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A B S T R A C T

Food waste is one of society's biggest problems, with huge ecological, economic and social consequences. Hence, there is a necessity to derive a better insight in how consumers can be triggered to avoid food waste. Although it is generally known that motivations are important drivers of human behavior, limited attention has been paid to motivations in the food waste context and no viable measurement instrument exists that systematically takes into account the different motivations underlying the avoidance of food waste. Current scales related to food waste concern encompass attitude and awareness items only. The current paper aims to fill this gap and develops a 21-item *Motivation to Avoid Food Waste* (MAFW) scale. Since consumers may be driven by different motivations to avoid food waste, special attention is paid to the multidimensionality of food waste avoidance motivations. Specifically, the MAFW-scale consists of four motivations: environmental, moral, financial and social motivations. Three studies demonstrate the scale's internal reliability, test-retest reliability, nomological validity, and predictive validity. The MAFW-scale fosters research into the genesis of consumers' food waste behaviors, and can serve as a tool to segment and target (un)motivated consumers.

1. Introduction

Approximately one-third of food produced for human consumption is either lost or wasted (FAO, 2011). Recent analyses suggest that food waste numbers may even be significantly larger (van den Bos-Verma et al., 2020). Food waste has a tremendous impact on the environment, economy, and society (WRI, 2019). To illustrate, food waste is responsible for 8–10% of global anthropogenic greenhouse gas emission (Mbow et al., 2019). Households have been recognized as the largest generators of food waste in industrialized countries (WRI, 2019; Xue et al., 2017). For example, in the European Union, 53% of the food waste happens at the household level (Stenmarck et al., 2016). If we want to build a sustainable food future, it is crucial to at least reduce the amount of food loss and food waste by half, in line with the Sustainable Development Goal (SDG) of the United Nations (Willett et al., 2019).

Scholars have identified several factors that influence consumers' food waste behaviors (see Principato et al. (2021) for a review), and we focus on motivations because they have been identified as a crucial first step for behavior change (Nakabayashi et al., 2020; van Geffen et al., 2020; Vermeir et al., 2020). In doing so, we follow the advice of Stöckli et al. (2018), who argued that the integration of behavior change literature is of key importance for understanding household food waste. Models from the behavior change literature – that have been successfully applied to healthy and pro-environmental behaviors – serve as our theoretical basis (Bamberg, 2013; Nakabayashi et al., 2020; Vermeir et al., 2020). When looking at these models, a striking observation is that motivations are the starting point in all. So, while food waste behaviors do not solely depend on consumers' motivations, improving them is key for behavior change to occur.

Motivation is a key driving force of human behavior (Ryan, 2012). It can be defined as the process that determines the energization and direction of behavior (Elliot, 2006), and is generally understood as the reason why humans and other animals initiate, continue, or terminate a specific behavior (Wasserman and Wasserman, 2020). Applied to the current context, we define motivations to avoid food waste as a combination of one's specific reasons to avoid food waste with one's degree

of willingness to initiate, continue and complete actions that avoid generating food waste. Although several different motivations have been proposed, it is unclear whether some or all of these are relevant, whether they occur simultaneously, and how strong these motivations are. Graham-Rowe et al. (2014) put forward financial and ethical concerns as important motivations. In addition, several authors mention that environmental concern is another reason why people dislike food waste (Doron, 2013; Roodhuyzen et al., 2017), while others conclude that environmental concern is not a key motivation (Graham-Rowe et al., 2014; Neff et al., 2015).

Despite its crucial importance to foster further research, no scale that measures these different motivations currently exists. Therefore, we aim to develop a scale that measures a broad range of potential motivations consumers may have to avoid food waste. Specifically, the main goal of the present research is to develop and validate a psychometrically sound, multidimensional scale to assess the various types of food waste avoidance motivations. We integrate literature on environmental psychology (Schultz, 2001; Stern and Dietz, 1994), impression management (Leary, 2001; Piff et al., 2010; Zhang et al., 2019), and consumers' food waste (Graham-Rowe et al., 2014; van Geffen et al., 2020). Combining this literature review with experts' views, we propose a distinction between environmental, moral, financial, and social food waste avoidance motivations.

Existing measures for consumers' food waste concern do not accurately capture consumers' motivations to avoid food waste. First, current food waste concern scales include attitude (Sheen et al., 2020; Le Borgne et al., 2021; Raghunathan and Chandrasekaran, 2021) or awareness items only (Rasool et al., 2021). Yet, attitudes and problem awareness do not explain why individuals behave in a certain way. Second, the current measures include items that relate to some but not all motivational dimensions. Sheen et al. (2020) and Raghunathan and Chandrasekaran (2021) relate to the moral aspect of wasting food (such as feelings of guilt or ethical concerns) only, whereas Le Borgne et al. (2021) also include one item on environmental concern and concern about social judgement when wasting food. Despite the importance of price on (food) purchases, none of the before mentioned scales captures consumers' financial motivations to avoid food waste. As such, none of the current food waste avoidance measures seems to cover a wide spectrum of food waste avoidance motivations.

The present work contributes to both theory and practice. We contribute to food waste literature by gaining a deeper understanding of the variety of motivations that drive food waste behaviors. In doing so, we respond to calls from previous research to further explore consumer motivations to avoid food waste (Graham-Rowe et al., 2014; Wunder et al., 2019; van Geffen et al., 2020). Moreover, the scale can be used as a tool by both researchers and policy makers to: (1) investigate factors that modify or hinder the effect of motivations on food waste reduction behaviors, (2) identify consumer segments that are driven by particular motivations and, consequently, launch targeted campaigns to increase motivation, and (3) test if campaigns effectively increase motivations. In sum, the present study develops an important measurement instrument and provides relevant insights into which different motivations practitioners and policy makers can appeal to in order to curb household food waste.

2. Theoretical background

Motivation is a construct that is used to describe, define, and/or account for goal-directed aspects of human behavior (Elliot, 2006; Wasserman and Wasserman, 2020). While we focus on motivation, a lot of prior research has examined attitudes towards food waste. Attitudes are defined as a general positive or negative evaluation of someone or something (Eagly and Chaiken, 1993), and negative attitudes towards food waste can influence intentions to reduce food waste, and amount of food waste (Stefan et al., 2013; Stancu et al., 2016; Visschers et al., 2016; Barone et al., 2019; Aydin and Yildirim, 2021). However, attitudes do

not always translate in behavior. The latter is reflected in the limited predictive power of attitudes on food waste behavior (Graham-Rowe et al., 2015). As motivations, unlike attitudes, are directly linked to goal-directed behavior, insights into these underlying motivations may help practitioners design more effective interventions to bring about behavioral change. As a result, the current research aims to uncover and measure the various motivations people may have to avoid wasting food.

