Waste Management 201 (2025) 114810

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Research Paper

Exploring incentives to move up the food waste Hierarchy: A case study of the Australian cheese manufacturing sector

Jack B. Hetherington [a,b,c,*], Adam J. Loch [a], Pablo Juliano [a], Wendy J. Umberger [d,e]

[a] The Centre for Global Food and Resources, School of Economics and Public Policy, The University of Adelaide, 10 Pulteney St, Adelaide SA 5005, Australia
[b] CSIRO Agriculture and Food, 671 Sneydes Rd, Werribee VIC 3030, Australia
[c] End Food Waste Cooperative Research Centre, L1, Wine Innovation Central Bld, Cn Hartley Grove & Paratoo Rd, Urrbrae SA 5064, Australia
[d] The Australian Centre of International Agriculture Research (ACIAR), 38 Thynne St, Canberra ACT 2617, Australia
[e] School of Agriculture, Food and Ecosystem Sciences, The University of Melbourne, Grattan St, Parkville, VIC 3010, Australia

ARTICLE INFO

Keywords:
Motivators
Circular Economy
Food loss and waste
Food Waste Hierarchy
Extended Institutional Theory

ABSTRACT

Halving food loss and waste by 2030 is a major global challenge. The Food Waste Hierarchy underpins strategies to achieve this, but understanding the relative importance of motivators to incentivise change is limited. This study utilises a pertinent case study of the major by-product of cheese-making, 'whey', to explore this in Australia and is underpinned by the Extended Institutional Theory as a key analytical framework. Through semi-structured interviews with 42 nationally-representative firms (31% of the industry), motivators were quantified using a novel 100-point allocation instrument, complemented with direct quotes from participants. Profit maximisation, environmental protection, and government regulation emerge as key motivators, but there is significant heterogeneity. Regulatory pressures are different across hierarchy-levels. However, results suggest they are not sufficient to result in firms 'moving up' the hierarchy. Notably, one participant that was currently disposing of whey and receiving AU$160,000 in non-compliance penalties, made a 'sideways' move within the lowest hierarchy level (disposal). Based on this study's sample, 41% of the industry's target could be achieved if all whey currently classified as 'waste' is diverted but findings indicate a potential failure of markets, governments, and social license to drive efficient resource allocation while limiting negative externalities. Pathways to challenge the status quo and transform the food system are discussed, which will likely require simultaneous forces to move enough firms up the hierarchy by 2030.

1. Introduction

Approximately a quarter to a third of all produced food is lost or wasted (1.92 gigatonnes) (Gatto and Chepeliev, 2024), prompting Sustainable Development Goal (SDG) 12.3 to halve food loss and waste (FLW) by 2030. FLW comprises food and/or associated inedible parts being removed from the food supply chain (Hanson et al., 2016) and the urgent need for action is underscored by the substantial and interrelated economic, environmental and social consequences of FLW (Hanson and Mitchell, 2017; Lade et al., 2020; Reynolds et al., 2015; Zhu et al., 2023). Yet, despite there being varying definitions of FLW (Boiteau and Pingali, 2023), all intrinsically refer to the end destination of the food material and diverting it to a preferred use. Various heuristic-based frameworks, including the Circular Economy (CE) and Food Waste Hierarchy (FWH), have been proposed to guide decision-making processes for FLW reduction. These frameworks reimagine traditional linear production and consumption models to focus on reducing, reusing, recycling, and recovering materials in all stages of production, distribution, and consumption (Kirchherr et al., 2017). The FWH, represented as a pyramid, is a framework that provides decision makers guidance about the prioritised order of management practices, with prevention of surplus food production as being the most desirable management practice through to recovering soil nutrients and energy and, lastly, disposal (e.g., through landfill or wastewater). This is based on the assumption that moving up the hierarchy drives more desirable economic, environmental and social outcomes (Papargyropoulou et al., 2014) and is discussed more in Section 2.1.

Despite ongoing debate about the definition of FLW (Boiteau and

* Corresponding author at: Level 6, 10 Pulteney st, University of Adelaide SA 5005, Australia.
E-mail addresses: jack.hetherington@adelaide.edu.au (J.B. Hetherington), adam.loch@adelaide.edu.au (A.J. Loch), pablo.juliano@csiro.au (P. Juliano), wendy.umberger@aciar.gov.au (W.J. Umberger).

https://doi.org/10.1016/j.wasman.2025.114810
Received 24 October 2024; Received in revised form 25 February 2025; Accepted 10 April 2025
Available online 19 April 2025

Pingali, 2023) and optimal order of prioritisation within the FWH (Parsa et al., 2023), many governments and organisations have adopted variations of the FWH to set targets and strategies including the United States, United Kingdom and Australian governments (Jones et al., 2022). Moreover, there is a growing coalition of sectors and private firms that have aligned their strategies with the FWH, including Unilever, Aldi and the dairy sector in Australia (EFWA, 2024; USDA, 2022). As the order of priority illustrated in the FWH is used by governments to set targets, it will be increasingly necessary to consider how firms' strategic waste management choices align with the different FWH tiers. Moreover, as the current definition of FLW is concerned with end destinations, this creates various business models through which firms can contribute to the CE. Such Circular Business Models (CBMs)[1] may reduce resource inputs and emissions across the entire (food) system via a firm's own operations or its value network (Bocken et al., 2016). But as many of the national strategies rely on voluntary agreements and implementation by firms to reduce FLW (SFWA, 2021; USDA, 2022; WRAP, 2022a), where firms will bear most of the costs, what motivates a firm to engage or invest in these arrangements? Also, do firms engaged in practices at different levels of the FWH perceive different pressures that might explain why they would 'move up' the FWH?

There is a substantial body of evidence that examines the many reasons a firm may choose to adopt new technologies, practices or business models. These can be the pursuit of financial or non-financial goals, adherence to social norms (Rogers, 2003) and may include synergies or trade-offs between goals, especially when considering changes that affect the natural environment (Pannell et al., 2006). It is by understanding these factors that can help identify if, at all, markets, governments and/or social licenses to operate are playing their role in achieving the desired outcome leading to efficient resource allocation and limiting negative externalities. Existing research on CBMs has highlighted various motivators influencing a firm's decision to participate in these models (Ranta et al., 2018), including profit outcomes, social norms, government regulations (Arranz and Arroyabe, 2023; Goodman-Smith et al., 2020). Additionally, there are motivational differences among firms (Do et al., 2022). Given these complexities, Institutional Theory has been recommended as a lens through which to evaluate CE behaviour (Hussain et al., 2023). Institutional Theory is a framework in organisational and social sciences that explains how institutions—established rules, norms, and structures—shape the behaviour of individuals and organisations. It highlights the role of social, political, and economic pressures in influencing organisational decision-making, often beyond purely rational or profit-driven motives. By utilising this theoretical basis to framing diverse decision-making incentives in the context of FLW management we can better understand what affects behaviours aligned with the FWH.

However, there are notable gaps in the literature. Firstly, many studies are descriptive in their approach to motivators of CBMs, so there have been calls to quantify the relative importance of factors (Do et al., 2022; Tura et al., 2019). Although there have been attempts to quantify the importance of factors (Arranz and Arroyabe, 2023), current approaches have not captured trade-offs between factors. Secondly, no study has yet analysed the varying degree of motivators across hierarchy-levels. While Arranz and Arroyabe (2023) considered multiple CE practices they did not consider any order of priority outlined by a CE framework. This is crucial for driving behaviour change and achieving SDG12.3. Thirdly, there are opportunities to expand CBM literature based on specific firm types. Some studies compare diverse sectors with limited contextual similarities, calling for more sector-level focus (Vermunt et al., 2019). Others concentrate on narrow segments like start-ups or multinational firms (Geissdoerfer et al., 2022; Ranta et al., 2018; Tura et al., 2019), which limits the diversity of potential motivators. Our study aims to address the lack of empirical research that quantifies the relative importance of different motivators for firms to adopt different levels of the FWH.

Using a cross-section of the Australian cheese manufacturing sector as a case study we focus on cheese whey to explore the issues raised above (further context is provided in Section 3.1). It's estimated the dairy sector contributes to 14.8% of all FLW in Australia (FIAL, 2021) of which, approximately half is whey (Dairy Australia, 2023a). Despite multiple possible management practices across all levels of the FWH (Gregg et al., 2020; Hetherington et al., 2023) (see Fig. 1), with many high-value options in the Australian commercial context (see Fig. 2)—such as protein supplements, alcohol products, or kombucha-style beverages—this sector continues to have considerable whey waste costing manufacturers AU$578 million each year (Dairy Australia, 2023a). This is partly owing to it being mostly comprised of water, making it energy-intensive to extract components and transport, as well as other financial, organisational and supply chain barriers (Hetherington et al., 2024).

This study overcomes some of the limitations of previous studies on motivational differences to adopt CBMs and offers a new quantitative comparison of incentives for behaviour change. Ultimately, this study aims to answer the following research question:

> *What is the relative importance of different motivators for firms to change their FLW management practice, and how does this change as firms 'move up' the Food Waste Hierarchy?*

This study contributes to the literature on CBMs, quantifying the relative importance of different motivators for firms to change their FLW management practices within the context of the FWH. By focusing on the CM sector and the management of cheese whey, this research is able to also address key gaps in understanding how firms' strategic decisions vary across different levels of the FWH, offering insights that are critical for achieving SDG 12.3 objectives.

