

Review report on impact assessment

Deliverable D1.1

March 2024 (updated October 2025)

Authors:

University of Natural Resources and Life Sciences (BOKU):
Nadine Brunnhuber, Gudrun Obersteiner, Elisabeth Schmied

IVL Swedish Environmental Research Institute:

Frida Hermansson, Gustav Sandin Albertsson, Matilda Lidfeldt

Tampere University (TAU):

Mari Ainasoja, Martta Vänskä, Nina Mesiranta, Elina Närvänen, Malla Mattila

Deliverable Information

Deliverable No.	D1.1
Deliverable Title	Review report on impact assessment
Work Package No.	WP1
Work Package Title	Evaluation of CARE activities' environmental and sustainable well-being impacts
Lead Organisation	BOKU
Main author(s)	Nadine Brunnhuber (BOKU), Gudrun Obersteiner (BOKU), Elisabeth Schmied (BOKU), Frida Hermansson (IVL), Gustav Sandin Albertsson (IVL), Matilda Lidfeldt (IVL), Mari Ainasoja (TAU), Martta Vänskä (TAU), Nina Mesiranta (TAU), Elina Närvänen (TAU), Malla Mattila (TAU)
Contributors	
Reviewers	Rosalyn Old (CSCP), Christian Fuentes (Lund University)
Type	R — Document, report
Dissemination Level	PU – Public
Deliverable Due Date	31/03/2024
Deliverable Date	28/03/2024 (first submission) 10/10/2025 (updated version)
Version	Updated deliverable

CARE project summary

CARE (Circular consumption Activities to tRansform households toward material Efficiency) aims to empower consumer-citizens in European households in the transition to a circular economy (CE). The objective of CARE is to transform a total of 100 households in five European countries (Finland, Norway, Sweden, Germany, and Estonia) to circular model households. To achieve its aim, CARE will further develop, test and validate two pilots related to two critical material flows: food and clothing. They both have high potential for circularity at the household level. The CARE pilots will be implemented in five regions – both urban and rural - that are part of the Circular Cities and Regions Initiative (CCRI): Tampere, Asker, Gothenburg, Berlin, and Lääne-Harju. The pilots are based on the practice-theoretical approach, which goes beyond state-of-the-art by focusing on holistic, social and material aspects of everyday life instead of individualistic and awareness-raising interventions. The pilots will contain both customized, inclusive, and cost-free circular advisory services as well as food and clothing related interventions that target changes in consumption practices. CARE will make a strong contribution towards accelerating fair, inclusive and sustainable consumer-based transition to CE.



Summary

The goal of the CARE project is to empower European households to reduce their environmental impacts related to their food waste and their clothing consumption and use as a means to foster circular economy (CE). To measure these environmental impacts and quantify improvements, a robust method for environmental impact assessment for food waste and clothing consumption and use is necessary. For this, this deliverable provides an overview of the respective environmental assessment and food waste quantification methods used in relevant scientific literature.

This impact assessment review deliverable, conducted by experts from BOKU, IVL and TAU, is divided into two parts. **Part 1** gives an overview how environmental impacts of food waste and of clothing consumption and use are quantified in literature. This was done through a systematic literature review. Regarding food waste, the deliverable emphasises the importance of clear definitions and categorisations for food waste quantification, recommending methods such as waste composition analysis and food diaries for accurate measurements of food waste quantities. The majority of publications reviewed in the literature screening used life cycle-based methods like LCA to assess the environmental impacts of food waste.

Regarding clothing consumption and use, this deliverable highlights that only a few studies collect primary data through surveys or interviews, with most relying on literature, statistics, or supplier data. While some studies use literature based on surveys, the creation of specific questionnaires tailored to the study's needs is uncommon. The report emphasises the importance of considering various factors in the production stage of clothing items, as different environmental impacts are associated with factors like fibre types, fabric production, wet processing, confectioning, and energy sources used in these processes.