Previous research also has stressed that looking at the different types of motivations people have to avoid food waste is necessary when trying to explain households' food waste behaviors (Stancu et al., 2016; Stöckli et al., 2018; van Geffen et al., 2020). For example, people can have mixed, heterogeneous motives why they adopt certain environmental behaviors (Lindenberg and Steg, 2007; Steg et al., 2014a; Gkargkavouzi et al., 2019). Likewise, one may want to avoid food waste because of (a combination of) different reasons. We expect that environmental (CO_2 gas emissions), moral (guilt towards the hungry), financial (not wasting money) and/or social (judgement by significant others) reasons play a role. While these motivations are conceptually distinct, they may be correlated.

2.1. Environmental motivation

Environmental motivations are worries about the burden food waste imposes on the environment. The literature is divided on whether concern for the environment is a primary motivation in the food waste context. On the one hand, several researchers mention that worries about environmental impact constitute an important motivation (Doron, 2013; Roodhuyzen et al., 2017). On the other hand, concerns about environmental impact are rarely mentioned in qualitative research which leads other researchers to conclude that environmental concern is not important (Watson and Meah, 2012; Graham-Rowe et al., 2014; van Geffen et al., 2020). In fact, more concrete goals, such as saving money and thinking about hungry people have been found to be more important motivations to reduce food waste than environmental concerns (Neff et al., 2015). Lack of knowledge on the environmental impact of food waste may explain this (Graham-Rowe et al., 2014; Neff et al., 2015; Principato et al., 2015). For example, common misperceptions are that the environmental impact of food waste is smaller than that of food packaging (Principato et al., 2015; Djekic et al., 2019), and is negligible when composted (Neff et al., 2015). In reality, food waste frequently exceeds the environmental impact of packaging (Grant et al., 2015; Licciardello, 2017; Dilkes-Hoffman et al., 2018; Qin and Horvath, 2022), and food emits methane (CH_4) and nitrous oxide (N_2O) during home composting (Andersen et al., 2010; Ermolaev et al., 2014).

The conflicting results from previous research may indicate that there is a specific group of individuals who are aware of the environmental consequences, and for whom environmental reasons are important drivers of food waste reduction behaviors. In this respect, prior research has shown that consumers who have high environmental consciousness indeed waste less food (Williams et al., 2012; Jörissen et al., 2015; Abdelradi, 2018; Principato et al., 2021). These results suggest that – even though there may be large individual differences in environmental motivation – it is essential to include environmental motivations in the new measurement instrument to obtain a broad overview of motivations to avoid food waste.

2.2. Moral motivation

Moral motivations relate to concerns about and feelings of guilt towards people that do not have sufficient access to food. As food is essential for human survival, wasting it has something inherently immoral about it (Misiak et al., 2018, 2020). People often spontaneously mention moral concern as an important driver of their intention to reduce their food waste in qualitative studies (Graham-Rowe et al., 2014; van Geffen et al., 2020). Also, it is widely documented that

consumers world-wide feel guilty when wasting food (Quested et al., 2013; Stefan et al., 2013; Goodwin et al., 2014; Graham-Rowe et al., 2014; Neff et al., 2015; Parizeau et al., 2015; Qi and Roe, 2016; McCarthy and Liu, 2017).

Despite the foregoing, results regarding the link between moral norms, food waste avoidance intentions, and food waste avoidance behaviors are mixed. While moral attitudes and moral norms have been linked to intentions to avoid food waste by some researchers (Stefan et al., 2013; Visschers et al., 2016; Wang et al., 2021), Stancu et al. (2016) and Aschemann-Witzel et al. (2018) find that moral norms do not influence intentions to avoid food waste. The items used to measure the constructs may explain this discrepancy. The former studies include items that relate to feelings of responsibility to avoid food waste and guilt towards the hungry (similar to our definition) in their moral norm measure, whereas the latter two studies also include items about the environment (Stancu et al., 2016) or about feeling morally obliged to buy 'suboptimal' food products (Aschemann-Witzel et al., 2018) in their moral norm measures. Thus, the way moral motivation was measured may have influenced the results. This stresses the importance of using a psychometrically sound measurement instrument that clearly distinguishes between the different food waste avoidance dimensions.

People who consider wasting food immoral have been found to engage less in behaviors that result in food waste (McCarthy and Liu, 2017; Misiak et al., 2020; Aydin and Yildirim, 2021). Yet, moral motivations do not always translate into food waste reduction. Gjerris and Gaiani (2013) argue that consumers have an intuitive feeling that wasting food is wrong, but that moral imperatives alone are not enough to persuade them to handle food differently. Moreover, consumers trivialize the moral consequences of their own food waste (van Geffen et al., 2020). This explains why moral motivations are sometimes overruled by other food-related goals. To illustrate, the goals to provide healthy, safe and enough food (i.e., good provider identity) are considered more important than the moral norm to avoid food waste (Watson and Meah, 2012; Abdelradi, 2018; van Geffen et al., 2020; Wang et al., 2021). In conclusion, even though moral motivations do not always translate into a reduction of food waste, for some people and in some circumstances moral motivations show a strong association with food waste intentions and behaviors. Hence, moral motivations should also be included in the multidimensional motivations to avoid food waste instrument.

2.3. Financial motivation

Financial motivations encompass the concern about the cost of food that is disposed. The desire to avoid wasting food for monetary reasons has been found to be a powerful motivating factor in both qualitative (Watson and Meah, 2012; Graham-Rowe et al., 2014; Grandhi and Appaiah Singh, 2016; van Geffen et al., 2020) and quantitative research (Graham-Rowe, et al., 2014; Neff et al., 2015; Principato et al., 2015; Qi and Roe, 2016; Visschers et al., 2016; Aschemann-Witzel et al., 2018). The majority of studies agree that consumers who are price sensitive are less prone to waste food (Koivupuro et al., 2012; Jörissen et al., 2015; Visschers et al., 2016; Roodhuyzen et al., 2017; Aschemann-Witzel et al., 2018). For example, Jörissen et al. (2015) observed households that consider prices important, waste less food than households who do not consider prices important. On the other hand, deal-proneness (i.e., price-orientation) has been shown to increase household food waste (Schmidt, 2016; Aschemann-Witzel et al., 2018). Despite these mixed findings, financial motivations should be included in the measure. In general, saving money seems to be an even more important driver than environmental and moral concerns for many people (Graham-Rowe et al., 2014; Neff et al., 2015), due to its more personal consequences.

