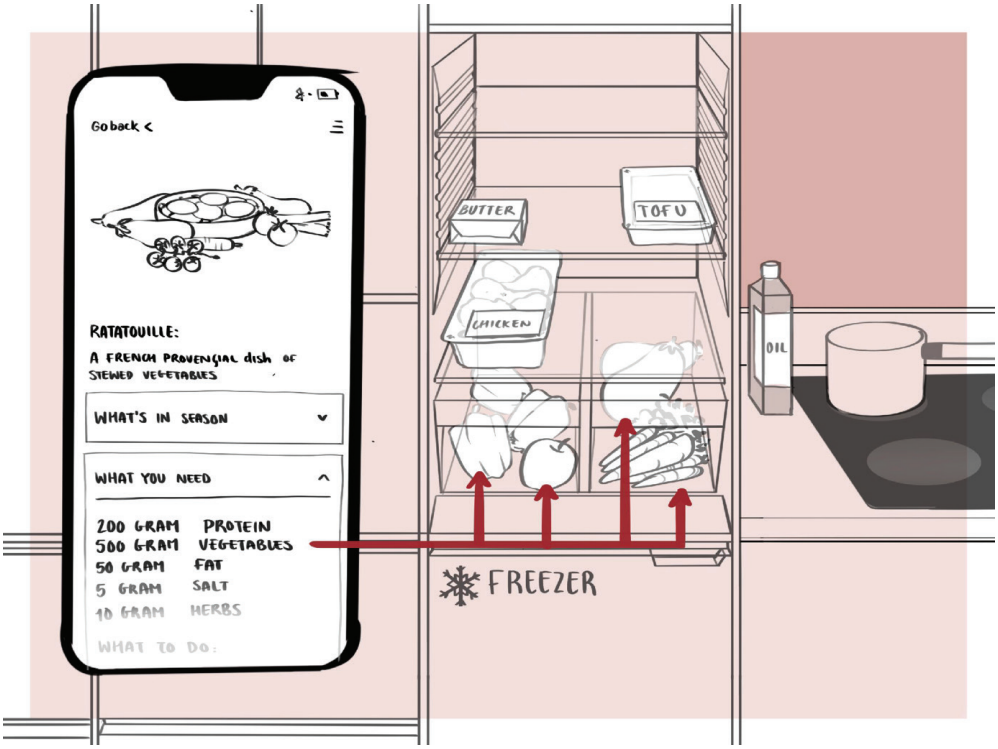


Figure F19 | Ingredientless recipes. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Laura's Story 2

One Friday evening, Laura begins planning what she will serve her parents for dinner tomorrow night. She opens the Ingredient-Less Menus app on her phone and scrolls through the different menus, ranging from the number of courses to specific holidays and moods. Laura selects a 'Feel the Sunshine 3-course Menu' which is meant to evoke a bright, fresh, and vibrant theme for dinner. The menu advises that she select ingredients that are in season in her region to get the best flavours, but it leaves the choices to her. It also stimulates her to try and use the ingredients she has at home.

Laura looks in her fridge and finds zucchini (courgette) and tomatoes; knowing that these items are seasonal and local, she decides to shape the menu around them. For the appetiser, she reads that she should prepare 100 grams per person, so she decides on zucchini carpaccio. The menu says she should add a touch of sourness and natural fat after slicing the zucchini. "I can use the leftover lemon I saw in the fridge and some olive oil," Laura thinks. For the main course, the app suggests a pasta-based dish that is about 200 grams per person. Laura decides on simple tomato pasta—she notes that she will go to the store tomorrow morning to buy pasta and cheese. For dessert, she reads that she can transform any remaining zucchini into a sweet dish by baking it with a natural sweetener. "I can use some of my honey for this" Laura thinks.

As she plans each dish, the Ingredient-Less Menu app supports her in creatively using whatever she has at home. This has helped Laura expand her cooking skills and focus on seasonal and local innovations. As she closes the app, Laura is excited to serve her parents this special dinner tomorrow night.

