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Analysing disparities between household food waste metrics and their socioeconomic drivers in Chamwino District, Tanzania

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ABSTRACT

Food waste measurement has garnered significant attention in recent years due to its critical role in devising interventions to mitigate the environmental, social, and economic impacts of food waste. However, the absence of a standardized protocol for Food Waste (FdW) quantification remains a key obstacle in formulating and evaluating effective minimization strategies. This study utilizes Bland-Altman plots and regression analysis to evaluate the agreement between Self-Reported Food Waste (SR_{FW}) and Direct Weighing Food Waste (DW_{FW}) in a sample of 402 randomly selected households in Chamwino District, Tanzania. It also investigates the socio-economic factors influencing disparities between these measurement methods, providing valuable insights into the drivers of these discrepancies. The findings reveal a bias of 0.100067 Kilogram (kg), indicating that SR_{FW} measurements significantly underestimate household FdW. On average, respondents report edible FdW of 0.032703 kg through SR_{FW}, while DW_{FW} measures 0.132769 kg. Furthermore, gender, age, marital status, house ownership, awareness, and price and cost sensitivity are identified as significant factors influencing the bias between the two methods. The study concludes by advocating for increased awareness creation, the combined use of SR_{FW} and DW_{FW} methods, and measures to foster household accountability. These recommendations aim to enhance the accuracy of FdW quantification and support the development of effective waste reduction strategies.

Introduction

The increased rate of FdW along the food supply chain has been a substantial obstacle in efforts to build safe food systems. According to a recent assessment from the United Nations Environmental Program (UNEP), every year, around one-fifth of the world's food supply is wasted, with households accounting for about 60 % of the total FdW (UNEP, 2024). FdW is economically, environmentally and socially undesirable, it poses detrimental effects throughout its occurrence in the food supply chain (Shukla et al., 2024; Chengqin et al., 2022; de Oliveira Pontes et al., 2022; Edjabou et al., 2016; Filimonau et al., 2019; Tonini et al., 2018; Varjani et al., 2024). With incomparable and diverse methodologies, the impact of FdW has been derived, though the quest for accurate amount is still at hand.

Divergence from comparability of FdW data roots from the definition of FdW towards measurement approaches (Ilakovac et al., 2020; Joshi and Visvanathan, 2019; Thyberg and Tonjes, 2016; Withanage et al., 2021), for example some studies have treated FdW and food loss as one and the same (Dou et al., 2016), others find this inappropriate (Delgado et al., 2021). However, may be defined as food and its uneatable parts that was originally meant to be consumed by human is removed from the human consumption chain for any other purpose apart from being consumed by human being (UNEP, 2024).

Though FdW cannot completely be eliminated due to existence of unavoidable dimensions (Bhattacharya et al., 2021) that are not universal (Withanage et al., 2021), researchers seek to minimize as much as possible including, conversion to energy source (Sridhar et al., 2021). Moreover, wasting decisions depending on individual decisions can be considered rational (Jamaludin et al., 2022). One of the needed understanding is the actual amount that is wasted at domestic setting so that any interventions made progress can be monitored (Thyberg et al., 2015), this inadequacy of measured quantities is very high in developing economies (Bhatia and Sharma, 2023; Delgado et al., 2021), which is crucial for the achievement of the SDG 12.3 (Ananda et al., 2023a). From national to international community there is great concern on knowing the amount of FdW (Aitken et al., 2024; Flanagan and

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Priyadarshini, 2021; Lang et al., 2020).

Obtaining accurate measures has for long stood as a substantial obstruction in manifestations of the outcomes of minimization strategies of household FdW (Merian et al., 2024; Withanage et al., 2021). Due to the diversity of assessment techniques and data, ongoing control initiatives have had only patchy success in residential settings (Portugal et al., 2020). Attempts have been made to have a standard measurement that will be cost effective (Read and Muth, 2021), but reaching a standard measurement seems very difficult (Quested et al., 2020) even at prioritizing for tracking progress (Giordano et al., 2019). Without accurate measures it will be difficult to manage FdW at household level (Elimelech et al., 2018; Merian et al., 2024; Withanage et al., 2021). Moreover, enacting effective strategies that can be tracked and their performance monitored requires reliable measurements (Ilakovac et al., 2020; Tamasiga et al., 2022).

In getting reliable measures earlier studies focused in developing better measurements that can be comparable (Thyberg and Tonjes, 2016), studies that are based on SR_{FW} have been found to be less reliable due to biasness and inaccurate reporting of amount wasted (Merian et al., 2024). SR_{FW} such as questionnaires and diaries have been verily used due to conveniences in cost and time (Ilakovac et al., 2020), observations and photographing found to be costly in many dimensions, however this reveal to have embedded biasness (Giordano et al., 2019; van Herpen et al., 2019), under reporting (Herzberg et al., 2020; Parizeau et al., 2021) and inconsistent results (Withanage et al., 2021), hence the quest for accurate and reliable is an ongoing widely researched phenomenon.

Analysis of wasting behavior can bring a break through to setting strategic reduction interventions, but at end will still require accurate quantities to asses and determine the impact of this strategies (Delgado et al., 2021). Accurate measures are key for successive setting, implementation and monitoring of intervention measures (Hartikainen et al., 2016; Withanage et al., 2021). Studies have tried to do earlier comparison on measures of FdW (Giordano et al., 2019; Merian et al., 2024; Quested et al., 2020; van der Werf et al., 2020; Withanage et al., 2021), but this studies are focused in high income and urban settings, leaving rural areas under explored. In rural districts such as Chamwino were challenges in food security mingles with economic and cultural factors (Lukiko et al., 2023) influencing accuracy in waste reporting. Understanding the disparities between SR_{FW} and DW_{FW} is very important for improving accuracy in FdW measurement. The current study aims to address this gap by focusing on Chamwino District, by comparing the SR_{FW} and DW_{FW} and assessing how household socioeconomic dynamics influence FdW reporting. By addressing these disparities, the research seeks to inform interventions that can effectively reduce FdW in rural Tanzania.

Materials and methods

Area of study

The study was conducted in Chamwino district in Dodoma region. It is an agrarian economy characterised with steppe climatic condition (Awoke et al., 2024, 2025), informal food markets, and a wide spread of low household food security (Ally and Lutengano, 2024; Kalumanga, 2024). Food handling practices are highly influenced by changes in seasons, gender roles (Kalumanga, 2024) and inadequate cold storage facilities among other inefficient food handling practices compared to high income and urban settings. These characters differentiate the current study from others providing comparative insights for FdW patterns across settings in rural African.

Study design

Quantification of household FdW involved two measurement methods the SR_{FW} and DW_{FW}. In DW_{FW} the measurement of aggregate amount was measured for five consecutive days to ensure a balance in compliance by households, logistical feasibility and data reliability, since fewer days' capture less variation in data while longer periods risks leading to survey fatigue (Mariam et al., 2022; Merian et al., 2024). Moreover, the five-day period align with previous surveys providing reliable FdW measurement (Betz et al., 2015; Wang et al., 2023), to ensure measured units are more robust weekends were inclusive of the five days (Filimonau et al., 2023). A digital kitchen scale was used in measurement, capable of measuring even the minute's amount of FdW. In measurement process households were served with plastic bags to which they fill in their FdW, in the day of survey FdW was categorized into avoidable and unavoidable food parts, measurements are then recorded in log sheet. In addition, a questionnaire was used to capture household demographic information, SR_{FW} and the food handling practices of the households in the study area.

Sample and procedure

The study poll was conducted from July to August 2024. To ensure capturing the social economic diversity of Chamwino households the study employed stratified random sampling, stratified based on location of household (rural versus *peri*-urban), income and household size. Using Taro Yamane (1967) formula $N/1+N(e^2)$ where; N is 486,176 according to 2022 population census, and a margin error (e) of 0.05, a sample of 402 was finally obtained that participated in the study, this number coincides with UNEP's recommendation for household surveys.

Data collection and quality control

Sampled households were asked to supply an aggregate amount of their FdW for five consecutive days, as well as complete out a questionnaire on their characteristics and food management procedures.

Prior to data collection, residents were educated on the fundamental definitions and dimensions of FdW, allowing them to provide the overall amount of wasted food in their households including edible and inedible food parts. On the first day of the visit, head of the household was asked to complete a questionnaire, and was provided with a plastic bag in which to store households FdW, additionally, in the absence of the household's head, the questionnaire was only filled out by an elderly household member of sound mind; this was done to ensure precise and accurate data collection. During measurement food was categorized based on edibility and preventability, thus inedible food parts were systematically separated from edible food items in case of mixed waste, weighed and recorded into log sheet separately, to ensure accuracy in measurement weighing scale were calibrated including quality control checks to ensure consistency in measurement. Before leaving the residence, the enumerator delivered a plastic bag for the next day's waste material from the particular household. Furthermore, the questionnaire recorded the households' food management methods, with questions modified from earlier studies to meet the current study's setting.