2.4. Social motivation

Social food waste avoidance motivations cover concerns about how

one is perceived by others. Social motivation to avoid food waste relates to social norms. Social norms concern the influence that others have on a person's own behavior (either stemming from what others think one should do, i.e., injunctive norms, or what others do themselves, i.e., descriptive norms). The social motivation that we examine here relates to the way a person presents him- or herself towards others, and is presumably based on one's understanding of the injunctive norms. More specifically, when people want to portray a positive image of themselves, they may be concerned about breaking injunctive norms.

Impression management (or self-presentation) is the process of controlling how one is perceived by others (Leary, 2001; Schlenker, 2012). Research on impression management suggests that individuals are often very concerned with how other people perceive and evaluate them, and are highly motivated to make a positive impression on others (Goffman, 1959; Leary, 1986; Kenny and DePaulo, 1993; Vartanian, 2015). We rarely do things that make us seem unattractive, incompetent or immoral (Leary, 2019). Consumers also select certain types, amounts and varieties of foods in order to convey a positive image (Ratner and Kahn, 2002; Vartanian et al., 2007; McFerran et al., 2010; Vartanian, 2015). For example, women may select healthier and smaller meals to appear more feminine (Pliner and Chaiken, 1990; Vartanian et al., 2007). Also, individuals have a stronger preference for green products (Zhang et al., 2019) and behave more pro-socially (Piff et al., 2010) when they want to impress others. Along a similar line, social judgement may also influence the extent to which people manage and deal with food waste.

While research on impression management suggests that anxiety about social judgement is a powerful motivator, research regarding social motivations in the food waste context is lacking. Social influence is never mentioned as a primary motivation to avoid food waste in qualitative studies (Watson and Meah, 2012; Graham-Rowe et al., 2014; Grandhi and Appaiah Singh, 2016; van Geffen et al., 2020). Yet, the scale of Le Borgne et al. (2021) contains two items that seem to relate to social motivations (e.g., "Around me, throwing food away is frowned upon"). This in combination with the impression management literature indicates that the social dimension may be very relevant. More research is needed to understand if the social dimension should be included as a dimension to the scale.

2.5. Existing scales

Existing items from environmental (e.g., de Groot and Steg, 2008; Dunlap et al., 2000) or food waste concern scales (e.g., Raghunathan and Chandrasekaran, 2021; Sheen et al., 2020) are not sufficient to reflect the four proposed motivational dimensions, for several reasons. First, there are several scales that measure environmental concern or motivations (Dunlap et al., 2000; Gkargkavouzi et al., 2019; Milfont and Duckitt, 2010), some of which specifically refer to the loss of resources (de Groot and Steg, 2008; Dunlap et al., 2000). Yet, as far as we know, there is only one sustainability scale that contains an item about food waste (Grunert et al., 2014). Indeed, motivations to protect the environment and avoiding food waste are closely related. Nevertheless, developing a separate scale for food waste avoidance is valuable because people may treat food differently than other products (e.g., paper, furniture, electronics) as food is essential for human survival (Raghunathan and Chandrasekaran, 2021).

Second, current food waste scales focus on consumers' general attitude towards wasting food (Sheen et al., 2020; Le Borgne et al., 2021; Raghunathan and Chandrasekaran, 2021). Sheen et al. (2020) proposed a unidimensional food-waste-concern scale. The scale consists of 5 items on a 7-point Likert scale (1 = Strongly disagree, 7 = Strongly agree) and addresses consumers' concern about wasting food (e.g., "Even if I felt full, I would rather finish what is on my plate than see it go to waste"). The extent to which the respondent considers it morally wrong to waste food is measured with one item (addressing the moral dimension) (Sheen et al., 2020).

Another measure of attitudes is developed by Raghunathan and Chandrasekaran (2021). The six-item scale assesses individual attitudes of food-waste-aversion. People indicate the extent of (dis)agreement with two affective items (e.g., "In general, I hate to waste food"), two cognitive items (e.g., "Growing up, I was taught not to waste food by my parents"), and two conative items (e.g., "I always eat whatever is put on my plate"). Feelings of guilt towards people who do not have enough food are assessed with one item.

Le Borgne et al. (2021) proposed an eight-item food waste concern scale and assess whether concern is related to food waste-prevention routines (e.g., planning meals in advance, storing leftovers in closed boxes). Their food-waste-concern scale encompasses two dimensions, namely: individual and global concern. Items from the individual dimension relate to the social motivation (e.g., "Around me, throwing food away is frowned upon") and the moral motivation dimension ("Throwing away food poses an ethical problem to me as regards those who are starving"). One item from their global dimension relates to the environmental motivations ("Food waste has really harmful consequences for the planet").

In sum, there are three scales that measure consumers' concern about food waste (Sheen et al., 2020; Le Borgne et al., 2021; Raghunathan and Chandrasekaran, 2021). These scales are designed to address food waste concern in relation to eating behavior and primary focus on addressing consumers' general attitudes towards food waste (e.g., "In general, I hate to waste food"). In doing so, these scales address the moral aspect of wasting food, but fail to examine other potentially important motivational aspects of human behavior such as monetary costs. Therefore, we concluded that items from literature were not sufficient to grasp the four motivational dimensions.

Building on environmental psychology (Stern and Dietz, 1994; Schultz, 2001), impression management (Leary, 2001; Zhang et al., 2019) and food waste literature (Watson and Meah, 2012; Graham-Rowe et al., 2014; Neff et al., 2015; Roodhuyzen et al., 2017; van Geffen et al., 2020), we hypothesize that environmental, moral, financial and social motivations need to be distinguished in a scale measuring the motivation to avoid food waste.