2. Conceptual framework

This study draws upon the FWH and the Extended Institutional Theory (EIT) as the basis for the conceptual framework, as explained further below and illustrated in Fig. 1.

2.1. Food Waste Hierarchy

The FWH has undergone numerous iterations, each with slight variations in terminology, behaviours and prioritisation order (Jones et al., 2022). While evidence suggests that the generalised order in the FWH may not universally optimise outcomes for every sector (Parsa et al., 2023), there is some consensus that helps frame the issues.

The overarching priority is to avoid FLW (which implies all edible food is eaten), followed by redistributing surplus food or value-adding unavoidable by-products into other foods for human consumption (or *'Upcycled Foods'*) (Papargyropoulou et al., 2014; Teigiserova et al., 2020). Collectively, these options can be considered ***'human food products'*** and assume the highest priority. Next, established FWHs generally agree with using FLW for ***'animal feed'*** as the next priority, as it maintains nutritional value and reduces the necessity for producing virgin agricultural products solely for animal consumption. After feeding animals, the hierarchy considers practices that *recycle* (typically extraction of non-food materials, anerobic digestion, or composting) and *recover* (energy via incineration or application to land) food and drink material; but this is the most inconsistent section of the hierarchy among the many iterations of the FWH (Jones et al., 2022). Further, there is evidence suggesting sector-level frameworks may be more beneficial due to variable benefits of individual practices across industries (Parsa

[1] CBMs are defined as *'business models that are cycling, extending, intensifying, and/or dematerialising material and energy loops to reduce the resource inputs into and the waste and emission leakage out of an organisational system. This comprises recycling measures (cycling), use phase extensions (extending), a more intense use phase (intensifying), and the substitution of products by service and software solutions (dematerialising)'* (Geissdoerfer et al., 2020, p.7).

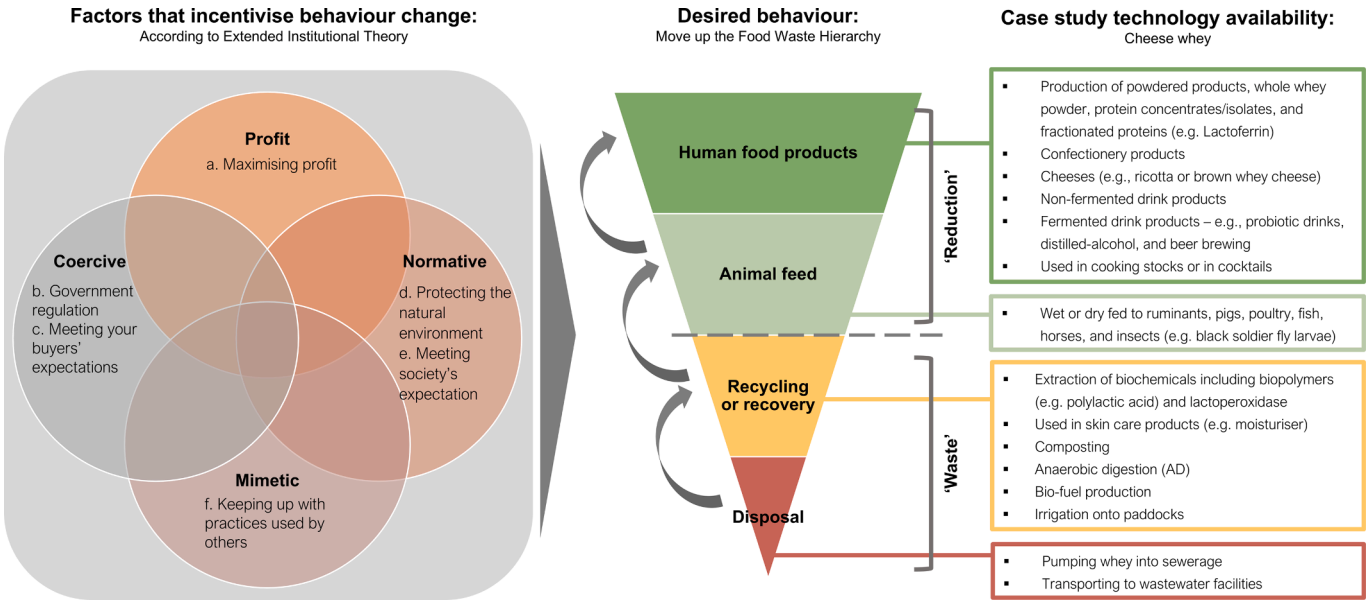

Fig. 1. Conceptual framework and case study relevance.

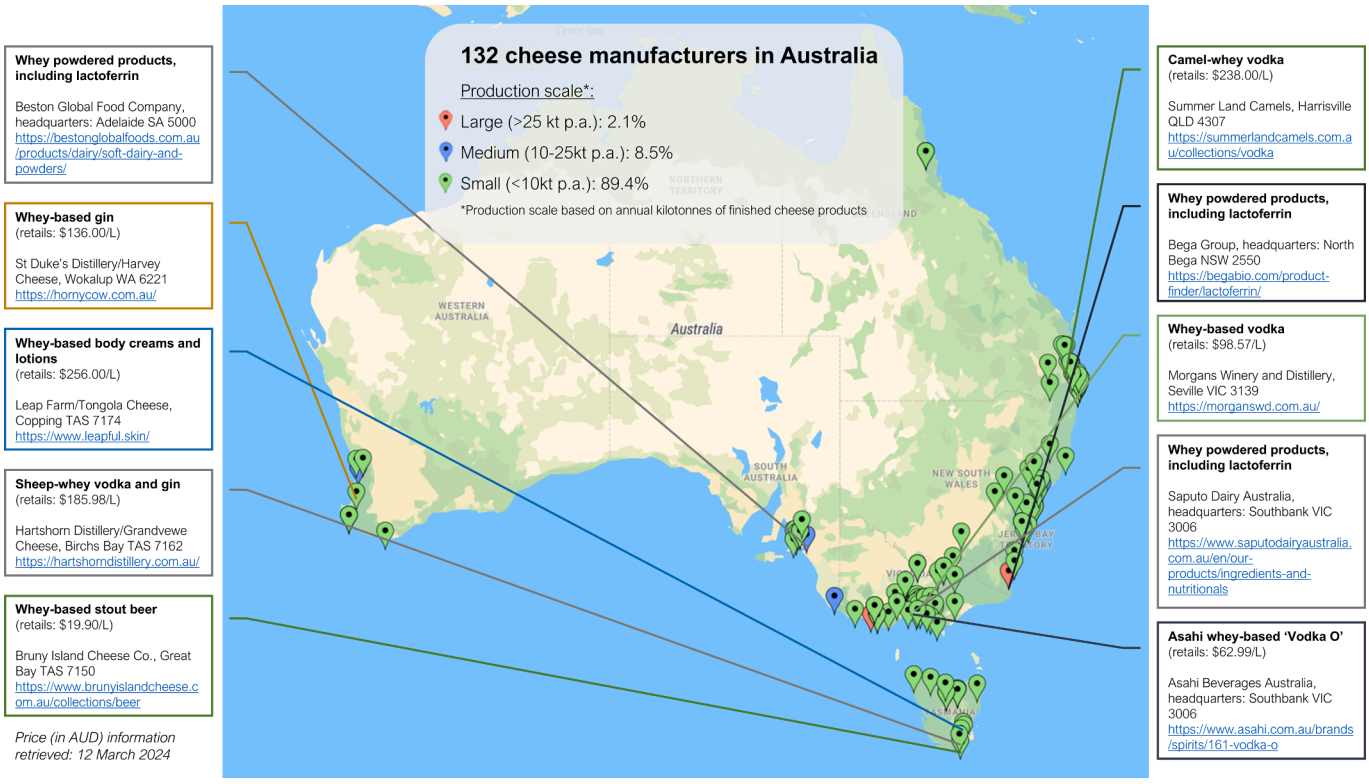

Fig. 2. Map of Australian cheese manufacturers and examples of whey-product manufacturers (with retail price information where available). Information based on a review of all manufacturers' websites and is not limited to the study sample.

et al., 2023). Despite a lack of clear guidance at mid-to-low tiers of the hierarchy for practice prioritisation, for the purposes of this study we consider the broader classification of ***'recycling or recovery'*** as a suitable basis for comparing motivators at a third priority level. This is because we are interested in seeing differences that largely transcend hierarchy-levels rather than differences between practices that may yield less-clear benefits. This classification includes whole-of-biomaterial diversion practices (e.g., anerobic digestion or composting) and extraction or conversion into specific biomaterials, which often produce additional residue or by-products. Lastly, there is consensus the least preferred (and prioritised) option is ***'disposal'***. Together, these four groups of management practices help us explore differences in behaviour-change motivators.

To explore motivational differences across hierarchy-levels we also consider a higher-level grouping. As discussed previously, many of the frameworks to measure progress to SDG12.3 have determined that diverting FLW towards human food products or animal feed contributes to the ***'reduction'*** of FLW (e.g., see Dairy Australia (2023a); SFWA

(2021); WRAP (2022b)). This means that any FLW that is diverted from disposal to either recycling or recovery does not contribute towards FLW reduction targets and is therefore still considered ***'waste'*** and remains less desirable. These overlapping 4- and 2-group categories are considered in the present study and illustrated on the middle section of Fig. 1, with examples of each for the whey case study on the right-hand side.

2.2. Motivators

Regarding factors that incentivise firms to change behaviour, Institutional Theory identifies three broad types of 'isomorphic' force (i.e., coercive, normative and mimetic) that explain why firms exhibit similar behaviours over time to maintain legitimacy (Scott, 2008). The EIT distinguishes profit drivers alongside these forces (Kauppi, 2013).