Handling potential bias and the Hawthorne effect

In directly weighing of FdW one of the major challenges is when households change their behavior in FdW measurement period, that makes them cautious of their wasting habits leading to underestimation. Such behavioral change is commonly referred to as the Hawthorne effect (Sigala et al., 2024), to address this the current study ensured households had familiarized themselves with the process and dimensions of FdW to reduce reactivity to their usual behavior (Merian et al., 2024), randomized weighing schedules in household settings, weighing was also done with minimum supervision with households being encourage to dispose waste as normal, moreover DW_{FW} was also supported with unstructured covert observation. Despite this measures to ensure minimum behavioral changes still some of the changes cannot be eliminated, other researches can consider extended durations in household waste

collection, use of waste bins integrated with weight sensors incorporating such convert observational practices ensures having more actual FdW estimate.

Analysis

To assess the difference between SR_{FW} and DW_{FW} measurement methods the study employed a Bland-Altman analysis (BAA), different from correlation coefficient which does not reveal the divergence from equality (Van Stralen et al., 2008), the BAA is robust in its ability to identify biasness of agreement between the two measurement methods and evaluate whether the level of their differences is within acceptable range, moreover the plot provides a visual picture that can help identify outliers and trends in the measured units. Using the BAA to compare level of agreement requires meeting the normality assumption (Doğan, 2018), hence we used the Shapiro – Wilk test to check for normality of data from the two measurements, this is because it's found to be more powerful than other methods such as Kolmogorov-Smirnov test, Lilliefors test and Anderson-Darling test (Mohd Razali and Bee Wah, 2011).

We also run a regression analysis to assess the social-economic factors that influence the difference between the two measurement approaches. The Variance Inflating Factor (VIF) was used to check the correlation between the independent variables (multicollinearity), and non-constant variance of the residuals was tested using Breusch- Pagan/ Cook-Weisberg test for heteroscedasticity. To ensure having robust results we conducted a sensitivity analysis through Cook's D, additionally bootstrapping was performed to ensure stability and consistency of the results of the model.

Results

Demographic features of the respondents

A total of 402 households participated in the study, out of which 70.4 % were headed by male and the rest 29.6 % were headed by female, Age of the household head ranged from 18 to 80 years' old. Years of schooling ranged from four years to 16 years, while the household size ranged from 1 to 9 members. Only 69.9 % of the household owned the house they live in, and 45.5 % of the respondents had more than one income source the rest depended on one source only. More descriptions are presented in Table 1.

Table 1
Descriptive statistics of variables.

Variable	Obs	Measurement	Mean	Std. Dev
Gender	402	Gender of head of household	0.699005	0.4592621
Age	402	Years	41.86567	12.60376
Education	402	Years of schooling	10.61194	2.147586
Marital	402	Dummy ((1)Married, (0) Otherwise)	0.6393035	0.480801
Household size	402	Numerical	3.746269	1.74576
Income	402	Number of income sources	1.472637	0.5146216
House ownership	402	Dummy ((1)Own, (0) Otherwise)	0.6965174	0.4603347
Purchase list	402	Do you buy groceries in a prepared list?((0)Never, (1)Sometimes, (2)Always)	0.7960199	0.8894976
Impulsive buying	402	I purchase more food items when price is low. ((4)strongly agree…(0) strongly disagree)	2.131841	1.343695
Frequency of cooking	402	Number times cooking in a day	2.679104	0.5942461
Overcooking	402	I only cook what can be finished in a meal.((0) Never, (1)Sometimes, (2) Always)	1.542289	0.6312342
Price sensitivity	402	I compare groceries price before I buy.((0)Never, (1) Sometimes, (2)Always)	0.9651741	0.6463256
Awareness	402	Do you know the effect of FdW in the environment? ((0)No, (1)Not very conversant, (2)Yes)	1.134328	0.7110567
Eating leftover	402	Do you eat leftover food? ((0)No we don't, (1)Yes we eat)	0.6716418	0.4702011
Cost sensitivity	402	Wasting food cost me a lot. ((0)Disagree, (1)Agree)	0.6691542	0.471104
Reduction intention	402	I intend to reduce FdW in future.((0)Strongly Disagree..,(4)Strongly Agree)	2.927861	1.036621

Source: Field survey, 2024.

Comparison of SR_{FW} and DW_{FW} measured amounts

In evaluating the level of agreement between SR_{FW} and DW_{FW} measurement methods, the BAA results are presented in Fig. 1. Before plotting a normality condition of the difference of the two measurements ($SR_{FW} - DW_{FW}$) through Shapiro – Wilk test was conducted, the results presented strong significance evidence to reject the null hypothesis that the variables are normally distributed as presented in Table 2. For this reason, to achieve the normality assumption we performed a log transformation of the data and tested normality of the transformed data. We found that the data of our variable was still not normally distributed even after a log transformation. To address this (Chen and Kao, 2021) has suggested the use of non-parametric approach for BAA. Since our data is still not normally distributed we use the non-parametric BAA.

Before plotting the BAA we conducted a sensitivity analysis on different Limits of Agreement (LoA), results reveal that the standard approach $(Mean \pm 1.96SD)$ assuming normality results in a narrower range $(-0.343 to 0.143)$, Percentile $(2.5^{th} to 97.5^{th})$ has slightly wider interval capturing skewness $(-0.421 to 0.055)$ while the $1^{st} to 99^{th}$ percentile accommodates extreme values in having broader range $(-.694 to 0.191)$ to get a clear picture we have displayed this in appendix (Fig. 3). Further reveal a skewness of −2.221 and Kurtorsis of 11.74 reveals non normality of the difference, therefore using the standard deviation could result in underestimation of the true LoA while the $2.5^{th} to 97.5^{th}$ percentile ensures extreme values do not distort results offering distribution independent alternative, additional results of the bootstrapped LoA confirms this robustness with confidence intervals that validate the range. Hence the LoA were calculated at 2.5th and 97.5th percentile, and used in the BAA (Gerke, 2020).

Results of BAA are presented in Fig. 1, whereby the y-axis is the difference of SR_{FW} and DW_{FW}, and the x-axis is the average of the two measured FdW amounts $\frac{SR_{FW}+DW_{FW}}{2}$. The mean measurement for SR_{FW} edible FdW measurement was 0.0327027, and standard deviation of 0.0379007, while for DW_{FW} had a mean value of 0.1327692 and standard deviation of 0.1168171. Moreover, for the difference of the two measurements' the descriptive statistics reveal the upper limit of 0.05487, a lower limit of −0.4211 and a bias of 0.100066.

While the plot in Fig. 1 reveals that majority of points fall within the agreed limits, however still a large number of points are found outside the agreed limits, some outliers are also observed beyond the upper and lower limits of agreement. Specifically, we observe that 19 observation fall outside the 2.5th and 97.5th percentile LoA which indicate significant deviations. Majority of this households reveal extreme underreporting of FdW, further examination reveal that these households are predominantly; highly educated, male headed and large size households. This suggest that SDB, systematic reporting difference, difficulty in recalling may influence wasting estimates in this groups.

A significant trend is also seen in the observed points with clustering of points below the zero limit line and above the mean difference line