3. Scale development and validation

Across three studies, we develop and validate a measure for consumers' motivations to avoid food waste (MAFW). In study 1a, items to measure the dimensions were derived from the literature review complemented with input from qualitative research. In study 1b, we refined the initial list of 36 items into a 21-item measurement scale and tested its four-dimensional structure. Study 2 demonstrates that the scale has strong test-retest reliability and nomological validity, and is not subject to socially desirable responding. The predictive validity of the MAFW-scale is tested in study 3.

3.1. Study 1: scale development

3.1.1. Study 1a: initial item pool

The aim of the first study was to create a list of potential items. A review of existing items from established questionnaires was performed. Previous scales primarily focused on attitudes and by doing so neglected motivations to avoid food waste. As a result, there were insufficient items available to start with. To generate potential items beyond the existing literature, we ran a qualitative study. A survey with open-ended questions was administered for each dimension. Participants (UK) were asked if they agreed that and prompted to explain why they consider wasting food environmentally unfriendly ($N = 125$, 64% female, $M_{age} = 40.8$, $SD = 11.5$), immoral ($N = 126$, 73.8% female, $M_{age} = 40.6$, $SD = 12.7$), financially irresponsible ($N = 125$, 68.8% female, $M_{age} = 38.1$, $SD = 12.0$), or socially unacceptable ($N = 124$, 62.1% female, $M_{age} = 39.6$, $SD = 13.2$). Participants' agreement with the statements was measured by means of a 7-point Likert scale (1 = Strongly disagree, 7 = Strongly

agree). Participants were recruited via Prolific Researcher and were paid for participation.

Participants' answers were labelled, categorized, and transformed into an initial item list (see Web Appendix A). Subsequently, as Hardesty and Bearden (2004) and Rossiter (2002) stress the importance of expert judgments to correctly define a construct, three experts from a Dutch research institute in the field of sustainable food evaluated the face and content validity of the list of items. The experts indicated the need to rewrite some items. Results showed that 96.0%, 90.5%, 94.4% and 31.4% of the participants agreed that wasting food is environmentally unfriendly, immoral, financially irresponsible and influenced by social pressure respectively. These results confirm that in order to cover the full spectrum of food waste avoidance motivations including social motivations is essential. The final pool consisted of 36 items.

3.1.2. Study 1b: Item purification

Our next step was to reduce the number of items, and to assess the four-factor structure and basic psychometric properties of the MAFW-scale. A first purification study indicated that three items should be excluded (due to low factor loading) and suggested a possible dimension related to food management skills that led to the addition of two items (see Web Appendix B for details). The goal of study 1b was to confirm these results with a new sample and further refine the 35-item MAFW-scale.

3.1.2.1. Participants and procedure.
A sample of 310 UK participants was recruited via Prolific. Participants were presented with the 35-item MAFW-scale in randomized order (see Web Appendix C). Participants responded to each item using a seven-point scale ("To what extent do you personally avoid wasting food because of the following reasons:" 1 = Not at all, 7 = Very much). Included in the item list was an attention check: "Please select not at all". Six participants that failed the attention check were excluded (remaining $N = 304$, 68.8% female, $M_{age} = 37.4$, $SD = 12.5$). The survey ended with some socio-demographic questions.

3.1.2.2. Results.
Sampling adequacy was sufficient: KMO value was 0.947 and Bartlett's Test of Sphericity was significant (<0.001). Exploratory factor (principal axis) analysis with oblique rotation (direct oblimin) in SPSS statistics 27 resulted in four factors with eigenvalues exceeding 1. The four-factor solution largely resembled the theorized structure and explained 61.8% of the total variance, with 37.68%, 11.98%, 7.84%, 4.29% for environmental, social, financial, and moral motivation respectively.[5]

Next, we looked at the individual items to further refine the item list. None of the items had an anti-image correlation below 0.8 or a high cross-loading on another factor (>0.35). We eliminated items that revealed a low factor loading (<0.55) on their focal factor and/or were redundant. The final scale consists of 21 items (Table 1).

An exploratory factor analysis on these 21 items resulted in a four-factor solution (Table 2). The four factors account for 69.1% of the total variance and each factor explains at least 5.2% of the total variance. The Pearson correlations between the four factors were all significant and ranged between 0.25 and 0.63.

For each of the subscales, we first assessed internal reliability through Cronbach's alpha ($\alpha_{environmental} = 0.91$; $\alpha_{moral} = 0.81$; $\alpha_{financial} = 0.84$; $\alpha_{social} = 0.92$), and found these sufficiently high (Nunnally, 1994). We also calculated coefficient omega as this is the recommended alternative to address limitations of alpha (Revelle and Zinbarg, 2009; Peters, 2014; DeVellis, 2017). The coefficient omega for the environmental $\omega = 0.91$, 95% CI[0.89, 0.92], moral $\omega = 0.80$, 95% CI[0.76, 0.84], financial $\omega = 0.85$, 95% CI[0.82, 0.88], and social $\omega = 0.92$, 95%

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[5] Note that the fifth (so called food management) dimension found in the first purification study did not show up, even when multiple representative items were included.

Table 1
The motivation to avoid food waste (MAFW) scale.

Factor		Items
Environmental	1	Food waste leads to excess pollution caused by the production, distribution and disposal of food
	2	Wasting food leads to overproduction that damages our environment
	3	Wasting food is a waste of the energy and labor that went into the production of it
	4	I try to avoid food waste because of the environmental impact of food packaging
	5	Food waste has huge economic consequences for society
	6	Food waste is not fair because it depletes resources for future generations
	7	When food is wasted, some animals suffered unnecessarily
Moral	8	Food waste is not acceptable because it can be avoided by saving and eating leftovers
	9	Wasting food is unnecessary because the food can be reused, frozen or better portioned instead of wasted
	10	I try to avoid food waste because food should not be taken for granted
	11	Wasting food is disrespectful to poor people in this country
Financial	12	Wasting food is a shame because I could have saved the money
	13	Wasting food worries me because I could have spent the money on other things
	14	I try to avoid food waste because I worked hard to earn the money I paid the food with
	15	Wasting food is a waste of my money
Social	16	I avoid food waste because I don't want other people to think I'm greedy
	17	I don't want to waste food because I'm afraid other people will think that I'm ungrateful
	18	I avoid wasting food because I'm afraid people will think I'm flaunting my wealth
	19	I try not to waste food because otherwise people will think that I'm unable to run my household properly
	20	I try to avoid food waste because I worry that people think that I'm a wasteful person
	21	I refrain from wasting food because I fear that people think I don't care about food waste problems

Table 2
Factor loadings 21 items study 1b.