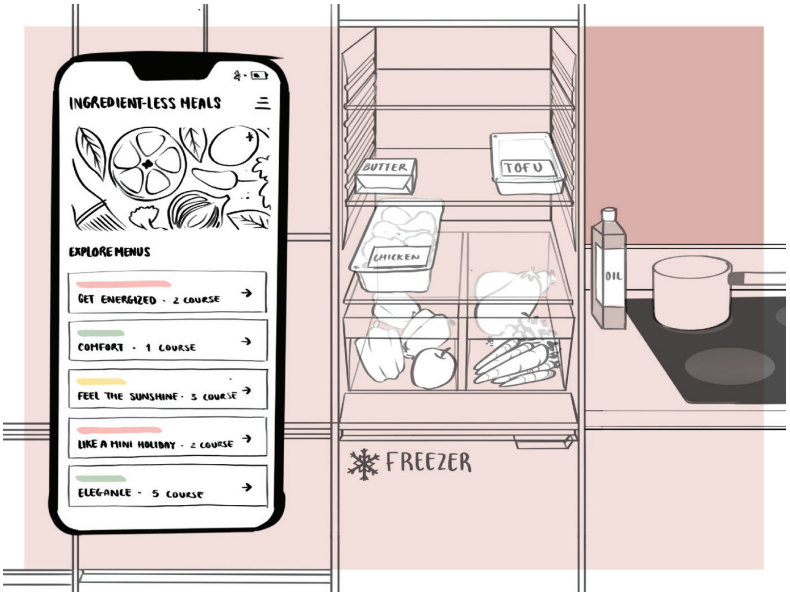


Figure F20 | Ingredientless menus. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Laura's Story 3:

One evening, Laura begins to prepare dinner for herself and opens her Ingredient-Less Eating app. She's in the mood for something spicy, so she scrolls through the taste theory section to brush up on what creates spiciness in food. She also reads about balancing spice with fat undertones to ensure her dish isn't too spicy. Inspired, she heads to her kitchen and finds sweet potato, eggplant (aubergine), onions, and radishes. Laura doesn't really like radishes but they are left over from dinner the other night.

Laura decides to roast the vegetables she found and takes a risk to also roast the radishes since they already look a bit soft and she does not want to waste them. She opens the Ingredient-Less Eating app again and selects 'Roasting' in the preparation style section. Setting her oven to a high temperature to caramelise the vegetables, she cuts everything to equal sizes as suggested by the app. She tosses the vegetables in olive oil and adds hot spices like chilli and cayenne, then she slides them into the oven. Following the flavour theory, she also prepares a full-fat yoghurt dip.

Once the vegetables are finished, she sees the radishes have caramelised nicely and she actually finds them tasty. The Ingredient-Less Eating app has given her more ideas for trying different ingredients in various ways by providing guidance on the science behind cooking and matching flavours. Laura takes the vegetables out of the oven, serves herself a plate, and sits down at her table to enjoy the meal.

Figure F21 | Ingredientless eating. Drawing by Sterre Witlox. © 2025 Goss, H.M., Schifferstein, H.N.J., de Koning, J.I.J.C., & Tromp, N.

Appendix G: Overview of participants

Table G1 | Demographic and background characteristics of respondents (n = 312).

Characteristics	Consumers	Companies	Experts
Number of participants	220	33	59
Gender (%)			
Female	38	58	54
Male	60	42	44
Other	2	0	2
Age (years)			
Range	18 – 75	25 – 67	25 – 79
Average	32	43	42
Number of evaluations per PSS	72 – 75	8 – 15	15 – 26
Median time (minutes) spent on survey	18	42	41
Currently live in the Netherlands (%)	100	97	92
Location of activities (%)[a]	-		
Western Europe (e.g., UK, France, Netherlands)		92	97
Other		23	27
Area of expertise (%)[b]	-		
Consumer behaviour (including food waste specialisation)		52	4
Design (service, social, systemic, transition)		24	34
Product Development non-food		21	17
Food technologist and Nutritionist		24	24
Product Development food		30	24
Retailer behaviour and logistics (including food waste specialisation)		15	17
Transitions research		0	17

Notes

[a] Participants were able to select more than one geographical region.

[b] Participants were able to select more than one area of expertise.

Appendix H: Ratings for the 21 Product Service Systems

Table H1: Means and standard errors (SE) for all 21 Product Service System (PSS) for each participant group. Responses varied from 1 = strongly disagree to 7 = strongly agree.

