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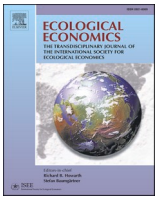

Exploring South Australian households' perceptions towards various food waste policies

By Sarah Ann Wheeler [a,b,*], Ying Xu [a], Daniel Gregg [a]

[a] National Centre for Groundwater Research and Training, Centre for Social Impact, College of Business, Government and Law, Flinders University, Bedford Park, SA 5042, Australia
[b] School of Economics and Public Policy, Faculty of ABLE, The University of Adelaide, Nexus 10, Adelaide, SA 5005, Australia

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ABSTRACT

Increasing landfill and environmental costs are driving municipalities to search for effective policies to change household food waste disposal, balancing competing attributes such as effectiveness, fairness and feasibility. In order to better understand households' policy perspectives, we conducted an online survey with 1520 South Australians regarding four different food waste policies, namely: 1) frequency-based pricing for bin collection; 2) penalties for bin misuse; 3) changing bin collection timing; and 4) extension and education. A structural equation modelling approach was used to model overall policy preference, based on perceived policy attributes and household socio-demographics. Results highlighted that respondents' rated economic incentives (pricing and penalties) as the most effective in changing food waste behaviour, but rank these policies low in feasibility or acceptability. Conversely, education and information campaigns were rated as the lowest in effectively changing behaviour, but the most acceptable and fairest policy overall. Overall, respondents from households producing less food waste were more favourable towards introducing economic incentive food waste policies.

1. Introduction

Food waste is a growing global concern that leads to a variety of environmental, social and economic issues (Food and Agriculture Organization [FAO], 2019). Globally, 1.3 billion tonnes of edible food, accounting for a third of global food consumption, is wasted annually (FAO, 2015). Food waste not diverted into an organic bin often ends up in landfill wasting economic resources and contributing to environmental degradation through the production and release of greenhouse gases (Grizzetti et al., 2013). In Australia, as in many other developed countries, more than half of total food waste is attributable to households (Karunasena and Pearson, 2022). As a result, household food waste is a key target for food waste reduction strategies among municipalities in Australia (Boulet et al., 2023; Australian Government Department of the Environment and Energy, 2017) and globally (Du et al., 2023; Verghese and Lockrey, 2019). This means programs aimed at influencing household behaviour play a crucial role in policy strategies designed to minimise food waste (Buzby and Hyman, 2012; Katare et al., 2017). However, changing household behaviour remains a highly uncertain endeavour, more so for governments and public organisations for whom households are both policy targets and the original drivers of policy demand. As a result, even small behavioural changes can be hard to achieve with households often regarding pro-environmental activities such as food waste reduction and diversion as having high inconvenience costs (Lee et al., 2017).

In Australia, as in many other regions, household waste collection is a municipal government role based on a fixed-frequency waste collection service (Chowdhury and Chowdhury, 2007). Households are typically charged a waste collection fee at a fixed and homogenous annual or quarterly frequency collected through municipal council rates. This uniform charging policy does not account for the amount of waste a household generates within the bin or the type of waste they generate (organic, general, recyclables). Nor do uniform charging policies typically account for improper allocation of household waste to the appropriate collection receptacle (e.g. organic waste placed in general waste streams). These policy characteristics along with other factors contribute to limited external or policy incentives, and even potential disincentives, for improved treatment of household food waste. For example, the low collection frequency of organic bins (fortnightly) can generate perceived (or real) sanitation issues and undesirable odours

* Corresponding author at: National Centre for Groundwater Research and Training, Centre for Social Impact, College of Business, Government and Law, Flinders University, Bedford Park, SA 5042, Australia.
E-mail address: sarah.wheeler@flinders.edu.au (B.S.A. Wheeler).

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that disicentivise households from full and proper usage of organic waste bin collection services (Department of Environment and Conservation NSW, 2007; Benyam et al., 2020).

Hence, developing and implementing appropriate policies to inspire individuals with the motivation to change food waste behaviour, diverting home food waste away from landfill and towards green organics recycling, is critical and a current priority for Australian municipal government (Du et al., 2023; Verghese and Lockrey, 2019). Yet policy design with respect to within-household behaviours can be challenging (van Geffen et al., 2020). So, while there is substantial need for policy change with respect to household food waste, there is also substantial scope for adverse or even perverse outcomes (Skeldon et al., 2018), as well as concerns around social protest from overly intrusive household waste policies. Effective policy changes involving large-scale behavioural changes require widespread public support (van Geffen et al., 2020), which is associated with people's perceptions of such policies (e.g. Anderson et al., 2017; Huber et al., 2020; Wan et al., 2017). It is within this paradigm – one of a growing need for household food waste policies to be improved but one also in which many households' regard such policies as overly intrusive – that municipal governments are seeking insights to design effective policies to reduce household food waste that also have strong public support.

There is current limited research that examines households' perceptions of, and preferences for, food waste policies. The majority of previous studies have focused on the effectiveness of food waste policies (Pinto et al., 2018; Reynolds et al., 2019; Young et al., 2017), whereas details around the public's perceptions of other essential policy characteristics are less known, though perceived fairness and unintrusiveness have been shown to be important characteristics that underpin overall views on the acceptability of a policy (e.g. Huber et al., 2020; Börjesson et al., 2016).

Moreover, household behavioural change is a complex process with interactions between household characteristics, policy structure, perceived policy impacts/outcomes and overall policy preference (Benyam et al., 2018; van Geffen et al., 2020). There remains limited concrete research to support the design of household food waste reduction and diversion programs. In particular, there is a gap in understanding around the types of policies that households may regard overall positively, the characteristics of policies regarded positively or negatively by households, and the characteristics of households themselves that describe cohorts with substantially different views on household food waste policies. These limitations hinder the ability of municipal governments to create effective, efficient, and broadly accepted policy programs for improved management of household food waste.

We worked with a major provider of municipal waste services in the Adelaide region of South Australia (SA) to select and describe prospective policies with objectives to: (1) reduce household food waste; and (2) increase the utilisation of the existing organic waste stream for remaining household food waste. The aim of this study is to understand a) the public's perceptions towards the most effective policy approach in generating changes in household food waste behaviours; and b) which form of policies are more likely (or less likely) to have has widespread approval. The study considers four potential policies, namely: (1) charging based on bin frequency collection; (2) penalties for food waste contamination; (3) changing the frequency of bin collection; and (4) information, social norm messaging and education. The focus of this study is on the interactions between households' various perceptions of proposed policies, and how those perceptions relate to overall preference and views of the policies. A Structural Equation Modelling (SEM) framework was used to examine mediation pathways for food waste policy preferences of households in SA.

This study contributes to the literature in a number of ways. First, this study provides insights into public overall views into different policies and also explores the perceived consequences of policies in terms of their attributes that commonly underpin their favourability (or unfavourability). Secondly, unlike most other policy studies, which only focus on one or two policies, this study compares overall views for multiple policies, including the policy interventions in all main categories (e.g. structural changes to waste collection, market-based instruments, information and education campaigns). Thirdly, by investigating the impacts of various variables on the public perceived consequences of policies, this study identifies cohorts in society may be opposed/supportive of various policies. This provides essential information to support the government in developing effective policies to obtain sufficient public support, thus stimulating households to change food waste behaviour.

2. Overview on food waste policies and behavioural responses

2.1. Food waste policy overview

Food waste policies can be divided into three main categories: (1) market-based instruments (e.g. pricing and penalties); (2) information and education campaigns (e.g. social norms, information, education); and (3) structural changes to waste collection (e.g. providing increased collection services for green organics, decreasing the frequency of the landfill bin, or allowing food waste to go into the green organics bin).

Market-based instruments are policy tools that aim to divert food waste from landfill and reduce food waste through economic incentives, namely fees, taxes, pricing, penalties, and subsidies (e.g. landfill levies, price support mechanisms or incineration taxes) (UNEP, 2014; Schanes et al., 2018). Previous studies have found evidence from other countries that market-based instruments, such as a weight-based waste fee system and taxes, can have significant waste reducing and recycling effects (Dahlén et al., 2007; Dahlén and Lagerkvist, 2010; EEA, 2009; Pfister and Mathys, 2022; Reichenbach, 2008; Skumatz, 2008). However, other studies have highlighted that waste disposal fees as a policy instrument might not be efficient in reducing the generation of food waste overall and may generate unwanted side effects such as an increase in illegal dumping (Bartelings et al., 2004; Hamilton and Richards, 2019; Kirakozian, 2016).

Information-education campaigns are one of the most commonly implemented tools for food waste prevention and reduction, aiming at providing information to the target group, such as households, to change their behaviour (Priefer et al., 2016; Schanes et al., 2018; Fight Food Waste CRC, 2022). Previous studies have shown varied results regarding the success of this intervention. Some studies found that information-education campaigns can change food waste behaviours - leading to substantial food waste reduction (Martins et al., 2016; Reynolds et al., 2019; Young et al., 2017). However, some evidence shows that information approaches are generally less effective than other types of interventions as they may raise awareness but do not always change behaviours (Abrahamse and Matthies, 2018; Staats et al., 1996). Also, a number of authors have suggested that such campaigns could be ineffective if implemented alone (Quested et al., 2013; Secondi et al., 2015), indicating the need for such campaigns to be combined with other strategies to achieve long-term behavioural change (Bernstad et al., 2013; Dai et al., 2016; Hamilton and Richards, 2019).

