

Dolnicar, Sara; Gray, Angus; Grün, Bettina; Li, Hongwei; Portmann, Marius

Article

Automatically monitoring environmental performance in tourism: The example of plate waste at all-you-can-eat buffets

Annals of Tourism Research Empirical Insights

Provided in Cooperation with:

Elsevier

Suggested Citation: Dolnicar, Sara; Gray, Angus; Grün, Bettina; Li, Hongwei; Portmann, Marius (2023) : Automatically monitoring environmental performance in tourism: The example of plate waste at all-you-can-eat buffets, Annals of Tourism Research Empirical Insights, ISSN 2666-9579, Elsevier, Amsterdam, Vol. 4, Iss. 2, pp. 1-3, <https://doi.org/10.1016/j.annale.2023.100100>

This Version is available at:

<https://hdl.handle.net/10419/337762>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>



Automatically monitoring environmental performance in tourism – The example of plate waste at all-you-can-eat buffets

Sara Dolnicar^{a,1,*}, Angus Gray^a, Bettina Grün^b, Hongwei Li^a, Marius Portmann^a

^a The University of Queensland, Australia

^b Wirtschaftsuniversität Wien, Austria

ARTICLE INFO

Editor: Dr. Kirilova Ksenia

Keywords:

Sustainable tourism
Environmental performance
Engineering
Benchmarking
Experiments

1. Introduction

Multi-site field experimentation is critical to creating practically relevant context-independent and scientifically robust knowledge (Viglia & Dolnicar, 2020). Yet, field studies are rare in tourism research. When used, they are typically implemented at one specific field site (e. g., Kallbekken & Sælen, 2013; Knežević Cvelbar, Grün, & Dolnicar, 2021), severely limiting the generalisability of findings in several ways: Conclusions are valid only for a specific geographical region, a specific type of business, a specific consumer segment, or a specific season of the year. Field experiments are rare and limited to individual sites because they are expensive and labour-intensive to implement. Automatic data collection would make field studies affordable, increasing their uptake and, ultimately, strengthening conclusions. Automation of measuring target behaviours, therefore, represents a key methodological contribution that would facilitate studies developing and testing interventions aimed at improving the target behaviour. Automated measurement also responds directly to United Nations Sustainable Development Goal 12, Target 12b, which calls for developing and implementing “tools to monitor sustainable development impacts for sustainable tourism”.

Yet, to date, few automatic measurement systems of real behaviour are available. The present study makes a step towards filling this gap by developing an automated data collection system for one specific environmental performance indicator for tourism businesses that offer food

service: plate waste (food served on a plate but left behind uneaten at the end of the meal). The system, a methodological contribution to tourism knowledge and future knowledge development by tourism researchers, provides performance feedback to management and serves as real-world laboratory for field studies by tourism researchers who develop, and test behavioural change interventions aimed at reducing plate waste. Consumers have been identified as the most promising target for food-related carbon emissions reduction (Poore & Nemecek, 2018), and plate waste is 92% preventable (Papargyropoulou et al., 2016) without compromising the enjoyment of diners (Dolnicar, Juvan, & Grün, 2020).

2. Prior work

Food production uses 43% of the world's ice- and desert-free land, two thirds of all fresh water, and generates 26% of anthropogenic greenhouse gas emissions (Poore & Nemecek, 2018). Tourism contributes substantially to global food waste, yet little action has been taken to reduce food waste (Beretta & Hellweg, 2019; Gössling, 2015), possibly because tourism businesses do not want to reduce guest satisfaction (Dolnicar, 2020). Despite the increased interest in understanding the drivers of plate waste (Juvan, Grün, & Dolnicar, 2018; Juvan, Grün, Zabukovec Baruca, & Dolnicar, 2021; Wang et al., 2018), only a few interventions have proven effective in reducing plate waste in tourism: Smaller plates at buffets (20% reduction; Kallbekken & Sælen, 2013), a

* Corresponding author at: The University of Queensland, Room 439, GP North Building (39A), St Lucia Campus, Brisbane, Qld 4072, Australia.