	Motivational dimensions			
	Environmental	Moral	Financial	Social
1	0.872			
2	0.868			
3	0.818			
4	0.749			
5	0.692			
6	0.622			
7	0.581			
8		−0.742		
9		−0.683		
10		−0.679		
11		−0.512		
12			0.848	
13			0.759	
14			0.702	
15			0.625	
16				0.865
17				0.837
18				0.828
19				0.799
20				0.776
21				0.770
α	0.91	0.81	0.84	0.92
ω	0.91	0.81	0.85	0.92
AVE	0.59	0.67	0.59	0.51
M	5.16	5.61	5.61	2.96
SD	1.24	1.07	1.11	1.48
EV	7.50	1.10	2.25	3.67
%VA	35.72	5.21	10.71	17.45

Note: α = Cronbach's alpha, ω = Coefficient omega, AVE = Average variance extracted, M = Mean, SD = Standard deviation, EV = Eigen values, %VA = Percent of variance explained.

CI[0.91, 0.94] dimensions were all good. Furthermore, the composite reliabilities of the four motivations were 0.91, 0.82, 0.85, and 0.92 respectively. The corrected item-to-total correlations were above the threshold of 0.50 (Netemeyer et al., 2003). These indicators indicate that the MAFW-subscales have a high degree of internal reliability.

To assess discriminant validity, we compared the average variance extracted within factors with the square of the bivariate correlations between factors (Fornell and Larcker, 1981). The variance extracted for the four dimensions was 0.59 for environmental, 0.51 for moral, 0.60 for financial, and 0.67 for social. The squares of the correlations between the dimensions varied between 0.06 and 0.40. Since none of the variance extracted estimates was smaller than the between-factor squared correlations (shared variance), we can assume discriminant validity.

Next, we conducted a confirmatory factor analysis with Maximum Likelihood (ML) estimation using R (see Table 3). Results showed that the four-factor correlated model yields a good fit as indicated by the $\chi^2(183) = 392.06$, Comparative Fit Index (CFI) of 0.946, Tucker-Lewis index (TLI) of 0.938, Standardized Root Mean Residual (SRMR) of 0.060, and Root Mean Square Error of Approximation (RMSEA) of 0.061. Then, we compared the four-factor model with a one-factor (i.e., all items load on one latent variable) and a three-factor model (which combines the environmental and moral items in a self-transcendence variable). From the alternative models, the one-factor model performs worst: $\chi^2(189) = 2126.47$, CFI of 0.497, TLI of 0.441, SRMR of 0.177, and RMSEA of 0.184. The three-factor model also fitted the data worse than the proposed four-factor model: $\chi^2(186) = 590.94$, CFI of 0.895, TLI of 0.881, SRMR of 0.077, and RMSEA of 0.085. The latter results provide evidence for the discriminant validity of the dimensions.

Next, we compared the means on each of the four motivations to

assess which is most strongly held, using a repeated measures analysis. As Mauchly's test indicated a violation of the assumption of sphericity we used the Greenhouse-Geisser correction. Results showed that means were significantly different ($F(2.42, 734.22) = 485.67$, $p < .001$, $\eta_p^2 = 0.616$). Post hoc analysis with Bonferroni correction revealed that social motivations ($M = 2.96$, $SD = 1.48$) were less important than the other motivations ($ps < .001$). Environmental motivations ($M = 5.16$, $SD = 1.24$) were less important than moral ($M = 5.61$, $SD = 1.07$) and financial ($M = 5.61$, $SD = 1.11$) motivations ($ps < .001$). Finally, no significant difference between moral and financial motivations was found ($p = 1.000$).

3.2. Study 2: scale validation

Our second study aimed to assess test-retest reliability, nomological validity, and sensitivity to socially desirable responding. Moreover, we tested whether the scale structure generalizes outside Europe.

3.2.1. Study 2a: nomological validity and socially desirable responding

3.2.1.1. Participants and procedure. A sample of 426 USA participants was gathered by Qualtrics (53.8% male, $M_{age} = 51.4$, $SD = 17.1$). Participants were removed if they did not fill in the survey completely, provided the same answer on each item of our focal measure, or indicated not being a proficient and/or native English speaker. The developed scale was administered along with the following related constructs: for the environmental dimension, the consumers' green consumption value (GREEN-scale; Haws et al., 2012), for the moral dimension, the individual focused subscales of the Moral Foundation Questionnaire (MFQ; Graham et al., 2011), for the financial dimension, frugality (Lastovicka et al., 1999), and for the social dimension, a measure of social sensitivity (concern about what others think subscale of Personal

Table 3
Fit indices across four samples.

	Web Appendix B N = 307 UK 33 items			Study 1b N = 304 UK 21 items			Study 2a N = 426 USA 21 items			Study 3 N = 200 UK 21 items		
	Four-factor df = 371	Three-factor df = 374	One-factor df = 377	Four-factor df = 183	Three-factor df = 186	One-factor df = 189	Four-factor df = 183	Three-factor df = 186	One-factor df = 189	Four-factor df = 183	Three-factor df = 186	One-factor df = 189
CFI	0.932	0.912	0.657	0.946	0.895	0.497	0.928	0.909	0.663	0.932	0.872	0.468
TLI	0.925	0.904	0.630	0.938	0.881	0.441	0.917	0.897	0.625	0.922	0.855	0.409
SRMR	0.060	0.068	0.132	0.060	0.077	0.177	0.073	0.078	0.128	0.073	0.086	0.194
RMSEA	0.058	0.065	0.128	0.061	0.085	0.184	0.076	0.085	0.162	0.078	0.106	0.214
χ^2	748.77	862.58	2273.37	392.06	590.94	2126.47	637.37	755.32	2303.22	405.01	604.11	1920.02
AIC	28276.8	28384.6	29789.4	19724.9	19917.8	21447.3	30661.6	30773.6	32315.5	13085.1	13278.2	14588.1
BIC	28515.3	28612.0	30005.6	19903.3	20085.0	21603.4	30856.2	30956.0	32485.7	13243.4	13426.6	14726.6

Note: CFI = Comparative Fit Index, TLI = Tucker-Lewis index, SRMR = Standardized Root Mean Residual, RMSEA = Root Mean Square Error of Approximation, χ^2 = Chi-Square, AIC = Akaike information criterion, and BIC = Bayesian information criterion.