Research involving structural changes to waste collection has found that a reduction in the collection of general waste from weekly to fortnightly led to more recycling (WRAP, 2009). Xu et al. (2023) found that changing waste collection services (such as introducing a green organics bin service and allowing food waste to be diverted into it) increased diversion rates in Adelaide, South Australia.

2.2. Behavioural policy responses in wider environmental and health literature

Although research on food waste is growing, few studies have examined household behavioural preferences across a variety of differing food waste policies and how these are related to concepts

underpinning the performance of behavioural change policies. Behavioural responses to public policies have been a key area of research across a range of literature, including economics, social psychology, political science and more. This research identifies a range of factors that influence, firstly, preferences for policies and, secondly, (expected or actual) behavioural responses to proposed policies based on both the policy and whether that policy is regarded positively by individuals or cohorts.

The key factors identified across a number of the literature include acceptability, fairness, feasibility, intrusivity and effectiveness. We are particularly interested in this study on how people's overall views on policy community factors drive their own personal individual preferences on whether a policy is a 'great idea and should be implemented'.

Acceptability of a policy can be linked to a number of factors (fairness, feasibility, intrusiveness and effectiveness) reviewed here, and provides an indication of the overall acceptability of a policy (Ulph and Ulph, 2021). ***Fairness*** has been widely explored with respect to preferences over policies across a number of literatures. Beyond well-known justice frameworks (e.g. procedural and distributive justice), economists and social scientists have begun to explore the relationship of people's fairness perspectives with behavioural responses to interventionist policies. In general, the more fair a policy is perceived, the greater the overall positive view towards it (e.g. Kim et al., 2013). ***Feasibility*** judges how feasible someone views the implementation of a policy to be given current institutions and technologies. In a study of household food waste reduction, Mariam et al. (2022) find that feasibility perceptions both play a major role in overall policy perspectives and are malleable over time. ***Intrusiveness*** is the extent to which a policy is regarded as intruding upon preferred behaviours, norms, or other preferences of agents (e.g. Bos et al., 2015, 2018). It has been widely explored as a key factor in policy perspectives for a range of policy programs, including environmental policies and food waste policies. For example Bos et al. (2018; 2015) show that perceived and actual intrusiveness of a policy have major impacts on overall policy preferences, behavioural responses to policies and even people's emotive responses to policy interactions for nutritional policies. ***Effectiveness*** is the extent to which the policy will be effective and efficient at achieving target objectives. Policy effectiveness plays a role in overall policy preference based on linkages to cost efficiency and/or the use of valuable resources. Akter and Bennett (2011) and Huber et al. (2020) found that a lack of confidence in the effectiveness of policies would influence respondents' decision to support the policy.

While many of the policy factors have been explored in a range of literature, to the best of our knowledge, there are none that explore the impact of the various factors on overall household food waste policy views. Household food waste behaviours differ from other public environmental behaviours in important ways that are likely to be related to our individual policy factors, and also individual socio-demographics of respondents, their location and their current food waste behaviour. We investigate issues of policy views further in a structural equation model of Adelaide residents' food waste policy preferences based on household characteristics (e.g. current food waste behaviours, attitudinal factors, socio-economic characteristics) - mediated by their policy perceptions.

3. Data and methods

3.1. Location and case study

Australia faces many of the same challenges around food waste behaviours as other developed countries (Ananda et al., 2021; Karunasena et al., 2021; Reynolds et al., 2019; Wang et al., 2021) and has many municipalities currently experimenting with alternative food waste diversion programs, SA being one such state. The current aim of the SA state government is for zero avoidable waste to be sent to landfill by 2030 (Green Industries SA, 2020). The current policy for waste charges in most parts of Australia including SA is a single, uniform charge for each household. We designed a survey to explore people's preferences for differing food waste policies, and used SA as our representative state case study to do so.

3.2. Data

This study used data from an online survey about food waste policies in Adelaide (the capital and major population centre of SA), conducted in mid-2022 by Pure Profile. The population surveyed were metropolitan Adelaide residents (i.e., not including rural SA residents). In total, 1520 households were surveyed, with a median completion time of just over 21 minutes per survey. The survey was initially piloted among 100 households, with minor changes subsequently made. The survey was originally stratified by location, age, and gender, to ensure a representative sample of the SA population.[1] The response rate for the survey was 52%, or 60% when excluding the over-quota respondents.

The online survey questions covered the following information: food waste policy views (e.g. attitudes towards the four policy programs described below); food waste policy experiment; personal attitudes towards the world's environmental issues; food consumption choices and habits; food waste behaviours; and demographic, psychological and socioeconomic characteristics of the respondent and household.

The mean age of respondents was 43, with an age range from 18 to 88. Most participants (62%) identify as female, whereas 38% identify as male. The survey encompassed households of diverse sizes, ranging from one to twelve members, with an average household size of three (see Table B1 in Appendix B for the descriptive statistics).

The wording in the survey provided first detail about the existing food waste policy in Adelaide, and then detail about alternative food waste policy differences. Appendix A provides the exact wording. The four policies reviewed in this study include:

1. ***Pricing by Bin Frequency Collection:*** Charges for the number of times the red/blue (general) waste landfill bin is collected over a normal rates period for a single household: This option would involve household's fixed waste charges being converted to a per 'lift' bin charge, based on how many times their red/blue waste landfill bin was picked up each quarter. Payment based on the frequency that households' general bin was collected would encourage households to divert more food waste into organic bins to reduce collection times. There was no charge for collecting the green organics or yellow recycling bins.
2. ***Penalties***: Fines and penalties for persistent contamination of organic bins with non-organic waste by a single household. Such households would be identified through random checks, with warning letters issued first, and then a significant penalty (such as green organics bin taken away) or monetary fine.
3. ***Bin Frequency Collection Structural Change***: This option would involve council[2] changing the current frequency of bin collection times. Green organics bin would be picked up more often (e.g. weekly), with general red/blue waste (and yellow recycling) bin picked up less often (e.g. fortnightly).
4. ***Information, Social Norms and Education***: This would involve councils providing new information to households on their general

[1] We compared our survey sample to key SA ABS census population data, and our survey sample results matched in terms of household income, age, children in family and household details. We had slightly more females and older respondents answering the survey than the SA population average, but this is because our survey sample does not include anyone below 18. Females were oversampled towards the end once minimum sample sizes were met, and we controlled for gender in the regressions.

[2] Council is Australian local government with the roles of decision-making, communication facilitation between the community and the council, scrutiny of decisions, representing their ward and others.

bin waste volumes, and launching large-scale education and information campaigns on food waste. For example, on each rates notice, households would receive information on how much tonnes were thrown out in their general bin in that time-period, compared to previous time-periods. Information would also be provided on the average tonnage thrown out by other households in the council area.

To keep fatigue bias down, each respondent only answered two policies allocated randomly with a view to achieving balance across the policy options presented (consequently giving us a total of 3040 policy observations to model overall). In particular, we were interested in understanding respondents' overall views towards different food waste policies, that is, why respondents thought (or did not think) that each policy option 'was a great idea and should be implemented in my area'. Hence, we asked respondents to rank the following 'policy preference' statements on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree):

- *Acceptability*: 'This option would be unacceptable to most people' (reverse-coded)[3];
- *Unintrusiveness*: 'Most people probably wouldn't be too affected by this option';
- *Effectiveness*: 'This option would probably increase the diversion of food waste into the green organics bin in my council area';
- *Fairness*: 'This option is unfair to some households' (reverse-coded);
- *Feasibility*: 'I don't see how this option would be able to be implemented' (reverse-coded).

Our overall dependent variable was respondents' overall individual policy view. Respondents were asked: "I think this option is a great idea and needs to be implemented in my area", with answers provided on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree).[4] This was particular for each policy assessed.

3.3. Econometric modelling methodology

The study used mediation analysis through a structural equation model to assess the direct effect and the indirect effects of policies dummies on overall view through different perceived consequences of policies. Structural equation modelling is an established and well-known statistical technique that establishes structural models to address complicated behaviour relationships with a focus on latent variable analysis and/or mediation and moderation of core hypothesises impact pathways (Gunzler et al., 2013). Unlike general regression methods, it allows the development of complex path models, allows for multiple dependent variables that also act as independent variables in other model elements, and can quantify direct and indirect effects allowing inference on all elements of these complex models (e.g. Gunzler et al., 2013; Kowalski and Tu, 2007). It fundamentally differs from regression and provides a stronger inferential method compared to multivariate linear regression techniques, including multiple regression (Cheng, 2001). Fig. 1 shows the pathways of policies, environmental concerns, food waste behaviours and socio-economic status and other factors on the overall policy view. These variables are selected based on the review of other household food waste studies.