Part 2 provides an overview of assessment methods used in previous literature related to sustainable well-being. By combining insights from a mapping review and a researcher workshop, it builds knowledge that will contribute to selecting suitable indicators for assessing well-being effects in participating households within the CARE project. The document highlights the multidimensional perspective required for well-being assessments within the project, emphasising the need for indicators beyond hedonic well-being. It acknowledges the absence of a single comprehensive sustainable well-being scale validated for

food waste and sustainable clothing consumption contexts, leading to the adoption of a pragmatic approach of combining indicators tested in other contexts.

Key implications from literature and workshops stress the significance of building on needs-based well-being theory, considering multidimensional well-being, and using a combination of indicators, both context-specific and general. The report addresses challenges in measuring sustainable well-being, such as income level effects on sustainability evaluations and the recruitment criteria for CARE pilots. It also discusses the potential need for country-specific well-being indicators and the importance of qualitative data collection for insights into well-being effects.

Overall, the report serves as a valuable resource which will be used to understand and evaluate the environmental and sustainable well-being impacts of CARE activities, offering insights, methodologies, and considerations for researchers and practitioners in the field, particularly in the context of food waste and textile consumption.

Glossary of abbreviations

CO ₂ eq	Carbon dioxide equivalent
EU	European Union
EoL	End of Life
LCA	Life cycle assessment
MFA	Material flow analysis



Disclaimer

The CARE project is funded by the European Union under Grant Agreement No. 101135141. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

All intellectual property rights are owned by the CARE consortium members and are protected by the applicable laws. Except where otherwise specified, all document contents are: “© CARE project - All rights reserved”. Reproduction is not authorised without prior written agreement.

The commercial use of any information contained in this document may require a license from the owner of that information.

All CARE consortium members are also committed to publish accurate and up to date information and take the greatest care to do so. However, the CARE consortium members cannot accept liability for any inaccuracies or omissions nor do they accept liability for any direct, indirect, special, consequential or other losses or damages of any kind arising out of the use of this information.



TABLE OF CONTENTS

Glossary of abbreviations	3
1. Part 1: Household food waste and domestic clothing consumption and use	7
1.1. Introduction on household food waste and domestic clothing consumption and use	7
1.2. Materials and methods	8
1.2.1. Review of food waste quantification and environmental assessment	8
1.2.2. Review of domestic consumption and use of clothing	11
1.3. Food waste review	14
1.3.1. Publication year	14
1.3.2. Geographical scope	15
1.3.3. Categorisation of food waste	17
1.3.4. Quantification of food waste	20
1.3.5. Environmental assessment of food waste.....	25
1.3.5.1. System boundaries	25
1.3.5.2. Environmental assessment methods	26
1.3.5.3. Functional unit	29
1.3.5.4. Impact categories	31
1.4. Domestic consumption and use of clothing review	33
1.4.1. Publication year	33
1.4.2. Geographical setting of use phase	34
1.4.3. System boundaries	35
1.4.4. Data collection method	36
1.4.5. Functional unit.....	36
1.4.6. Allocation	40
1.4.7. Impact assessment categories	41
1.5. Conclusions on food waste and clothing consumption and use	42
1.5.1. Food waste conclusions	42
1.5.2. Clothing consumption and use conclusion	43
2. Part 2: Sustainable well-being indicators	45
2.1. Introduction to Part 2	45
2.2. Sustainable well-being in CARE	45
2.3. Literature on measuring sustainable well-being.....	46
2.3.1. Method for the mapping review	47
2.3.2. Conceptual overview.....	48
2.3.2.1. Needs-based and capability-based approach	48
2.3.2.2. Hedonic, eudaimonic and social measures	49

2.3.3.	Measuring sustainable well-being in the context of sustainable consumption	51
2.3.4.	Measuring sustainable well-being in the context of food and clothing.....	52
2.3.5.	Reflections from the literature to CARE project	54
2.4.	Researcher workshop	55
2.4.1.	Workshop participants	56
2.4.2.	Organising the workshop	56
2.4.2.1.	Theme 1: Potential well-being effects.....	57
2.4.2.2.	Theme 2: Indicators or metrics for sustainable well-being	58
2.4.2.3.	Theme 3: Best practices for studying sustainable well-being	59
2.4.3.	Reflections from the workshop to CARE project	59
2.5.	Key implications on sustainable well-being	61
3.	Final conclusions.....	62
References	64