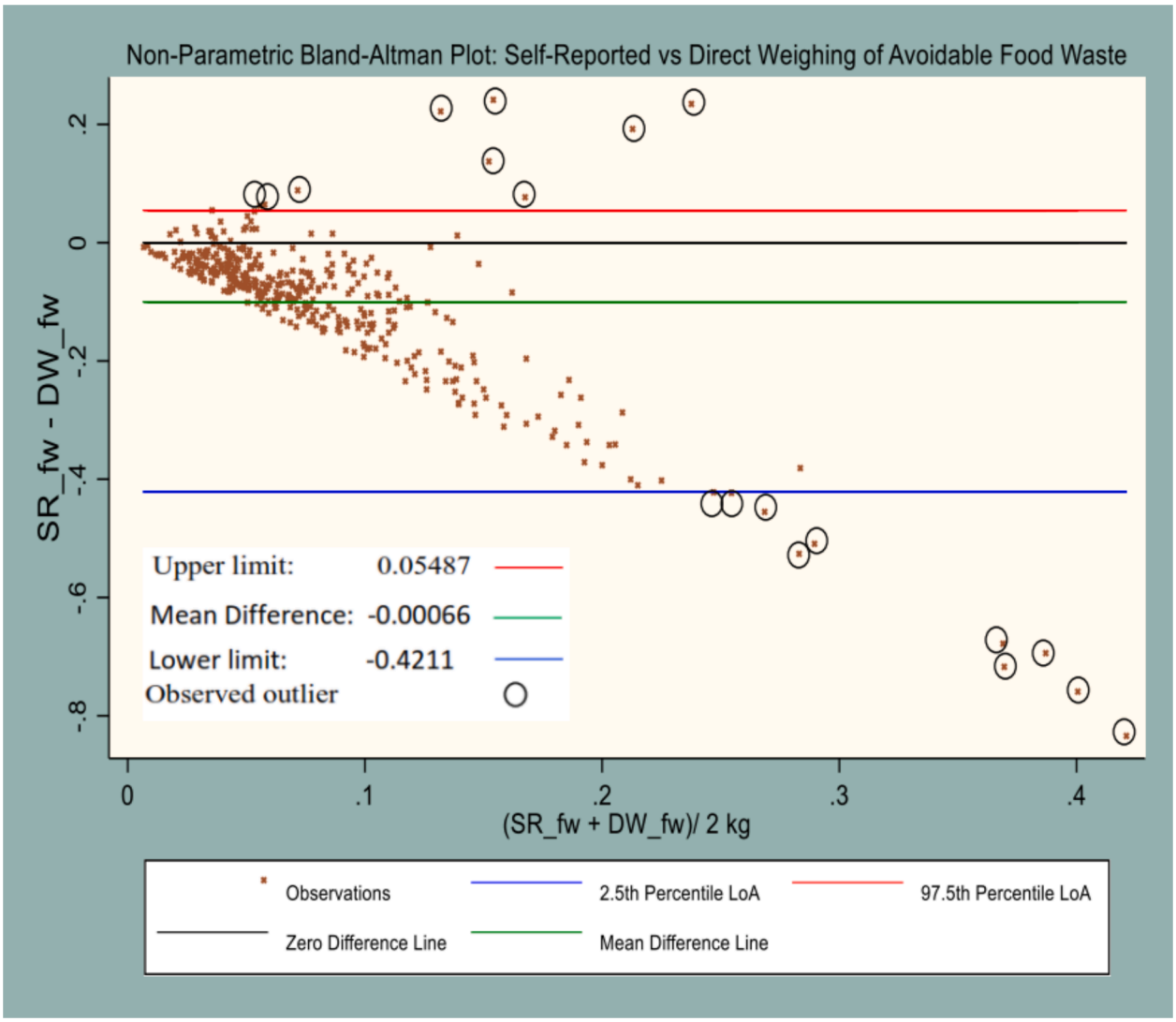

Fig. 1. Non-Parametric Bland-Altman plot of the difference between SR_{FW} and DW_{FW} measured household food waste.

Table 2
Shapiro Wilk test for normality.

Shapiro Wilk (W) Test for normal data					
Variable	Obs	W	V	Z	*Prob* > *Z*
$SR_{FW} - DW_{FW}$	402	0.79748	56.004	9.581	0.000
$Log(SR_{FW} - DW_{FW})$	402	0.60573	109.027	11.166	0.000

Source: Authors estimation from field survey, 2024.

indicated in the plot. Trend in Fig. 1 signifies inconsistency in the level of agreement between the two methods of measurements, moreover we run a regression to check for proportional bias in the BAA due to the observed trend and the result revealed a slope of −1.645013 with a p-value of 0.000 which is statistically significant, thus as the measurement values increase the discrepancy reduces, and that the two methods diverge more at smaller values, signifying evidence of negative proportional bias.

Relationship with social economic variables

In assessing the social-economic factors influencing the difference between the two methods the results of the linear regression are presented in Table 3. Diagnostic checks were performed, to check for multicollinearity via the Variance Inflation Factor (VIF). Test indicates that for all the variables in our model the VIF is less than 10, and hence we conclude that multicollinearity is not a major problem in our model (O'Brien, 2007), to cement this the mean VIF was 1.32 which is also close to 1 indicating across all variables multicollinearity is not a problem. We performed a sensitivity analysis using the Cook's Distance to identify potential influential variables that may disproportionally affect the model, nineteen observations are revealed as displayed in Fig. 2, to fall above the threshold value $(4/N)$ thus observations that may influence the results of our model.

Bootstrapping regression was also estimated with 1500 replications to understand the stability of the model results. The both regression results reveal that the results of the original model are stable. Further in the original model heteroscedasticity was diagnosed using Breusch-Pagan/Cook-Weisberg test results reveal $\chi^2 = 55.26$ and $Prob > \chi^2 = 0.000$. Results from the test of heteroscedasticity is highly significant, and hence we reject the null hypothesis and conclude that the variance of error terms is not constant, hence to address the problem of heteroscedasticity we use robust standard errors which are reported in the regression results in Table 3.

Out of all the sixteen variables that were used in the regression only eight of the variables were found to be significantly associated with the difference in the amount of FdW measured as seen in Table 3. Four demographic variables (gender of the household head, age of the

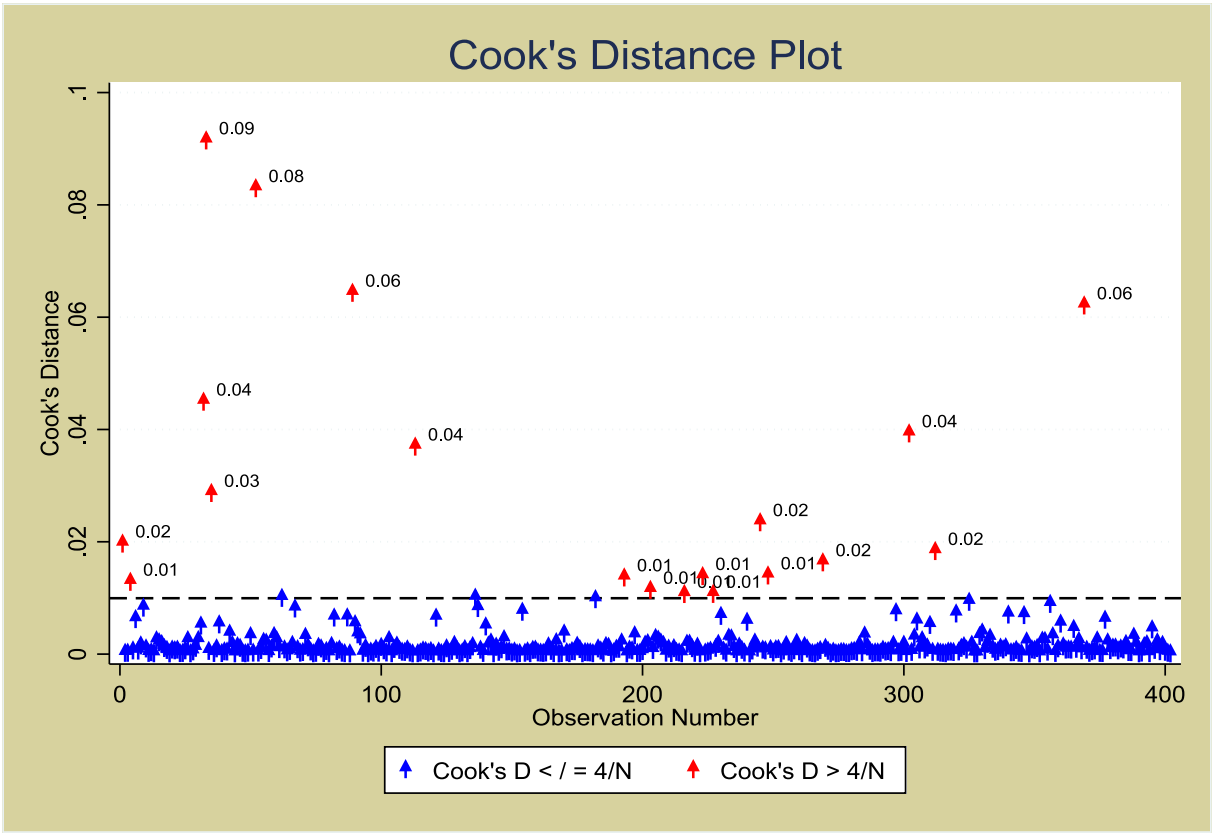

Fig. 2. Cook's Distance plot.