For respondent i, the mediation model can be specified as:

$$\text{Acceptability}_i = P_i r_1 + X_i' \partial_1 + e_{1i}$$
$$\text{Intrusiveness}_i = P_i r_2 + X_i' \partial_2 + e_{2i}$$

$$\textit{Effectiveness}_i = P_i r_3 + X_i' \partial_3 + e_{3i}$$

$$\textit{Fairness}_i = P_i r_4 + X_i' \partial_4 + e_{4i}$$

$$\textit{Feasibility}_i = P_i r_5 + X_i' \partial_5 + e_{5i}$$

$$\begin{aligned}\text{Overall policy view}_i = {} & P_{ij} w_j + \beta_1 \text{Acceptability}_i + \beta_2 \text{Intrusiveness}_i \\ & + \beta_3 \text{Effectiveness}_i + \beta_4 \text{Fairness}_i \\ & + \beta_5 \text{Feasibility}_i + X_i' \partial_6 + e_{6i}\end{aligned}$$

$$\text{Corr}\,(e_{mi}, e_{ni}) \neq 0, m \neq n, m, n = 1\ldots,5; j = 1\ldots,4$$

P_j is a vector of policy variables that include: (1) pricing frequency collection charges; (2) penalties; (3) frequency bin collection structural change; and (4) information, social norms, and education (this policy group is set as base group). X is the vector of covariates that include a variety of socio-economic factors, awareness of environmental issues of waste generation and climate change, food consumption choice (e.g. vegetarian or vegan or not), food waste behaviours (e.g. food waste disposal via general bin, and kitchen caddy use) and knowledge of food waste disposal; r,w, β and ∂ are coefficient vectors; e_i is a vector of error terms for the i^{th} respondent that are allowed to be correlated between consequence equations (but not between respondents).

The approach taken to check the violation of sequential ignorability assumption was to apply a set of sensitivity analyses, that allow consideration of the potential violation of sequential ignorability by quantifying the robustness of empirical conclusions (Imai et al., 2010). Moreover, to explore the influence of various factors on the overall view of individual policy, we estimated four separate models for each policy including different sets of covariates (see Fig. B1 in Appendix B for the pathway of each policy).

4. Results

Table 1 presents the empirical results of various factors' direct, indirect, and total effects on the overall view of food waste policies, mediated by five perceived consequences.

To better understand people's preferences, exploring the effects of the perceived consequences of policies on respondents' overall views is essential. The estimated results suggest that all perceived consequences of policies are highly significant predictors of the level of individual respondent agreement with the overall view that a policy is a "great idea".

Yet these perceived policy consequences played different roles in overall policy views, while some perception factors appear to be far more critical than others. First, the effectiveness of the policy has the highest level of positive correlation with the overall view of the policy (β=0.26; p<0.01). Second, concern around the fairness of the policy significantly decreases the overall preference, signifying the importance of effectiveness and fairness as policy criteria. This finding is consistent with previous policy literature (e.g. Börjesson et al., 2016; Chung et al., 2011; Huber et al., 2020).

Furthermore, our study provides insights into the significant impacts of the other three perceived consequences (e.g. feasibility, acceptability and unintrusiveness) on overall policy view. The impacts of these perceived consequences are not negligible, although the magnitude is not as large as those for effectiveness and fairness. Compared to fairness, the unintrusiveness of the policy has a slightly weaker association with

[3] We reverse-coded three questions in the modelling so all policy consequences could be interpreted positively.

[4] Respondents' overall policy view and other perceived consequences of policies (e.g. acceptability, fairness, feasibility, unintrusiveness, and effectiveness) are asked for each policy in the questionnaire. In the most empirical model, this wide data is restructured to long-form so that policy dummies can be generated. In this way policy dummies can be used as independent variables so they can be compared in regard to the overall policy view and perceived consequences of policies (see Tables 1, 2 and B2 in Appendix B). However, there is an exception while modelling the influence of various factors on the overall view of individual policy, since there is no need to compare the effects of policies, the original data is therefore applied in this model (Table B3).

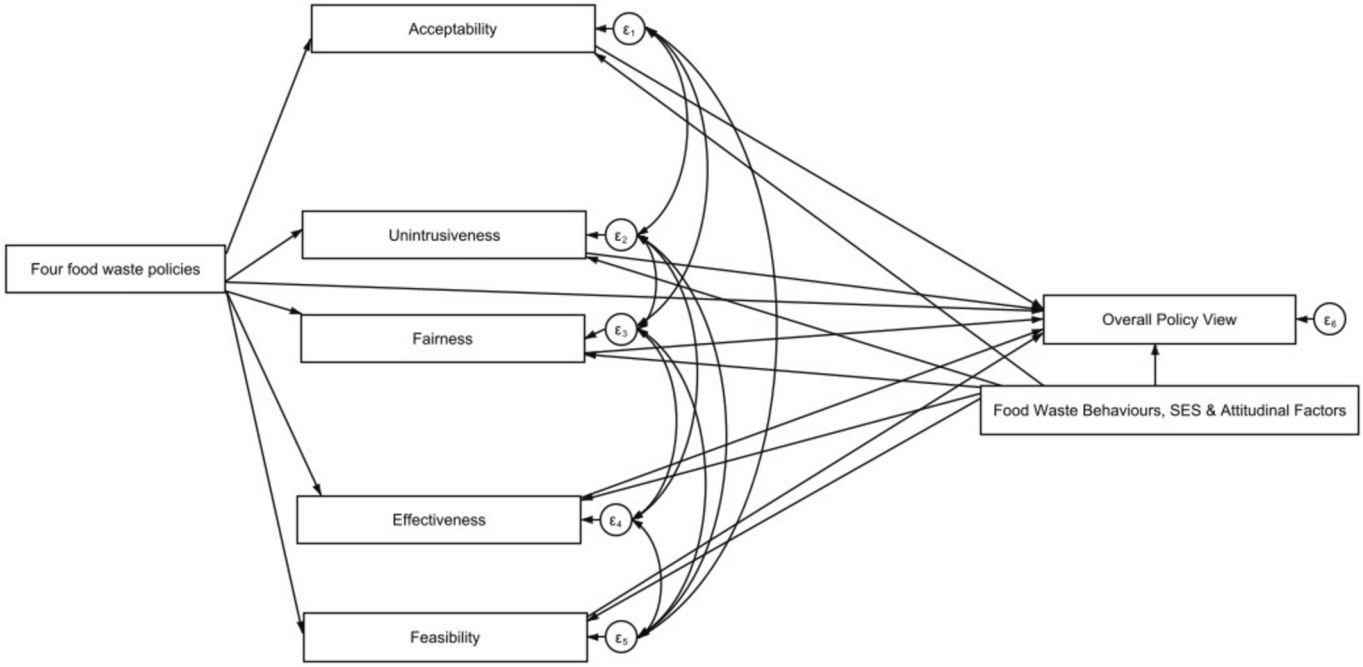

Fig. 1. Outline of full path analysis model showing the direct and indirect effects of factors on overall policy view.
Four food waste policies include pricing, penalties, bin collection frequency, and information and education. They are dummies generated by reshaping the original data so that they can be used as independent variables and therefore be compared in regard to the overall policy view and perceived consequences of policies. SES is socio-economic status represented by a variety of socio-economic factors.

the overall view of food waste policies (β=0.26; p<0.01 and β=0.24; p<0.01, respectively). Acceptability is another policy aspect, and it is positively associated with the overall policy preference (β=0.15; p<0.01). In contrast, feasibility, whilst significant, has the least impact on the overall policy preference.

4.1. Effects of different policies on perceived consequences and overall policy view

The estimated results of mediation analysis also show that compared to pricing, other policies except penalties are rated by respondents as less effective in reducing food waste into landfill (by increasing usage of the green organic bin) (Table 1) ($\beta = -0.01$; p>0.1 for penalties; $\beta = -0.13$; $0.05 < p < 0.1$ for bin collection frequency change; and $\beta = -0.24$; p<0.01 for information and education). However, penalties, bin collection frequency change, and information and education are perceived to be more fair and acceptable, and more unintrusive, while the latter two policies are also considered more feasible than pricing. Therefore, compared with pricing, more positive views on these three policies are indirectly associated with a more positive overall policy view through four of the five policy perception items (excepting effectiveness). Specifically, people's higher indirect overall views on penalties and information and education campaigns are mainly through high unintrusiveness and high fairness, while people have higher indirect overview of bin collection frequency change mainly due to positive views on fairness and feasibility (Table B2 in Appendix B).

To compare the impact of all policies on perceived consequences and overall policy view, a Wald test (Bollen and Stine, 1990; Wald, 1943) was conducted of the coefficients obtained from mediation analysis, which allowed the impacts in the order of magnitudes to be ranked (see Table 2).

Coefficients of the policies of pricing and penalties on effectiveness show no difference between them ($\beta = -0.01$; p>0.1 in Table 1). Pricing and penalties are, therefore, considered the most effective in reducing food waste to landfills (by increasing usage of the green organic bin). In contrast, bin collection frequency change and information/education campaigns are believed by respondents to be less effective, while information/education campaigns are also less effective than bin collection frequency change based on the coefficients in Table 1 ($\beta = -0.13$ for bin collection frequency change and $\beta = -0.24$ for information and education) and the significant identified difference in the Wald test ($x^2(1) = 2.77$, $0.05 < p < 0.1$).

In regards to perceived fairness, participants' view pricing as least fair (Table 1). At the other end of the scale, penalties and information/education are believed to be the most fair (the difference between them is not statistically significant as shown in Table 2: $x^2(1) = 0.08$, p>0.1). This result suggests that a pricing policy is perceived as least fair even though it is regarded as the most effective policy to reduce food waste into landfill. Our results regarding perceptions of pricing policies coincide with other environmental policy studies that found economic instruments (e.g. road pricing to reduce vehicle emissions, carbon taxes) are regarded as less fair than other policies (e.g. information campaigns) (Huber et al., 2020; Povitkina et al., 2021).

