



**AALBORG UNIVERSITY**  
DENMARK

**Aalborg Universitet**

## **Factors influencing changes in island waste systems**

*The case of Bornholm, Denmark*

Hjul-Nielsen, Jens; Santos, Aginaldo; Christensen, David Andreas Mana-Ay; Andrade, Bruna

*Published in:*  
Cleaner Waste Systems

*DOI (link to publication from Publisher):*  
[10.1016/j.clwas.2023.100080](https://doi.org/10.1016/j.clwas.2023.100080)

*Creative Commons License*  
CC BY-NC-ND 4.0

*Publication date:*  
2023

*Document Version*  
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

*Citation for published version (APA):*  
Hjul-Nielsen, J., Santos, A., Christensen, D. A. M.-A., & Andrade, B. (2023). Factors influencing changes in island waste systems: The case of Bornholm, Denmark. *Cleaner Waste Systems*, 4, Article 100080. <https://doi.org/10.1016/j.clwas.2023.100080>

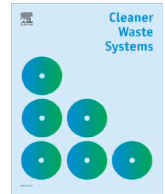
### **General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

### **Take down policy**

If you believe that this document breaches copyright please contact us at [vbn@aub.aau.dk](mailto:vbn@aub.aau.dk) providing details, and we will remove access to the work immediately and investigate your claim.



# Factors influencing changes in island waste systems: The case of Bornholm, Denmark



Jens Hjul-Nielsen<sup>a</sup>, Aginaldo Santos<sup>b,\*</sup>, David Christensen<sup>a,d</sup>, Bruna Andrade<sup>c</sup>

<sup>a</sup> Bornholm's Waste Treatment (BOFA), Denmark, Almegårdsvej 8, 3700 Rønne

<sup>b</sup> Design Department, Parana Federal University, Rua General Carneiro, 460, sala 717, Centro, Curitiba, Paraná CEP: 80060-150, Brazil

<sup>c</sup> Design Post-graduate Program, Paraná Federal University, Brazil

<sup>d</sup> Department of Planning, Aalborg University Copenhagen, A.C. Meyers Vænge 15, 2450 Copenhagen SV

## ARTICLE INFO

### Keywords:

Waste system  
Island  
ISWM framework  
Zero waste

## ABSTRACT

The study investigates the factors influencing the waste system change in the island of Bornholm, Denmark. The study uses the ISWM (Integrated Sustainable Waste Management) framework as its main theoretical foundation. The research was carried out using a large-scale (3 % of the population in the island), representative, quantitative survey with questions informed by the ISWM framework, including circular economy perspectives. To analyze the expectations in the hypotheses the data was run through a Z-test. The study unveils that a high baseline level of awareness about environmental issues is one of the key factors influencing the waste system change. Furthermore, the interests in the local (i.e. island) angle are preferred, where the consideration for solutions that directly benefit the island are preferred over solutions based on mainland activities. There is an acceptance of increased costs when the changes are implemented but as cost rises, acceptance decreases.

## 1. Introduction

Waste management is a great challenge for islands where policies, programs and projects should account for peculiarities such as the typical seasonal fluctuation of inhabitants throughout the year and the complexity of operations due to inherent spatial constraints. The challenge is exacerbated when taking into consideration current consumption and production patterns, characterized by a high level of waste generation per capita (Iyamu et al., 2020). In this context, the present paper intends to contribute to this issue by investigating the factors that can influence the changes in waste systems. The study was carried out on the Danish Island of Bornholm, in the Baltic Sea Region, with a population of 39,552 as per January 1, 2022 (Bornholm Municipality, 2022). Bornholm has an area of 588 square kilometers and is a popular tourist destination with approximately 600,000 visits annually (Horesta, 2022), with accompanying seasonality in the number of inhabitants throughout the year which reflects in the waste generated. Approximately 80,000 metric tons of waste in total is generated from all sources annually (i.e. from households and commercial sources), of which 5,4 % is landfilled, 26,9 % incinerated and 67,7 % sent for recycling in 2021. Waste variability between the summer and the winter period reaches approximately 150 %.

One critical challenge for Bornholm is the difficulty of reaching critical mass for public services. Due to its geographical remoteness its waste management services are provided primarily by local stakeholders. This includes a waste incineration plant, a landfill, and recycling facilities, all owned and operated by the municipality. This situation has often caused the need for exemptions from national legislation.

Bornholm adopted the vision of the municipal waste company BOFA, of a waste-free Bornholm by 2032. The vision's main goal focuses on elimination of incineration as a waste treatment strategy in accordance with the waste hierarchy. Today, approximately 26 % of the total amount of waste on Bornholm is incinerated in the sole incinerator on the island while 6 % is landfilled. The remainder is either sent for recycling or reused, e.g., through second-hand stores (Christensen et al., 2021). According to the vision, incineration and landfilling will both be eliminated by 2032 and all waste will be either recycled or reused while also increasing focus on waste prevention. This positions Bornholm as determined to carry out a radical change from a linear to a circular economy (Christensen, 2022), and will have implications for society at large that goes beyond the technical issues.

Underpinning guidance for the 2032 Vision has been the concept of provisioning of public value (Moore, 1995) and of benefiting from

\* Corresponding author.

E-mail address: [asantos@ufpr.br](mailto:asantos@ufpr.br) (A. Santos).

constraints (Elster, 1977), i.e., converting Bornholm's geographical characteristics into opportunities. The vision further stresses that results of changing from linear to circular economy will be scalable and transferrable nationally and internationally. Scalability is important. Other islands and small communities are also working with sustainability issues. For example Vlieland Island in the Netherlands carries out active studies on circular business models in association with its energy self-sufficient goals (Metabolic, 2017) but often islands and small communities do not have the complexity (agrarian, industry, rural, urban, etc.) to be able to scale the results to national and international levels. However, it is the ambition of BOFA that the implementation of the vision has scalability potential and benefits several sectors/dimensions such as tourism, job creation, education, businesses, nature and climate.

This paper seeks to answer the following question: **What factors should be considered that influence local stakeholders' adherence to changes in the waste system within an island?** Besides its theoretical dimension the answer to this question has a pragmatic relevance, as it is instrumental to support the implementation of BOFA's 2032 vision and, hopefully, can contribute to those involved in establishing policies and strategies for island waste management elsewhere around the world. Notice that the concept of "waste system" here is concerned with the related physical elements, from generation to final disposal, as well as waste hierarchy elements.

Previous participatory studies on waste management provided limited contributions to understand the factors that could influence the selection and adoption of new practices and technologies on waste management within islands. Back-casting, the most common foresight tool for islands, could benefit from a deeper understanding about these factors, avoiding the need to adapt parameters to the specific islands contexts. Fuldauer et al. (2019), for instance, has adopted KPIS in association with SDG goals when carrying out a back-casting on their investigation of scenarios of waste management within islands.