1. Part 1: Household food waste and domestic clothing consumption and use

1.1. Introduction on household food waste and domestic clothing consumption and use

The production of food consumes energy and valuable resources (e.g., water, land), which results in environmental impacts, such as (among others) global warming, acidification or eutrophication. If food is thrown out, the valuable resources and energy needed for its production are wasted. It is estimated that one third of global food produced is not consumed, but instead ends up as food waste (Gustavsson et al., 2011). Scherhauser et al. (2018) estimate that in about 88 Mt of food are wasted in the EU, which result in a global warming potential of 186 Mt CO₂ eq. SDG subgoal 12.3 aims to halve per capita food waste from retailers and consumers by 2030 (SDG12 2022). With households being responsible for 53% of total food waste in the European Union (FUSIONS 2016), reducing household food waste avoids environmental impacts and contributes to sustainability and circularity.

The textile and clothing sector is widely acknowledged as one of the most environmentally harmful industries on a global scale. It is linked to substantial greenhouse gas emissions, extensive water usage, pollution from chemicals and microplastics, and a growing amount of waste stemming from both the production and consumption of clothing (Niinimäki et al., 2020). Additionally, the use phase (e.g., washing, ironing, tumble drying of clothing) contributes to clothing-related environmental impacts (Allwood et al. 2006). With increased speed of fashion cycles (Kleinhüchelkotten et al. 2018) global clothing production and consumption are on the rise. This results in an increasing number of textiles being disposed of and increased clothing-related environmental impacts. To counteract this, the EU strategy for sustainable and circular textiles proposes the circular use of clothing (e.g., donating, re-use) or measures to prolong the clothing use phase (e.g., repair) (European Commission 2022). Consumers decide both whether and how many new textiles they buy and which ones they buy (e.g., durable materials, sustainable production) (Gwozdz et al., 2017). Furthermore, they also decide how to use, how long to use and how to discard their clothing (Gwozdz et al., 2017). Therefore, consumers can directly

influence their clothing-related environmental footprint and thus reduce environmental impacts and contribute to circularity and sustainability.

CARE addresses these issues by working together with households by providing incentives and opportunities for households to change their current consumption practices towards circularity and reduce their environmental footprint. This is done through strategies to reduce household food waste and changes in clothing consumption patterns. As part of the CARE project, the consumption-related environmental footprints of the households are assessed. Then, the changes in the household environmental impact through the CARE interventions are quantified as well. The aim of this deliverable is to provide a review of existing impact assessment methods and actions in the context of food and clothing. For this, a systematic literature review was conducted. The systematic literature on food waste was conducted by University of Natural Resources and Life Sciences, Vienna (BOKU) and the systematic literature review on textiles was conducted by IVL Swedish Environmental Research Institute (IVL). The results are presented in the following chapters. The goal of D1.1 is to give an overview of how environmental impacts of food waste and clothing consumption and use were evaluated in literature. For this, the data collection methods (e.g., food waste quantification) and methodological specifications of the conducted LCAs (e.g., functional unit, system boundaries, allocation, impact assessment categories) were assessed and compared through a systematic literature review.

1.2. Materials and methods

A systematic literature review was conducted to identify methodologies to environmentally assess household food waste behaviour and clothing consumption. Scientific literature was screened for the methodologies used to quantify food waste and clothing consumption as well as their respective environmental impacts.

1.2.1. Review of food waste quantification and environmental assessment

The aim of this literature review is to identify methods used in scientific literature to quantify the amounts of food waste and assess the food waste-related environmental impacts. The questions to be answered in the review concerning household food waste were:

- What methods are available for quantifying food waste?
- Which of these methods are suitable for recording food waste in households?
- How (e.g., into which waste streams) is food waste categorised?
- What methods are available for assessing the environmental impact of food waste?
- How do these methods differ in their framework specifications (e.g., system boundaries, functional unit, impact category)?
- What is a useful functional unit in LCAs of food waste?
- What primary data needs to be collected from households in the project?
- What type of impact assessment methods should be included?