		Desirability						**Plausibility**					
		Consumers (n=220)		Companies (n = 33)		Experts (n = 59)		Consumers (n=220)		Companies (n = 33)		Experts (n = 59)	
SET	**PSS**	***means***	***SE***	***means***	***SE***	***means***	***SE***	***means***	***SE***	***means***	***SE***	***means***	***SE***
Waste Bins	**1**	4.10	0.16	4.15	0.36	3.51	0.40	4.77	0.15	4.77	0.34	4.06	0.39
	2	4.98	0.17	4.30	0.45	4.54	0.25	5.29	0.16	4.94	0.34	4.52	0.25
	3	5.20	0.16	5.33	0.25	5.14	0.21	5.41	0.14	5.66	0.34	5.26	0.25
Use-me-later Tools	**4**	4.93	0.14	5.29	0.28	4.58	0.33	5.47	0.13	5.58	0.20	5.55	0.20
	5	5.34	0.12	5.80	0.27	4.81	0.26	5.67	0.12	5.80	0.18	4.95	0.23
	6	5.59	0.14	5.10	0.38	4.91	0.26	5.77	0.11	5.31	0.36	5.43	0.22
Freezer Integration	**7**	4.35	0.16	4.22	0.54	4.93	0.26	4.62	0.15	4.36	0.54	4.79	0.27
	8	5.13	0.16	5.27	0.37	5.03	0.25	5.52	0.12	5.78	0.20	5.36	0.27
	9	5.38	0.16	5.33	0.34	5.06	0.25	5.63	0.14	5.89	0.24	5.40	0.20
Frozen Ingredients	**10**	4.64	0.13	4.33	0.50	4.72	0.33	5.06	0.11	5.05	0.35	5.33	0.22
	11	4.86	0.14	5.18	0.38	4.09	0.26	5.36	0.11	5.75	0.22	4.79	0.21
	12	4.65	0.17	5.23	0.37	4.84	0.26	4.78	0.15	5.52	0.18	5.14	0.27
Consumption Boxes	**13**	4.63	0.14	4.60	0.34	4.92	0.21	4.83	0.14	5.03	0.25	5.03	0.29
	14	4.75	0.15	5.21	0.25	5.03	0.23	4.89	0.14	4.63	0.44	4.65	0.22
	15	4.80	0.15	5.33	0.28	5.13	0.19	5.22	0.13	5.30	0.33	4.91	0.27
Assessment Labels	**16**	5.49	0.16	5.37	0.47	5.19	0.22	4.82	0.17	5.10	0.53	4.21	0.26
	17	5.05	0.15	5.28	0.28	4.56	0.23	5.49	0.11	5.73	0.27	5.01	0.17
	18	4.38	0.14	3.94	0.37	4.96	0.25	4.95	0.13	4.80	0.44	5.33	0.28
Ingredientless Recipes	**19**	4.90	0.14	4.67	0.48	4.84	0.20	5.64	0.10	5.39	0.50	5.69	0.13
	20	5.11	0.15	5.13	0.35	4.35	0.28	5.83	0.13	5.79	0.32	5.21	0.26
	21	4.84	0.15	4.00	0.42	4.38	0.25	5.44	0.13	4.75	0.39	5.35	0.24
Portfolio		**4.91**	**0.03**	**4.90**	**0.09**	**4.75**	**0.06**	**5.26**	**0.03**	**5.31**	**0.08**	**5.03**	**0.06**

Underlined means are the highest and lowest ratings for each participant group.
Each PSS was evaluated by consumers between 72 and 75 times, by companies between 8 and 15 times, and by experts between 15 and 26 times.

End bits

Acknowledgments

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Jotte, your late addition to my supervisory team was a blessing. I still remember our first supervision meeting: after the Zoom call ended, I told Ben I was worried that I sounded like I didn't know what I was talking about since the conversation had sort of gone in circles. A few days later, I brought it up to you and we shared a laugh when we realised we both felt that way. Even though we had not worked together before, I immediately felt comfortable being open with you. What stands out about you is how genuinely you care. You sincerely wanted to help and worried when you thought you might have confused me. While bringing a new supervisor on board at a late stage was challenging, your involvement brought clarity to my work. You quickly caught up, eagerly asked questions, and dove into the content with authentic enthusiasm. Your expertise in transition design brought greater depth and nuance to the project, and I truly value all our discussions these last few years. You definitely kept my confidence up when I lost the forest through the trees. Beyond your professional contributions, your kindness and inspiring presence makes working together a true privilege. I'm delighted our collaboration continues in the Systemic Design Lab.

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Designing adaptable consumption: A new practice to foster food system transitions

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INNOV

INTRODUCTION

Designers are engaging in transition challenges, developing innovations that steer change. Yet, little is known about how designers use their expertise in these contexts. We investigate how designers develop joint innovations to transition the Dutch food system to embrace flexibility and cater to enough.

PROJECT BACKGROUND

We are part of a research group trying to transition to a food system with hardly any food waste. Five actors (a national nutrition centre, a food waste foundation, a food manufacturer, a waste collector, and a meal delivery company) participated in two workshops:

1. Focused on understanding the actors' network, power and interest, and selecting an innovation pathway.
2. Evaluated innovations from a societal and business perspective.