The literature review has unveiled that most studies focus on the factors that affect waste generation and not so much on the factors that affect the direction of changes in the waste system. Diaz-Farina et al. (2020), for instance, has investigated factors that impact waste generation (ex: consumption patterns, population size, average age of population, household size and climate) including both demand and supply side perspectives. The topic has received more attention in non-island contexts, with investigations on issues such as factors that affect public acceptance and engagement or strategies to overcome public resistance waste to waste management practices (Caferra et al., 2023; Moustairas et al., 2022).

## 2. Theoretical background

### 2.1. The complexity of waste management within islands

The geographical peculiarities of islands present several challenges with regards to waste handling. Some of these peculiarities include a) high per-capita infrastructure costs; b) remoteness; c) restricted resource availability; d) lack of scale and, for many islands, d) high dependence on tourism (Fuldauer et al., 2019). Islands are directly affected by marine litter pollution, depending on their location and urban development characteristics, where a portion of the waste can be traced elsewhere in the globe (Verlis and Wilson, 2020).

Within the theme of tourism, the literature describes that waste handling is complicated due to many islands having a large tourist industry (Estay-Ossandon and Mena-Nieto, 2018; Panaretou et al., 2017; Camilleri-Fenech et al., 2018; Skordilis, 2004), which is often seen among Mediterranean Islands and Small Island Developing States (SIDS). The study of Diaz-Farina et al. (2020) estimated that main tourism activities generated 0,40 kg of mixed waste per tourist daily whilst residential and economic sectors account for 1,19 kg per resident daily. Hence, seasonal fluctuation puts a high strain on the waste

management system within islands with variability up to 40 % in waste amounts during the course of a year.

The scale issue deals with critical mass resource availability and waste treatment and logistics options. The need for transportation in association with the lack of critical population mass is exacerbated with the relative remoteness of islands. Because of such context, Mancini et al. (2017) suggest viewing islands as "self-contained waste management systems, with the goal of maximizing the recovery, whilst limiting transportation costs". Wang et al. (2021) takes a skeptical perspective, suggesting that in the case of small islands it is not possible to practice waste reduction as they depend on imported goods.

The general literature on waste management on islands is centered mostly on tropical islands and (in a European setting) on Mediterranean islands. In the context of islands in developing countries the literature shows that the lack of financial resources adds further to the complexity of carrying waste management. As an example, Mohee et al. (2015) provided an overview of 52 island communities in the developing world and their individual states with regard to both collection schemes and waste treatment. They find that waste management is a matter of great concern, particularly for SIDS and that sustainable waste management practices, previously absent, are now emerging although there still are many difficulties in the implementation of these practices.

In the Mediterranean area the studies on the topic of waste management are propelled by the sheer number of islands, their popularity as tourist destinations, and the work of organizations such as Network of Sustainable Greek Islands and The Conference of Peripheral Maritime Regions. Although under a wealthier context, the studies on the Mediterranean area point to many similar findings regarding the factors that influence changes in the waste system. In a study of the Canary Islands, Santamarta et al. (2014) find that the common problems affecting waste handling on all islands are "Reduced number of facilities for treatment or disposal; importance of tourism; high population density; limited territory to locate landfills; difficult to achieve economies of scale; transportation of waste to the mainland" (p 163). They recommend decreasing waste generation as the most successful strategy to overcome these challenges, whereas Vilms and Voronova (2016) suggest focusing on financing the waste handling system primarily through additional charges and fees on the tourist sector.

Concerning the "strengths" issue, Eckelman et al. (2014) analyze conditions on a number of islands and conclude somewhat similarly with Santamarta et al. (2014) that the most severe waste handling problems stem from "limited land resources, high energy costs, large seasonal fluctuations in waste volumes, and complex social and political dynamics." (p 306). On the positive side, they also point out the strength of islands as a base for model systems as islands tend to be "tractable in their size and physical complexity, naturally bounded on a systems level, with unique biophysical and socio-cultural assets, and with political (and accounting) systems that generally match geographic boundaries." (p 307). Despite this potential strength of islands, Wang et al. (2021) calls attention to the fact that, in the case of small islands where there are few landfill options, governments often resort to open dumps and open-pit solid waste burning.

The literature that describes circular economy aspects within islands often tend to focus on peripheral issues to waste management such as sewage (Levlin, 1999) or the tourism industry (Matecki, 2020). Most literature, however, describes islands where landfilling is still an important waste treatment strategy and incineration is not used. Thus, the situation described in these places is not comparable with nor entirely relevant to the vision set for Bornholm in 2032. In more general terms, the literature review showed that research on studies on specific characteristics of the Baltic Sea Islands is still sparse.

### 2.2. Integrated sustainable waste management

The investigation into the factors that affect changes on waste systems in an island requires a holistic perspective considering the specific

local characteristics and needs. [Weekes et al. \(2021\)](#) argues that each island is a territory with a peculiar mix of factors and a waste management system derived must be customized according to these factors, encompassing the socioeconomic, cultural, economic, legislative, institutional and environmental context of the territory.

Among the various models to achieve this holistic perspective is the ISWM (Integrated Sustainable Waste Management) Model, which connects on one hand technical and social aspects and, on the other hand, enables to set a more complete picture of a waste system ([Guerrero et al., 2013](#)). The resulting holistic view minimizes the risk of overlooking important issues by stressing the connectivity of the different elements of the waste system. This differs from a number of other models that might primarily focus on technical issues, such as waste hierarchy or on organization issues such as the public value as per [Moore \(1995\)](#). [Fig. 1](#) illustrates the ISWM model proposed by [Anschütz et al. \(2004\)](#), with its emphasis on all elements of the process including waste streams and stakeholders.

The ISWM Model has been used as an analytical tool in several large comparative studies such as [Wilson et al.'s \(2013\)](#) which included 20 cities and on [Christensen's \(2018\)](#) which compared two countries. [Gopal et al. \(2018\)](#) use ISWM models to identify drivers and barriers for system integration in India. However, while the ISWM model has been used extensively in low and middle-income countries, it is less often used in the analysis of matured waste handling systems in high-income countries.

Another attempt to provide a more holistic and integrated perspective on the factors that can affect waste systems is the proposition provided by [Kirchherr et al. \(2017\)](#), which integrate circular economy strategies with the waste hierarchy levels. Their proposition derived from a study that revised 114 definitions of circular economy, resulting on the relationships between circular economy and the waste hierarchy as illustrated on [Fig. 2](#):

Upon examination of the different strands of literature for the present study, the ISWM framework was selected as the most suitable model. Despite its most common usage in middle and low-income countries, the ISWM framework excels by having a holistic perspective on waste systems including both social and technical elements and stressing the connectivity of various issues identified in the literature. In contrast, the circular economy and waste hierarchy model proposed by [Kirchherr et al. \(2017\)](#) lacks the social element in particular. As Bornholm is striving to change from a linear to circular economy starting from the waste sector, the ISWM framework was considered to be suitable as it narrows on waste systems as a unit of analysis with importance placed on the social element as well as the technical waste system elements and their inter-relations.