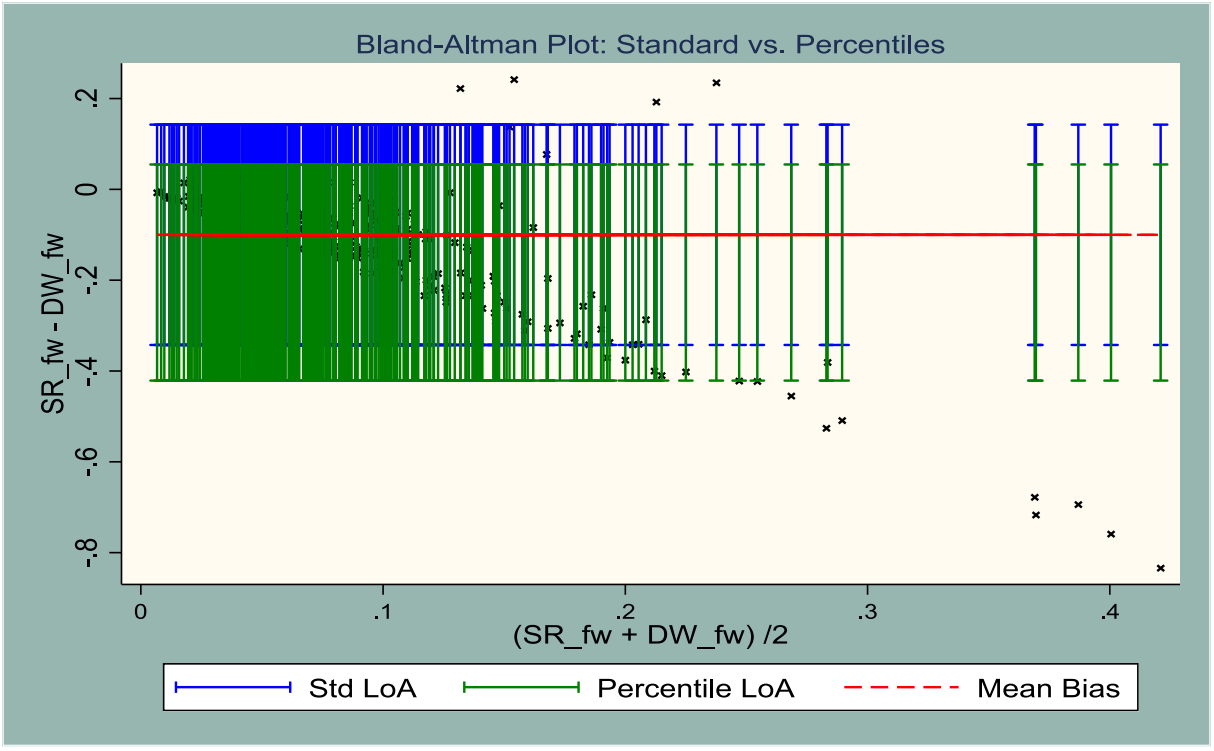

Fig. 3. Bland Altman Plot Standard (std) and Percentile limits of agreement.

Table 3
Regression results.

$SR_{FW} - DW_{FW}$	Coef.	Std. Err.	t	$P > t$	[95 % Conf. Interval]	
_cons	−0.17612	0.053481	−3.29	0.001	−0.28127	−0.07097
Gender	0.033249**	0.015852	2.1	0.037	0.002082	0.064416
Age	−0.00138**	0.000574	−2.4	0.017	−0.00251	−0.00025
Education	0.00767***	0.002952	2.6	0.01	0.001866	0.013473
Marital status	−0.02914*	0.016747	−1.74	0.083	−0.06207	0.00379
Household size	0.005172	0.004785	1.08	0.28	−0.00424	0.014581
Income	0.008836	0.011581	0.76	0.446	−0.01393	0.031606
House ownership	0.035549*	0.020078	1.77	0.077	−0.00393	0.075026
Purchase list	0.007692	0.008067	0.95	0.341	−0.00817	0.023554
Impulsive buying	−0.00648	0.004407	−1.47	0.142	−0.01515	0.002181
Overcooking	0.0067	0.00974	0.69	0.492	−0.01245	0.02585
Reduce intention	−0.00327	0.005084	−0.64	0.521	−0.01326	0.006729
Price sensitivity	−0.02594**	0.011425	−2.27	0.024	−0.0484	−0.00348
Frequency cooking	0.007589	0.012016	0.63	0.528	−0.01604	0.031215
Awareness	0.022996**	0.009638	2.39	0.018	0.004046	0.041946
Eat leftovers	−0.01016	0.013204	−0.77	0.442	−0.03612	0.0158
Cost sensitivity	−0.02548**	0.012431	−2.05	0.041	−0.04992	−0.00104

F (16, 385) = 2.44, Prob > F = 0.0016, R^2 = 0.1083, Root MSE = 0.11929.

household head, education and marital status) and four social economic variables (cost of FdW, house ownership, awareness and price consciousness) were found significantly able to explain the difference between the SR_{FW} amounts and DW_{FW} amount. Other variables did not show any significance association with the difference in the two measurement amounts, can be due to the nature of the variable found in other studies to have inconclusive results with FdW; income (Everitt et al., 2022), shopping list, discounted price (Ananda et al., 2023a; Bhatia and Sharma, 2023) or other social-cultural settings of respondents.

Gender indicates that an increase in male headed households increase the difference by 0.0332 kg of FdW. This means that male headed households report more bias estimates of FdW than female headed households, that is the SR_{FW} in male-headed households is likely to either overestimate or underestimate DW_{FW} by 33.2 g. It can be reasoned that female headed households are more likely to have less bias in reporting due to being actively involved in preparation and management of leftover food at household, unlike men who have less direct oversight and stand as breadwinners of the household positioning them as potential in misreporting of SR_{FW}. However, Painter et al., 2016 found that female waste more than male, possible due to reduced concern in FdW or negligence. Similarly Li et al., 2023 found inconsistency in gender related FdW patterns, revealing that gender by itself cannot explain household FdW behaviours, hence future studies can venture into exploring how decision making at household level interact with gender to determine biasness in reporting of FdW.

Age of the household reveal an increase in household age decreases the difference by 0.0014. This means that older household head report FdW more accurately and younger household heads report with greater bias in SR_{FW}. This is explainable by household food management practices, experience, awareness, that is older households have more experience food utilization and budgeting making them conscious to their wasting and therefore more accurate compared to younger household head, unlikely to younger household head who have less experience and may even have no structure of their meal planning habits. Younger households are less likely to know their wasting behavior and estimates, hence a possible influence in the discrepancy. Tonini et al., 2023 have indicated age of household children influences FdW generation in the household.

Education of the household head reveals that an increase in a year of schooling increases the difference by 0.00767 kg of FdW. Highly educated household-head have a more bias in the measurement of FdW than uneducated. Education has also been found to influence other characteristics in wasting (Veselá et al., 2023), thus its consideration is important as human beings are rational they tend to portray themselves in a better status, most educated households would not like to paint their image behaving in unethical manner hence they will increase the level of biasness in SR_{FW} (Quested et al., 2020).

Marital status, a unit increase in married household decreases the difference by −0.0291 kg of FdW. This can be explained in that household head marital status matters a lot in his or her concern in wasting. Living without a spouse reveals less responsibilities and hence little concern on wasting thus more likely to provide inaccurate estimates, Silvennoinen et al., 2014 reveal that single women households waste more food than married. But households that is married will have a greater sense of the amount wasted and hence more likely to provide accurate estimate due to concern on wasting behavior, resulting to low bias in such households.

Increase in number of households who own a house increases the difference by 0.035548 kg of FdW. This means that households who are living in their own home are less likely to know an exact amount of food that they waste. Management practices of FdW involves feeding of domestic animals and pets, landfilling whenever food staff not to be eaten is available, hence knowing the accurate figure may not be very possible unlike for those living in rented buildings were most do not have domestic animals and may have a bin to which they trash their leftover and unwanted food items, moreover large households mostly live in their own houses who on average waste a lot of food (Jörissen et al., 2015).

Increase in price consciousness decreases the difference by 0.02594 kg of FdW. This means that price sensitive households are more likely to give a more accurate FdW estimate, while households that are not price sensitive are prone to misreporting their actual waste amount. Price sensitive households are mostly those with low income, this are very conscious of their food price (Veselá et al., 2023) which transcends to more likely to monitor their consumption behavior and waste, thus more likely to report accurate FdW (Ananda et al., 2023b). On the other hand, price insensitive households typically those with high income, may perceive cost of FdW as an insignificant financial concern, have less attention on quantity they waste resulting in greater bias in SR_{FW}. Thus being price insensitive can be a source of biasness as households my report a lower wastage amount while in reality they waste a higher amount.

Increase in awareness increases the difference by 0.023 kg of FdW. This can be explained that when an individual knows that he or she is being observed will change the behavior, thus even in reporting those who are more informed on the consequences of FdW, they are likely to report a lower estimate than those that are unaware. The findings of (Ananda et al., 2023b) remarks on less reporting to fit to what the society expects as behavior reactivity which cements the existence of biasness in the two measurements, has also been reported in other studies (Quested et al., 2020).

Increase in perception on the cost of FdW reduces the difference by

0.02548. Households who perceive that FdWcost them a lot of money will have more concern in wasted amount of food items at their household than those who perceive FdW to cost them less. Hence households who are more concern tend to know more about the accurate estimates than those who have little concern, thus biasness will be less when a household's consciousness is high, with high consciousness accuracy in SR_{FW} is also high. Households as rational consumers will prefer to incur lesser cost following FW and cascade to making follow-ups within the household for cost reduction and in this they will be at a better position to reveal more accurate estimate of FdW and hence likely to have low biasness between the two measurement methods.

Discussion

Interpretation of the study's key findings

The findings reveal a clear disparity in the SR_{FW} and DW_{FW} measured amounts, the SR_{FW} measure clearly underestimate the amount of FdW that is wasted by households cementing earlier FdW findings (Amicarelli and Bux, 2020; Ananda et al., 2023b), however DW_{FW} is the best method of FdW measurement as it's lowly influenced by behavior adaptations (Merian et al., 2024). A significant difference exists between the two measurement methods; this difference is accountable with gender, age, education, marital status, house ownership, price sensitivity, perceived cost and awareness on the environmental consequences. Moreover, the measurements revealed non-normality, which is attributable to specific demographic groups with extreme underreporting especially among highly educated households due to Social Desirability Bias (SDB), large size household's difficulty in tracking waste generation and influence of outliers due to near zero reporting of wasted food. Systematic underreporting may affect generalizability of the findings due to underestimation of actual FdW level making designed policies ineffective. To improve generalizability and have effective policies complementary measurement methods, thus the need for accurate measure of FdW cannot by any means be bypassed (Aitken et al., 2024).