Style Inventory; Robins et al., 1994). To test whether the MAFW-scale is sensitive to socially desirable responding, we also included the Balanced Inventory of Desirable Responding (BIDR-16; Hart et al., 2015; Paulhus, 1988). Moreover, the survey included an attention check (no one failed) and basic demographic questions.

3.2.1.2. Results. Confirmatory factor analysis with Maximum Likelihood (ML) estimation using R (see Table 3) shows that a four-factor model produces an acceptable fit as indicated by the $\chi^2(183) = 637.37$, CFI of 0.928, TLI of 0.917, SRMR of 0.073, and RMSEA of 0.076. As in previous studies, a three-factor model ($\chi^2(186) = 755.32$, CFI of 0.909, TLI of 0.897, SRMR of 0.078, and RMSEA of 0.085) and an one-factor model ($\chi^2(189) = 2303.22$, CFI of 0.663, TLI of 0.625, SRMR of 0.128, and RMSEA of 0.162) fitted less well.

Table 4 shows the correlation between the MAFW-scale dimensions and the other measures. The strongest correlation observed is between the environmental dimension and the green scale ($r = 0.71$), followed by the correlation between the financial dimension and frugality ($r = 0.58$), and between the social dimension and the CAWOT-subscale ($r = 0.55$). The correlation between the moral dimension and the MFQ-subscale was moderately high ($r = 0.43$). The frugality scale ($r = 0.51$) and the GREEN-scale ($r = 0.44$) also correlated moderately with moral motivations. Finally, social motivation was weakly positively correlated to the social desirability bias ($r = 0.16$). The other three dimensions do not relate to socially desirable responding ($ps > .124$).

3.2.1.3. Discussion. The environmental, financial and social MAFW-subscales relate to other measures as expected. The moral motivation correlated relatively low with the MFQ subscales compared to its correlations with the frugality and the GREEN scale. In hindsight, this low correlation may have occurred because the MFQ scale is intended to measure individual differences in five dimensions of moral concerns (e. g. fairness, authority, in-group), and touches upon topics that are not directly related to food waste (e.g., "I think it's morally wrong that rich children inherit a lot of money while poor children inherit nothing"). The correlation between the social desirability bias and the social

motivation makes sense since both measure a form of apprehension to social judgement.

3.2.2. Study 2b: test-retest reliability

3.2.2.1. Participants and procedure. The participants of study 2a were contacted again 8 weeks later to assess whether the scale is stable over time. A total of 234 participants responded to our second request (55.1% female, $M_{age} = 57.0$, $SD = 16.6$), a response rate of 52.7%. Participants were removed based on the same criteria as in the previous study. To further assess the construct validity of the moral dimension, the Test of Self-Conscious Affect (TOSCA-3) was administered (Tangney et al., 1989). The TOSCA-3 is one of the most widely used measures of guilt-proneness. The short TOSCA-3 presents 11 scenarios and assesses one's tendency to respond to these situations with guilt, shame, externalization and detachment. More specifically, we wanted to test whether guilt-prone individuals are more motivated to avoid food waste because of moral reasons, as one would expect according to our definition.

3.2.2.2. Results. Pearson's test-retest correlation coefficients for the four MAFW-dimensions were: environmental = 0.70, moral = 0.70, financial = 0.58 and social = 0.66. All test-retest correlations were significant ($p < .001$). The consistency of participants' MAFW-scores over the two test occasions was further analyzed by examining the intra-class correlation coefficient (ICC). A single measurement, absolute agreement, two-way mixed-effect model (2,1) was utilized (Shrout and Fleiss, 1979; McGraw and Wong, 1996; Koo and Li, 2016). Results indicated that the environmental, moral and social motivation show good stability over time. The stability of the financial motivation was a bit lower but still within the acceptable limits (environmental: ICC = 0.70, 95% CI[0.62, 0.76]; moral: ICC = 0.70, 95% CI[0.63, 0.76]; social: ICC = 0.66, 95% CI[0.58, 0.73]; financial: ICC = 0.58, 95% CI[0.49, 0.66]). The lower reliability of the financial dimension is possibly due to fluctuating financial circumstances of participants. We can conclude that the test-retest reliability of all subscales is moderate to good (Koo and Li, 2016).

As expected, the TOSCA-guilt subscale correlated most strongly with the moral motivation ($r = 0.46$, $p < .001$; see Table 4). Respondents that are more guilt-prone are more motivated to avoid food waste because of moral reasons, providing further evidence for the validity of the scale.

3.3. Study 3: predictive validity

The goal of this study was to obtain evidence of the predictive validity of the MAFW-scale by examining the scale's relation with consumers' intention to reduce food waste and food waste related

Table 4
Correlations with the motivational dimensions.

	GREEN	MFQ	Frugality	CAWOT	BIDR-16	Guilt
Environmental	0.71*	0.53*	0.35*	0.33*	0.02	0.32*
Moral	0.44*	0.43*	0.51*	0.16*	-0.08	0.46*
Financial	0.30*	0.29*	0.58*	0.21*	0.03	0.38*
Social	0.47*	0.36*	0.20*	0.55*	0.16**	0.04

*Note: * = p <.001. Data to assess guilt-proneness was gathered at adifferent time point.*

behaviors.

3.3.1. Participants and procedure

A sample of 200 UK participants was gathered via Prolific (66.5% female, $M_{age} = 38.4$, $SD = 14.9$). Next to the developed scale, we asked participants about their intention to reduce food waste (Barone et al., 2019) and routines frequently related to food waste (Stancu et al., 2016).

3.3.2. Results

For exploratory purposes simple linear regressions were employed. When other motivations are *not* controlled, three out of four motivations have a significant relationship with intentions to avoid food waste. Specifically, environmental ($b = 0.52$, $p < .001$), moral ($b = 0.60$, $p < .001$), and financial ($b = 0.34$, $p < .001$) motivations significantly relate to food waste avoidance intentions. The effect of social motivations on these intentions does not reach conventional significance levels, but does indicate a trend in the expected direction ($b = 0.10$, $p = .080$).