### 3. Research method

The research problem of this investigation could be characterized as having a descriptive nature since a variety of factors that influence changes in waste systems are already described in the literature, although with a reduced amount of studies into the relevance of these factors for the idiosyncrasies of island contexts. According to [McCartan and Robson \(2016\)](#) descriptive research aims to accurately and systematically describe a population, situation or phenomenon, enabling the answer of what, where, when and how questions, but not why questions. Hence, under such context the investigation has selected Survey as the main research method. Other authors within this theme have also adopted a similar research method strategy. [Moustairas et al. \(2022\)](#), for instance, have investigated factors that influence environmental awareness also using Survey as the research method.

The survey consists of two parts: part 1: background and general questions: deals with background variables such as gender, age, income and educational level, and housing type; part 2: it consists of questions generated based on the ISWM model (Waste System Element Perspective Questions).

The interviewees for the qualitative part of the research were selected using ISWM as a guide. Thus, interviewees representing all the relevant stakeholders mentioned such as local authorities, NGOs, users, private sector (formal and informal) were all identified. Recruiting was primarily based on foreknowledge of the sector and to a lesser degree on snowball sampling ([Bryman et al., 2019](#)) particularly in order to identify representatives of the “user” stakeholder group.

The reviewed literature about the ISWM framework offered insights to interconnected perspectives in a waste system but did not necessarily offer propositions that could be directly transformed into hypotheses for Bornholm's waste system. To analyze the expectations in the hypotheses the data was run through a Z-test ([Bryman et al., 2019](#)) as a chosen statistical testing method. The range of possible values for the statistic test was divided into two parts: an Acceptance Region, and a Critical Region.

Due to the COVID-19 pandemic, all interviews were performed and recorded using a web-based video conference platform. No interviews were carried out face-to-face. The average interview lasted between 20 and 30 min. The interviews were semi-structured with emphasis on open-ended questions using probing and prompting ([Weller et al., 2018](#)). The interviews were subsequently coded ([Bryman et al., 2019](#)) and a point of saturation was reached where no new themes arose through the coding process ([Kvale, 2007](#); [Lowe et al., 2018](#)). In this process a series of themes were identified of which four were recurring in a substantial number of interviews: a) the municipality's leadership role; b) the information deficit; c) the acceptance of increased cost, and d) the opportunities for new and strengthened partnerships. All interviews were conducted in Danish, the native tongue of the interviewees, and the coding was based on the Danish language interviews. Thus, only those parts which are quoted in the paper, have been translated into English.

## 4. Results

### 4.1. Implementation of the survey

The implementation of a Survey which was conducted April–May 2021 with 1049 respondents out of 3325 sampled, i.e. a response rate of 35.4%. Indeed, the survey was deemed sufficient to provide statistically significant results, as a figure of 500 respondents for Bornholm's population could have been acceptable ([Krejcie and Morgan, 1970](#)). The study has a high rate of response when compared to similar studies such as the work of [Moustairas et al. \(2022\)](#), which achieved 1% of the island population. The Integrated Sustainable Waste Management (ISWM) framework ([Guerrero et al., 2013](#)) provided the structure of the questioning framework. As stated earlier in this paper the results regarding the dimension of “waste system elements” of ISWM are reported.

The first part of the survey, which deals with background variables such as gender, age, income and educational level, provides the socio-economic profile of the respondents. [Table 1](#) provides the main characteristics of the survey respondents (gender, age and educational level) against their correspondent household's annual gross income (in DKK, the Danish currency<sup>1</sup>). It is worth mentioning that 44% of the respondents are over 60 years old, 50% are male and 50% are female, and 43% have technical education:

The paper focuses on Questions 8–17 of the survey that addresses various aspects of the Waste System Elements perspective. In these series of questions, respondents were asked about their attitudes to changes in waste collection schemes to a more-refined curbside collection method, and the technical artifacts that these changes will result in, i.e. bins and waste sorting at home (Questions 8–9). Additionally, respondents were asked about their attitudes about where the treatment

<sup>1</sup> Exchange rate at the time of the research: 1 EUR = 7.4359 DKK.

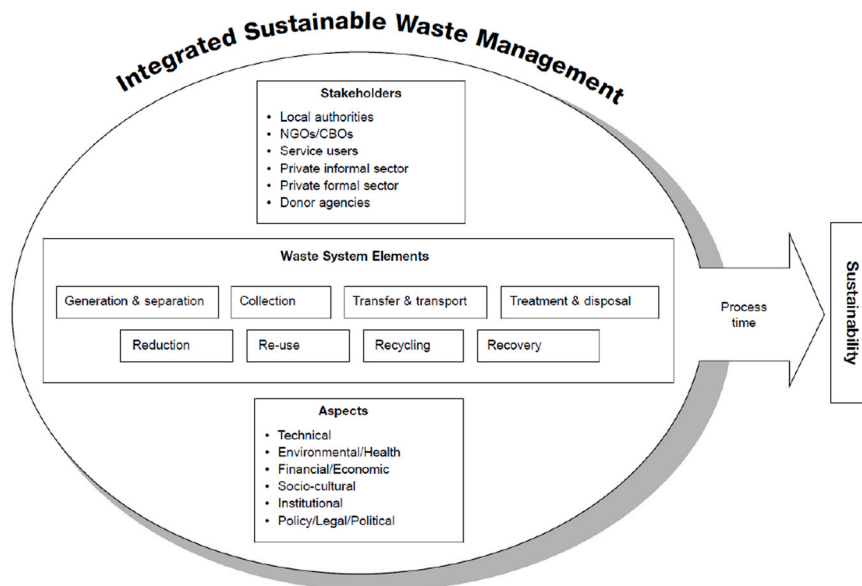


Fig. 1. The ISWM model (Anschütz et al., 2004).

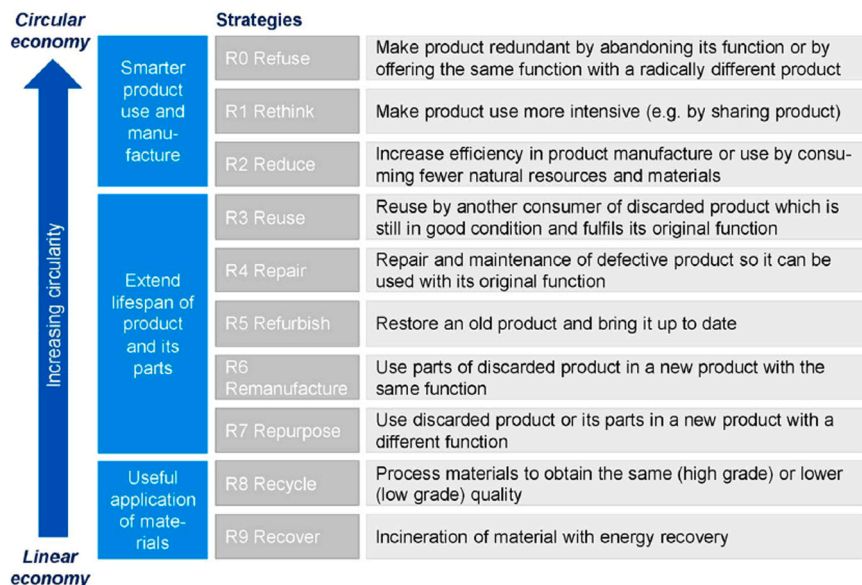


Fig. 2. Connections between circular economy and the waste hierarchy (Kircherr et al., 2017).