Results for unintrusiveness reflect those for fairness to a certain extent with respondents regarding penalties and information/education campaigns as the most unintrusive and pricing as the least unintrusive. Bin collection frequency change is ranked in the middle. These results correlate with Huber et al. (2020), in that fairness tends to mirror perceived unintrusiveness.

Furthermore, pricing both has low acceptability and low feasibility. The penalties policy shows similar patterns being considered slightly more acceptable and with similar levels of perceived feasibility. These findings are not surprising given the difficulty in monitoring household waste streams under the current waste programs present in Australia. This finding is in accord with other studies finding that food waste penalties or taxes are less feasible because households can easily avoid penalties by illegal dumping (including into neighbouring households' bins), waste incineration or in-sink garbage disposals (Fullerton and Wu, 1998; Hamilton and Richards, 2019). In contrast, information and education policy is viewed as the most acceptable, and bin collection frequency change is believed to be the most feasible.

Regarding the overall view that the policy is a great idea (last column

Table 1
Empirical mediation analysis results of direct, indirect and total effects of various variables on overall policy view.

	Direct effect						Indirect effect	Total effect
Variable	Effectiveness	Fairness	Unintrusiveness	Acceptability	Feasibility	Direct effect on overall view	Indirect effect on overall view	Total effect on overall view
Concern about waste generation	0.25***(0.02)	0.08** (0.03)	0.06** (0.03)	−0.01 (0.03)	0.06** (0.03)	0.13*** (0.02)	0.13*** (0.02)	0.26***(0.03)
Concern about climate change	0.06***(0.02)	0.03 (0.03)	0.04* (0.02)	0.05** (0.02)	0.08*** (0.02)	0.06***(0.02)	0.05*** (0.02)	0.11***(0.02)
Engaged or contributed to environment	0.08 (0.06)	0.20** (0.08)	0.08 (0.07)	0.22***(0.07)	0.28*** (0.07)	0.04 (0.06)	0.15*** (0.05)	0.19** (0.08)
Live in separate house	−0.10 (0.06)	0.03 (0.08)	−0.05 (0.07)	−0.04 (0.08)	0.03 (0.07)	−0.11* (0.06)	−0.04 (0.05)	−0.15* (0.08)
Family with children	0.20***(0.06)	0.00 (0.08)	0.01 (0.07)	−0.01 (0.08)	−0.17** (0.08)	0.09 (0.06)	0.06 (0.05)	0.15* (0.08)
Vegetarian or vegan	−0.01 (0.12)	0.24 (0.16)	−0.09 (0.14)	0.46***(0.15)	0.15 (0.14)	0.12 (0.12)	0.12 (0.10)	0.24 (0.15)
European	−0.08 (0.05)	−0.13* (0.07)	−0.10* (0.06)	0.02 (0.06)	−0.00 (0.06)	−0.08 (0.05)	−0.08* (0.04)	−0.16** (0.07)
Annual household income	0.00* (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00* (0.00)	0.00 (0.00)
Bachelor's degrees or above	−0.05 (0.05)	0.08 (0.07)	0.01 (0.06)	0.11 (0.07)	0.14** (0.06)	0.03 (0.05)	0.04 (0.04)	0.06 (0.07)
Knowledge: food waste should go into green bin	−0.02 (0.06)	0.19** (0.08)	0.11* (0.07)	0.05 (0.08)	0.16** (0.08)	−0.03 (0.06)	0.09* (0.05)	0.06 (0.08)
Number of people in the household	−0.07*** (0.02)	−0.08** (0.03)	−0.07** (0.03)	−0.07** (0.03)	−0.06** (0.03)	−0.01 (0.02)	−0.08*** (0.02)	−0.09***(0.03)
Male	0.02 (0.05)	0.24*** (0.07)	0.27*** (0.06)	0.17**(0.07)	0.21*** (0.06)	−0.20*** (0.05)	0.18*** (0.04)	−0.02 (0.07)
Age	−0.00 (0.00)	−0.01** (0.00)	−0.00 (0.00)	−0.01*** (0.00)	−0.01*** (0.00)	0.00 (0.00)	−0.00*** (0.00)	−0.00 (0.00)
Food waste disposal via general bin	−0.00 (0.03)	−0.13*** (0.03)	−0.10*** (0.03)	−0.03 (0.03)	−0.02 (0.03)	0.02 (0.03)	−0.06*** (0.02)	−0.05 (0.03)
Kitchen caddy use	0.12** (0.06)	0.29*** (0.07)	0.05 (0.07)	0.10 (0.07)	0.22*** (0.07)	0.20*** (0.06)	0.16***(0.05)	0.36*** (0.07)
Food Waste Policy: Pricing (policy reference)								
Penalties	−0.01 (0.07)	0.72*** (0.09)	0.61***(0.08)	0.39***(0.09)	0.07 (0.08)	0.13* (0.07)	0.40***(0.06)	0.53*** (0.09)
Frequency Bin Collection Structural Change	−0.13* (0.07)	0.53*** (0.09)	0.31***(0.08)	0.58***(0.09)	0.72*** (0.08)	0.02 (0.07)	0.31***(0.06)	0.34*** (0.09)
Information, Social Norms and Education	−0.24*** (0.07)	0.70*** (0.09)	0.64***(0.08)	0.76***(0.09)	0.50*** (0.08)	−0.03 (0.07)	0.40***(0.06)	0.38*** (0.09)
Acceptability						0.15*** (0.02)		0.15*** (0.02)
Unintrusiveness						0.24*** (0.02)		0.24*** (0.02)
Fairness						0.26*** (0.02)		0.26*** (0.02)
Effectiveness						0.36*** (0.02)		0.36*** (0.02)
Feasibility						0.08*** (0.02)		0.08*** (0.02)
Log likelihood	−98,484.13							
R^2	0.27							
Number of observations	3040							

Robust standard errors are reported in parentheses. *, ** and *** represents statistical significance at 10 %, 5 % and 1 % levels, respectively.

Table 2
Ranking of policies on five different perceived consequences and overall view using mediation analysis and Wald test.

Ranking	Fairness	Unintrusiveness	Acceptability	Feasibility	Effectiveness	Direct effect on overall view	Indirect effect on overall view	Total effect on overall view
Pricing	4	4	4	3	1	2	4	4
Penalties	1	1	3	3	1	1	1	1
Bin collection frequency	3	3	2	1	3	2	1	2
Information and education	1	1	1	2	4	2	1	2
Wald test								
Coefficient of penalties equals coefficient of bin collection frequency	4.52**	13.77***	4.72**	59.61***	2.86*	2.28	2.00	4.48**
Coefficient of penalties equals coefficient of information and education	0.08	0.09	18.28***	26.55***	11.28***	5.04**	0.02	2.82*
Coefficient of bin collection frequency equals coefficient of Information and education	3.41*	16.07***	4.42**	6.46**	2.77*	0.52	2.47	0.19

*, ** and *** represents statistical significance at 10 %, 5 % and 1 % levels, respectively.
Wald test compares the coefficients of different policies (except base group pricing) on perceived consequences and overall view. Ranking is based on the Wald test and estimated results of three policies in structural equation model.

in Table 2), penalties rank first in total effect on overall view, followed by bin collection frequency change and information and education ranking joint second as there is no significant difference between their total effects; with pricing last. Sensitivity analysis indicates that results are robust with no potential violation of the sequential ignorability assumption (Imai et al., 2010).[5]

4.2. Other influences on overall policy views

Besides policy instruments, many other variables are also found to be significantly associated with the five policy consequence perceptions and so are found to influence overall policy view (see Table 1). Specifically, environmental concerns and environmental group participation play an essential role in perception. For example, concern about environmental issues arising from waste generation significantly increases perceptions of effectiveness, fairness, feasibility and unintrusiveness. Concern about environmental issues from climate change also significantly raises the perception of effectiveness and feasibility. Moreover, people who engage with, or contribute to environmental groups, are more likely to perceive all the food waste policies as fair, acceptable and feasible. As such, results suggest that people with higher environmental concerns and participation have more favourable overall policy views. These findings are consistent with other studies, in that people with pro-environmental behaviours are more likely to change their behaviour to reduce food waste into landfill (Quested et al., 2013; Melbye et al., 2017; Williams et al., 2018; Pellegrini et al., 2019; Chen, 2019) – and we show they ultimately favour food waste policies.

Respondents who already have better food waste behaviours (namely have reduced food waste and are putting food waste in the organics bin) tend to be more favourable overall towards all food waste policies. Specifically, people who dispose of more (less) food waste in landfill are less (more) likely to consider any of the policies as fair and unintrusive. In contrast, people using caddies to collect food waste tend to view all the policies to be effective, fair and feasible and therefore have a higher overall view of all policies.

Socio-economic and other factors also affect perceptions in different ways. Specifically, males are more receptive to food waste policies as they are more likely to believe such policies to be fair, feasible and have low intrusivity. Higher educated people and those with more food waste disposal knowledge believe food waste policies to be more feasible; while people with more food disposal knowledge are also more likely to view food waste policies as fair and having higher levels of unintrusiveness. Larger families with more people in households have a lower overall policy view, but other socio-economic characteristics such as age and income do not significantly affect the overall policy view, while living status and family size only have marginal significant effects. Many of these findings on socio-economic characteristics are reflected somewhat within the general food waste attitude and behaviour literature (e.g. Fami et al., 2019; Secondi et al., 2015; Visschers et al., 2016).