E-mail address: s.dolnicar@uq.edu.au (S. Dolnicar).

¹ Authors listed in alphabetical order.

table sign inviting tourists to return to the buffet (21% reduction; Kallbekken & Sælen, 2013), and a stamp collection game for families (34% reduction among families; Dolnicar et al., 2020). These studies have limited generalisability because they have been conducted in very specific settings. Any research investigating plate waste generation and, more importantly, testing new approaches to reduce plate waste, relies on labour-intensive and expensive manual measurement of food waste. The process of empirically testing many promising new behaviour change interventions could be sped up materially if measurement were automatic, reducing substantially the cost and effort of field experiments. Automatic measurement can also prevent data contamination by errors caused by human data entry. Several commercial plate waste systems exist (see Supplementary Materials for a comparison), but they do not count how many diners have been served at any given time (making per diner measures impossible to calculate), do not provide raw data (needed by researchers), and require manual intervention (they do not operate in a fully automatic way).

3. An automatic plate waste measurement system

Our newly developed Internet of Things equipment package contains two core devices (weighing scale, people counter) and several complementary devices. The scale measures plate waste in grams in a waste bin. The people counter records how many people enter and exit the dining room.

The scale is under the bin used by waiters to dispose of plate waste. It is a commercial steel-framed load cell scale, rated for weights up to 150 kg and a precision of 10 g. An unmodified scale cannot transmit data. We integrated two components to build a custom-made connected weighing scale Internet of Things system. Due to reliability issues with the hotel's Wi-Fi network, we installed a dedicated wireless network for our Internet of Things system to ensure continuous connectivity. The scale is plugged into a standard power supply to avoid the need to recharge batteries.

The second system component is a dual-camera-based people counter, counting people entering and exiting the dining room with 95% accuracy. There is a small residual error, but this error is systematic and therefore will not negatively affect testing of behavioural change interventions. Reducing this error would require capturing more information from diners, which may risk breaching privacy laws. It is installed above the door to the dining room – making it virtually invisible to diners – and sends data via Wi-Fi to a cloud-based database managed by the manufacturer. From there, the data is read in one-minute intervals, and copied to our server. We have since developed an alternative system that allows data to be transmitted directly into our database, bypassing the manufacturer.

The two core devices work together to obtain synchronised data of plate waste and the number of diners, generating a time-series of cumulative plate waste in the kitchen bin and the cumulative number of people entering and exiting the restaurant. These time series are at different resolutions, both fine grained enough to identify spurious measurements and allowing for coarsening to different time periods of interest, e.g., to obtain hourly or daily measurements of total plate waste and total number of guests. From these measurements we calculate average plate waste per person per period of time.

The current system has the limitation of requiring a power source. The scale needs to be plugged into a power-point; the people counter needs to be hardwired.

4. Illustration

In our test hotel, weight data is available every ten seconds; the scale is calibrated and initialised to zero before the breakfast service. Weight increases monotonically over time, corresponding to waiters disposing of plate waste in the bin during breakfast and lunch. The (large) bin is emptied daily – after the last meal service. These measurements allow

calculation of kilograms of plate waste in the bin for specific time windows. Measurement errors can occur. For example, staff may forget to empty the bin at the end of the last meal service. Such errors can be detected and compensated for in the data pre-processing stage of our system. For example, if the weight measurement is not zero in the morning, the base weight can be subtracted from the daily measurement. If weight drops during the day, the bin has been emptied earlier than planned; this can also be corrected.

The people counter provides the cumulative number of people who entered/exited the dining room on any given day. Every morning, the counter is reset to zero. The difference between people entering and exiting serves as an estimate of the number of diners at any given time interval. At the end of the day, the number of people entering should be equal to the number of people exiting. Measurement errors can be caused by device inaccuracies, by staff using the dining room and the kitchen door, or by hotel guests temporarily exiting the dining room to go to their room or the restrooms. The extent of the measurement error is expected to be consistent, thus not affecting the ability to determine if an intervention has been effective.