Firstly, a common and logical motivator for a firm is to prioritise ***'profit maximisation'***. This includes adapting to market demands and enhance production efficiency, especially evident in resource-scarce industries like dairy (Smithers, 2008). Secondly, *coercive* mechanisms relate to firms' adherence to formal rules and regulations. ***'Government regulations'*** drive compliance via penalties imposed on environmental violations, exampled by dairy sector whey disposal (e.g., dumping to local sewers) (Gregg et al., 2020). ***'Buyers' expectations'*** exert a coercive pressure back through the supply chain either directly from end consumers or through intermediaries like supermarkets, imposing product and manufacturing standards including FLW management practices (Devin and Richards, 2018; O'Connor et al., 2023). Thirdly, *normative* mechanisms relate to moral governance and social obligations (Scott, 2008). Norms are extrinsic motivators that specify appropriate actions based on ***'society's expectations'*** (Nilsson et al., 2004). This can cause firms to change behaviour; for instance, in order for a firm to maintain their social license to operate (Dumbrell et al., 2020). On the other hand, the goal to ***'protect the natural environment'*** is aligned with intrinsic values based on one's own moral compass. These values have been shown to explain the behaviour of some firms, especially for practices that result in environmentally beneficial outcomes (Adams et al., 2022; Ramanathan et al., 2014). While very much interconnected, social norms and values are two distinct motivators affecting decision making. Finally, the *mimetic* force indicates copying (miming) the behaviour of others in the presence of uncertainty (DiMaggio and Powell, 1983). Therefore, the pressure to ***'keep up with practices used by others'*** in the industry or follow prevailing industry trends can lead firms to adopt similar management practices. This has been observed with practices such as corporate reporting and governance frameworks (Haque and Ntim, 2018).

These six motivators are aligned with the four forces and serve as the basis for exploring incentives within the FWH (left-hand side of Fig. 1). Importantly, EIT supports the notion that multiple motivators can occur simultaneously and that specific drivers can cut across multiple forces. For example, a buyers' expectations may be set by responsible environmental management, which is affected by social expectation norms. The EIT underpinning our framework recognises the overlapping nature of profit, coercive, normative, and mimetic forces (represented by the Venn diagram in Fig. 1).

3. Methods

3.1. Case study overview

3.1.1. Whey challenges and management practices

Whey is the liquid by-product from the manufacturing of dairy products, such as cheese, and has been an ongoing waste issue for cheese manufacturing throughout history (Smithers, 2008). While whey is also generated from yoghurt, this study is focused exclusively on cheese whey. As with raw milk (comprised of 87% water), whey is predominantly comprised of water (94%). However, whey contains approximately 50% of total nutrients and, depending on the type of product being manufactured, 75–90% of the total mass of the raw milk (Tsermoula et al., 2021). Its composition varies depending on the cheese production method, resulting in distinctions between sweet and acid whey that each contain diverse nutrient profiles and pH levels. Various management practices for whey have been explored by firms including its transformation into human food products, animal feed, recycling, recovery processes, and the less desirable disposal option. These practices align with the FWH categories and have been documented previously (Dairy Australia, 2023a; Hetherington et al., 2023). Examples of these practices are summarised against the FWH framework in Fig. 1.

3.1.2. Overview of the Australian cheese manufacturing sector

In Australia, 8.1 billion litres of milk goes into dairy product manufacturing each year, of which 43% contributes to cheese production (Dairy Australia, 2023b). At the time of the study there were 132 firms manufacturing cheese products from cow, goat, sheep, and camel milk. The industry comprises a few large manufacturers (2.1% of firms) and many small manufacturers (89.4%) that are mainly concentrated in the south-east of Australia (see Fig. 2). These firms exhibit diverse business configurations and product mixes, ranging from exclusive cheese production to a broader array of dairy and non-dairy products. Some firms are vertically integrated (e.g., farm production, manufacturing, and retailing), while others are solely focused on manufacturing. Therefore, there is a great deal of variability in the characteristics of the firms. Also, complex relationships between firms are also present. For instance, Bega Group, the largest cheese manufacturers (CMs) in Australia (Reeves, 2023) has a license agreement with Fonterra Co-op Group, another major cheese manufacturer, to market and distribute all Bega-branded products in Australia (https://begagroup.com.au/student-resources/). Similarly, Saputo Dairy Australia have joint venture agreements in place others (https://www.saputodairyaustralia.com.au/en/our-products/joint-ventures).

In terms of whey product manufacturing in the 2022–23 financial year, Australian manufacturers produced 58 kilotonnes of whey powder, with half exported predominantly to Asia (Dairy Australia, 2023b). Notably, the three largest CM (Bega Group, Saputo Dairy Australia, and Fonterra Co-op Group) and some of the mid-scale manufacturers (e.g., Beston Global Food Company) produced whey powder products such as whole whey powder, concentrates and protein isolates, and individual supplements (e.g., lactoferrin). These predominantly go into food manufacturing uses (e.g., ice cream, baked goods, infant formula, health and sport supplement products (Fahey, 2023)). The global whey protein market was estimated to be US$10.9 billion in 2022 and is expected to experience a 7.9% compounded annual growth rate between 2022 and 2027 (Technavio, 2023). Growing markets for whey-based alcohol, such as vodka and beer, are also emerging. Examples of this are evident across all production settings, including small-scale artisanal (e.g., Hartshorn distillery in Tasmania, retailing for AU$185.98 per litre) and industrial scale products (Asahi-owned "Vodka O" in Melbourne, retailing AU $62.99 per litre). Another niche but high-end product option is skincare products (e.g., "Leapful" in Tasmania, retailing for AU$256.00 per litre). Examples of these products are provided in Fig. 2. While not an exhaustive list of whey-product manufacturers this highlights the range of high-value manufactured product options that are commercially available across production scales.

Despite these market opportunities, whey has been recognised as the most significant FLW issues for the dairy sector with the peak dairy industry body, Dairy Australia, committing to SDG12.3 (Dairy Australia, 2023a). This is because whey accounts for half of the FLW in the Australian dairy sector (approximately 350,000 tonnes p.a.), is the largest share of FLW across all stages of the chain and is estimated to cost manufacturers AU$578 million each year. This suggests the sector needs to reduce annual whey waste by 175,000 tonnes by 2030.

3.2. Data collection

To collect the data for this study semi-structured interviews were conducted with employees of Australian CMs actively involved in whey management decisions. Participants were identified through the Dairy Australia database (https://www.dairyaustralia.com.au/manufacturing-support/australian-dairy-manufacturers) and industry contacts of the research team. A total of 42 firms, representing 31% of the industry, were interviewed between November 2022 and June 2023. Purposive-proportional sampling was used to ensure representation across scales of production and states. A summary list of study participants is provided in the Supplementary Material (Table S1).

Descriptive statistics of the sample against industry data is provided in Table S2 in the Supplementary Material. Summaries of the business characteristics (Table S3), and whey generation and current practices (Table S4) are also presented in the Supplementary Material. Interviews were conducted in-person, via telephone, or Zoom and were subsequently transcribed. The study was approved by the Human Research Ethics Committee of the lead author's institution (approval number: H-2022-206).

3.3. Relative importance of motivators

A 100-point allocation question was used to measure the relative importance of factors affecting the firm's decision to change their whey management practice. This is because, unlike other options such as Likert-scales (as implemented by Arranz and Arroyabe (2023)) and other ranking options, 100-point allocations (also called 'Budget pies') force respondents to make trade-offs between factors and identifies the relative intensity of their choice (Mullen, 1999). This is particularly relevant to this context where some factors may be perceived to be overlapping and/or interconnected. For example, with something that is seen to be socially desirable because it protects the environment the respondent has the option to split points equally between these factors. Alternatively, they could choose to allocate more of their points to protecting the environment and fewer to social expectations as a secondary consideration.

Participants were asked to distribute 100-points among six predefined factors: (1) profit maximisation; (2) government regulation; (3) buyers' expectations (e.g., supermarkets); (4) society's expectations; (5) protecting the natural environment; and (6) keeping up with practices used by other CMs. An 'Other' option was also provided. The questionnaire design was based on others (Dumbrell et al., 2022; Loch et al., 2016; Malek and Umberger, 2021) and was pre-tested. The exact wording of the question is shown in Fig. S1 in the Supplementary Material. Three versions of the interview instrument were used, varying the order of the factors to reduce potential bias.

3.4. Categorising hierarchy-level behaviour

Given many firms engaged in multiple whey management practices, we categorised options based on predominant behaviour. For instance, 95% of whey goes to making human food products with incidental amounts going to disposal, or *vice versa*. Membership to a group was therefore based on the category that accounted for 50% or more of the end destination of the firm's whey. We performed two sets of groupings based on the behaviour categories already discussed. Firstly, a 4-group comparison was performed consisting of (1) human food products, (2) animal feed, (3) recycling or recovery, and (4) disposal. Secondly, a 2-group comparison was performed to compare (1) reduction and (2) waste.

3.5. Data analysis

A mixed-methods approach was used to analyse data and address the research question. Statistical tests were carefully selected based on sample size and data characteristics to ensure appropriate analysis without over-interpretation. The quantitative findings were complemented by qualitative insights, adding depth to the analysis.