To test the influence of these characteristics on the views of each policy, we ran separate models for each. Results are shown in Appendix B. Like our pooled model (Table 1), the estimated results of separated models show that people with higher environmental concerns and participation, smaller household size, better food waste behaviours and caddy use, generally have significantly more positive views of food waste policies (Table B3 in Appendix B). More specifically, people with higher environmental concerns have a significantly higher overall view of all four policies. People using akitchen caddy are associated with a higher overall view on three policies: pricing, penalties, and information and education campaign, while people disposing food waste in organics bin are more favourable to pricing and penalities. It indicates people with better food waste behaviour are more favourable to a variety of food waste policies, but especially economic incentives. It makes sense as households with better food waste behaviour are more likely to generate less food waste and consequently incur lower costs for the collection of their general waste bin, and also are less likely to pay penalties for the reduced contamination in their organic bin.

In contrast, people with larger family sizes are less likely to prefer bin collection frequency change and information and education campaigns. The reduced overall view of bin collection frequency change might be because large families generate more waste and therefore the reduced collection frequency of general bins can not meet their needs. In contrast, the reduced preference for information and education campaigns might arise from time constraints in large families. Interestingly, families with children were more likely to have a higher overall view of penalties.

5. Discussion

Developing food waste policies to reduce food waste, divert food waste from landfill and mitigate rising environmental deterioration (and associated economic issues) is a major emerging challenge for Austrlaian municipalities. To effectively implement policies and achieve policy goals, understanding public preferences and perceptions towards such policies is likely to be an important prerequisite to gaining sufficient public support. In-turn, public support for behavioural change policies, the perceived acceptability of these, is regarded as a critical element of policy performance. Our study sheds light on why people support certain policy instruments, while opposing others. We provide quantitative findings on the influence of public beliefs around policy consequences on overall policy view, along with other drivers of perceptions around different policy consequences – encompassing effectiveness, fairness, unintrusiveness, acceptability and feasibility. However, we acknowledge the limitations of our dataset as being based on people's perceptions only, and undertaking real-world experiments or data analysis of actual councils strategies in Australia would be highly advantageous.

Estimates of mediation analysis show that economic instruments, such as pricing and penalties, are perceived to be the most effective policy to increase the diversion of food waste into approved organic waste streams, thereby reducing food waste in landfill. This finding is consistent with previous food waste policy studies, which found that economic instruments are efficient with a significant waste-reducing effect (Dahlén et al., 2007; Skumatz, 2008; Reichenbach, 2008; EEA, 2009; Dahlén and Lagerkvist, 2010). However, even though pricing is the most effective policy in reducing food waste in landfill, it is considered the least fair compared to all other policies – even less fair than financial penalties for placing food waste in general waste bins. Furthermore, pricing is ranked the lowest in terms of acceptability, feasibility and unintrusiveness. This explains why there is minimal support and a low overall view for pricing schemes, even though such policies have often been regarded as the most effective (Bamberg and Rölle, 2003). These results may be more of a function of the existing program of waste collection with household waste based on streetside bin collection in which it is not currently possible for households to secure their own bins against usage by other households – as a result it is very difficult for municipal governments to monitor and enforce waste penalties.

Our proposed penalty-based policy fares much better when assessing all the perceived consequences, ranking the highest overall. With similar perceived effectiveness levels, penalties rank the highest in fairness and unintrusiveness. The corresponding score in acceptability is also higher than pricing. What is most interesting is that respondents with reduced food waste (namely discarding less food waste than the average in the landfill bin) – are more likely to be supportive of economic incentives as a food waste policy tool.

Both bin collection frequency change and information and education

[5] Results of sensitivity analysis provided upon request. The goodness of fit is checked while the comparative fit index (CFI) of the models is always greater than 0.95, and the root mean square error of approximation (RMSEA) is always less than 0.08, indicating reasonable fit.

are ranked in the middle, lower than penalties and higher than pricing. Regarding information and education, previous studies and respondents in this survey suggest that perceived low effectiveness in reducing food waste in landfill contributes to a low overall view of education programs (e.g. Quested et al., 2013; Secondi et al., 2015). Nevertheless, information and education is regarded strongly as a policy in terms of being considered most fair, most acceptable, most unintrusive, and as having relatively high feasibility. Hence, this suggests that although information and education campaigns are unlikely to be effective alone, they may be effective when combined with other policies to increase food waste reduction and diversion (Bernstad et al., 2013; Dai et al., 2016).

The bin collection frequency structural change scheme, which either entails collecting the green organic bin more often or collecting the general red bin less often, is not significantly different from information and education. It is perceived to be more effective than information and education, but slightly less effective than economic instruments in reducing food waste in landfill. However, the feasibility of bin collection frequency is perceived as the highest among all policies but as being somewhat low in fairness. Overall, according to the total overall view, penalties rank first; bin collection frequency change and information and education joint second; and pricing last.

There are several limitations of our study that future research could overcome. First, this study focuses on four policy options using an online survey, and respondents' policy perceptions are subjective. A real-world experiment would increase insights into household behaviour, as well as investigate different combinations of food waste policies (e.g. regulations and regulatory instruments, "pay-as-you-throw", the weight or volume charging schemes). Second, this study focuses on the population of metropolitan Adelaide, a clearer picture of public preferences could be obtained by including: a) more cities in Australia; and b) more cities around the world. Additional research will allow the further development of actionable plans and guidelines for policy-makers and councils who seek to reduce food waste world-wide.

6. Conclusion

Given the goal of SA to achieve zero avoidable waste sent to landfill by 2030, developing food waste policies that are effective, feasible and acceptable to the public is critical to reducing food waste in landfill. Using an online survey incorporating 1520 households in Adelaide, we modelled how respondents form their preferences over different food waste policy instruments (namely pricing, penalties, bin timing collection change and education) based on what they thought were perceived consequences, as well as their current food waste behaviour and socio-economics. This study highlights that effectiveness and fairness are considered by households to be the most important factors in influencing their overall views. However, other perceived consequences – such as unintrusiveness, feasibility and acceptability – also play an important role in shaping overall public views and support towards policy instruments. Overall, of the policy instruments, penalties ranked first; followed by bin collection frequency change and information and education; and pricing last. One interesting insight is that households discarding less food in the landfill bin were more supportive of economic incentive policy instruments than other households. Our research provides new insights for policymakers to design policies that could be more efficiently implemented with greater public support.

CRediT authorship contribution statement

By Sarah Ann Wheeler: Conceptualization, Funding acquisition, Investigation, Supervision, Writing – review & editing. **Ying Xu:** Formal analysis, Investigation, Methodology, Writing – original draft. **Daniel Gregg:** Conceptualization, Investigation, Writing – review & editing.

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.

Data availability

Data will be made available on request.

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Appendix A. Survey experiment information

A.1. Food waste policy survey preamble

As outlined in the participation letter for this survey, food waste going into landfill represents a significant cost for Adelaide councils, plus having a significant environmental impact. In order to meet changing goals of society with respect to food and green waste, there is an increasing need to consider different policies for food waste by local councils.

An important element of changes to how waste is collected and treated is to understand household perspectives on the range of policy options available.

The options presented here are hypothetical. However, they have been considered by councils and governments across Australia and internationally and thus may be considered as possible policy programs within South Australia. Understanding potential options for managing food waste.

In the following short section we will present you with two randomly selected policy options to approach food waste management in South Australia. These options have been randomly selected from a large range of potential options, some of which are used elsewhere in Australia and overseas, that could be considered for South Australia in the future.

Please note these options are only presented here to gain information on what options might be 'best' for South Australia from the perspective of improved management of food waste and from the perspective of South Australians.

For each of the two options we will describe, briefly, how that option might work, then ask you to outline how your household would respond to that policy, and seek your views/perceptions of that option. This provides you with the opportunity to express your interests or concerns on the options presented to you.

A.2. Food waste policy survey questions

Policy Option	What It Involves…	How it Would Work…	Policy costs
Charges for the amount of times the red/blue waste landfill bin are collected	This option would involve your fixed waste charge per household being converted to a per 'lift' bin charge based on how many times your red/blue waste landfill bin was picked up each quarter (each 3 months). There would be no charge for (correctly) using your green organics or yellow recycling bin.	Waste trucks would use bin identifiers (by household) to identify how many times your landfill red/blue bins was picked up each quarter, and charged accordingly per pickup. A basic 'lift' allowance for each household would be allocated for free for the quarter. The charge rate would be calibrated to current levels of bin usage so the 'average' household would not see a change in costs. You would also be able to reduce your waste bill by increasing the correct utilisation of recycling and green organics bins.	Costs for the program would be calibrated to match current fixed costs of waste management. There is opportunity for your household to save on rates by reducing waste generation (you would be charged less than the current fixed charge regime if you are a high divertor of food waste and recycling material to the green organics and yellow recycling bins).
Penalties for persistent green organics bin contaminator households	This option would involve council identifying households that are persistent and significant green organics bin contaminators.	This policy would be targeted at households that are significant contaminators of green organics bins (only a small number of households are serious contaminators). Such households will be identified through random checks, with warning letters issued first, and then a significant penalty (such as green organics bin taken away) or monetary fine. Revenue received from green bin organics fines would fund ongoing educational food waste campaigns	This policy should be cost neutral for councils, and seek to reduce contamination issues and increase the quality of the green organics material provided for recycling.
Changing bin frequency pickup	This option would involve council changing frequency of bin collection times. Green organics bin would be picked up more often (e.g. weekly), with general red/blue waste (and yellow recycling) bin picked up less often (e.g. fortnightly).	There would be no change in waste landfill charge costs for households. Households could opt in to have their red/blue waste bins picked up more frequently via the council website, but at a higher cost for waste collection.	This policy should be cost neutral for councils, and seek to reduce the problems with smells and mess from food waste in green organics bin.
Bin waste volumes information provision	This option would involve councils providing new information to households on their general bin waste volumes, and launching large-scale education and information campaigns on food waste. For example, on each rates notice, households would receive information on how much tonnes were thrown out in their general bin in that quarter (or for the year), compared to previous quarters (years). Information would also be provided on the average tonnes thrown out by households in the council area.	There may be a slight increase in waste charge costs for households. This policy is dependent upon waste trucks using bin identifiers (by household) to calculate the weight of household waste each quarter (year) by bin type (general, recycling, and green bins).	Council costs for the bin identifiers and education provision via rates notices would increase, which may have to be funded through a slight increase in waste charges. However, if the program worked to reduce households' general waste volumes, then councils' landfill levies may decrease and offset the need to increase rates slightly to households.