Higher education level linked with greater household underreporting, possibly being a result of SDB, where households navigate their behavior and responses to reflect being responsible consumers (Hermanussen et al., 2022; Zhu et al., 2024). In addition, male headed households revealed to overestimate FdW, this is attributable to low direct involvement in preparation and disposal of food. Younger households were found to have lower FdW awareness, cementing the need for promoting waste conscious behaviors that target this demographic group. Moreover, lower price sensitive households were less mindful of waste similar found in Jia et al., 2022, strengthening the need for awareness campaigns that emphasize the economic cost of FdW. These findings accentuate the use of more objective measurement methods such as DW_{FW}, or complementing SR_{FW} with more accurate and reliable FdW measurement methods such as real time monitoring and convert observation.

Factors influencing reporting bias

The level of agreement between the measurements methods are largely influenced by household demographic factors and household food routines revealed existence of systematic bias were the SR_{FW} measure was verily underestimated by households, these disparities largely relates to household awareness, social desirability and food handling behaviors. Moreover, considering the timings of research, measurements may vary considering seasons (Grant et al., 2023; Jeswani et al., 2021), harvest cycles (Gonçalves and Maximo, 2023; Jerie et al., 2024; UNEP DTU Partnership and United Nations Environment Programme & UNEP DTU Partnership, 2021), community festivals (Mandal et al., 2024; Phasha et al., 2020) and even days of the week (Corrado et al., 2019; Parizeau et al., 2021).

The results of the linear regression in Table 3 reveal that included variables explain a very low variation (R^2) of only 11 % in the difference between the two measurements. This low variation is however explainable in behavioural studies. Human behaviour has numerous influencing factors including individual emotions, interests and group dynamics such that capturing all relevant variables in a model becomes challenging due to difficultness in quantifying and predicting behaviour (Ozili, 2023). Low R^2 may be attributable due to unobserved household behavioural factors, household varying FdW interpretations and possibly omitted variables, however statistical significance of key variables reveal that essential behavioural and household demographic patterns are engaged in, therefore it can be acceptable as it accounts meaningful results (Gupta et al., 2024; Ozili, 2023). To check potential influential observation sensitivity analysis was conducted through Cook's Distance, revealing that the main result are robust, to further cement this findings we performed bootstrap with 1500 replications, bootstrap standard errors and confidence intervals confirmed the key findings are consistent with original estimates, results are not overly sensitive to specific variation of sample observations.

Households with higher level of education tend to underestimate the amount of FdW, this reveals the SDB, in a tendency to align with perceived norms of responsible behavior, coincides with the environmental awareness factor which also shows a significant positive association with this difference. Other studies (Quested et al., 2020) have also coined on behavior reactivity leading to social bias due to high education, leading to reporting less FdW than what is actually wasted (Li et al., 2023). This implies that households have less of enough knowledge on the consequences of FdW and definitions of FdW or what is being accounted, this is evident in the field survey were households were unaware of the dimensions of FdWsuch as food residuals burnt during cooking and food that is left on a plate after eating they only knew it as food that is rotten or spoiled.

Education influences other individual features (Veselá et al., 2023) including reduction intentions(Qian et al., 2021), households in Chamwino have to be educated on the various categories so that they can know the amount of food that they waste, moreover intervention measures should consider timely reporting of FdWsurvey results to households so they can know the amount that they actually waste as this will make them mindful of the wasting behavior and wasting amount. Disagreeing with Filimonau et al., 2020; Jamaludin et al., 2022, a study by Ananda et al. (2023b) reveals that educated households waste a lot of food than less educated, there is urgency for creating campaigns on awareness on the channels through which food goes into waste and having real time reports of FdW statistics so that they can be conscious of their wasting behavior. Intervention measures should consider awareness in relation to age as older households are reluctant to behavioral change (Jiang et al., 2024) solidifying the consequences and timely reports will prove added advantage.

Male headed households are revealed to overestimate the amount FdW which may be attributable to the variances in roles and food wasting behaviours in respective households. Bias reporting in male headed households reveals the existence of knowledge gaps, level of consciousness on wasting habits. In general men are more engaged in away from home activities and less of home which may cause them not to know the actual wastage in their households, which will be beneficial for cost reductions, women have in earlier studies found to waste more than men (Lima et al., 2024; Qian et al., 2021). Respondents in Chamwino reveal an important need for targeted education campaign among men to ensure adequate knowledge on wasting habits and amount of food that they waste, moreover this could be transformed into monetary terms to arise their consciousness as they engage in finding income to feed their homes, there is also an amount that is wasted away. Earlier inconsistence findings on gender and FdW (Veselá et al., 2023) reveal the need for accurate measures in targeting FdW interventions, this study advocates none dependency on one FdW measure but rather a more DWFW approach or a combination of more than one measurement

method.

Older households are less biased to SR_{FW} of amount of FdW this can be due to their role, management of food items, experience in ups and downs of food shortages with this they are more conscious on their wasting behavior ending up wasting less amounts (Hermanussen et al., 2022). Unease with wasting behavior entails follow-ups of wastage amount and likely to be more accurate in SR_{FW}, similarly (Lima et al., 2024) found out that as households age increase they waste less. Younger households tend to be less conscious on wasting behaviors as they may not know efforts and sacrifices to make food available and hence paying no attention on wasting behaviors, previously described as attitude behavior gap (Clement et al., 2023). Findings reveal an urgent need for proper awareness among younger households requiring clarifications, providing visual aids to ensure clarity on, peer to peer conversations. Complementation of SR_{FW} with DW_{FW} to ensure validity of data from young consumers, and successfully execute interventions which may not be easy for older consumers (Lang et al., 2020), moreover in measurements more objective measurement tools will further improve efficacy especially for younger households (Clement et al., 2023).

Engaging in household activities especially in the management of food items by married households enables reporting of more accurate measure of FdW compered to unmarried households (Ang et al., 2021), that is married households reveal consistency in estimates compared to single households this can be attributable to consistency in the food routines within the households. Unmarried household heads require awareness interventions to enable them keep track of their wasting behaviors to reduce bias in SR_{FW}. Moreover, when unmarried households eating away from home can lead to spoilage of unconsumed leftovers or rotting of groceries and more FdW, singles are unconscious in wasting behavior and hence waste much food (Jörissen et al., 2015). Awareness in the factors causing FdW should be made clear to unmarried households in Chamwino, being made aware on the quantity being waste and how this reduces their disposable income will enable interventions achieve desired targets. Sensitizing on accountability among singles especially those who do not cook frequently, encouraging them to keep track of their wasting practices in their homes, we recommend on unanimous reporting and developing protocols for FdW measurement but also conclusion of confirmatory methodology.

Saving the rent that would otherwise be paid when household do not own a house is a good achievement that can be a breakthrough to ensure food availability. However, if food availability is prevailing with FdW it becomes unethical practice, were money is wasted away through wasting of food items (Porpino et al., 2015). House ownership is a good indicator of financial status of household, which may drive biasness due in attempt to portray their societal image as being efficient FdW management practice, additionally higher income has been found associated with FdW generation (van der Werf et al., 2020). In the survey none of the households who own a house was found to living alone, transcend relating to household size, marital status and income level, thus this factors have in earlier studies related to FdW (Silvennoinen et al., 2014; van der Werf et al., 2020). Rearing of domestic animals is more common among households who live in their own house, which is a factor that accounts for much wastage unknowingly when these animals are fed frequently with leftovers whenever they are available, this can deflate the actual amount found to be wasted. During survey one of the households remarked, "*I fed leftovers to my ducks*'', another "*if you want to measure you have to come early before I feed my domestic animals*''. Practice of frequent feeding of domestic animals and especially pets with unavoidable human food may underestimate the amount wasted. There is a need to sensitize households on tracking wasting behavior so that the purpose of human food is retained for human consumption.

Financial consciousness in terms of price of food and the cost of FdW reveal that households in Chamwino need to be made more aware on the financial implications of FdW so as to ensure more consciousness in wasting behaviors which will automatically lead to reduction in FdW similarly obtained in China (Liao et al., 2022). As rational consumers they would prefer to waste less of their earning through FdW (Jamaludin et al., 2022; Porpino et al., 2015). High biasness in wasting of food is related to lesser concern in wasting of food items as rational consumers. Unconsciousness of the financial implication of households is revealed in the statement from one of the households who questioned "*Why do you have to search for wasted foods? Because I don't throw the food I feed my animals all food remains and nothing is wasted.*" Household with this notion does not clearly understand the cost of food that is meant for human consumption and that which is for none human consumption. While domestic animals food may be cheaper and while human food has a chain of costings until its ready for consumption, throwing of avoidable leftovers results in incurring of avoidable costs and wasted investments (Ünlüönen and Şimşek, 2021). Thus households require to be made aware of the implication of FdW cost and the amount of financial resources that they could actually avoid, this will be effective mechanism for FdW intervention, moreover transforming households to become financially conscious will lead to FdW reduction (Bhatia and Sharma, 2023; Jia et al., 2022), but this may work less for high income earners (Jamaludin et al., 2022). We recommend more awareness and feedbacks on the wasting status and trend this may result to high consciousness among all income groups and less biasness in FdW reporting.