Multiple linear regression was used to test if intentions to reduce food waste indeed relate to the motivational dimensions (see Table 5). As the residuals were not normally distributed 5000 bootstrap samples were employed. Age was added as a covariate as its negative relation with food waste is widely documented (Schanes et al., 2018). Other demographic variables did not have a significant relation with intention (Web Appendix F). Results showed that environmental motivations ($b = 0.33$, $p < .001$), moral motivations ($b = 0.33$, $p < .001$), and age ($b = 0.01$, $p = .028$) were significant predictors of intentions to reduce food waste. Financial motivations ($b = 0.07$, $p = .392$) and social motivations ($b = -0.06$, $p = .153$) did not significantly predict intentions.

With regard to the food waste related behaviors, results are mixed. Planning routines are not related to any of the motivations or to age ($p > .164$). Contrary to our predictions, shopping routines are positively related to environmental motivations ($b = 0.18$, $p = .013$) and social motivations ($b = 0.12$, $p = .044$). This implies that people that are motivated to reduce food waste because of environmental and social concerns tend to perform more wasteful shopping behaviors. Finally, leftover food reuse routines were related to moral ($b = 0.46$, $p < .001$) and environmental motivations ($b = 0.16$, $p = .043$) only. For more information on the effects of the socio-demographic variables on food waste related behaviors, see Web Appendix F.

3.3.3. Discussion

The results provide evidence for the predictive validity of the MAFW-subscales. Moral- and environmental motivations are related to consumers' intentions to reduce food waste and food leftover reuse behavior. Leftover reuse is the last stage of the household food management process, and therefore the closest to disposal. At this point of the process consumers decide directly whether food will be saved or wasted, thus where motivations can have a direct influence on waste. Other food waste reduction behaviors are not related to moral and environmental motivations, possibly indicating a motivation-behavior gap. Interestingly, despite strong theoretical foundations, financial motivations and social motivations do not exhibit a significant relation

to intention or food waste related behaviors above that of environmental and moral motivations. Yet, financial and social motivations may still be important in specific situations, which we will elaborate upon in the General Discussion.

4. General discussion

Although no one buys food with the intention of wasting it, still 1.6 billion tons of food is wasted every year (Hegnsholt et al., 2018). A big share of this food waste is produced within households (Stenmarck et al., 2016). Motivations play an important role when it comes to household food waste and behavior change in general (Bamberg, 2013; Nakabayashi et al., 2020; Vermeir et al., 2020). Yet, a psychometrically sound multidimensional scale to measure the different types of motivations to avoid food waste was lacking. Therefore, we introduced the 21-item Motivation to Avoid Food Waste (MAFW) scale that distinguishes between environmental, moral, financial and social motivations to avoid food waste.

The scale is the result of three studies; using both semi-qualitative (study 1a; $N = 1000$) and quantitative research methods (study 1b–3; $N = 1237$). Together, the latter studies – using both UK and USA samples – provide evidence for the scale's reliability, validity and factor structure. Expert judgement has been employed as first assessment of the content validity (as recommended by Hardesty and Bearden (2004) and Rossiter (2002)). The internal and test-retest reliability of the subscales are also good. Moreover, we find that environmental, moral, financial and social motivations correlate in the expected direction with environmental concern, guilt-proneness, frugality and social sensitivity respectively. These results provide evidence of the scale's nomological validity. In addition, we show that in general the scale is not sensitive to socially desirable responding, albeit that there is a weak correlation between the social motivation subscale and social desirability bias. Finally, three of the four motivations were shown to relate to food waste avoidance intentions and/or some food waste avoidance behaviors, providing evidence for the scale's predictive validity.

4.1. Theoretical and practical contributions

Current food waste aversion or food waste concern scales focus on consumers' general attitude towards food waste (Sheen et al., 2020; Le Borgne et al., 2021; Raghunathan and Chandrasekaran, 2021). All three existing scales dedicate an item to the moral aspect of food waste, yet seem to overlook its environmental, financial and social aspects. Consistent with Le Borgne et al. (2021), we identify social repercussion and environmental consequences as important motivations to avoid food waste. In contrast to this approach, we disentangle them into separate, individual dimensions. Results of both exploratory and confirmatory factor analysis clearly indicate that the distinction is valuable. Moreover, wasting money is frequently mentioned as one of the most important reasons to reduce food waste (Graham-Rowe et al., 2014; Neff et al., 2015; Aschemann-Witzel et al., 2018) and is therefore, for the first time, included as a motivational dimension. This paper shows that the distinction between environmental, moral, financial and

Table 5

Regression of MAFW subscales and age on DV's.

	Intention			Planning			Shopping			Leftover use		
	b	SE	boot CI	b	SE	boot CI	b	SE	boot CI	b	SE	boot CI
Constant	1.50	0.47	(0.57, 2.42)	3.42	0.76	(1.86, 4.80)	2.89	0.48	(1.97, 3.87)	1.71	0.46	(0.83, 2.63)
Environmental	0.33	0.09	(0.16, 0.50)	0.12	0.11	(−0.11, 0.33)	0.18	0.07	(0.03, 0.32)	0.16	0.08	(0.01, 0.32)
Moral	0.33	0.09	(0.16, 0.53)	0.20	0.14	(−0.07, 0.49)	−0.07	0.09	(−0.25, 0.10)	0.46	0.10	(0.27, 0.66)
Financial	0.07	0.08	(−0.09, 0.22)	−0.05	0.11	(−0.26, 0.17)	0.07	0.09	(−0.09, 0.24)	0.04	0.08	(−0.11, 0.19)
Social	−0.06	0.08	(−0.14, 0.02)	0.03	0.07	(−0.12, 0.17)	0.12	0.06	(0.00, 0.24)	−0.08	0.05	(−0.16, 0.02)
Age	0.01	0.08	(0.00, 0.02)	0.00	0.01	(−0.01, 0.02)	−0.01	0.01	(−0.02, 0.00)	0.00	0.01	(−0.01, 0.01)

Note: Bootstrapped confidence intervals based on 5000 bootstrap samples.

social motivations to avoid food waste is not only theoretically relevant, but also empirically plausible.

Distinction between four types of motivations is meaningful as it allows to test which of the four motivations is most strongly held by consumers and which motivation has most explanatory power for behavior. The results indicate that environmental but even more so moral and financial motivations are very important motivations to avoid food waste for the population at large. Social motivations, however, can be specifically important in those occasions where other people are present (e.g., dinner with friends in a restaurant). Yet, further research should examine this.