of their waste occurs, whether on the island of Bornholm or off-island, as well as their attitude to knowing about what happens to their waste once they dispose of it (Questions 10–11). Respondents were also asked about whether their consumption practices take due consideration to environmental and packaging considerations, and the importance they placed on avoiding overconsumption (Questions 12–13). Respondents’ reuse behavior and attitudes were the subject of a few questions, where they were asked about the frequency of discarding and taking items for reuse, respectively, and whether they thought further reuse platforms were needed (Questions 14–16). Finally, respondents were asked a key question about their attitude toward reuse and recycling versus incineration, including due consideration to the economics of waste incineration perhaps being the cheaper treatment option. It can be observed among the responses for Question 8 (see Fig. 3) that they are distributed almost perfectly symmetrically in bell-curve fashion with most respondents adhering to the statement square in the middle: “neither easy nor difficult”. This shows a neutral attitude to the question as the majority opinion, though could also be taken to indicate a polarization of the matter.

As for Question 9, Fig. 4 shows that while 25 % of respondents believe it to be “Difficult” or “Very difficult” to live up to using a maximum of 4 waste bins, 45 % of respondents believe they would “Easily” or “Very easily” live up to it. Since a majority of respondents (58 %) live in detached houses as per the background variables with presumably enough space for up to 4 waste bins, this could be an explanatory factor behind an overall positive response to this question. However, 25 % of respondents with potential difficulties in accommodating up to 4 waste bins marked this issue as an important point of attention.

Worth mentioning that for Question 8 and 9, the hypothesis was of a moderate level of concern and difficulty in living up to national requirements. However, the statistical tests did not support this hypothesis, although it should be noted that the tested proportion was exactly 50 %.

As can be observed, with respect to where waste ought to be treated in Question 10 (see Fig. 5), there is strong importance associated with this question: 31 % deem it important, and 29 % deem it very important. Conversely, only 7 % deem it less important, and 9 % deem it not important at all. While technically this question doesn’t actually correlate a high level of importance to the question with an opinion that

**Table 1**  
Socio-economic profile of the survey respondents. (The authors, 2022).

	Household's annual gross income						Total (%)
	Under 200k (%)	200–299k (%)	300–399k (%)	400–499k (%)	500–599k (%)	600k or more (%)	
<b>GENDER</b>							
Male	44	52	49	53	56	50	50
Female	56	48	51	47	44	50	50
<b>AGE</b>							
18–30 years	18	6	8	6	22	9	10
31–40 years	8	10	8	2	10	21	11
41–50 years	6	10	12	13	18	22	15
51–50 years	7	12	20	21	26	26	20
+ 60 years	61	63	51	59	24	23	44
<b>EDUCATION</b>							
Primary school	55	35	21	15	27	11	24
High school	13	5	6	3	3	4	6
Technical Education	26	44	45	55	38	44	43
Short higher education	2	4	6	8	3	4	5
Intermediate higher education	3	9	18	14	23	23	16
Bachelor	1	1	1	1	2	1	1
Long higher education	1	1	4	3	5	12	6

### Survey - Question 8

The Danish parliament has decided that everyone is to sort their waste in at least 10 waste fractions (cardboard, paper, textiles, plastic, metal, glass, food and beverage cartons, food waste, residual waste and hazardous waste). How would you be able to live up to this?

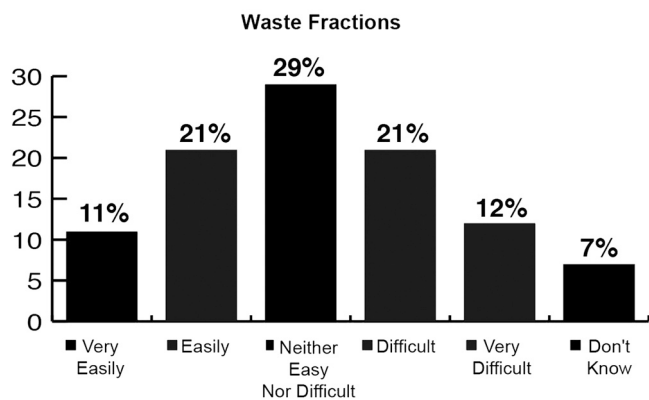


Fig. 3. Attitudes to a more-refined curbside collection method.

waste should remain and be treated on Bornholm, this may be inferred from the responses. For Question 10, the hypothesis was an expectation that the geographical location of treatment was less important. The results showed that 7% answered “Less important”. Hence, the statistical test did not result in support of this hypothesis.

With respect to Question 11 (see Fig. 6), it can be observed that there are moderately high levels of importance associated with knowing what happens when waste is disposed of: 13% of respondents deem it not important, while 15% deem it very important, a more-or-less-equal split among the extremes. However, fully 24% and 28% respectively deem the question important or somewhat important. While the question isn't able to specify whether strong levels of curiosity or strong opinions about particular waste treatment pathways are behind these responses, nonetheless the results show that the matter does preoccupy most people in their relationship with their waste. For Question 11, the hypothesis was expectation of a moderate to high level of environmental awareness. The proportion tested was the combined proportion of respondents who answered “Somewhat important” (28%), “Important” (24%) and “Very important” (15%). The statistical test resulted in support of the hypothesis.

### Survey - Question 9

The Danish parliament has decided that there are to be maximum 4 waste bins per house. How would you be able to live up to this?

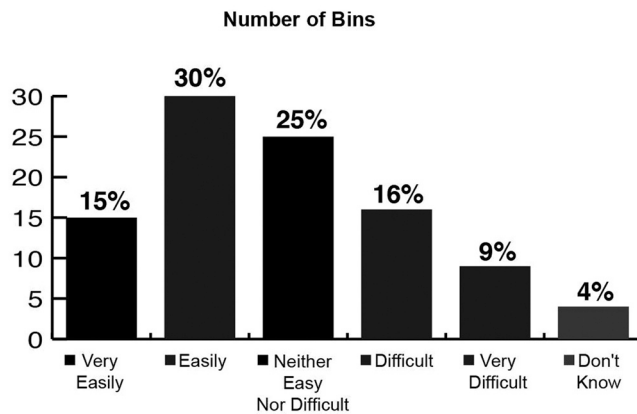


Fig. 4. Attitudes to changes regarding technical artifacts.

### Survey - Question 10

How important is it for you whether waste is treated on Bornholm or off-island?