How would your household change behaviour under this policy of ___ (compared to now)? Please indicate the extent to which you agree with the statements below about how your household food waste behaviours would change under this policy:

[7-point Likert scale from "Completely Disagree to 'Neutral' to "Completely Agree"]

- We would seek to reduce the total amount of our un-used food or food scraps
- We would seek to reduce the total amount of our unused food or food scraps going into the red/blue lidded waste landfill bin
- We would seek to increase the total amount of our unused food or food scraps going into the green organics bin
- We would seek to increase the total amount of our unused food or food scraps going into other sources (e.g. compost, garden, pets, other).

Please indicate your agreement with the following statements in regard to this option of ___.

[7-point Likert scale from 'Completely disagree' to 'Neutral' to 'Completely agree']

- I think this option is a great idea and needs to be implemented in my area
- This option would be unacceptable to most people
- Most people probably wouldn't be too affected by this option
- This option would probably increase the diversion of food waste into the green organics bin in my council area
- This option is unfair to some households
- I don't see how this option would be able to be implemented
- This option would cause other problems (eg _____).

Appendix B. Figures and tables

Table B1. Descriptive statistics of variables ($n = 3040$).

Variable definition	Mean	Std. Dev.	Min	Max
Overall policy view: I think this policy is a great idea and should be implemented in my area: from 1 (completely disagree) to 7 (completely agree)	4.35	1.86	1	7
Unfairness: This option is unfair to some households: from 1 (completely disagree) to 7 (completely agree) – reverse-coded to represent *Fairness*	3.75	3.42	1	7
Effectiveness: This option would probably increase the diversion of food waste into the green bin in my council area: from 1 (completely disagree) to 7 (completely agree)	4.75	1.44	1	7
Unacceptability: This option would be acceptable to most people: from 1(completely disagree) to 7 (completely agree) – reverse-coded to represent *Acceptability*	3.50	2.95	1	7
Unintrusiveness: Most people wouldn't be too affected by this option: from 1 (completely disagree) to 7 (completely agree)	3.93	1.63	1	7
Unfeasibility: I don't see how this option would be able to be implemented: from 1 (completely disagree) to 7 (completely agree) – reverse-coded to represent *Feasibility*	3.77	2.88	1	7
Concern about waste generation: from 1 (not at all serious) to 7 (extremely serious)	5.64	1.31	1	7
Increased food waste disposal via general bin: from 1 = discard much less food waste than average in the landfill bin to 5 = discard a lot more food waste than the average in landfill bin	2.03	1.01	1	5
Kitchen caddy use: (Yes = 1; No = 0)	0.69	0.47	0	1
Concern about climate change: from 1 (not at all serious) to 7 (extremely serious)	5.83	1.57	1	7
Engaged with, or donated to environmental group (Yes = 1; No = 0)	0.24	0.43	0	1
Live in separate house: (Yes = 1; No = 0)	0.77	0.42	0	1
Family with children: (Yes = 1; No = 0)	0.37	0.48	0	1
Vegetarian or vegan: (Yes = 1; No = 0)	0.05	0.21	0	1
European: (Yes = 1; No = 0)	0.50	0.50	0	1
Annual household income: ($ '000)	94.66	63.04	25	300
Bachelor's degrees or above: (Yes = 1; No = 0)	0.39	0.49	0	1
Knowledge: food waste should go into green bin: (Yes = 1; No = 0)	0.79	0.41	0	1
Number of people in the household	2.85	1.37	1	12
Male: (Yes = 1; No = 0)	0.38	0.49	0	1
Age	43.37	15.55	18	88
Policy: Pricing Frequency Collection Charges: (Yes = 1; No = 0)	0.25	0.43	0	1
Policy: Penalties: (Yes = 1; No = 0)	0.25	0.43	0	1
Policy: Bin frequency Collection Structural Change: (Yes = 1; No = 0)	0.25	0.43	0	1
Policy: Information, Social Norms and Education: (Yes = 1; No = 0)	0.25	0.43	0	1

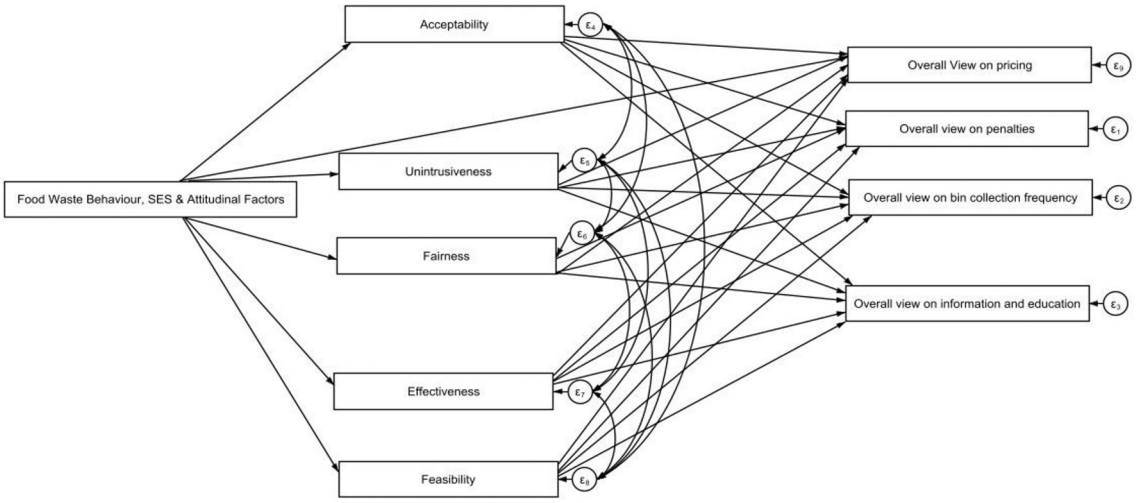

Fig. B1. Outline of full path analysis model showing the direct and indirect effects of factors on overall policy view on each policy.
SES is socio-economic status represented by a variety of socio-economic factors. Original data are used here while overall policy view and perceived consequences are provided for each policies.

Table B2. Empirical mediation analysis results of indirect effects of policies through perceived consequences.

Indirect effects	Indirect effect through acceptability	Indirect effect through unintrusiveness	Indirect effect through effectiveness	Indirect effect through fairness	Indirect effect through feasibility	Total indirect effect on overall view
Penalties Overall policy view	0.06*** (0.02)	0.15*** (0.02)	−0.00 (0.03)	0.19*** (0.03)	0.01 (0.01)	0.40***(0.06)
Bin collection frequency Overall policy view	0.09*** (0.02)	0.07*** (0.02)	−0.05* (0.03)	0.14*** (0.03)	0.06*** (0.01)	0.31***(0.06)

(*continued on next page*)

(*continued*)

Indirect effects	Indirect effect through acceptability	Indirect effect through unintrusiveness	Indirect effect through effectiveness	Indirect effect through fairness	Indirect effect through feasibility	Total indirect effect on overall view
Information & education Overall policy view	0.12*** (0.02)	0.15*** (0.02)	−0.09*** (0.03)	0.18*** (0.03)	0.04*** (0.01)	0.40***(0.06)

Robust standard errors are reported in parentheses. *, ** and *** represents statistical significance at 10 %, 5 % and 1 % levels, respectively.

Table B3. Selected results of mediation analysis: total effects of socio-economic and attitudinal factors on the overall view of four food waste policies.