ADAPTABLE CONSUMPTION: A NEW PRACTICE

Accepting variability in the type of products available due to seasons and success of harvest (changing contracts between producers and retailers).

Framing consumption as meal types (e.g., vegetable curry) rather than exact ingredients (e.g., red lentil, paprika, coconut milk etc).

Developing food literacy around due dates and mixing ingredients to increase self-confidence in adapting meal plans.

We link consumer food waste-free behaviours with flexibility/risk-taking behaviours through several innovations (Figure 1).

PRELIMINARY FINDINGS

Choosing one transition path ('Embracing Flexibility') helped to align design efforts and communicate what adaptable consumption might mean in the future.

Participants mainly focused on reducing consumer food waste in their ideation but faced challenges connecting these ideas to the larger goal of a more flexible food system.

Exploring each innovation's potential to support behavioral adaption (i.e., a practice perspective) rather than its specific details (e.g., form) helped identify behaviours with the greatest/least potential for change (Figure 2).

Collection
Adjusting
on waste

Repositioning
the kitchen, re
part

Surpris
Learnin
includin
mixing

Increasing f
learning how
and accepting in

Ingredientless R
Thinking on a m
and balancing n
food preparatio

Fro
Completing and adjusti
preferences a

Use-
Prese
consu
ingre

Integrating frozen into a cooking routine

Organizing by category (e.g., food zones)

Figure 2: Exploration of the practice for the frozen storage innovation (increasing in ridiculity of behavioural adaption from left to right). Drawings by Mario Solla

DISCUSSION

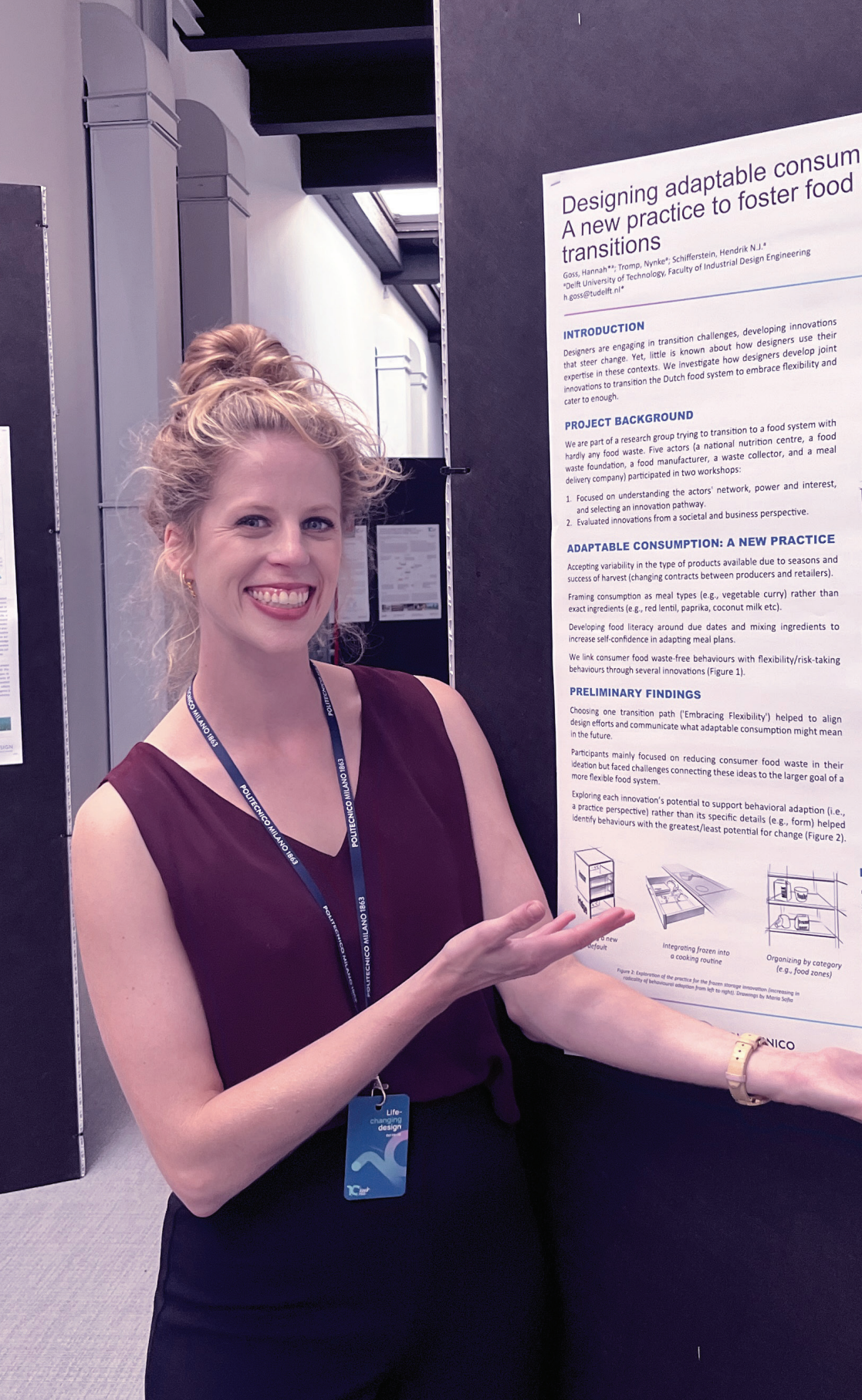
Consumer-facing innovations t
structures (e.g., regulations) a
and sustainability.