Policy implications

The results of the study have revealed important policy implications to improve strategies to reduce household FdW. Since the SR_{FW} reveal significant underestimation of amount wasted policies should prioritize more accurate measurement methods such as DW_{FW} or complementing SR_{FW} with more accurate methods. Research institutions should develop standard protocols for FdW measurement that fit local settings to obtain accurate estimates and reduce biasness.

Underreporting is accountable to SDB hence policy makers should consider national awareness and educational campaign to ensure public understanding on FdW dimensions, measurement and environmental effects, specifically these campaigns should target all sectors; households, food service and retail. Moreover, policy makers should design tailored interventions that are gender responsive and demographically specific to address arising variations, such as increasing men awareness on the monetary value of wasted food, young adults and unmarried households encouraged to be conscious of their wasting behaviors and the use of adequate planning and storage facilities.

Considering the settings of this study, Chamwino district could benefit from FdW reduction programs at community level, such us sensitizing household level food management strategies, local food reduction incentives such as tax discounts for participants, support local food sharing and composting programms at local level, emphasizing FdW reduction in village meetings, FdW discussions, through religious gatherings targeting price insensitive consumers and school based programms. Additionally, integrating the reduction initiatives into national food security and climate change action plans will ensure longtime behavioral change. With these policies the government will effectively lead to FdW reduction, heighten food security, minimize the environmental effects and hence strengthen sustainable food system.

Limitations in DW_{FW} measurement

Directly weighing FdW is regarded a better way in estimating the amount of food wasted than SR_{FW} however it is not without limitations. To obtain accurate measurements of FdW depends on compliance of the households in collection and separation guidelines. However, some of the FdW may be unaccounted for such as liquid waste when disposed via drainage. Variation in measurements can still exist considering seasonal changes, festivals, cultural practices and patterns in food consumption. This suggest the need for multiple studies in this dimensions to provide comprehensive understanding of FdW patterns.

The need for complementary approaches in measuring FdW

Effective interventions can never be achieved without first considering accurate measurements. The current study significantly highlights the disparities in the SR_{FW} and DW_{FW} methods of measuring FdW. The observed underreporting of the SR_{FW} reveal the need for less reliance on single measurement method to avoid wrong conclusions on the measurement and FdW drivers, it's important to complement and integrate FdW measurements.

SR_{FW} may be desirable because it's easy to administer and less costly, however its prone to SDB, and recalling errors. Moreover, may not adequately capture composted waste and FdW used to feed domestic animals further underreporting. DW_{FW} is resource demanding and intrusive due to Hawthorne effect, and may not capture perception, motivation and contextual factors that influence FdW behavioral factors, hence it cannot stand on its own to fully result in adequate understanding of FdW. Hence to ensure accuracy and reliability the study advocate mixed measurement approaches. DW_{FW} combined with SR_{FW} to validate results and adjust for any potential estimation bias, and better targeted interventions.

Conclusion

This study presents unique findings into discrepancies between self-reported food waste (SR_{FW}) and directly weighed food waste (DW_{FW}), with SR_{FW} systematically underestimating actual amount of FdW. Our analysis reveals gender, price sensitivity and other social-economic factors significantly influence the degree of biasness in measuring FdW. The variables included in this study account only 11 % of the variation in differences between the two methods, suggesting that additional relevant factors remain unexplored, such as household food management practices, cultural attitudes, variation in season may also play a significant role. Future studies could consider undertaking longitudinal variation to explore how patterns of FdW vary according to festivals, seasonality and different harvest periods.

Our findings also emphasize the importance of using accurate measures in estimating FdW, as bias in the self-reported measurement could contribute to inconsistency in FdW research and formulation of policy. Establishing a standard protocol for measuring particularly in lower cost methods such as the SR_{FW} is important for reducing errors in reported FdW estimates, and increase data reliability.

With awareness creation remaining as a major factor in reducing household FdW, intervention should consider targeting gender based differences in FdW perceptions, encouraging price sensitive behaviors, and youth initiatives. In Chamwino District and similar social-economic context, policy makers can integrate FdW education in village meetings, religious gathering, open discussions. Additionally, providing tax incentives to households participating in FdW reduction programs will encourage change in behavior. By advancing reliable and accurate measurements alongside awareness interventions, these findings directly contribute to the global agenda of SDG 12.3, which aims to halve per capita FdW at consumer level by 2030. Prioritizing the quality of FdW measurement and integrating supportive policies will not only help mitigate FdW but also reduce its environmental impact reduce its impact to the environment and hence strengthen food security.

Ethical statement

The University of Dodoma's Ethics Committee approved this study (Reference No. HA.107/249/015/231). All participants provided informed consent after being fully informed of the study's objectives. We confirm that this paper is original, has not been published elsewhere, and is not under consideration for publication in another journal.

CRediT authorship contribution statement

Denis M. Silayo: Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Abiud J. Bongole:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **Mary Kulwijila:** Writing – review & editing, Software, Resources, Methodology, Conceptualization.

Declaration of competing interest

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

References

Aitken, J.A., Sprenger, A., Alaybek, B., Mika, G., Hartman, H., Leets, L., Maese, E., Davoodi, T., 2024. Surveys and diaries and scales, Oh My! A critical analysis of household food waste measurement. Sustainability (Switzerland) 16 (3). https://doi.org/10.3390/su16030968.

Ally, M.H., Lutengano, M., 2024. Food Science & Nutrition Research Prevalence of Poor Nutritional Status and Associated Factors Among Children in Dodoma Region of Tanzania. 7(2), 1–7.

Amicarelli, V., Bux, C., 2020. Food waste measurement toward a fair, healthy and environmental-friendly food system: a critical review. Br. Food J. 123 (8), 2907–2935. https://doi.org/10.1108/BFJ-07-2020-0658.

Ananda, J., Karunasena, G.G., Kansal, M., Mitsis, A., Pearson, D., 2023a. Quantifying the effects of food management routines on household food waste. J. Clean. Prod. 391 (January 2022), 136230. https://doi.org/10.1016/j.jclepro.2023.136230.

Ananda, J., Karunasena, G.G., Pearson, D., 2023b. A comparison of online and in-store grocery shopping behaviour and its effects on household food waste. Technol. Forecast. Soc. Chang. 194 (April). https://doi.org/10.1016/j.techfore.2023.122698.

Ang, W.Z., Narayanan, S., Hong, M., 2021. Responsible consumption: addressing individual food waste behavior. Br. Food J. 123 (9), 3245–3263. https://doi.org/10.1108/BFJ-03-2021-0328.

Awoke, M.D., Löhr, K., Kimaro, A.A., Efraim, C., Lana, M.A., Hafner, J.M., Sieber, S., Hafner, J.M., 2025. Agroecology and Sustainable Food Systems Understanding farmers' choices in climate-smart agriculture : adoption of agroecology principles and impacts on rural livelihoods in semi-arid Tanzania. Agroecol. Sustain. Food Syst. 00 (00), 1–28. https://doi.org/10.1080/21683565.2025.2466439.

Awoke, M.D., Löhr, K., Kimaro, A.A., Lana, M., Soh Wenda, B.D., Buabeng, K., Hafner, J. M., Sieber, S., 2024. Exploring gender dynamics in climate-smart agriculture adoption: a study in semi-arid Dodoma, Tanzania. Front. Sustainable Food Syst. 8 (January). https://doi.org/10.3389/fsufs.2024.1507540.

Betz, A., Buchli, J., Göbel, C., Müller, C., 2015. Food waste in the Swiss food service industry - Magnitude and potential for reduction. Waste Manag. 35, 218–226. https://doi.org/10.1016/j.wasman.2014.09.015.

Bhatia, A., Sharma, S., 2023. Identifying determinants of household food waste behavior in urban India. Cleaner Waste Syst. 6 (May), 100105. https://doi.org/10.1016/j.clwas.2023.100105.

Bhattacharya, A., Nand, A., Prajogo, D., 2021. Taxonomy of antecedents of food waste – A literature review. J. Clean. Prod. 291, 125910. https://doi.org/10.1016/j.jclepro.2021.125910.

Chen, L.A., Kao, C.L., 2021. Parametric and nonparametric improvements in Bland and Altman's assessment of agreement method. Stat. Med. 40 (9), 2155–2176. https://doi.org/10.1002/sim.8895.

Chengqin, E.K., Zailani, S., Rahman, M.K., Aziz, A.A., Bhuiyan, M.A., Gazi, M.A.I., 2022. Determinants of household behavioural intention towards reducing, reusing and recycling food waste management. Nankai Bus. Rev. Int. 15 (1), 128–152. https://doi.org/10.1108/NBRI-01-2022-0011.