The literature review was conducted in February 2024. The data sources for the food waste-related literature review were Web of Science and Scopus. Additional literature from Google Scholar was also included in the review to close any knowledge gaps. Only scientific literature was reviewed. Grey literature was excluded from this literature review. There were no restrictions based on the publication date for the selected literature and the geographical scope of the studies. A graphical overview of the literature review process is shown in Figure 1.



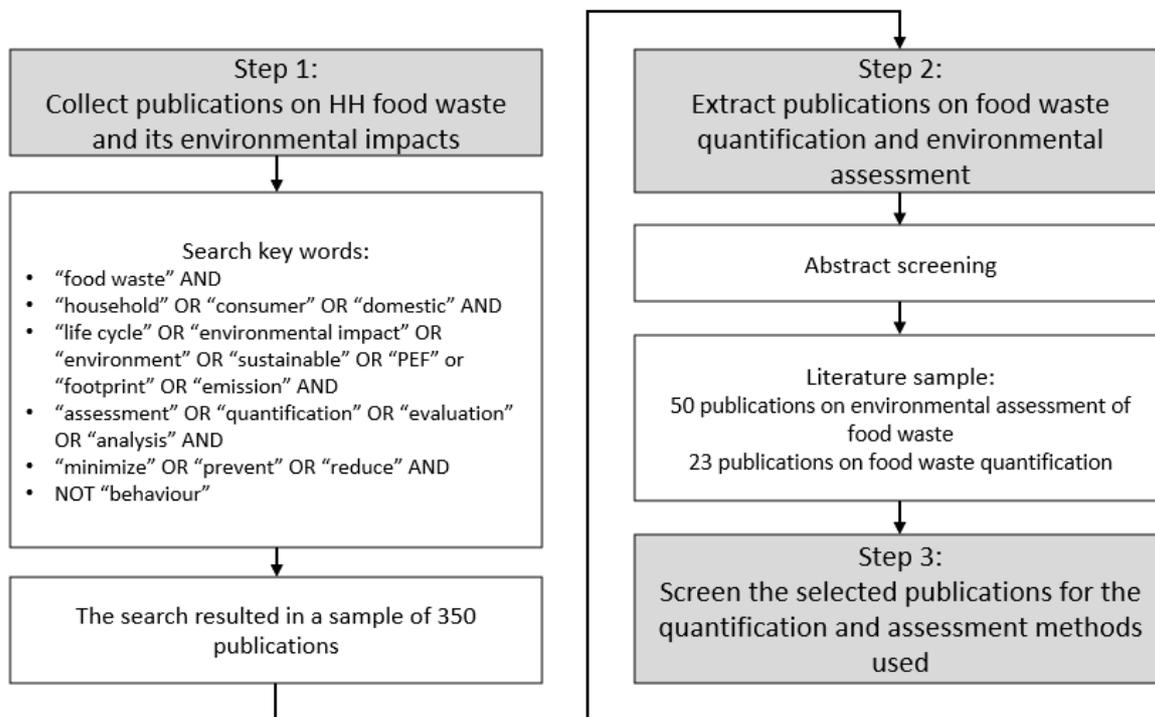


Figure 1: Graphical overview of the literature screening process for the literature review on the quantification and environmental assessment of food waste

First, relevant publications on life cycle-based environmental assessment of household food waste were identified. Publications on household food waste reduction and assessment of its environmental impacts were of special interest for this review. The keywords for identifying relevant literature are shown in Figure 1.

The literature search on Web of Science delivered 300 publications and the Scopus search delivered 280 publications. The database exports were then imported into Citavi and double entries were removed. This resulted in a total of 350 papers for further analysis. Then, publications thematically not relevant for the review were excluded from the sample. This included papers on the following topics:

- Consumer attitudes or food management practices resulting in food waste
- Energy generation from food waste, life cycle assessment (LCA) of food waste management practices and waste management systems or studies on the general end of life (EoL) treatment of food waste

- Studies on food waste in industry and retail (e.g., shipment policies, post-harvest losses)
- Food security or malnourishment
- Packaging (e.g., food packaging waste, how food packaging affects food waste generation)
- Studies on food waste prevention in general, without any environmental assessments
- Food waste in general (e.g., composition)
- Food waste-related economic or social assessments without consideration of environmental aspects

Thematically not relevant publications were identified through a manual abstract screening of all publications. Publications only focusing on the quantification of food waste were also included in the literature review to identify methods for food waste quantification. As previously mentioned, additional publications obtained from Google Scholar were also included to close knowledge gaps (14 publications). This resulted in a final sample of 50 publications on environmental assessment of household food waste and 23 publications on food waste quantification. These publications were then screened for their food waste quantification methods, environmental impact assessment methods, assessment scope, system boundaries, environmental impact indicators, food waste quantification methodology and the different food groups analysed.