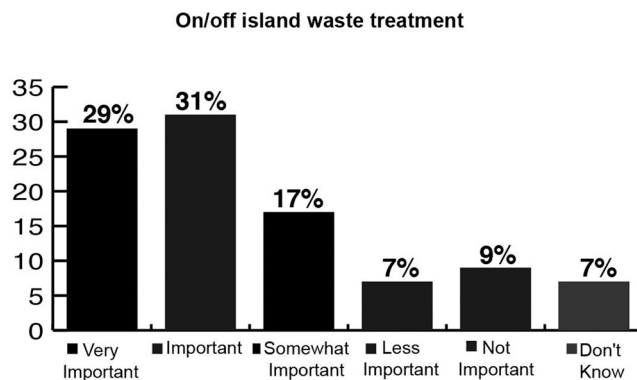


Fig. 5. Attitudes about where the treatment of their waste occurs.

### Survey - Question 11

To what extent is it important for you to know what your waste turns into when you dispose of it?

Treatment option attitudes

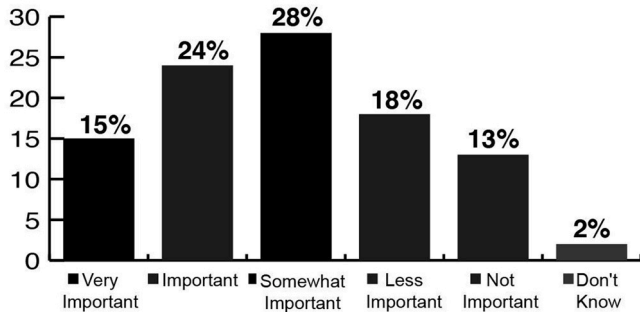


Fig. 6. Attitude to knowing about what happens to their waste once it is disposed.

The underlying common theme of these questions is the waste prevention step in the waste hierarchy. In Question 12, as illustrated on Fig. 7, 4% of respondents believe that the matter is not important for them. 17% believe the matter is very important, while 32% and 33% respectively believe that the matter is important or somewhat important.

For Question 13, as illustrated on Fig. 8, 5% believe it is not important to purchase less with a mind to reducing overconsumption, while 17% believe it to be very important followed by 36% and 32% respectively who deem the matter important or somewhat important.

For Questions 12 and 13, the respective hypothesis provided an expectation of a moderate to high level of environmental awareness. The proportion tested was the combined proportion of respondents who answered “Somewhat important”, “Important” and “Very important”. The statistical test resulted in support of the hypothesis. The common theme of these questions is the reuse step in the waste hierarchy.

In Question 14 about frequency of discarding items for reuse, 4% never do this while 40% do this monthly, as shown on Fig. 9.

Observably, it is a commonplace practice to deposit items to be used again by others for the same purpose on Bornholm. Question 15 focuses

### Survey - Question 12

To what extent is it important for you to purchase environmentally friendly products and avoid packaging?

Products and Packaging

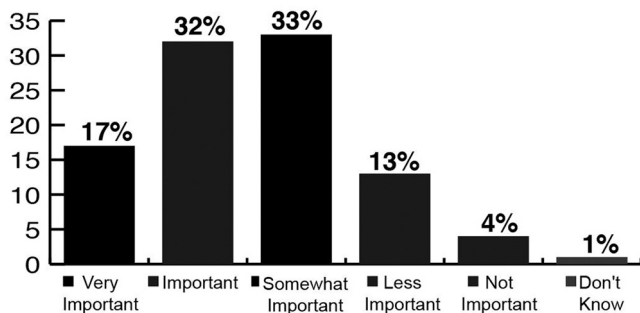


Fig. 7. Use of environmental criteria when purchasing products and avoiding packaging.

### Survey - Question 13

To what extent is it important for you to purchase less with a mind to reducing overconsumption?

Consumption

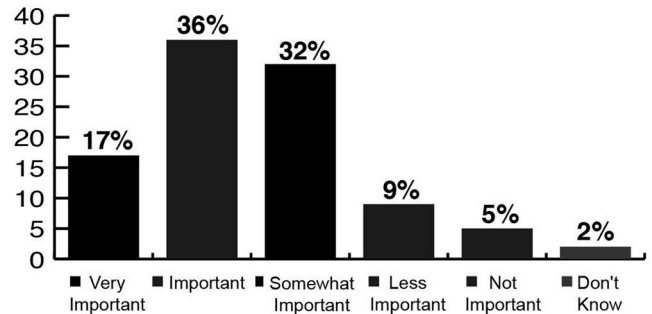


Fig. 8. Importance placed on avoiding overconsumption.

### Survey - Question 14

How often do you discard items for reuse, so that these items can be used again for the same purpose?

Reuse Supply

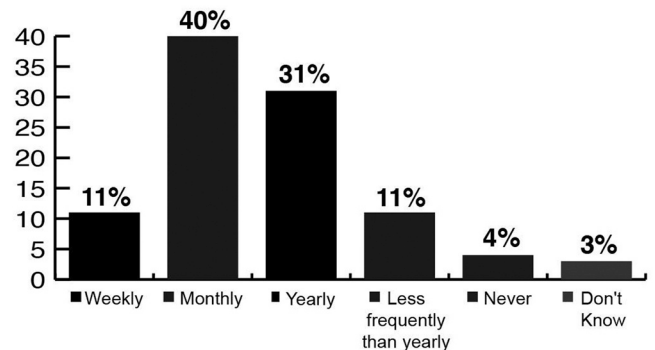


Fig. 9. Frequency of discarding for re-use according to respondents.

on taking items for reuse. While 11% never do this, 38% do this only once in a while, and 24% do this rarely. This would seem to indicate a casual practice of taking previously-owned items for personal use.

Question 16 deals with whether further platforms are seen as needed for reuse items. 8% believe they lack such platforms to a high extent, and 4% to a very high extent. 33% believe to a lesser extent that such platforms are lacking, and 27% have indicated that they do not lack such platforms at all. From this, it can be reasonably observed that the market or system of reuse platforms on Bornholm is perceived to be saturated.

Question 17 assessed the backing or resistance to a cornerstone of Bornholm’s Vision 2032, i.e. the phase-out of waste incineration in favor of reuse and recycling even if economics may favor the former. From the results, as shown on Fig. 12, 10% believe that the economic costs of recycling and reuse dictate that waste should be incinerated instead. This is followed by 4% on the survey option next after that; 36% fully back the statement that materials should be reused and recycled even if it increases financial expenses, followed by 23% who responded on the next survey option. Taken together, there is quite a strong backing to reuse and recycling.

For Question 17, the hypothesis provided an expectation that the economic parameter has a moderate to high degree of influence. The proportion tested was the combined proportion of respondents who

answered “4” (4 %) and “5” (10 %). The results obtained during the statistical test did not result in support of this hypothesis.

## 5. Discussion

The research commenced with the hypotheses of a moderate level of concern and difficulty in living up to national requirements (number of fractions and number of bins). The survey results have confirmed this hypothesis, confirming this as a relevant factor to take into account when considering factors that influence changes of waste systems. Indeed, it showed a moderate acceptance from Bornholm residents regarding the implementation of more refined curbside collection methods as 29 % of the respondents find it neither easy nor difficult (Question 8) (See Fig. 3) with a more positive attitude towards changes the waste system technical artifacts, with 30 % of the answers considering it easy (Question 9) (See Fig. 4). Interestingly, the statistical tests seem to indicate that implementing a new and more refined waste separation and collection system might not be as problematic as feared.