Also, the scale can be utilized to examine which motivation has the most explanatory power for actual behavior. Our third study provides some first insights into this enquiry. Consumers' intention to avoid food waste may be predominantly driven by moral and environmental motivations. In contrast to other pro-environmental behaviors (Steg et al., 2014b), we expected moral motivations to be more strongly linked to food waste than environmental motivations. That is because the impact that food waste has on the environment is complex and often misunderstood, but its moral consequences are more evident as food is essential for human survival. Indeed, the results showed that moral motivations are more strongly linked to meal leftover reuse behaviors.

Despite it being stated as the second most important motivation and its strong theoretical foundation, financial concern did not exert a significant effect on intentions and food waste reduction behaviors above and beyond the effect of moral and environmental motivations. Further research should delve into how financial motivations are intertwined with moral and environmental motivations. In certain situations (e.g., when expensive food items are wasted, in a fancy restaurant, during an economic crisis) or to some individuals (e.g., people that spend a big share of their income on food or frugal consumers), financial motivations may become particularly relevant. Rapidly rising food prices may further boost consumers' concerns about the cost of food waste, and social disapproval as more people struggle to make ends meet. Social motivations, however, do not always translate in food waste reduction according to our results. There are two reasons why. First, social motivations compete with other social goals like the goal to provide plenty of food for family and friends (i.e., good provider identity). Indeed, our results indicate that social motivations are related to more wasteful shopping behaviors. Second, social motivations are expected to become particularly activated in the presence of others (e.g., dinner with friends), and less in more private, food-related behavior within the household.

There are several practical contributions that follow from this study. First, the scale can be used as a tool by both researchers, and policy makers to investigate factors that modify or hinder the effect of motivations on food waste reduction behaviors (such as storing facilities, busy lifestyles or competing goals). Second, the scale can be used to measure if food waste reduction campaigns effectively increase motivations. More importantly, the impact of interventions on the different motivations can be checked. Third, the scale can be used as a segmentation tool to distinguish distinct groups in the population. Personalized messages that target the motivation most important for a segment, can be used to strengthen the motivation of this segment. Personalized messages and targeted campaigns are believed to be a promising avenue for food waste reduction (Schmidt, 2016; Stöckli et al., 2018).

4.2. Limitations

Predictive validity of the scale needs further examination. The first study reported here indicates that indeed the motivations relate to consumers' intention to avoid and likelihood to reduce food waste. The results provide insights into on how the MAFW-subscales relate to consumers' intentions to avoid food waste, planning, shopping, and consumption of meal leftovers. Yet, more research is needed to assess how the four motivations uniquely contribute to food waste and

different types of food management behaviors (e.g., food preservation, overconsumption, donation). For instance, moral motivations may be highly predictive of food donation behavior, whereas social motivations may be related to the use of a doggy-bag in a restaurant and financial motivations to buying nearly expired, discounted food.

Another interesting avenue for future research is to examine the cross-cultural validation of the MAFW scale. Future research should focus on the predictive power of the dimensions, as country-level cultural backgrounds and economic differences may lead to substantial differences. For instance, after the economic crisis of 2008 Greek consumers became very conscious of their spending (i.e., financial motivation), and, as a result, carefully plan and shop their food purchases (Abeliotis et al., 2014). Moreover, in individualistic cultures the goal to be a good provider competes with the goal to avoid food waste, but in collectivistic cultures it does not (Wang et al., 2021). Yet, more research is necessary to understand the cross-cultural differences in motivations to avoid food waste.

We cannot recommend using MAFW as a single measure and advice against taking the average of the items as the scale is not conceptualized and validated in this way. Someone who scores high on only one dimension then would not be recognized as being motivated, even though according to our definition this person would be. If one wants the full profile of a food waste avoiding consumer, all four dimensions should be administered. In this sense, the MAFW-scale is a formative scale consisting of four motivational dimensions, which in turn are reflective constructs.

4.3. Future research

Further research could look at the antecedents of the four motivations. Food waste awareness could be an important predictor of food waste avoidance motivations (Rasool et al., 2021). For example, a consumer who is aware of food insecurity issues may be more likely to be motivated by the moral motivation to avoid food waste. Looking more closely at personality traits that cohere with consumers' motivation to avoid food waste may be another fruitful area of research. For instance, people who are high in agreeableness and openness will probably have stronger environmental and moral motivations, and we expect social motivations to be positively related to extraversion and neuroticism (i.e., emotional instability).

Another interesting avenue for further research is looking into variables that modify/hinder the effect of motivations on behavior. Research shows that the goal to avoid food waste often gets overruled by other food related goals, such as eating healthy or enjoying food (Barone et al., 2019; van Geffen et al., 2020). As environmental and moral motivations are abstract, long-term and non-personal they might get overruled by more personal (health) or immediate gratification (eating tasty food) goals. As such, competing goals would form a relatively big barrier for these two motivations. Also, when a consumer sets a goal to avoid food waste this does not always translate into food waste reduction behaviors. Three factors need to be present to encourage desirable behavior: individual motivation, opportunities provided by the context, and abilities in terms of knowledge and skills (MOA framework; cf. Olander and Thøgersen, 1995; Rothschild, 1999). Opportunities refer to structures in the environment of consumers that facilitate the desirable behavior. Abilities are the skills and knowledge needed to successfully conduct a desired behavior (van Geffen et al., 2020). In sum, increasing consumers motivation alone does not suffice to elicit behavior change; opportunities and abilities need to be present as well.

4.4. Conclusion

Motivations are an important driver of human behavior, yet remain largely understudied in the food waste domain. We developed a 21-item Motivation to Avoid Food Waste (MAFW) scale with a unique four-dimensional structure that captures a broad range of motivations to

avoid food waste (environmental, moral, financial and social). Such a distinction is very important for the study and promotion of food waste avoidance behaviors as people may adopt the same behaviors for different reasons. Practitioners and policy makers alike can use the scale to develop more effective food waste reduction campaigns in order to tackle 1.6 billion tons of food that are wasted yearly.

CRediT authorship contribution statement

Daphne Ribbers: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Visualization, Project administration. **Maggie Geuens:** Conceptualization, Methodology, Writing – review & editing, Supervision. **Mario Pandelaere:** Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition. **Erica van Herpen:** Conceptualization, Methodology, Writing – review & editing, Supervision.

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

The data of this article is available here: https://data.mendeley.com/datasets/b2sd5k632c/draft?a=2b8cf4ea-fe82-41f4-b229-01f836362118

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2022.102626.

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