Total effect on overall policy view[a]	Pricing Frequency Change	Penalties	Frequency Bin Collection Structural Change	Information, Social Norms and Education
Concern about waste generation	0.16** (0.07)	0.27***(0.06)	0.32*** (0.06)	0.31*** (0.06)
Concern about climate change	0.14**(0.06)	0.15*** (0.05)	0.09* (0.05)	0.08* (0.05)
Engaged or contributed to the environment	0.10 (0.17)	0.15 (0.15)	0.35** (0.15)	0.20 (0.17)
Live in a separate house	−0.27(0.17)	−0.02 (0.16)	−0.25 (0.16)	−0.07 (0.15)
Family with children	0.07(0.18)	0.34** (0.16)	−0.03 (0.16)	0.23 (0.15)
Vegetarian or vegan	0.45(0.31)	0.21 (0.29)	0.10 (0.34)	0.13 (0.28)
European	−0.10(0.14)	−0.11 (0.13)	−0.26** (0.13)	−0.16 (0.12)
Annual household income	0.00 (0.00)	−0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Bachelor's degrees or above	0.15 (0.15)	0.07 (0.13)	0.09 (0.14)	−0.06 (0.13)
Knowledge: food waste should go into green bin	0.15 (0.18)	0.18 (0.16)	−0.03 (0.17)	−0.06 (0.13)
Number of people in the household	−0.01 (0.07)	−0.04 (0.06)	−0.16*** (0.06)	−0.12** (0.06)
Male	−0.17 (0.15)	0.09 (0.13)	−0.05 (0.14)	−0.01 (0.13)
Age	0.00 (0.01)	−0.00 (0.00)	0.00 (0.00)	−0.01** (0.00)
Food waste disposal via general bin	−0.14* (0.07)	−0.13* (0.07)	0.03 (0.07)	0.05 (0.06)
Kitchen caddy use	0.41*** (0.15)	0.53*** (0.15)	0.17 (0.14)	0.38*** (0.14)
Log likelihood	−23,471.691	−23,573.577	−23,257.817	−23,270.347
R^2	0.24	0.32	0.31	0.24
Number of observations	760	759	760	761

Robust standard errors are reported in parentheses. *, ** and *** represents statistical significance at 10 %, 5 % and 1 % levels, respectively.

[a] Results of direct and indirect effects through perceived consequences are not reported due to the large space required. Full results are provided upon request.

References

Abrahamse, W., Matthies, E., 2018. Informational strategies to promote pro-environmental behaviour: Changing knowledge, awareness, and attitudes. In: Linda, S., Judith, I.M.G. (Eds.), Environmental Psychology: An Introduction. John Wiley & Sons Ltd., pp. 261–272

Akter, S., Bennett, J., 2011. Household perceptions of climate change and preferences for mitigation action: the case of the Carbon Pollution Reduction Scheme in Australia. Clim. Change 109, 417–436.

Ananda, J., Karunasena, G.G., Mitsis, A., Kansal, M., Pearson, D., 2021. Analysing behavioural and socio-demographic factors and practices influencing Australian household food waste. J. Clean. Prod. 306, 127280.

Anderson, B., Böhmelt, T., Ward, H., 2017. Public opinion and environmental policy output: a cross-national analysis of energy policies in Europe. Environ. Res. Lett. 12 (11), 114011.

Australian Government Department of the Environment and Energy, 2017. National Food Waste Strategy: Halving Australia's Food Waste by 2030. November 2017. Available at: https://www.environment.gov.au/protection/waste-resource-recovery/publications/national-food-waste-strategy.

Bamberg, S., Rölle, D., 2003. Determinants of people's acceptability of pricing measures–replication and extension of a causal model. In: Schade, J., Schlag, B. (Eds.), Acceptability of Transport Pricing Strategies. Emerald Group Publishing Limited, Leeds, pp. 235–248.

Bartelings, H., Dellink, R.B., van Ierland, E.C., 2004. Modelling market distortions in an applied general equilibrium framework: The case of flat-fee pricing. In: van den Bergh, J.C., Janssen, M. (Eds.), Economics of Industrial Ecology: Materials, Structural Change, and Spatial Scales. MIT Press, Cambridge, MA, pp. 255–286.

Benyam, A., Kinnear, S., Rolfe, J., 2018. Integrating community perspectives into domestic food waste prevention and diversion policies. Resour. Conserv. Recycl. 134, 174–183. https://doi.org/10.1016/j.resconrec.2018.03.019.

Benyam, A., Rolfe, J., Kinnear, S., 2020. Willingness to pay for a domestic food waste diversion policy option in regional Queensland, Australia. J. Clean. Prod. 270, 122485. https://doi.org/10.1016/j.jclepro.2020.122485.

Bernstad, A., la Cour Jansen, J., Aspegren, A., 2013. Door-stepping as a strategy for improved food waste recycling behaviour – evaluation of a full-scale experiment. Resour. Conserv. Recycl. 73, 94–103. https://doi.org/10.1016/j.resconrec.2012.12.012.

Bollen, K.A., Stine, R., 1990. Direct and indirect effects: classical and bootstrap estimates of variability. Sociol. Methodol. 20, 115–140.

Börjesson, M., Eliasson, J., Hamilton, C., 2016. Why experience changes attitudes to congestion pricing: the case of Gothenburg. Transp. Res. Part A Policy Pract. 85, 1–16. https://doi.org/10.1016/j.tra.2015.12.002.

Bos, C., Van Der Lans, I., Van Rijnsoever, F., Van Trijp, H., 2015. Consumer acceptance of population-level intervention strategies for healthy food choices: the role of perceived effectiveness and perceived fairness. Nutrients 7, 7842–7862. https://doi.org/10.3390/nu7095370.

Bos, C., van Der Lans, I.A., van Kleef, E., Van Trijp, H.C., 2018. Promoting healthy choices from vending machines: effectiveness and consumer evaluations of four types of interventions. Food Policy 79, 247–255. https://doi.org/10.1016/j.foodpol.2018.07.001.

Boulet, M., Stott, A., Kneebone, S., 2023. Which behaviours matter? Prioritising food waste reduction behaviours for targeted policy and program approaches. J. Environ. Manag. 345, 118668.

Buzby, J.C., Hyman, J., 2012. Total and per capita value of food loss in the United States. Food Policy 37, 561–570. https://doi.org/10.1016/j.foodpol.2012.06.002.

Chen, H.S., 2019. Environmental concerns and food consumption: what drives consumers' actions to reduce food waste? J. Int. Food Agribus. Mark. 31, 273–292. https://doi.org/10.1080/08974438.2018.1520179.

Cheng, E.W., 2001. SEM being more effective than multiple regression in parsimonious model testing for management development research. J. Manag. Dev. 20, 650–667. https://doi.org/10.1108/02621710110400564.

Chowdhury, B., Chowdhury, M.U., 2007. RFID-based real-time smart waste management system. In: 2007 Australasian Telecommunication Networks and Applications Conference. IEEE, pp. 175–180.

Chung, J.Y., Kyle, G.T., Petrick, J.F., Absher, J.D., 2011. Fairness of prices, user fee policy and willingness to pay among visitors to a national forest. Tour. Manag. 32, 1038–1046. https://doi.org/10.1016/j.tourman.2010.08.016.

Dahlén, L., Lagerkvist, A., 2010. Pay as you throw: strengths and weaknesses of weight-based billing in household waste collection systems in Sweden. Waste Manag. 30, 23–31. https://doi.org/10.1016/j.wasman.2009.09.022.

Dahlén, L., Vukicevic, S., Meijer, J.E., Lagerkvist, A., 2007. Comparison of different collection systems for sorted household waste in Sweden. Waste Manag. 27, 1298–1305. https://doi.org/10.1016/j.wasman.2006.06.016.

Dai, Y.C., Lin, Z.Y., Li, C.J., Xu, D.Y., Huang, W.F., Harder, M.K., 2016. Information strategy failure: personal interaction success, in urban residential food waste segregation. J. Clean. Prod. 134, 298–309. https://doi.org/10.1016/j.jclepro.2015.12.104.

Department of Environment and Conservation NSW, 2007. Co-Collection of Domestic Food Waste and Garden Organics the Australian Experience. Sydney.

Du, L., Zuo, J., Chang, R., Zillante, G., Li, L., Carbone, A., 2023. Effectiveness of solid waste management policies in Australia: an exploratory study. Environ. Impact Assess. Rev. 98, 106966. https://doi.org/10.1016/j.eiar.2022.106966.

EEA, 2009. Diverting Waste from Landfill. Effectiveness of Waste-Management Policies in the European Union. European Environment Agency Report No 7/2009. ISSN 1725-9177. https://www.eea.europa.eu/publications/diverting-wastefrom-landfill-