Designers should encourage f
to experience discomfort and
beyond business as usual.

Designers may need to take up
and reframing moral conflicts.

NICO

SCUOLA DEL DESIGN
NTO DI DESIG



About the author

Hannah Goss was born in Toronto, Canada, in early 1994. Her interest in science and technology began in high school, where she enrolled in the SciTech (Science and Technology) program at Port Credit Secondary School. In 2012, she moved to Ottawa to study Industrial Design at Carleton University. During her studies, she actively pursued international experiences—working in Toronto and Cape Town, and travelling from South Africa to Kenya, through the Netherlands, and across Scandinavia and Iceland—before returning to Ottawa to complete her degree. She graduated with honours in 2017. Her final project was a balance-based learning toy that encouraged children to play, develop movement skills, and build physical literacy through interaction. This project reflected her growing interest in user-centred design and in designing for positive interactions and well-being.

In 2018, Hannah relocated to the Netherlands to pursue a Master of Science in Design for Interaction at the Faculty of Industrial Design Engineering at Delft University of Technology (TU Delft). There, she developed Blip, a design installation exploring embodied experiences of unexpected happiness. The project was exhibited at Dutch Design Week 2019 and later included in research led by Professor Pieter Desmet. This experience introduced her to the world of academic design research. She graduated cum laude in 2020 and began her PhD at TU Delft shortly after.

Hannah's doctoral research focused on the role of design expertise in supporting transitions toward more sustainable and desirable food systems. Using a transition design approach, she investigated how designers engage in visioning, framing, and evaluation practices to foster systemic change. Alongside her research, Hannah was active in teaching across both Bachelor and Master programmes at TU Delft. She mentored two Master's graduation students and contributed to several courses, including Food and Eating Design Elective; Systems Thinking in Science, Engineering, and Design; Designing for Complexity; Designing for Society; and Design Approaches.

Throughout her PhD, Hannah was an active member of two research labs: the Food & Eating Design Lab and the Systemic Design Lab. In the former, she collaborated with researchers and students to improve everyday food-related interactions. In the latter—a cross-departmental initiative advancing design's role in societal change—she co-organised a PhD event for the RSD10 Symposium and gave workshops in the Systemic Design Masterclass for design professionals.

Her research has resulted in several first-author publications and presentations at international conferences, such as RSD (2019, 2024), DRS (2022), and IASDR (2023). She also gave guest lectures at the Istanbul Technical University and Carleton University. Outside academia, she appeared in the Tegenlicht x DDW 2023 live episode *Picture This: We're Done with the Throwaway Society* (NPO Start), which spotlighted innovative approaches to sustainable living. The following

year, she presented at Dutch Design Week in collaboration with Samen Tegen Voedselverspilling (Food Waste Free United), encouraging the foundation's partners to rethink household food waste through a systemic design lens.

In 2023, after several years of living and working in the Netherlands, Hannah became a Dutch citizen—a personal milestone in her journey. She now holds dual Canadian-Dutch citizenship and continues to work towards speaking *uitstekend Nederlands*. Hannah is currently a postdoctoral researcher in systemic design at TU Delft, within the Department of Design, Organisation and Strategy. Her work builds on the foundations of her PhD, focusing on portfolio-based approaches to transition design and bridging the gap between research and practice. She remains actively involved in teaching, mentoring, and lab activities, continuing to explore how design can support long-term societal change.

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Goss, H. M., Schifferstein, H. N. J., de Koning, J.I.J.C., & Tromp, N. (under review). The proof of the pudding: Introducing quantitative testing in transition design reasoning. *Contexts—The Systemic Design Journal*.

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Peer-Reviewed Conference

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