With respect to analysis descriptive statistics and comparisons were first conducted to test variations in the relative importance (i.e., the 100-point score allocation) across the seven factors for all participants. Subsequently, comparisons were made for each factor based on FWH sub-groups as described above. Given the non-parametric nature of the relative importance data, the Kruskal-Wallis Test to compare group medians was considered appropriate (Lee and Lee, 2018). Post-hoc pairwise comparisons were then performed using Dunn's Test with Bonferroni correction to minimise the risk of false positives (Type I errors), resulting in conservative estimates. This approach was primarily applied to the first set of comparisons between factors. For the second set of comparisons among FWH sub-groups the initial level of stringency was moderated. The smaller sub-group suggested that excessively strict criteria might produce false negatives (Type II error). ANOVA with Dunnett's T3 test was also employed to check the robustness of the results. In this case, a log-transformation was performed on score values with a small constant (0.01) added to all values to avoid a zero-log transformation. The data analyses were conducted in RStudio (version 2023.06.1). The results for these different tests and groupings are reported in Table S5 in the Supplementary Material.

To further explore why participants allocated their points as they did and to unpack the complexities of their decision-making, direct quotes from interview transcripts were extracted. These qualitative insights provide context, particularly across hierarchy levels, by examining extreme cases.

4. Results

4.1. Relative importance of motivators

Fig. 3 illustrates the results of participants' weighting (based on a 100-point allocation) of the various motivators influencing their decisions to change whey management practices. The findings emphasise a diverse range of factors affecting firms' decisions with *profit maximisation* emerging as the most important driver. The data reveal substantial heterogeneity in participant responses, particularly in the contexts of *profit maximisation, environmental protection, and government regulations*. The distribution of responses skews toward zero, with many respondents assigning a zero rating to factors such as *buyers' and society's expectations* and *keeping up with others*. Interestingly, many participants remarked the low level of awareness of consumers and retailers regarding whey, but some voiced their concern that this may change in the short- to medium-term.

4.2. Hierarchy-level differences

Table 1 presents the distribution of whey management practices across different production scales, grouped by hierarchy-level. Large manufacturers (≥100,000 tonnes p.a.) predominantly repurpose whey as human food products, as do some mid-sized, small, and micro-operations. Indeed, the smallest operation in the sample (<10 tonnes p.a.) also repurposes most of their whey via a partnership with a local distiller. For other hierarchy levels, the distribution of practices is more varied across production scales. Many of the mid-to-large scale manufacturers dispose of whey, indicating potential firms to target for reducing whey waste.

Generally, limited differences are observed in the motivators influencing behaviour across hierarchy-levels (see Fig. 4). Significant differences were found between firms repurposing whey for human food and those using it for animal feed or disposal, with profit maximisation and government regulations being key differentiators (p-value < 0.05). Firms producing human food rated profit higher and government regulations lower compared to other groups. However, differences

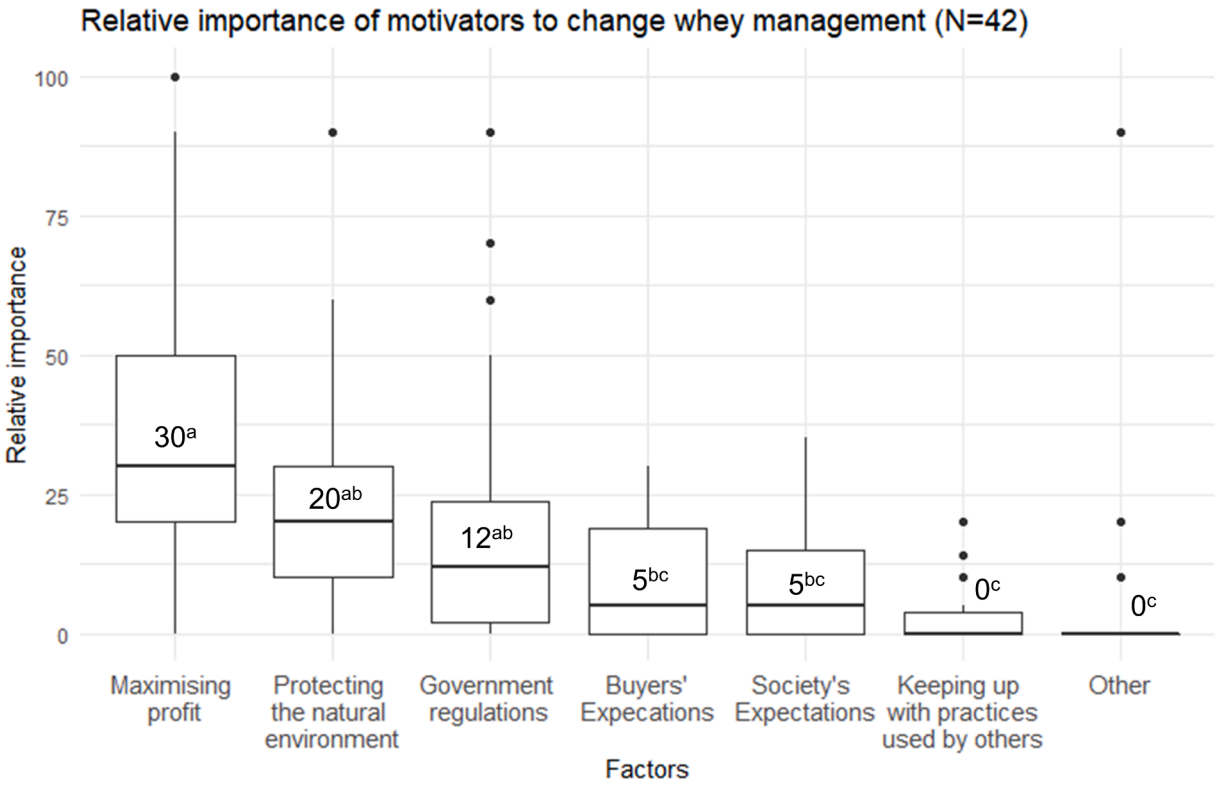

Fig. 3. Boxplot of the relative importance of motivators to change whey management. Different letters indicate significant differences (p-value < 0.05) based on Dunn's Test pairwise comparison with Bonferroni correction. The median value for each factor is displayed. Boxplot elements: centre line, median; box limits, upper and lower quartiles; whiskers, 1.5x interquartile range; points, outliers.

Table 1
The distribution of hierarchy-level groups based on production scale (n = 42).

Production scale (tonnes of liquid milk processed into cheese products p.a.)	Human food products	Animal feed	Recycling/ recovery	Disposal	Total
≥ 100,000	7.1%	0.0%	0.0%	0.0%	**7.1%**
10,000–100,000	0.0%	0.0%	0.0%	4.8%	**4.8%**
1,000–10,000	2.4%	11.9%	4.8%	11.9%	**31.0%**
100–1,000	0.0%	9.5%	9.5%	9.5%	**28.6%**
10 – 100	2.4%	11.9%	9.5%	2.4%	**26.2%**
<10	2.4%	0.0%	0.0%	0.0%	**2.4%**
Total	**14.3%**	**33.3%**	**23.8%**	**28.6%**	**100.0%**

observed in the 4-group comparison were not significant in the 2-group analysis, suggesting that grouping human food with animal feed may obscure these differences. The robustness check showed no significant differences, indicating a moderate trend. This supports the notion that firms higher on the hierarchy feel less pressure from government, environmental, and buyer-related factors, with profit being the primary motivator.

There was a higher rating for *keeping up with others* among firms that use whey in animal feed compared to all other groups; although the difference is modest (mean score: 0.5 v 5.3 out of 100). The 2-group comparison (Table S5) showed *keeping up with others* was consistently (albeit modestly) higher for firms in the *reduction* group.

To assess why participants allocated their scores and key differences between the hierarchy, four examples are explored. Fig. 5 shows motivator scores and direct quotes from four participants across different hierarchy-levels, highlighting differences in regulatory pressures, which range from local council approvals and utility charges to state environmental legislation and federal taxation. The cases emphasise varying motivators, synergies, and trade-offs. Case 1 (human food products) was a large manufacturer driven by synergistic profit goals and an ethos of maximising resource use (*"the principle of making the most from every drop of milk is key"*), with minimal regulatory influence and no perceived environmental benefit (compared to feeding whey to pigs). Case 2 (animal feed) perceived profit and environmental outcomes but was deterred by government scrutiny from repurposing whey. Case 3 (recycling/recovery) sees no profitable alternatives and would only change practices under significant legislative pressure. Case 4 (disposal), despite facing significant penalties (AU$160,000p.a.), continues to dispose of whey, highlighting a synergy between regulations and profit, but without moving up the hierarchy.

4.3. Potential for whey waste reduction

Finally, we calculated the potential whey diversion by all study participants (representing 31% of the national industry) and assess their ability to halve whey waste as part of the sector's SDG 12.3 ambitions (see Table 2). If all the firms in our sample redirected the whey currently destined for end uses that contribute to 'food waste' (e.g., recycling, recovery, or disposal) to human food products (totalling 72,280 tonnes annually), this would account for 41% of the Australian dairy sector's SDG 12.3 target. Additionally, while not directly contributing to this goal, another 19,007 tonnes p.a. could be repurposed into higher-value products. These results suggest that our sample does adequately represent the firms facing the challenge. The finding also aligns with the general expectation that the target, in terms of total mass, is achievable.