effectiveness-of-waste-management-policies-in-the-europeanunion/download (accessed 23 August 2012).
Fami, H.S., Aramyan, L.H., Sijtsema, S.J., Alambaigi, A., 2019. Determinants of household food waste behavior in Tehran city: a structural model. Resour. Conserv. Recycl. 143, 154–166. https://doi.org/10.1016/j.resconrec.2018.12.033.
FAO, 2015. The State of Food Insecurity in the World 2015. http://www.fao.org/publications/sofi/2015/en/ (accessed 21 February 2023).
FAO, 2019. The State of Food and Agriculture 2019. Moving Forward on Food Loss and Waste Reduction, Rome, Italy.
Fight Food Waste CRC, 2022. Food Waste in Australian Households Evidence for Designing Interventions. https://fightfoodwastecrc.com.au/wp-content/uploads/2022/04/Food-waste-in-Australian-households-final.pdf (accessed 21 February 2023).
Fullerton, D., Wu, W., 1998. Policies for green design. J. Environ. Econ. Manag. 36, 131–148. https://doi.org/10.1006/jeem.1998.1044.
van Geffen, L., van Herpen, E., van Trijp, H., 2020. Household food waste—How to avoid it? An integrative review. In: Närvänen, E., Mesiranta, N., Mattila, M., Heikkinen, A. (Eds.), Food Waste Management: Solving the Wicked Problem. Palgrave Macmillan, Cham, pp. 27–55.
Green Industries SA, 2020. Supporting the Circular Economy: South Australia's Waste Strategy 2020–2025. https://www.greenindustries.sa.gov.au/resources/sa-waste-strategy-2020-2025.
Grizzetti, B., Pretato, U., Lassaletta, L., Billen, G., Garnier, J., 2013. The contribution of food waste to global and European nitrogen pollution. Environ. Sci. Pol. 33, 186–195. https://doi.org/10.1016/j.envsci.2013.05.013.
Gunzler, D., Chen, T., Wu, P., Zhang, H., 2013. Introduction to mediation analysis with structural equation modeling. Shanghai Arch. Psychiatry 25, 390–394.
Hamilton, S.F., Richards, T.J., 2019. Food policy and household food waste. Am. J. Agric. Econ. 101, 600–614. https://doi.org/10.1093/ajae/aay109.
Huber, R.A., Wicki, M.L., Bernauer, T., 2020. Public support for environmental policy depends on beliefs concerning effectiveness, intrusiveness, and fairness. Env. Polit. 29, 649–673. https://doi.org/10.1080/09644016.2019.1629171.
Imai, K., Keele, L., Tingley, D., 2010. A general approach to causal mediation analysis. Psychol. Methods 15, 309. https://doi.org/10.1037/a0020761.
Karunasena, G.G., Pearson, D., 2022. Food Waste in Australian Households: Evidence for Designing Interventions. Fight Food Waste Cooperative Research Centre, Adelaide, Australia, pp. 1–28.
Karunasena, G.G., Ananda, J., Pearson, D., 2021. Generational differences in food management skills and their impact on food waste in households. Resour. Conserv. Recycl. 175, 105890. https://doi.org/10.1016/j.resconrec.2021.105890.
Katare, B., Serebrennikov, D., Wang, H.H., Wetzstein, M., 2017. Social-optimal household food waste: taxes and government incentives. Am. J. Agric. Econ. 99, 499–509. https://doi.org/10.1093/ajae/aaw114.
Kim, J., Schmöcker, J.D., Fujii, S., Noland, R.B., 2013. Attitudes towards road pricing and environmental taxation among US and UK students. Transp. Res. Part A Policy Pract. 48, 50–62. https://doi.org/10.1016/j.tra.2012.10.005.
Kirakozian, A., 2016. The determinants of household recycling: social influence, public policies and environmental preferences. Appl. Econ. 48, 1481–1503. https://doi.org/10.1080/00036846.2015.1102843.
Kowalski, J., Tu, X.M., 2007. Modern Applied U Statistics. Wiley, New York, USA.
Lee, M., Choi, H., Koo, Y., 2017. Inconvenience cost of waste disposal behavior in South Korea. Ecol. Econ. 140, 58–65. https://doi.org/10.1016/j.ecolecon.2017.04.031.
Mariam, N., Nina, L., Fabian, B., Florence, Z., Simone, A., Ulf, S., Daniel, F., 2022. The food waste lab: improving food waste reduction behavior through education. J. Clean. Prod. 370, 133447. https://doi.org/10.1016/j.jclepro.2022.133447.
Martins, M.L., Rodrigues, S.S., Cunha, L.M., Rocha, A., 2016. Strategies to reduce plate waste in primary schools–experimental evaluation. Public Health Nutr. 19, 1517–1525. https://doi.org/10.1017/S1368980015002797.
Melbye, E.L., Onozaka, Y., Hansen, H., 2017. Throwing it all away: exploring affluent consumers' attitudes toward wasting edible food. J. Food Prod. Mark. 23, 416–429. https://doi.org/10.1080/10454446.2015.1048017.
Pellegrini, G., Sillani, S., Gregori, M., Spada, A., 2019. Household food waste reduction: Italian consumers' analysis for improving food management. Br. Food J. 121, 1382–1397. https://doi.org/10.1108/BFJ-07-2018-0425.
Pfister, N., Mathys, N.A., 2022. Waste taxes at work: evidence from the canton of Vaud in Switzerland. Ecol. Econ. 193, 107314. https://doi.org/10.1016/j.ecolecon.2021.107314.
Pinto, R., dos Santos Pinto, R., Melo, F., Campos, S.S., Cordovil, C.M., 2018. A simple awareness campaign to promote food waste reduction in a university canteen. Waste Manag. 76, 28–38. https://doi.org/10.1016/j.wasman.2018.02.044.
Povitkina, M., Jagers, S.C., Matti, S., Martinsson, J., 2021. Why are carbon taxes unfair? Disentangling public perceptions of fairness. Glob. Environ. Chang. 70, 102356. https://doi.org/10.1016/j.gloenvcha.2021.102356.
Priefer, C., Jörissen, J., Bräutigam, K.R., 2016. Food waste prevention in Europe–a cause-driven approach to identify the most relevant leverage points for action. Resour. Conserv. Recycl. 109, 155–165. https://doi.org/10.1016/j.resconrec.2016.03.004.
Quested, T.E., Marsh, E., Stunell, D., Parry, A.D., 2013. Spaghetti soup: the complex world of food waste behaviours. Resour. Conserv. Recycl. 79, 43–51. https://doi.org/10.1016/j.resconrec.2013.04.011.
Reichenbach, J., 2008. Status and prospects of pay-as-you-throw in Europe–A review of pilot research and implementation studies. Waste Manag. 28, 2809–2814. https://doi.org/10.1016/j.wasman.2008.07.008.
Reynolds, C., Goucher, L., Quested, T., Bromley, S., Gillick, S., Wells, V.K., Koh, L., Kanyama, A.C., Katzeff, C., Svenfelt, Å., Jackson, P., 2019. Consumption-stage food waste reduction interventions–what works and how to design better interventions. Food Policy 83, 7–27. https://doi.org/10.1016/j.foodpol.2019.01.009.
Schanes, K., Dobernig, K., Gözet, B., 2018. Food waste matters-a systematic review of household food waste practices and their policy implications. J. Clean. Prod. 182, 978–991. https://doi.org/10.1016/j.jclepro.2018.02.030.
Secondi, L., Principato, L., Laureti, T., 2015. Household food waste behaviour in EU-27 countries: a multilevel analysis. Food Policy 56, 25–40. https://doi.org/10.1016/j.foodpol.2015.07.007.
Skeldon, A.C., Schiller, F., Yang, A., Balke-Visser, T., Penn, A., Gilbert, N., 2018. Agent-based modelling to predict policy outcomes: a food waste recycling example. Environ. Sci. Pol. 87, 85–91. https://doi.org/10.1016/j.envsci.2018.05.011.
Skumatz, L.A., 2008. Pay as you throw in the US: implementation, impacts, and experience. Waste Manag. 28, 2778–2785. https://doi.org/10.1016/j.wasman.2008.03.033.
Staats, H.J., Wit, A.P., Midden, C.J., 1996. Communicating the greenhouse effect to the public: evaluation of a mass media campaign from a social dilemma perspective. J. Environ. Manag. 46, 189–203. https://doi.org/10.1006/jema.1996.0015.
Ulph, A., Ulph, D., 2021. Environmental policy when consumers value conformity. J. Environ. Econ. Manag. 109, 102172. https://doi.org/10.1016/j.jeem.2018.09.001.
UNEP, 2014. Prevention and Reduction of Food and Drink Waste in Businesses and Households: Guidance for Governments, Local Authorities, Businesses and Other Organisations. http://www.fao.org/fileadmin/user_upload/save-food/PDF/Guidance-content.pdf (accessed 23 August 2022).
Verghese, K., Lockrey, S., 2019. National Food Waste Baseline-Final Assessment Report. Australian Government's Department of Environment and Energy (funded through Australia Government's National Environmental Science Program).
Visschers, V.H., Wickli, N., Siegrist, M., 2016. Sorting out food waste behaviour: a survey on the motivators and barriers of self-reported amounts of food waste in households. J. Environ. Psychol. 45, 66–78. https://doi.org/10.1016/j.jenvp.2015.11.007.
Wald, A., 1943. Tests of statistical hypotheses concerning several parameters when the number of observations is large. Trans. Am. Math. Soc. 54, 426–482.
Wan, C., Shen, G.Q., Choi, S., 2017. A review on political factors influencing public support for urban environmental policy. Environ. Sci. Pol. 75, 70–80. https://doi.org/10.1016/j.envsci.2017.05.005.
Wang, P., McCarthy, B., Kapetanaki, A.B., 2021. To be ethical or to be good? The impact of 'Good Provider' and moral norms on food waste decisions in two countries. Glob. Environ. Chang. 69, 102300. https://doi.org/10.1016/j.gloenvcha.2021.102300.
Williams, H., Wikström, F., Wetter-Edman, K., Kristensson, P., 2018. Decisions on recycling or waste: how packaging functions affect the fate of used packaging in selected Swedish households. Sustainability 10, 4794. https://doi.org/10.3390/su10124794.
WRAP, 2009. Analysis of Kerbside Dry Recycling Performance in England 2007/08. WRAP, Oxon.
Xu, Y., Wheeler, S.A., Doko Tchatoka, F., 2023. Evaluating policy changes on council waste generation and diversion: evidence from South Australia. Aust. J. Agric. Resour. Econ. 67, 541–557. https://doi.org/10.1111/1467-8489.12529.
Young, W., Russell, S.V., Robinson, C.A., Barkemeyer, R., 2017. Can social media be a tool for reducing consumers' food waste? A behaviour change experiment by a UK retailer. Resour. Conserv. Recycl. 117, 195–203. https://doi.org/10.1016/j.resconrec.2016.10.016.