Another hypothesis was not supported by the survey results. It dealt with the geographic location of waste treatment (on or off-island) which was expected to be of less importance for the inhabitants of Bornholm. The survey has shown a more holistic and responsible attitude of the island residents regarding the implication of the consumption and production practices on the planet. Indeed, 31 % of the respondents considered “important” where the treatment of their waste occurs (Question 10) (See Fig. 5). On the other hand, the results show a slightly lesser concern, yet still high, about knowing what happens to their waste once they dispose of it as 28 % find it “somewhat important” (Question 11) (See Fig. 6). These results are a strong challenge to the assumption that sending waste for treatment off-island is socially acceptable. Howell and Fielding (2019) suggest that a sense of civic duty is among the factors that can motivate or discourage more eco-efficient attitudes and opinions among island inhabitants with regards to environmental issues.

There was an expectation that the economic dimension of the factors that influence changes on the waste system would present a moderate to high degree of influence when considering incineration (lower cost) versus recycling and reuse (higher cost). However, the survey results showed a more positive attitude toward reuse and recycling when compared to incineration, with 36 % of the respondents considering that materials should be re-used and recycled even if it increases financial expenses. From an environmental perspective it is positive to observe that recycling or reuse, despite a higher cost, is more favored than waste incineration. Other surveys carried out in islands, such as the one carried out by Macusi et al. (2019) with students, also show a broader economic perspective of island residents when comparing waste management alternatives.

A clear bottleneck to enable the reuse of products within Bornholm island, and a factor that influences the adherence to changes in the waste system (a central concern on the research question), is the need for more widespread availability of services such as, for instance, those aiming at upgrading and/or refurbishing the functional or aesthetic aspects of a product. This demands actions that stimulate the development of products and services suitable for the circular economy within an island boundary, enabling products to re-enter the economic cycle with reduced environmental impact (Gharfalkar et al., 2016). As argued by Ottoni et al. (2020), reuse and recycling activities are facilitated when products adopt modular configurations, facilitating their disassembly, updating/replacement and/or recycling. Such perspectives might require a revision on the business scope of waste management companies, as they conventionally focus their value proposition at the post-consumption phases. It also requires deeper collaboration and new ties with a wide range of actors as new knowledge and business competencies are required in order to create effective and meaningful value (Moalem and Kerndrup, 2022). Implementing such new perspectives in Denmark and elsewhere in Europe, faces the challenge of

## Survey - Question 15

How often do you take items for reuse?

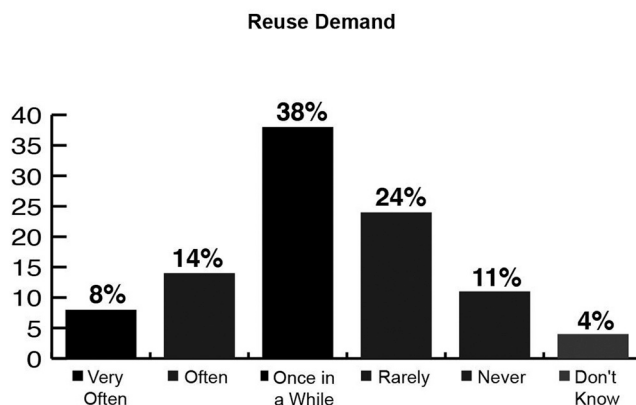


Fig. 10. Frequency of product re-use according to respondents.

an ambivalent legal framework regarding the role of players in waste management, not stimulating or inducing companies to break conventional boundaries (Moalem et al., 2023).

The respondent's active role on the life cycle of products is higher on proper discarding, aiming at the re-use of products (40 % report monthly practice – Question 14) (See Fig. 9). Yet, the survey results also showed a less widespread attitude towards the effective reuse of products, with 38 % report doing that “once in a while”. This, in turn, is in line with the perception of a lesser need for increasing the availability of reuse platforms (Question 15) (See Fig. 10). Notice that the effective re-use of products seems to be more an expectation directed to others than to oneself. Regardless of the motivation, these results present a positive prospect to implement a more regenerative system on Bornholm Island in which the inflows and outflows of resources could be minimized and optimized through design, maintenance, reuse, re-manufacturing, renovation and recycling.

Although it is already understood that prevention of waste generation offers a more effective strategy in the long term for waste management within islands, their characteristics often demand alternative solutions to deal with severe shortages of landfills and rising operating costs (Hoang and Fogarassy, 2020). When considering the various strategies to deal with waste, these survey results suggest that the concept of Circular Economy has a more promising perspective in Bornholm. Fuldauer et al. (2019)'s findings when comparing different scenarios on SIDS, also concluded that the adoption of the Circular Economy outperforms other strategies. It requires relatively less infrastructure requirements, thus saving costs and carbon while contributing to local job creation and reducing waste treatment needs. Investments to implement Circular Economy in islands, according to Fuldauer et al. (2019) included waste reduction campaigns and the reduction of the harbour and other taxes for recyclers.

Worth noting that the environmental awareness of the survey respondents is clearly higher at the consumption stage, as 65 % of them consider it important or somewhat important to use environmental criteria when purchasing products and avoiding packaging (Question 12) (See Fig. 7) and 26 % consider it “important” to avoid over-consumption (Question 13) (See Fig. 8). Yet, the results point out to the need for further efforts to effectively provoke deep change in consumption habits, attitudes, and opinions about product re-use. After all, as argued by Fuldauer et al. (2019), investing in education, prevention and re-use initiatives is far less expensive, nearly carbon-free, and more effective on dealing with island's waste than spending resources on expanding building waste infrastructure. Verlis and Wilson (2020) add that the development of a greater sense of place and appreciation regarding the uniqueness of an island environment is an effective strategy



### Survey - Question 16

Do you lack possibilities for reuse, for instance physical or online reuse shops platforms?

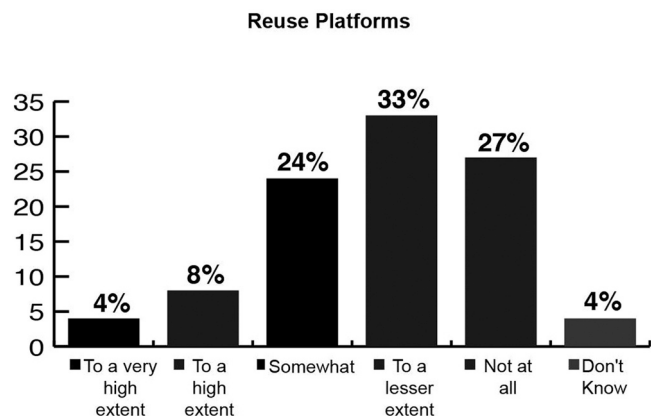


Fig. 11. Perception on the need to increase the availability of reuse platforms.

### Survey - Question 17

Should materials be reused and recycled rather than incinerated? (Indicate your opinion from 1-5 based on the 2 extremes).