5. Discussion

Achieving SDG12.3 necessitates diverting food and drink material towards human food products or animal feed, highlighting the

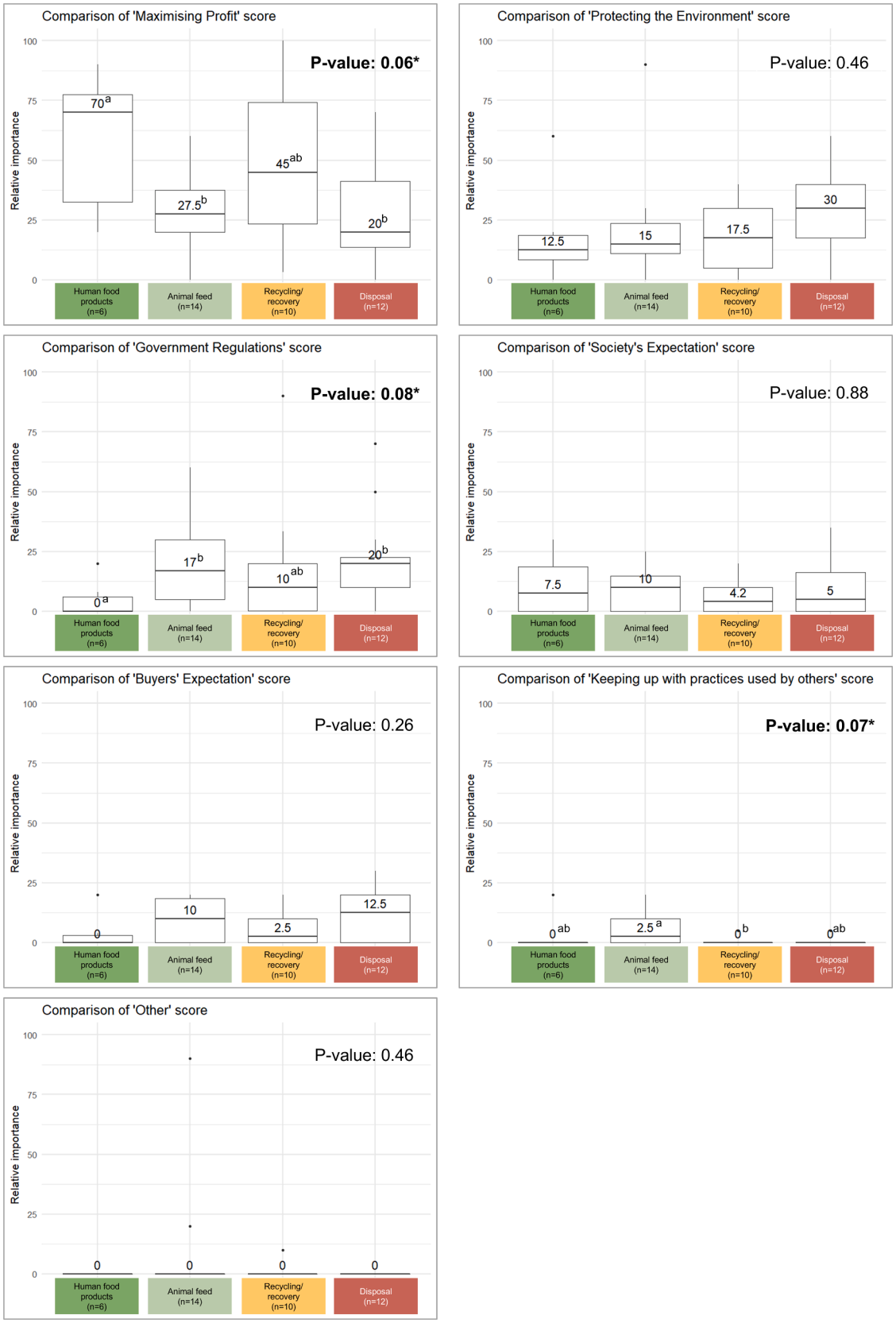

Fig. 4. Boxplots comparing relative scores of each motivator between Food Waste Hierarchy sub-groups. Notes: * P-value < 0.1. Different letters indicate significant differences (p-value < 0.05) based on Dunn's Test pairwise comparison. The median value for each factor is displayed. Boxplot elements: centre line, median; box limits, upper and lower quartiles; whiskers, 1.5x interquartile range; points, outliers.

Fig. 5. Motivator scoring and direct quotes from four individual cases from different hierarchy levels.

Table 2
Potential whey diversion by study participants (n = 42) to contribute the dairy sector's SDG12.3 target (halving food loss and waste by 2030).

	Tonnes p.a.	Contribution to SDG12.3 (175,000 t p.a. reduction)[a]
All whey diverted from 'waste' (e.g., composting, irrigation or disposal)	**72,280.18**	**41%**
Additional whey that could be repurposed from animal feed to human food	**19,007.74**	**0%**

[a] Based on Dairy Australia (2023).

importance of incentivising behavioural change. This paper explores the motivators driving firms to change their whey management practices and how these vary across different levels of the FWH. Using EIT as a framing tool, this study explores a diverse range of motivators influencing firms including profit maximisation, buyer expectations, and government regulations, environmental protection, social expectations and industry norms. We further explore heterogeneity based on FWH level. Our findings contribute to understanding what drives firms to engage in CBMs and 'move up' the FWH.

5.1. Key findings

We find firms are affected by multiple factors when considering the decision to change their whey management practice. Profit emerged as the most significant motivator for most participants (median score: 30 out of 100), which aligns with expectations for private firms. Environmental concerns (median: 20) and government regulations (median: 12) followed, with no significant difference compared to profit. Some participants may have overestimated their environmental concern, yet it is noteworthy that those with no costs associated with their current practices, or who view alternatives as commercially unviable, reported that environmental concerns were their primary driver. This is particularly relevant in the context of FLW reduction, where actions can (be perceived to) benefit both profit and environmental outcomes. Government regulations play a crucial role in influencing behaviour via waste management fees and non-compliance penalties, environmental legislations, and food safety regulations. Therefore, the relatively high scores across the sample for profit, environmental concern and government regulation are understandable. In contrast, expectations from

buyers and society regarding whey waste were minimal (median for both: 5). Many participants noted that "nobody knows what whey is" reflecting the low awareness among consumers and retailers. "Keeping up with others" was also deemed unimportant (median: 0), with participants indicating that there was an interest to understand what others are doing, but it would not drive them to change; that is, they would only change if their other objectives would be met (e.g., profit or environmental outcomes). Understanding the diverse range of motivators influencing this sectors decision reinforce the value of using EIT to explore this issue.

There was considerable heterogeneity in the importance of motivators among firms, reflecting differences in internal drivers and the external institutional environment, with some synergies and trade-offs. Some firms were solely profit-focused, while others, seeing no profitability in alternative practices, indicated that only significant legislative changes would prompt a shift in behaviour. Some were heavily impacted by government regulations, which negatively affected profits due to high penalties. From an FLW reduction perspective, these are synergistic—profit goals are hindered by regulation. However, there are trade-offs in other instances, such as when synergies between improved profits and environmental outcomes come at the cost of increased regulatory oversight. These diversity of motivators highlights the complex interplay of factors that drive CBM adoption, as identified in previous studies (Geissdoerfer et al., 2022; Goodman-Smith et al., 2020), demonstrating their heterogeneous nature (Do et al., 2022; Ranta et al., 2018). The constrained-choice instrument (100-point allocation) in this study allowed the quantification the relative importance of these factors, and qualitative responses helped explore the of synergies and trade-offs between motivating factors.

We also find that firms at different FWH levels perceive regulatory pressures differently, with no clear indication they will result in firms to 'move up' the hierarchy. Firms at the top of the FWH, regardless of production scale, experienced significantly less regulatory pressure to change (median score: 0) compared to those engaged in animal feed (median: 17) and disposal (median: 20). These firms likely already comply with all relevant food safety requirements and face no additional pressures to change. They also reported less pressure from buyers (median: 0) and environmental concerns (median: 12), possibly because they believe their current practices are already the best environmental option. Consequently, profit remains the only significant motivator influencing future decisions. Firms using whey for animal feed perceived regulatory disincentives to move higher up the hierarchy, citing increased administrative burdens as a concern. The recycling/recovery case in Fig. 5 (irrigating whey onto farmland) shows that the current regulatory environment is insufficient to drive change, with other factors having little to no effect on their choices. Even firms facing significant penalties were not coerced into 'moving up' the hierarchy but instead made a 'sideways' moves within the bottom level. The lack of significant differences between animal feed, recycling/recovery, and disposal suggests that firms are unlikely to adopt practices aligned with specific FWH levels, especially given the identified regulatory disincentives and lack of pressure from buyers and society. This a novel finding within the literature on FLW reduction, CE and CBMs. While other studies have considered CE practices within their contexts (Arranz and Arroyabe, 2023), this study rigorously applies the prioritisation principle, enabling comprehensive comparisons across hierarchy levels using whey as a case study.

Lastly, we also find it is plausible to for Australian dairy sector to achieve the needed reduction in the mass of whey waste, with 31% of the sector able to contribute to a 41% reduction of FLW. However, whether it is able to achieve this by 2030 remains a risk. The case of cheese whey suggests an instance of failures in markets, government, and social license motives to achieve efficient allocation of resources while limiting negative externalities. Despite numerous opportunities to add value to whey by converting it into products for human consumption over several decades, market conditions have prevented firms from accessing these technologies. Various government regulations play a role in discouraging undesirable behaviour, but not enough to move firms up the hierarchy-levels, while simultaneously increasing transaction costs for firms seeking to change their practices. Furthermore, this study underscores that whey management may not be a front-of-mind issue for society, as participants reported minimal pressure from these stakeholders.