Clement, J., Alenčikienė, G., Riipi, I., Starkutė, U., Čepytė, K., Buraitytė, A., Zabulionė, A., Šalaševičienė, A., 2023. Exploring Causes and Potential Solutions for Food Waste among Young Consumers. Foods 12 (13). https://doi.org/10.3390/foods12132570.

Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O.J., Hauser, H.E., van Holsteijn, F., Liu, G., Östergren, K., Parry, A., Secondi, L., Stenmarck, Å., Sala, S., 2019. Food waste accounting methodologies: challenges, opportunities, and further advancements. Glob. Food Sec. 20, 93–100. https://doi.org/10.1016/j.gfs.2019.01.002.

de Oliveira Pontes, T., da Silva César, A., Conejero, M.A., Rodrigues Deliberador, L., Otávio Batalha, M., 2022. Food waste measurement in a chain of industrial restaurants in Brazil. J. Clean. Prod. 369 (July). https://doi.org/10.1016/j.jclepro.2022.133351.

Delgado, L., Schuster, M., Torero, M., 2021. Quantity and quality food losses across the value Chain: a comparative analysis. Food Policy 98 (August 2019). https://doi.org/10.1016/j.foodpol.2020.101958.

Doğan, N.Ö., 2018. Bland-Altman analysis: a paradigm to understand correlation and agreement. Turk. J. Emerg. Med. 18 (4), 139–141. https://doi.org/10.1016/j.tjem.2018.09.001.

Dou, Z., Ferguson, J.D., Galligan, D.T., Kelly, A.M., Finn, S.M., Giegengack, R., 2016. Assessing U.S. food wastage and opportunities for reduction. Glob. Food Sec. 8, 19–26. https://doi.org/10.1016/j.gfs.2016.02.001.

Edjabou, M.E., Petersen, C., Scheutz, C., Astrup, T.F., 2016. Food waste from Danish households: generation and composition. Waste Manag. 52, 256–268. https://doi.org/10.1016/j.wasman.2016.03.032.

Elimelech, E., Ayalon, O., Ert, E., 2018. What gets measured gets managed: a new method of measuring household food waste. Waste Manag. 76, 68–81. https://doi.org/10.1016/j.wasman.2018.03.031.

Everitt, H., van der Werf, P., Seabrook, J.A., Wray, A., Gilliland, J.A., 2022. The quantity and composition of household food waste during the COVID-19 pandemic: a direct measurement study in Canada. Socioecon. Plann. Sci. 82 (January), 101110. https://doi.org/10.1016/j.seps.2021.101110.

Filimonau, V., Chiang, C.C., Wang, L., Muhialdin, B.J., Ermolaev, V.A., 2023. Resourcefulness of chefs and food waste prevention in fine dining restaurants. Int. J. Hospit. Manag. 108 (October 2022), 103368. https://doi.org/10.1016/j.ijhm.2022.103368.

Filimonau, V., Fidan, H., Alexieva, I., Dragoev, S., Marinova, D.D., 2019. Restaurant food waste and the determinants of its effective management in Bulgaria: an exploratory case study of restaurants in Plovdiv. Tourism Manag. Perspect. 32 (September). https://doi.org/10.1016/j.tmp.2019.100577.

Filimonau, V., Matute, J., Kubal-Czerwińska, M., Krzesiwo, K., Mika, M., 2020. The determinants of consumer engagement in restaurant food waste mitigation in Poland: an exploratory study. J. Clean. Prod. 247. https://doi.org/10.1016/j.jclepro.2019.119105.

Flanagan, A., Priyadarshini, A., 2021. A study of consumer behaviour towards food-waste in Ireland: attitudes, quantities and global warming potentials. J. Environ. Manage. 284 (February), 112046. https://doi.org/10.1016/j.jenvman.2021.112046.

Gerke, O., 2020. Nonparametric limits of agreement in method comparison studies: a simulation study on extreme quantile estimation. Int. J. Environ. Res. Public Health 17 (22), 1–14. https://doi.org/10.3390/ijerph17228330.

Giordano, C., Alboni, F., Falasconi, L., 2019. Quantities, determinants, and awareness of households' food waste in Italy: a comparison between diary and questionnaires quantities. Sustainability (Switzerland) 11 (12). https://doi.org/10.3390/su11123381.

Gonçalves, M.L.M.B.B., Maximo, G.J., 2023. Circular economy in the food chain: production, processing and waste management. Circular Econ. Sustain. 3 (3), 1405–1423. https://doi.org/10.1007/s43615-022-00243-0.

Grant, F., Di Veroli, J.N., Rossi, L., 2023. Characterization of household food waste in Italy: three year comparative assessment and evaluation of seasonality effects. Waste Manag. 164 (January), 171–180. https://doi.org/10.1016/j.wasman.2023.04.006.

Gupta, A., Stead, T.S., Ganti, L., 2024. Determining a Meaningful R-squared Value in Clinical Medicine. Academic Medicine & Surgery 1–6. https://doi.org/10.62186/001c.125154.

Hartikainen, H., Riipi, I., Katajajuuri, J., Silvennoinen, K., 2016. From Measurement to Management: Food Waste in the Finnish Food Chain. Springer International Publishing doi: 10.1007/978-3-030-20561-4.

Hermanussen, H., Loy, J.P., Egamberdiev, B., 2022. Determinants of food waste from household food consumption: a case study from field survey in Germany. Int. J. Environ. Res. Public Health 19 (21). https://doi.org/10.3390/ijerph192114253.

Herzberg, R., Schmidt, T.G., Schneider, F., 2020. Characteristics and determinants of domestic food waste: a representative diary study across Germany. Sustainability (Switzerland) 12 (11), 1–17. https://doi.org/10.3390/su12114702.

Ilakovac, B., Voca, N., Pezo, L., Cerjak, M., 2020. Quantification and determination of household food waste and its relation to sociodemographic characteristics in Croatia. Waste Manag. 102, 231–240. https://doi.org/10.1016/j.wasman.2019.10.042.

Jamaludin, H., Elmaky, H.S.E., Sulaiman, S., 2022. The future of food waste: application of circular economy. Energy Nexus 7 (December 2021), 100098. https://doi.org/10.1016/j.nexus.2022.100098.

Jerie, S., Shabani, T., Shabani, T., 2024. Life cycle assessment of household food waste in Zimbabwe: a systematic review. Discover Food 4 (1). https://doi.org/10.1007/s44187-024-00145-0.

Jeswani, H.K., Figueroa-Torres, G., Azapagic, A., 2021. The extent of food waste generation in the UK and its environmental impacts. Sustainable Prod. Consumption 26, 532–547. https://doi.org/10.1016/j.spc.2020.12.021.

Jia, L., Zhang, Y., Qiao, G., 2022. Consumer-related antecedents of waste behavior in online food ordering: a study among young adults in China. Foods 11 (19), 1–19. https://doi.org/10.3390/foods11193098.

Jiang, S., Chen, H., Shan, P., Wang, X., 2024. Efficacy of informational intervention on food waste: evidence from a randomized controlled trial. J. Clean. Prod. 443 (August 2023), 141106. https://doi.org/10.1016/j.jclepro.2024.141106.

Jörissen, J., Priefer, C., Bräutigam, K.R., 2015. Food waste generation at household level: results of a survey among employees of two European research centers in Italy and Germany. Sustainability (Switzerland) 7 (3), 2695–2715. https://doi.org/10.3390/su7032695.

Joshi, P., Visvanathan, C., 2019. Sustainable management practices of food waste in Asia: technological and policy drivers. J. Environ. Manage. 247 (January), 538–550. https://doi.org/10.1016/j.jenvman.2019.06.079.

Kalumanga, V., 2024. How gender roles determine resilience to food insecurity among agro-pastoral communities in central Tanzania: HFIAS analysis. NG J. Soc. Dev. 13 (2), 243–259. https://doi.org/10.4314/ngjsd.v13i2.16.

Lang, L., Wang, Y., Chen, X., Zhang, Z., Yang, N., Xue, B., Han, W., 2020. Awareness of food waste recycling in restaurants: evidence from China. Resour. Conserv. Recycl. 161 (May), 104949. https://doi.org/10.1016/j.resconrec.2020.104949.

Li, X., Jiang, Y., Qing, P., Singh, R., Lamba, S., Goodwin, L., Dhar, M., Hari, D., Yang, J. W., Chen, C.S.H., Dai, H.F., Chen, C.S.H., Yeh, W.Y., Schneider, F., de Gorter, H., Drabik, D., Just, D.R., Oikonomou, M., 2023. Estimates of household food waste by categories and their determinants: evidence from China. Foods 12 (4), 1–15. https://doi.org/10.3390/foods12040776.

Liao, C., Qiao, L., Wang, X., Lu, S., 2022. Exploring food waste prevention through advent food consumption: the role of perceived concern, consumer value, and impulse buying. Front. Sustain. Food Syst. 6. https://doi.org/10.3389/fsufs.2022.988260.