- 1 - Yes, materials should be reused and recycled even if it increases financial expenses.
- 5 - No, materials should not be recycled or reused if it is more expensive than incineration.

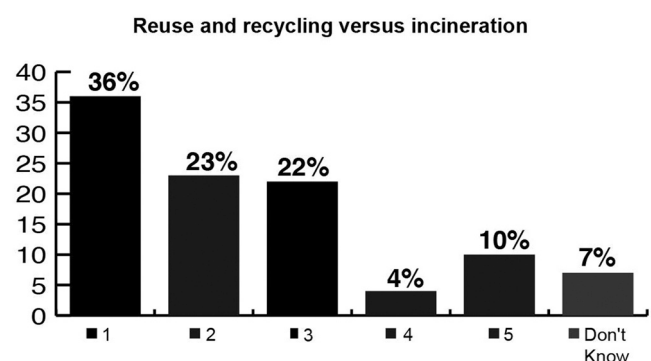


Fig. 12. Attitudes toward reuse and recycling versus incineration.

to reduce waste and litter among both locals and tourists (Fig. 11 and Fig. 12).

Finally, the authors understand that the factors that influence changes in the waste system, as reported on this study, do present potential to be adopted by those investigating similar issues within island contexts. Indeed, the present study could be positioned in what Bryman et al. (2019) describes as “representative case” (p.66), though the particularities of an island geography in a high-income country may build the argument that, as per Flyvbjerg (2011), this would be a “critical case” with rich data that has “strategic importance in relation to the general problem”, in this case pertaining to linear-to-circular waste system transitions.

### 6. Conclusion

When implementing BOFA’s 2032 Vision, the statistical analysis showed that factors that influence the waste system change are among others the surprising high baseline level of awareness of environmental

issues. Furthermore, the interests in the local (i.e. island) angle were the consideration for solutions that benefit the island as preferred over solutions based on mainland activities. There is an acceptance of increased costs when the changes are implemented but as cost rises, acceptance decreases.

The factors identified in this study are of particular relevance for the planning stage of participatory studies, for the content development of surveys, for the definition of the syllabus of competence development activities, for self-diagnosis tools aiming islands and waste management organizations and, also, to support wide initiatives on policy making. On this last aspect, the successful development and implementation of new policies on waste management within islands does need to consider factors and strategies to enhance the adherence of local stakeholders. The factors investigated on this paper do provide an initial framework that could support such initiatives.

### CRediT authorship contribution statement

The contributions of each author has been distributed as follows: **Jens Hjul-Nielsen:** Conceptualization, Methodology, Investigation, Validation, Formal analysis, Writing – original draft, Writing – review & editing. **Aguinaldo Santos:** Formal analysis, Writing – review & editing. **David Christensen:** Writing – review & editing. **Bruna Andrade:** Writing – original draft, Writing – review & editing, Visualization.

### Data Availability

The authors do not have permission to share data.

### Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Aguinaldo dos Santos reports financial support was provided by the Danish Agency for Higher Education and Science. Aguinaldo dos Santos reports a relationship with Federal University of Parana that includes: funding grants. The main author, Jens Hjul-Nielsen, is the CEO at BOFA, the waste management authority in the island of Bornholm.

### Acknowledgement

The authors are grateful to the Danish Agency for Higher Education and Science, which finances the project “Zero Waste Co-Lab” under the International Network Programme that enables the collaboration of the authors.

### References

Anschütz, J., Ijgosse, J., Scheinberg, A., 2004. Putting integrated sustainable waste management into practice: using the ISWM assessment methodology: ISWM methodology as applied in the UWEP plus programme (2001–2003). WASTE.BOFA. (2019). Showing the Way Bornholm without waste, 2032.

Bryman, Alan, Bell, Emma, Harley, B., 2019. *Business Research Methods, Fifth edition.* Oxford University Press, Oxford, United Kingdom.

Bornholm Municipality, 2022. Population forecast. Available at: <<https://www.brk.dk/Om-Kommunen/tal-og-fakta/sider/befolkningsprognose.aspx>>. (Accessed 12 December 2022).

Caferra, R., Adamo, I.D., Morone, P., 2023. Wasting energy or energizing waste ? The public acceptance of waste-to-energy technology. Energy 263 (PE), 126123(Available at: <<https://doi.org/10.1016/j.energy.2022.126123>>).

Camilleri-Fenech, M., Oliver-Solà, J., Farreny, R., Gabarrell, X., 2018. Where do islands put their waste? – a material flow and carbon footprint analysis of municipal waste management in the Maltese Islands. J. Clean. Prod. 195, 1609–1619. <https://doi.org/10.1016/j.jclepro.2017.07.057>

Christensen, D., 2018. *Bridging Actors in Sustainable Innovation for Developing Countries? Partnerships, Social Construction of Technology and Solid Waste Management in Vietnam and Uganda.* Aalborg University.

Díaz-Farina E., Díaz-Hernández J.J., Padrón-Fumero N., 2020. The contribution of tourism to municipal solid waste generation: a mixed demand-supply approach on the island of Tenerife. Waste Manag., vol. 102, pp. 587–97. <<https://doi.org/10.1016/j.wasman.2019.11.023>>. (Epub 2019 Nov 25. PMID: 31778970).