Average plate waste per person per day is calculated by dividing the maximum daily scale measurement by the maximum cumulative number of people entering the dining room on that day. Fig. 1 contains the daily time series for a three-week period. Days are plotted along the x-axis and measurements along the y-axis. The observed values appear as dots. A peak is visible on the 7th of March 2021, indicating that many people ate at the restaurant on that day, which was a Sunday, and total plate waste was unusually high as a result. The daily time series for average waste per person (in grams) is derived by dividing the plate waste by the number of people (right side of Fig. 1). The values range between 200 g and 300 g per person most of the time and the results show that plate waste per person was not particularly high on the 7th of March 2021.

Collecting plate waste and number of people in the dining room automatically over long periods of time – and optimally across many venues – offers a reliable benchmark for plate waste generated, allows venues to compare their performance and serves as the baseline for testing interventions aimed at reducing plate waste. In addition, one could investigate research questions such as a potential seasonality effect, specific regularities regarding plate waste variation or other variables influencing plate waste generation, such as guest mix. The guest mix could be derived based on de-identified data from the hotel database.

5. Conclusions

We have developed an automatic real-time measurement of plate waste that can be used to test the effectiveness of interventions aimed at reducing plate waste generated by patrons in food outlets. Food outlets may wish to install it to contribute to the testing of new behaviour change interventions aimed at reducing plate waste, or to be able to accurately report on plate waste as part of their environmental performance disclosure. We also identify key characteristics of such an automatic data collection system: (1) smooth integration into daily routine procedures, (2) minimum manual interference requirements, (3) ensuring reliable internet connectivity to transmit data on a continuous basis, (4) direct storage of raw data in a self-owned database instead of relying on interfaces provided by device manufacturers. Our system allows restaurants and hotels to monitor their plate waste and reduce it via two improvement pathways: (1) Direct feedback may encourage management to take action to reduce plate waste; and (2) automatic measurement enables researchers to experimentally test many different behavioural change interventions aimed at reducing plate waste, which reduces cost for food venues and helps contribute to the achievement of the UN aim of reducing food waste by 50% by 2050.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.annale.2023.100100>.