Lima, R., Yu, A., Liu, Q., Liu, J., 2024. Examining the determinants of food waste behavior in China at the consumer level. Food Secur. 16 (4), 867–881. https://doi.org/10.1007/s12571-024-01466-9.

Lukiko, D., Sokoni, C.H., Lukiko, D., Sokoni, C.H., 2023. Assessment of food security status in Tanzania's rural context : the case of Chamwino. 43(1), 55–77.

Mandal, M., Roy, A., Das, S., Rakwal, R., Kumar, G., Singh, P., Awasthi, A., Sarkar, A., 2024. Chemosphere Food waste-based bio-fertilizers production by bio-based fermenters and their potential impact on the environment. Chemosphere 353 (July 2023), 141539. https://doi.org/10.1016/j.chemosphere.2024.141539.

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 (December 2021), 133447. https://doi.org/10.1016/j.jclepro.2022.133447.

Merian, S., O'Sullivan, K., Stöckli, S., Beretta, C., Müller, N., Tiefenbeck, V., Fleisch, E., Natter, M., 2024. A field experiment to assess barriers to accurate household food waste measurements. Resour. Conserv. Recycl. 206 (7), 107644. https://doi.org/10.1016/j.resconrec.2024.107644.

Mohd Razali, N., Bee Wah, Y., 2011. Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. Journal of Statistical Modeling and Analytics 2 (1), 13–14.

O'Brien, R.M., 2007. A caution regarding rules of thumb for variance inflation factors. Qual. Quant. 41 (5), 673–690. https://doi.org/10.1007/s11135-006-9018-6.

Ozili, P.K., 2023. The acceptable R-square in empirical modelling for social science research. In: Social Research Methodology and Publishing Results: A Guide to Non-Native English Speakers. IGI Global, pp. 134–143. https://mpra.ub.uni-muenchen.de/115769/1/MPRA_paper_115769.

Painter, K., Thondhlana, G., Kua, H.W., 2016. Food waste generation and potential interventions at Rhodes University, South Africa. Waste Manag. 56, 491–497. https://doi.org/10.1016/j.wasman.2016.07.013.

Parizeau, K., von Massow, M., Martin, R.C., 2021. Directly observing household food waste generation using composition audits in a Canadian municipality. Waste Manag. 135 (September), 229–233. https://doi.org/10.1016/j.wasman.2021.08.039.

Phasha, L., Molelekwa, G.F., Mokgobu, M.I., Morodi, T.J., Mokoena, M.M., Mudau, L.S., 2020. Influence of cultural practices on food waste in South Africa — a review.

Porpino, G., Parente, J., Wansink, B., 2015. Food waste paradox : antecedents of food disposal in low income households. 39, 619–629. doi: 10.1111/ijcs.12207.

Portugal, T., Freitas, S., Cunha, L.M., Rocha, A.M.C.N., 2020. Evaluation of determinants of food waste in family households in the greater porto area based on self- reported consumption practices. Sustainability (Switzerland) 12 (21), 1–12. https://doi.org/10.3390/su12218781.

Qian, L., Li, F., Cao, B., Wang, L., Jin, S., 2021. Determinants of food waste generation in Chinese university canteens: evidence from 9192 university students. Resour. Conserv. Recycl. 167 (January), 105410. https://doi.org/10.1016/j.resconrec.2021.105410.

Quested, T.E., Palmer, G., Moreno, L.C., McDermott, C., Schumacher, K., 2020. Comparing diaries and waste compositional analysis for measuring food waste in the home. J. Clean. Prod. 262, 121263. https://doi.org/10.1016/j.jclepro.2020.121263.

Read, Q.D., Muth, M.K., 2021. Cost-effectiveness of four food waste interventions: is food waste reduction a "win–win?". Resour. Conserv. Recycl. 168 (January), 105448. https://doi.org/10.1016/j.resconrec.2021.105448.

Sigala, E.G., Chroni, C., Boikou, K., Abeliotis, K., Panagiotakos, D., Lasaridi, K., 2024. Quantification of household food waste in Greece to establish the 2021 national baseline and methodological implications. Waste Manag. 190, 102–112. https://doi.org/10.1016/J.WASMAN.2024.09.012.

Shukla, K.A., Bin Abu Sofian, A.D.A., Singh, A., Chen, W.H., Show, P.L., Chan, Y.J., 2024. Food waste management and sustainable waste to energy: current efforts, anaerobic digestion, incinerator and hydrothermal carbonization with a focus in Malaysia. J. Clean. Prod. 448 (October 2023), 141457. https://doi.org/10.1016/j.jclepro.2024.141457.

Silvennoinen, K., Katajajuuri, J.M., Hartikainen, H., Heikkilä, L., Reinikainen, A., Jörissen, J., Priefer, C., Bräutigam, K.R., 2014. Food waste volume and composition in Finnish households. Br. Food J. 116 (6), 1058–1068. https://doi.org/10.1108/BFJ-12-2012-0311.

Sridhar, A., Kapoor, A., Senthil Kumar, P., Ponnuchamy, M., Balasubramanian, S., Prabhakar, S., 2021. Conversion of food waste to energy: a focus on sustainability and life cycle assessment. Fuel 302 (May), 121069. https://doi.org/10.1016/j.fuel.2021.121069.

Tamasiga, P., Miri, T., Onyeaka, H., Hart, A., 2022. Food Waste and Circular Economy. Challenges and Opportunities. Sustainability (Switzerland) 14 (16). https://doi.org/10.3390/su14169896.

Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable policy development. Resour. Conserv. Recycl. 106, 110–123. https://doi.org/10.1016/j.resconrec.2015.11.016.

Thyberg, K.L., Tonjes, D.J., Gurevitch, J., 2015. Quantification of food waste disposal in the United States: a meta-analysis. Environ. Sci. Tech. 49 (24), 13946–13953. https://doi.org/10.1021/acs.est.5b03880.

Tonini, D., Albizzati, P.F., Astrup, T.F., 2018. Environmental impacts of food waste: learnings and challenges from a case study on UK. Waste Manag. 76, 744–766. https://doi.org/10.1016/j.wasman.2018.03.032.

Tonini, P., Odina, P.M., Durany, X.G., 2023. Predicting food waste in households with children: socio-economic and food-related behavior factors. Front. Nutr. 10 (October). https://doi.org/10.3389/fnut.2023.1249310.

UNEP, 2024. Food Waste Index Report 2024. Nairobi.

UNEP DTU Partnership and United Nations Environment Programme, & UNEP DTU Partnership, 2021. Reducing consumer food waste using green and digital technologies. In: UNEP DTU Partnership. https://forskning.ruc.dk/en/publications/reducing-consumer-food-waste-using-green-and-digital-technologies.

Ünlüönen, K., Şimşek, N., 2021. Causes of household food waste and motivations to reduce food waste: sample of Mersin Province. J. Tourism Gastronomy Stud. 9 (4), 2384–2397. https://doi.org/10.21325/jotags.2021.897.

van der Werf, P., Seabrook, J.A., Gilliland, J.A., 2020. Food for thought: comparing self-reported versus curbside measurements of household food wasting behavior and the predictive capacity of behavioral determinants. Waste Manag. 101, 18–27. https://doi.org/10.1016/j.wasman.2019.09.032.

van Herpen, E., van Geffen, L., Nijenhuis-de Vries, M., Holthuysen, N., van der Lans, I., Quested, T., 2019. A validated survey to measure household food waste. MethodsX 6, 2767–2775. https://doi.org/10.1016/j.mex.2019.10.029.

Van Stralen, K.J., Jager, K.J., Zoccali, C., Dekker, F.W., 2008. Agreement between methods. Kidney Int. 74 (9), 1116–1120. https://doi.org/10.1038/ki.2008.306.

Varjani, S., Vyas, S., Su, J., Siddiqui, M.A., Qin, Z.-H.H., Miao, Y., Liu, Z., Ethiraj, S., Mou, J.-H.H., Lin, C.S.K., 2024. Nexus of food waste and climate change framework: unravelling the links between impacts, projections, and emissions. Environ. Pollut. 344 (October 2023), 123387. https://doi.org/10.1016/j.envpol.2024.123387.

Veselá, L., Králiková, A., Kubíčková, L., 2023. From the shopping basket to the landfill: drivers of consumer food waste behaviour. Waste Manag. 169 (May), 157–166. https://doi.org/10.1016/j.wasman.2023.07.002.

Wang, Z., Jiang, J., Zeng, Q., 2023. The effect of dietary awareness on household food waste. Waste Manag. Res.: J. Sustain. Circular Econ. 41 (1), 164–172. https://doi.org/10.1177/0734242X221105435.

Withanage, S.V., Dias, G.M., Habib, K., 2021. Review of household food waste quantification methods: focus on composition analysis. J. Clean. Prod. 279, 123722. https://doi.org/10.1016/j.jclepro.2020.123722.

Zhu, O.Y., Greene, D., Dolnicar, S., 2024. Should the risk of social desirability bias in survey studies be assessed at the level of each pro-environmental behaviour? Tour. Manag. 104 (April), 104933. https://doi.org/10.1016/j.tourman.2024.104933.