While these observations hold true at the time of the study, the relative importance of motivators may evolve over time, emphasising the dynamic nature of behavioural incentives. The paragraphs below outline the policy implications of this dynamic setting. These are presented based on factors of greater importance including practices that improve profit and environmental outcomes, the role of government, expectations from buyers and society, and industry norms.

5.2. Policy implications

5.2.1. Profit and environmental drivers for change

This study underscores the important role of profitability alongside environmental benefits in driving behavioural change. This has also been observed in agricultural (Greiner et al., 2009) and corporate (Huang, 2022) contexts. While maximising profits is expectedly important, this study highlights the complex and multifaceted nature of firms' decision-making processes indicated by no statistical difference in the importance given to environmental protection. This is because, while CE principles aim to simultaneously achieve economic and environmental outcomes, trade-offs can occur. This is true in the context of whey, which can have considerable benefits or costs depending on the technology option (Risner et al., 2018) and scale of production (Juliano et al., 2017). Therefore, it is not always clear to firms which option is optimal given the broad range of factors that need to be accounted for. Decision support tools arguably have a very important role to assist. Technological innovations could also further drive improvements in the economic viability and environmental footprint of whey repurposing (Ayed et al., 2023; Rocha-Mendoza et al., 2021). For instance, biological solutions for processing acid whey—which is a particular challenge from certain types of cheese—are showing promising commercial applications (Zhao et al., 2023). These technological advances would be aided by more CE financing options (Ellen MacArthur Foundation, 2020).

5.2.2. Regulatory pressures incentivise and disincentivise change

Government regulations play a crucial role in shaping firm behaviour, but their impact varies across FWH levels. While regulations act as incentives (e.g., waste disposal fees/penalties or environmental management oversight) for exploring alternative practices, they also impose constraints at higher hierarchy-levels (food safety regulations or alcohol taxation in this study's context) hindering transition toward CE practices. Notably, at the time of writing (February 2025), the EU parliament passed a law requiring manufacturers to reduce FLW by 10%, demonstrating the significant potential role regulation can have. However, addressing regulatory disincentives and promoting higher FWH levels requires alternative policy instruments such as supply-side subsidies (Karunasena et al., 2022) (e.g., investment in cold chain, storage, or processing infrastructure); information-based policies (Arranz and Arroyabe, 2023) (e.g., better guidelines to overcome regulatory hurdles), industry coordination, and further investment in technology research and development to improve availability and access (Pannell and Claassen, 2020).

5.2.3. Social and buyer expectations could change

Currently, expectations regarding whey management practices appear to be low among buyers and society. However, evolving expectations could drive behaviour change in the future. This could manifest directly from consumers demanding new expectations on cheese products or creating demand for products derived from by-products. For example, whey-based vodka have been shown to have significant

environmental benefits (reduced GHG emissions and water) (Risner et al., 2018), which would appeal to certain segments of consumers (Aschemann-Witzel et al., 2023) such as those that proactively reduce food waste or are environmentally conscious (Nguyen et al., 2023a, Nguyen et al., 2023b). This could be aided from greater recognition of the 'Upcycle' certification standard (Upcycled Food Association, 2020), which, depending on the product, could appeal to both sustainability- and nutrition-conscious consumers (Nguyen et al., 2025). Alternatively, supply chain intermediaries such as supermarkets could set new expectations on the products they stock, which could be driven by shareholders rather than customers. While major supermarkets in Australia have reported plans to work with suppliers to reduce food waste in the supply chain (Coles, 2023; Woolworths, 2023) efforts appear to be prioritised towards avoidable FLW (e.g., fresh produce) (Devin and Richards, 2018). Recent changes to important accreditation schemes for accessing international markets have recently updated their requirements to include FLW management (FSSC, 2023). Collectively, changes across all of these areas (i.e., the demand-side) can play an important role in incentivising CMs upstream behaviour to manage whey more sustainably.

5.2.4. *Aligning all incentives and establishing new industry norms*

Mimetic pressures that involve firms imitating the practices of other reputable companies has previously been observed in the adoption of CE practices (Jain et al., 2020) but were largely insignificant in this study. However, efforts to align various incentives (discussed above) toward CBMs could establish new industry norms and best practices. Initiatives like the Australian Food Pact (SFWA, 2021) and the UK's Courtland Commitment (WRAP, 2022a) publicly recognise voluntary commitments of firms, contributing to the normalisation of industry behaviour. These initiatives also serve as success cases, which is important for late adopters of new technologies (Pannell et al., 2006; Rogers, 2003). The shift towards these industry norms fits with the Australian dairy sectors recently released strategy regarding FLW (Dairy Australia, 2023a) and may assist the future of sector facing many challenges – e.g., shrinking supply of milk, increasing costs of production, and increased expectations from consumers regarding ethical and environmental practices (Dairy Australia, 2021; Hampton et al., 2020).

While it is acknowledged that mimetic forces will likely result in the slowest adoption rate (Scott, 2005), it can be complemented by reducing barriers to CBMs where they assist in establishing norms through various pathways. This relies on providing information about the profitability and environmental benefits of alternative practices, addressing regulatory disincentives, enhancing supply-side conditions, and shaping new expectations from consumers, society, and buyers. Also, this needs to respond to distinct barriers to specific types of CBMs to allow for maximum adoption (Hetherington et al., 2024).

5.3. *Limitations*

The study encountered several limitations. Firstly, the small sample size may have impacted results, though efforts were made to ensure representation across the industry. While future studies could benefit from larger samples and detailed segmentation based on motivational profiles, the robustness checks did reflect consistent trends between motivators and behaviours. Secondly, this study did not assess the relationship between firm characteristics and their whey management practice. Such an approach would require a nuanced analytical approach to account for various management practices and business models within broader value networks (Geissdoerfer et al., 2020). Thirdly, the results were specific to Australia's cheese manufacturing sector, indicating the importance of considering contextual differences in other sectors generating FLW. However, given the maturity of processing technologies in the dairy sector and that these technologies have been considered decades ahead of other industries, there may be some future relevance to other agricultural sectors that generate unavoidable FLW (Gregg et al., 2020). That is to say that, even with the development of new technologies, the right motives need to be in place to incentivise change. Additionally, cheese whey is one of many FLW issues that face the dairy supply chain (e.g., on-farm spillage, cold-chain failures, spoilage of surplus stock). From the study participants, whey is not the only, but it was the most significant issue this section of the supply chain faced. This study is hence not adequately able to address all the other issues facing dairy supply chains. Additionally, as discussed, 'moving' enough firms up the hierarchy is a multi-stakeholder effort. Future research should examine the perspectives of these different stakeholders that are involved in the same FLW issue, including upstream and downstream in the supply chain as well as different government agencies. Other limitations include the choice and wording of the motivators and the possibility of social desirability bias. Given there were very few 'other' factors reported we argue that the predominant motivators have been considered. Social desirability bias is also possible; however, we see that profit maximisation was the most important factor and the normative 'social expectations' generally low. Thus, a more distinct contrast may be observed in larger sample sizes.

6. Conclusions

This study highlights diverse motivators influencing firms' movement up the FWH in the Australian cheese manufacturing sector. Profit maximisation and environmental concerns emerged as key drivers, underscoring the need to balance commercial viability with environmental outcomes. Government regulations played an important role, but fragmented regulations across jurisdictions have a conflicting effect. Currently, societal and buyer expectations regarding whey management practices appear to be low, likely resulting from limited pressure from these stakeholders. These findings indicate a potential failure of markets, governments, and social license motives to drive efficient resource allocation while limiting negative externalities and the achievement of SDG12.3.

However, despite the current status-quo, we discuss how these areas could be the driving force for change in the future. The heterogeneity found in the motivators suggests simultaneous, synergistic, and multi-stakeholder forces (e.g., profit, coercive, normative, and mimetic) will be needed to achieve the scale of behaviour change before the 2030 timeframe. This research provides insights for policymakers, industry stakeholders, and researchers to promote sustainability in the dairy manufacturing sector and beyond. Future research should delve into the complex factors influencing CBMs.

This research has several international implications. First, multiple factors drive a firm's behaviour change, with synergies and trade-offs among these factors. Understanding these dynamics is crucial for developing effective strategies to reduce FLW in other sectors. Second, although this study focused on the cheese manufacturing sector, which in many ways represents an 'ideal-type' industry for minimal waste due to the numerous technological options available for value-adding across production scales, the low incentive to change and significant adoption barriers have led to high waste levels in Australia. This suggests that even as other agricultural sectors or regions reach similar levels of technological advancement, reduced waste is not guaranteed. Therefore, efforts to incentivise firms to change must address multiple motivators.

CRediT authorship contribution statement

Jack B. Hetherington: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Adam J. Loch:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Pablo Juliano:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Wendy J. Umberger:** Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

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

Acknowledgements

The work has been supported by the End Food Waste Cooperative Research Centre whose activities are funded by the Australian Government's Cooperative Research Centre Program, the Commonwealth Scientific and Industry Research Organisation (CSIRO), and the University of Adelaide.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wasman.2025.114810.

Data availability

Data will be made available on request.

References

Adams, D., Donovan, J., Topple, C., 2022. Sustainability in large food and beverage companies and their supply chains: An investigation into key drivers and barriers affecting sustainability strategies. Business Strategy Environ. https://doi.org/10.1002/bse.3198.