- Christensen, T.B., 2022. Closing the material loops for construction and demolition waste: The circular economy on the island Bornholm, Denmark. *Resources, Conservation & Recycling Advances* 15, 200104.
- Christensen, D., Hjul-Nielsen, J., Moalem, R.M., Johansen, B., 2021. Circular Economy in Denmark: Bornholm's Vision to Achieve 100 Percent Reuse and Recycling. *Circular Economy: Recent Trends in Global Perspective* 385–424.
- Eckelman, M.J., Ashton, W., Arakaki, Y., Hanaki, K., Nagashima, S., Malone-Lee, L.C., 2014. Island waste management systems: statistics, challenges, and opportunities for applied industrial ecology. *J. Ind. Ecol.* 18 (2), 306–317. <https://doi.org/10.1111/jiec.12113>
- Elster, J., 1977. Ulysses and the Sirens: a theory of imperfect rationality. *Soc. Sci. Inf.* 16 (5), 469–526. <https://doi.org/10.1177/053901847701600501>
- Estay-Ossandon, C., Mena-Nieto, A., 2018. Modelling the driving forces of the municipal solid waste generation in touristic islands. A case study of the Balearic Islands (2000–2030). *Waste Manag.* 75, 70–81. <https://doi.org/10.1016/j.wasman.2017.12.029>
- Fuldauer, L.I., Ives, M.C., Adshear, S.T., Hall, J.W., 2019. Participatory planning of the future of waste management in small island developing states to deliver on the Sustainable Development Goals. *J. Clean. Prod.* 223, 147–162. <https://doi.org/10.1016/j.jclepro.2019.02.269>
- Flyvbjerg, B., 2011. Five misunderstandings about case-study research. *Qual. Res. Pract.* 390–404. <https://doi.org/10.4135/9781848608191.d33>
- Gharfalkar, M., Ali, Z., Hillier, G., 2016. Clarifying the disagreements on various reuse options: repair, recondition, refurbish and remanufacture. *Waste Manag. Res.* 1–11 (Available at: <<https://doi.org/10.1177/0734242X16628981>>).
- Gopal, C., Patil, G., K.T., S., Y.B., Prakash, A., 2018. Conceptual frameworks for the drivers and barriers of integrated sustainable solid waste management: a TISM approach. *Manag. Environ. Qual.* 29 (3), 516–546. <https://doi.org/10.1108/MEQ-10-2017-0117>
- Guerrero, L.A., Maas, G., Hogland, W., 2013. Solid waste management challenges for cities in developing countries. *Waste Manag.* 33 (1), 220–232. <https://doi.org/10.1016/j.wasman.2012.09.008>
- Hoang, N.H., Fogarassy, C., 2020. Sustainability evaluation of municipal solid waste management system for Hanoi (Vietnam)—why to choose the 'waste-to-energy' concept. *Sustainability* 12 (3), 1085. <https://doi.org/10.3390/su12031085>
- Horesta, 2022. Turismen på Bornholm. Available at: <<https://www.horesta.dk/>>. (Accessed 12 December 2022).
- Howell, L., Fielding, R., 2019. Motivating sustainable behavior: waste management and freshwater production on the Caribbean island of Saint Barthélemy. *Isl. Stud. J.* 14 (1), 9–20.
- Iyamu, H., Anda, M., Ho, G., 2020. A review of municipal solid waste management in the BRIC and high-income countries: a thematic framework for low-income countries. *Habitat Int.* 95.
- Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. *Resour. Conserv. Recycl.* 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>
- Krejcie, R.V., Morgan, D.W., 1970. Determining sample size for research activities. *Educ. Psychol. Meas.* 30 (3), 607–610. <https://doi.org/10.1177/001316447003000308>
- Kvale, S., 2007. *Doing Interviews*. SAGE Publications Inc. <https://doi.org/10.4135/9781849208963>
- Lowe, A., Norris, A.C., Farris, A.J., Babbage, D.R., 2018. Quantifying thematic saturation in qualitative data analysis. *Field Methods* 30 (3), 191–207. <https://doi.org/10.1177/1525822217749386>
- Macusi, E.D., Morales, I.D., Abreo, N.A.S., Jimenez, L.A., 2019. Perception of solid waste management and rate of accumulation in schools in Mati City, Mindanao island. *J. Mar. Isl. Cult.* 8 (2), 113–131. <https://doi.org/10.21463/jmic.2019.08.2.09>
- Mancini, G., Nicosia, F.G., Luciano, A., Viotti, P., Fino, D., 2017. An approach to an insular self-contained waste management system with the aim of maximizing recovery while limiting transportation costs. *Waste Biomass Valoriz.*
- Matecki, S., 2020. Circular Economy in the Tourism Sector. Retrieved from <<https://www.hospitalitynet.org/opinion/4095249.html>>.
- McCartan, K., Robson, C., 2016. *Real World Research*, 4th edition. Wiley.
- Metabolic, 2017. Vlieland circulair. Available at: <<https://www.metabolic.nl/publications/vlieland-circulair/>>. Last visit: 27/08/2022.
- Moalem, R.M., Kerndrup, S., 2022. The entrepreneurial role of waste companies in transforming waste streams to value streams: Lessons from a Danish Municipal waste company. *Waste Management & Research*, 0734242X221124048.
- Moalem, R.M., Remmen, A., Hirsbak, S., Kerndrup, S., 2023. Struggles over waste: Preparing for re-use in the Danish waste sector. *Waste Management & Research* 41 (1), 98–116.
- Mohee, R., Mauthoor, S., Bundhoo, Z.M.A., Somaroo, G., Soobhany, N., Gunasee, S., 2015. Current status of solid waste management in small island developing states: a review. *Waste Manag.* 43, 539–549. <https://doi.org/10.1016/j.wasman.2015.06.012>
- Moore, M.H., 1995. *Creating Public Value: Strategic Management In Government*. Harvard University Press.
- Moustairas, I., Vardopoulos, I., Kavouras, S., Salvati, L., Zorpas, A.A., 2022. Exploring factors that affect public acceptance of establishing an urban environmental education and recycling center. *Sustain. Chem. Pharm.* 25, 100605.
- Ottoni, M., Dias, P., Helena, L., 2020. A circular approach to the e-waste valorization through urban mining in Rio de Janeiro, Brazil. *J. Clean. Prod.* 261. <https://doi.org/10.1016/j.jclepro.2020.120990>
- Panaretou, V., Malamis, D., Papadaskalopoulou, C., Sotiropoulos, A., Valta, K., Plevri, A., Loizidou, M., 2017. Implementation and evaluation of an integrated management scheme for MSW in selected communities in Tinos Island, Greece. *Waste Biomass Valoriz.* 8 (5), 1597–1616. <https://doi.org/10.1007/s12649-016-9632-z>
- Santamarta, J.C., Rodríguez-Martín, J., Arraiza, M.P., López, J.V., 2014. Waste problem and management in insular and isolated systems. Case study in the Canary Islands (Spain). *IERI Procedia* 9, 162–167. <https://doi.org/10.1016/j.ieri.2014.09.057>
- Skordilis, A., 2004. Modelling of integrated solid waste management systems in an island. *Resour. Conserv. Recycl.* 41 (3), 243–254. <https://doi.org/10.1016/j.resconrec.2003.10.007>
- Verlis, K.M., Wilson, S.P., 2020. Paradise trashed: sources and solutions to marine litter in a small island developing state. *Waste Manag.* 103, 128–136. <https://doi.org/10.1016/j.wasman.2019.12.020>. (Epub 2019 Dec 24).
- Vilms, M., Voronova, V., 2016. Non-deposit system option for waste management on small islands. *Waste Manag. Res.* 34 (8), 748–754. <https://doi.org/10.1177/0734242X16654752>
- Weekes, J., Musa Wasil, J., Malave Llamas, K., Morales Agrinzoni, C., 2021. Solid waste management system for small island developing states. *Glob. J. Environ. Sci. Manag.* 7 (2), 259–272. <https://doi.org/10.22034/gjesm.2021.02.08>
- Wang, K.C.M., Lee, K.E., Mokhtar, M., 2021. Solid waste management in small tourism islands: an evolutionary governance approach. *Sustainability* 13 (11), 5896. <http://dx.doi.org/10.3390/su13115896>.
- Weller, S.C., Vickers, B., Russell Bernard, H., Blackburn, A.M., Borgatti, S., Gravlee, C.C., Johnson, J.C., 2018. Open-ended interview questions and saturation. *PLoS One* 13 (6), 1–18. <https://doi.org/10.1371/journal.pone.0198606>
- Wilson, D.C., Velis, C.A., Rodic, L., 2013. Integrated sustainable waste management in developing countries. *Proc. Inst. Civ. Eng.: Waste Resour. Manag.* 166 (2), 52–68. <https://doi.org/10.1680/warm.12.00005>