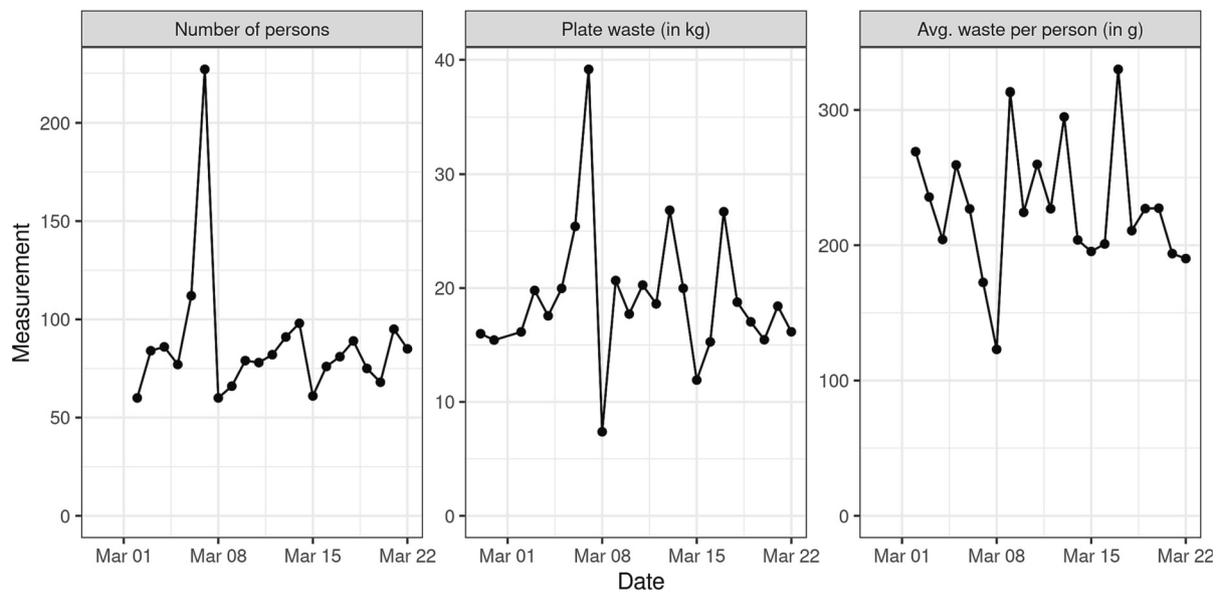


Fig. 1. Time series of daily measurements of number of persons, plate waste (in kg) and the average waste per person (in g).

Declaration of Competing Interest

There are no conflicts or potential conflicts of interest.

Acknowledgement

We thank the Australian Research Council for support under its Discovery Grant Scheme (DP180101855) and the Austrian Science Fund under the Joint Projects Grant Scheme (FWF: I 4367). Please note that authors are listed in alphabetical order.

References

- Beretta, C., & Hellweg, S. (2019). Potential environmental benefits from food waste prevention in the food service sector. *Resources, Conservation and Recycling*, *147*, 169–178.
- Dolnicar, S. (2020). Designing for more environmentally friendly tourism. *Annals of Tourism Research*, *84*, Article 102933.
- Dolnicar, S., Juvan, E., & Grün, B. (2020). Reducing the plate waste of families at hotel buffets. *Tourism Management*, *80*, Article 104103.
- Gössling, S. (2015). New performance indicators for water management in tourism. *Tourism Management*, *46*, 233–244.
- Juvan, E., Grün, B., & Dolnicar, S. (2018). Biting off more than they can chew. *Journal of Travel Research*, *57*(2), 232–242.
- Juvan, E., Grün, B., Zabukovec Baruca, P., & Dolnicar, S. (2021). Drivers of plate waste at buffets. *Annals of Tourism Research Empirical Insights*, *2*(1), Article 100010.

- Kallbekken, S., & Sælen, H. (2013). ‘Nudging’ hotel guests to reduce food waste as a win-win environmental measure. *Economics Letters*, *119*(3), 325–327.
- Knežević Cvelbar, L., Grün, B., & Dolnicar, S. (2021). To clean or not to clean? *Journal of Travel Research*, *60*(1), 220–229.
- Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R., & Ujang, Z. (2016). Conceptual framework for the study of food waste generation and prevention in the hospitality sector. *Waste Management*, *49*, 326–336.
- Poore, J., & Nemecek, T. (2018). Reducing food’s environmental impacts through producers and consumers. *Science*, *360*(6392), 987–992.
- Viglia, G., & Dolnicar, S. (2020). A review of experiments in tourism and hospitality. *Annals of Tourism Research*, *80*, Article 102858.
- Wang, L., Xue, L., Li, Y., Liu, X., Cheng, S., & Liu, G. (2018). Horeca food waste and its ecological footprint in Lhasa. *Resources, Conservation and Recycling*, *136*, 1–8.

Sara Dolnicar (University of Queensland) leads the Low Harm Hedonism Initiative which aims at reducing the negative environmental impacts of consumer behaviour in enjoyment-focused contexts, such as on vacations.

Angus Gray is a PhD candidate at The University of Queensland.

Bettina Grün (Wirtschaftsuniversität Wien) is an applied statistician with specific expertise in the analysis of field experiments.

Hongwei Li (University of Queensland) is an engineer with an interest in measuring environmental performance.

Marius Portmann (University of Queensland) is an expert in the Internet of Things.