Arranz, C.F.A., Arroyabe, M.F., 2023. Institutional theory and circular economy business models: The case of the European Union and the role of consumption policies. J. Environ Manage 340, 117906. https://doi.org/10.1016/j.jenvman.2023.117906.

Aschemann-Witzel, J., Asioli, D., Banovic, M., Perito, M.A., Peschel, A.O., 2023. Consumer understanding of upcycled foods – Exploring consumer-created associations and concept explanations across five countries. Food Qual. Prefer. 112, 105033. https://doi.org/10.1016/j.foodqual.2023.105033.

Ayed, L., M'Hir, S., Asses, N., 2023. Sustainable whey processing techniques: Innovations in derivative and beverage production. Food Biosci. 53, 102642. https://doi.org/10.1016/j.fbio.2023.102642.

Bocken, N.M., De Pauw, I., Bakker, C., Van Der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 33 (5), 308–320. https://doi.org/10.1080/21681015.2016.1172124.

Boiteau, J.M., Pingali, P., 2023. Can we agree on a food loss and waste definition? An assessment of definitional elements for a globally applicable framework. Glob. Food Sec. 37, 100677. https://doi.org/10.1016/j.gfs.2023.100677.

Coles, 2023. Sustainability report. Coles Group, Melbourne, Australia https://www.colesgroup.com.au/FormBuilder/_Resource/_module/ir5sKeTxxEOndzdh00hWJw/file/Sustainability_Report.pdf.

Dairy Australia (2023a). 'Dairy sector food waste action plan'. Dairy Australia, Melbourne, Australia. https://www.dairyaustralia.com.au/manufacturing-support/manufacturing-sustainability/dairy-sector-food-waste-action-plan#:~:text=The%20Dairy%20Food%20Waste%20Action,across%20the%20dairy%20supply%20chain.

Dairy Australia (2023b). 'In Focus 2023'. Dairy Australia, Melbourne, Victoria.

Dairy Australia, 2021. Focus 2021: The Australian dairy industry. Dairy Australia, Southbank, Australia. https://cdn-prod.dairyaustralia.com.au/-/media/project/dairy-australia-sites/national-home/resources/2021/11/19/dairy-industry-in-focus-2021/dairy-industry-in-focus-2021.pdf?rev=6d48d457eff34cc9a2c74ae6dcc51b14.

Devin, B., Richards, C., 2018. Food waste, power, and corporate social responsibility in the Australian food supply chain. J. Bus. Ethics 150 (1), 199–210. https://doi.org/10.1007/s10551-016-3181-z.

DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. Am. Sociol. Rev. 48 (2), 147–160. https://doi.org/10.2307/2095101.

Do, Q., Mishra, N., Colicchia, C., Creazza, A., Ramudhin, A., 2022. An extended institutional theory perspective on the adoption of circular economy practices: Insights from the seafood industry. Int. J. Prod. Econ. 247. https://doi.org/10.1016/j.ijpe.2021.108400.

Dumbrell, N.P., Adamson, D., Wheeler, S.A., 2020. Is social licence a response to government and market failures? Evidence from the literature. Resour. Policy 69, 101827. https://doi.org/10.1016/j.resourpol.2020.101827.

Dumbrell, N.P., Wheeler, S.A., Zuo, A., Adamson, D., 2022. Public willingness to make trade-offs in the development of a hydrogen industry in Australia. Energy Policy 165, 112987. https://doi.org/10.1016/j.enpol.2022.112987.

EFWA, 2024. 2024-2030 Strategic business plan. End Food Waste Australia, Adelaide, Australia https://endfoodwaste.com.au/wp-content/uploads/2024/07/EFWA-Strategic-Business-2024-2030.pdf.

Ellen MacArthur Foundation, 2020. Financing the circular economy. Ellen MacArthur Foundation, United Kingdom https://www.ellenmacarthurfoundation.org/financing-the-circular-economy-capturing-the-opportunity.

Fahey, J., 2023. Butter and dairy product manufacturing in Australia. Ibisworld. https://my.ibisworld.com/au/en/industry/C1133c/about.

FIAL, 2021. The national food waste strategy feasibility study–final report. Food Innovation Australia Ltd (FIAL), Werribee, Australia https://www.fial.com.au/sharing-knowledge/food-waste.

FSSC, 2023. FSSC 22000 guidance document: Food loss and waste. FSSC, The Netherlands https://www.fssc.com/wp-content/uploads/2023/03/Guidance-Document-Food-Loss-and-Waste-V6-1.pdf.

Gatto, A., Chepeliev, M., 2024. Global food loss and waste estimates show increasing nutritional and environmental pressures. Nat. Food 5 (2), 136–147. https://doi.org/10.1038/s43016-023-00915-6.

Geissdoerfer, M., Pieroni, M.P.P., Pigosso, D.C.A., Soufani, K., 2020. Circular business models: A review. J. Clean. Prod. 277, 123741. https://doi.org/10.1016/j.jclepro.2020.123741.

Geissdoerfer, M., Santa-Maria, T., Kirchherr, J., Pelzeter, C., 2022. Drivers and barriers for circular business model innovation. Bus. Strateg. Environ. 32 (6), 3814–3832. https://doi.org/10.1002/bse.3339.

Goodman-Smith, F., Mirosa, M., Skeaff, S., 2020. A mixed-methods study of retail food waste in New Zealand. Food Policy 92, 101845. https://doi.org/10.1016/j.foodpol.2020.101845.

Gregg, J.S., Jürgens, J., Happel, M.K., Strøm-Andersen, N., Tanner, A.N., Bolwig, S., Klitkou, A., 2020. Valorization of bio-residuals in the food and forestry sectors in support of a circular bioeconomy: A review. J. Clean. Prod. 267. https://doi.org/10.1016/j.jclepro.2020.122093.

Greiner, R., Patterson, L., Miller, O., 2009. Motivations, risk perceptions and adoption of conservation practices by farmers. Agr. Syst. 99 (2), 86–104. https://doi.org/10.1016/j.agsy.2008.10.003.

Hampton, J.O., Jones, B., McGreevy, P.D., 2020. Social license and animal welfare: Developments from the past decade in australia. Animals 10 (12), 2237. https://www.mdpi.com/2076-2615/10/12/2237.

Hanson, C., Lipinski, B., Robertson, K., Dias, D., Gavilan, I., Gréverath, P., Ritter, S., Fonseca, J., VanOtterdijk, R., Timmermans, T. (2016). 'Food loss and waste accounting and reporting standard'. https://flwprotocol.org/.

Hanson, C., Mitchell, P. (2017). 'The business case for reducing food loss and waste'. Champions of 12.3, Washington, DC, USA. https://champions123.org/sites/default/files/2020-08/business-case-for-reducing-food-loss-and-waste.pdf.

Haque, F., Ntim, C.G., 2018. Environmental policy, sustainable development, governance mechanisms and environmental performance. Bus. Strateg. Environ. 27 (3), 415–435. https://doi.org/10.1002/bse.2007.

Hetherington, J.B., Juliano, P., García-Flores, R., 2023. Developing closed-loop dairy value chains and tools to support decision-makers. In: Amon, B. (Ed.), *Developing Circular Agricultural Production Systems*. Burleigh Dodds Science Publishing, Cambridge, UK, pp. 1–31. https://doi.org/10.19103/AS.2023.0120.22.

Hetherington, J.B., Loch, A.J., Juliano, P., Umberger, W.J., 2024. Barriers to circular economy adoption are diverse and some are business-model specific: Evidence from the Australian cheese manufacturing sector. J. Clean. Prod. 477, 143879. https://doi.org/10.1016/j.jclepro.2024.143879.

Huang, D.-Z.-X., 2022. An integrated theory of the firm approach to environmental, social and governance performance. Account. Finance 62 (S1), 1567–1598. https://doi.org/10.1111/acfi.12832.

Hussain, M., Khan, M., Saber, H., 2023. Thematic analysis of circular economy practices across closed-loop supply chains: An institutional theory perspective. Sustainable Prod. Consumption 40, 122–134. https://doi.org/10.1016/j.spc.2023.06.017.

Jain, N.K., Panda, A., Choudhary, P., 2020. Institutional pressures and circular economy performance: The role of environmental management system and organizational flexibility in oil and gas sector. Bus. Strateg. Environ. 29 (8), 3509–3525. https://doi.org/10.1002/bse.2593.

Jones, R.E., Speight, R.E., Blinco, J.L., O'Hara, I.M., 2022. Biorefining within food loss and waste frameworks: A review. Renew. Sustain. Energy Rev. 154, 111781. https://doi.org/10.1016/j.rser.2021.111781.

Juliano, P., González, M.A., Castells, M.L., Di Risio, J., García-Flores, R., Rosenthal, A., Silva, C.M., Krolow, A.C.R., Zoccal, R., Walter, E., Dutra, A., Caicedo, I.B., Castañeda, C.G.G., Peñaranda, R.Q., Trujillo, R.S., Valencia, J.U.S., Álvarez, L.F.G., López, T., Jorcin, S., Miraballes, M., Mattos, C., Avellaneda, Y.A., Salazar, P.V., 2017. Whey value addition, First ed. San Martin, Argentina, Instituto Nacional de Tecnología Industrial - INTI.

Karunasena, G.G., Pearson, D., Guest, A., GoodmanSmith, F., Wheeler, S., Cameron, C., Lockrey, S., 2022. Co-creating policy research projects to assist Australia meet its commitment of halving food waste by 2030. Fight Food Waste Ltd, Adelaide. Australia https://fightfoodwastecrc.com.au/wp-content/uploads/2023/03/Food-Waste-Policy-Workshop-2022_Final-1.pdf.

Kauppi, K., 2013. Extending the use of institutional theory in operations and supply chain management research. Int. J. Oper. Prod. Manag. 33 (10), 1318–1345. https://doi.org/10.1108/IJOPM-10-2011-0364.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Resour. Conserv. Recycl. 127, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005.

Lade, S.J., Steffen, W., de Vries, W., Carpenter, S.R., Donges, J.F., Gerten, D., Hoff, H., Newbold, T., Richardson, K., Rockström, J., 2020. Human impacts on planetary boundaries amplified by Earth system interactions. Nat. Sustainability 3 (2), 119–128. https://doi.org/10.1038/s41893-019-0454-4.

Lee, S., Lee, D.K., 2018. What is the proper way to apply the multiple comparison test? Korean J Anesthesiol 71 (5), 353–360. https://doi.org/10.4097/kja.d.18.00242.

Loch, A., Boxall, P., Wheeler, S.A., 2016. Using proportional modeling to evaluate irrigator preferences for market-based water reallocation. Agric. Econ. 47 (4), 387–398. https://doi.org/10.1111/agec.12238.
Malek, L., Umberger, W.J., 2021. Distinguishing meat reducers from unrestricted omnivores, vegetarians and vegans: A comprehensive comparison of Australian consumers. Food Qual. Prefer. 88, 104081. https://doi.org/10.1016/j.foodqual.2020.104081.
Mullen, P.M., 1999. Public involvement in health care priority setting: an overview of methods for eliciting values. Health Expect. 2 (4), 222–234. https://doi.org/10.1046/j.1369-6513.1999.00062.x.
Nguyen, T.T.T., Hetherington, J.B., O'Connor, P.J., Malek, L., 2025. Sustainable food consumption: Sustainability-conscious consumers do not reduce food waste but nutrition-conscious consumers do. Resources, Conservation & Recycling 219, 108296. https://doi.org/10.1016/j.resconrec.2025.108296.
Nguyen, T.T.T., Malek, L., Umberger, W.J., O'Connor, P.J., 2023a. Food waste 'Warriors', 'Strugglers' and 'Slackers': Segmenting households based on food waste generation and sorting behaviours. Food Qual. Prefer. 112, 105000. https://doi.org/10.1016/j.foodqual.2023.105000.
Nguyen, T.T.T., Malek, L., Umberger, W.J., O'Connor, P.J. (2023b). 'Motivations behind daily preventative household food waste behaviours: The role of gain, hedonic, normative, and competing goals', *Sustainable Production and Consumption* 43, 278-296. https://doi.org/10.1016/j.spc.2023.11.003.
Nilsson, A., von Borgstede, C., Biel, A., 2004. Willingness to accept climate change strategies: The effect of values and norms. J. Environ. Psychol. 24 (3), 267–277. https://doi.org/10.1016/j.jenvp.2004.06.002.
O'Connor, J., Skeaff, S., Bremer, P., Lucci, G., Mirosa, M., 2023. A critical review of on-farm food loss and waste: future research and policy recommendations. Renewable Agric. Food Syst 38, e24.
Pannell, D.J., Claassen, R., 2020. The roles of adoption and behavior change in agricultural policy. Appl. Econ. Perspect. Policy 42 (1), 31–41. https://doi.org/10.1002/aepp.13009.
Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., 2006. Understanding and promoting adoption of conservation practices by rural landholders. Aust. J. Exp. Agric. 46 (11), 1407–1424. https://doi.org/10.1071/EA05037.
Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N., Ujang, Z.b. (2014). 'The food waste hierarchy as a framework for the management of food surplus and food waste', *Journal of Cleaner Production* 76, 106-115. https://doi.org/10.1016/j.jclepro.2014.04.020.
Parsa, A., Van De Wiel, M., Schmutz, U., Fried, J., Black, D., Roderick, I., 2023. Challenging the food waste hierarchy. J. Environ. Manage. 344, 118554. https://doi.org/10.1016/j.jenvman.2023.118554.
Ramanathan, R., Poomkaew, B., Nath, P., 2014. The impact of organizational pressures on environmental performance of firms. Business Ethics: A Eur. Rev. 23 (2), 169–182. https://doi.org/10.1111/beer.12042.
Ranta, V., Aarikka-Stenroos, L., Ritala, P., Mäkinen, S.J., 2018. Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. Resour. Conserv. Recycl. 135, 70–82. https://doi.org/10.1016/j.resconrec.2017.08.017.
Reeves, M., 2023. Cheese manufacturing in Australia. Ibisworld. https://my.ibisworld.com/au/en/industry/c1133a/at-a-glance.
Reynolds, C.J., Piantadosi, J., Boland, J., 2015. Rescuing food from the organics waste stream to feed the food insecure: An economic and environmental assessment of Australian food rescue operations using environmentally extended waste input-output analysis. Sustainability 7 (4), 4707–4726. https://doi.org/10.3390/su7044707.
Risner, D., Shayevitz, A., Haapala, K., Meunier-Goddik, L., Hughes, P., 2018. Fermentation and distillation of cheese whey: Carbon dioxide-equivalent emissions and water use in the production of whey spirits and white whiskey. J. Dairy Sci. 101 (4), 2963–2973. https://doi.org/10.3168/jds.2017-13774.
Rocha-Mendoza, D., Kosmerl, E., Krentz, A., Zhang, L., Badiger, S., Miyagusuku-Cruzado, G., Mayta-Apaza, A., Giusti, M., Jiménez-Flores, R., García-Cano, I., 2021. Invited review: Acid whey trends and health benefits. J. Dairy Sci. 104 (2), 1262–1275. https://doi.org/10.3168/jds.2020-19038.
Rogers, E.M., 2003. Diffusion of innovations, 5th ed. Free Press, New York.
Scott, W.R., 2005. 'Institutional theory: Contributing to a theoretical research program', *Great minds in management: The process of theory development.* Oxford University Press, Oxford, UK, pp. 460–484.
Scott, W.R., 2008. 'Institutions and organizations: Ideas and interests. Sage, Los Angeles, USA.
SFWA, 2021. Stop food waste Australia: Strategic plan. Stop Food Waste Australia, Adelaide, Australia.
Smithers, G.W., 2008. Whey and whey proteins—From 'gutter-to-gold'. *Int. Dairy J.* 18 (7), 695–704. https://doi.org/10.1016/j.idairyj.2008.03.008.
Technavio, 2023. Global whey protein market 2023-2027. Infiniti Research Limited.
Teigiserova, D.A., Hamelin, L., Thomsen, M., 2020. Towards transparent valorization of food surplus, waste and loss: Clarifying definitions, food waste hierarchy, and role in the circular economy. Sci. Total Environ. 706, 136033. https://doi.org/10.1016/j.scitotenv.2019.136033.
Tsermoula, P., Khakimov, B., Nielsen, J.H., Engelsen, S.B., 2021. Whey - The waste-stream that became more valuable than the food product. Trends Food Sci. Technol. 118, 230–241. https://doi.org/10.1016/j.tifs.2021.08.025.
Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., Valkokari, P., 2019. Unlocking circular business: A framework of barriers and drivers. J. Clean. Prod. 212, 90–98. https://doi.org/10.1016/j.jclepro.2018.11.202.
Upcycled Food Association, 2020. Upcycled certification standard (Version 1). Upcycled Food Association, Denver, USA https://www.upcycledfood.org/the-standard.
USDA, 2022. U.S. Food loss & waste 2030 champions milestones report (September 2022). USA, U.S, Department of Agriculture (USDA) and Environmental Protection Agency (EPA), Washington DC https://www.usda.gov/sites/default/files/documents/2030-Champions-2022.pdf.
Vermunt, D.A., Negro, S.O., Verweij, P.A., Kuppens, D.V., Hekkert, M.P., 2019. Exploring barriers to implementing different circular business models. *J. Clean. Prod.* 222, 891–902. https://doi.org/10.1016/j.jclepro.2019.03.052.
Woolworths, 2023. Sustainability report. Woolworths Group, Sydney, Australia https://www.woolworthsgroup.com.au/content/dam/wwg/investors/reports/2023/f23-full-year/Woolworths%20Group%202023%20Sustainability%20Report.pdf.
WRAP, 2022a. The courtauld commitment 2030: progress and insights report 2021/2022. Waste and Resource Action Programme, Branbury, UK https://wrap.org.uk/sites/default/files/2022-11/WRAP_The_Courtauld_Commitment_2030_Progress_and_Insights_Report_2022.pdf.
WRAP, 2022b. Food surplus and waste in the UK – key facts. Waste and Resources Action Programme (WRAP), Banbury, UK https://wrap.org.uk/resources/report/food-surplus-and-waste-uk-key-facts.
Zhao, G., Zhao, S., Hagner Nielsen, L., Zhou, F., Gu, L., Tilahun Tadesse, B., Solem, C., 2023. Transforming acid whey into a resource by selective removal of lactic acid and galactose using optimized food-grade microorganisms. Bioresour. Technol. 387, 129594. https://doi.org/10.1016/j.biortech.2023.129594.
Zhu, J., Luo, Z., Sun, T., Li, W., Zhou, W., Wang, X., Fei, X., Tong, H., Yin, K., 2023. Cradle-to-grave emissions from food loss and waste represent half of total greenhouse gas emissions from food systems. Nat. Food 4 (3), 247–256. https://doi.org/10.1038/s43016-023-00710-3.