1.2.2. Review of domestic consumption and use of clothing

The goal of this literature review is to gain knowledge on how the domestic consumption and use of clothing has previously been modelled in life cycle assessment (LCA). The main questions used in this review were:

- What is a useful functional unit in LCAs of domestic clothing consumption and use?
- How should data be collected, to model domestic clothing consumption and use?
- What primary data needs to be collected from households in the project?
- What life cycle phases of the clothing should be included in the system boundaries?
- What type of impact assessment methods should be included?

The overall aim is to identify literature relevant for future work to be done in the CARE project. The goal is to provide input to the goal and scope of the LCAs to be done in WP 1. Figure 2 shows the basic outline of a clothing item's life cycle and highlights (grey box) the activities that primary data will be collected for within the CARE project.

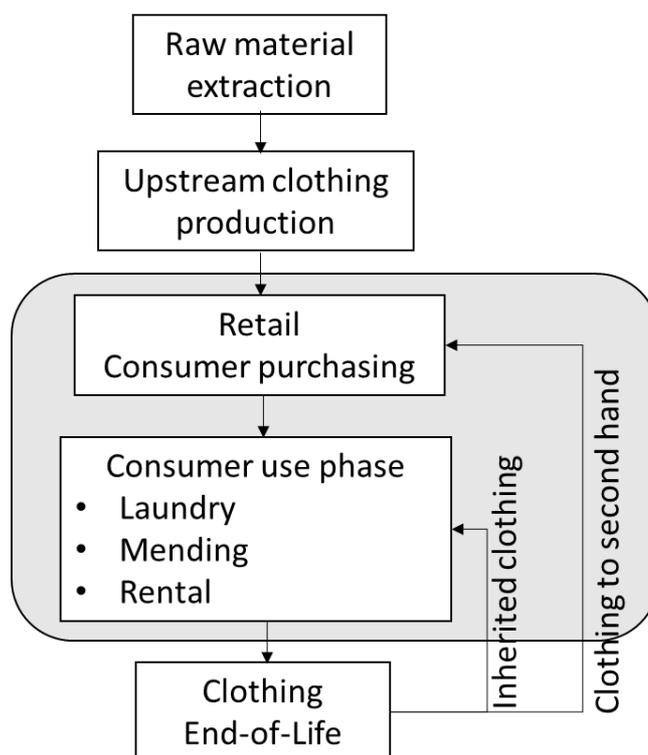


Figure 2: The basic outline of a clothing item's life cycle. The processes where primary data will be collected in the future LCAs within the CARE project are included in the grey box

This study is limited to the domestic consumption and use of clothing. This means that textiles such as reusable diapers, curtains and bedsheets have been excluded from the scope of this literature review.

The literature for the review was selected via two different search queries using the Web of Science and Science Direct databases in February 2024. The methodology is divided into two parts: Query 1 and Query 2. The reason for the dual queries is that after Query 1, we saw that there was a very limited number of articles that fit the criteria. To gain more insight on the modelling and data collection of domestic use of clothing, another query (Query 2) with broader exclusion criteria was added.

Query 1

In the first identification step, the query (LCA OR "life cycle assessment" OR "life cycle analysis") AND ("household textiles" OR "textile consumption" OR "household textile waste" OR "textile reuse" OR ("laundry" NOT detergent)) was used. The Web of Science search generated 34 articles and the Science Direct search delivered 513 articles, the latter limited to only include literature reviews and research articles. These publications were then exported to Endnote and six duplicates were identified, resulting in an initial sample of 544 articles.

The exclusion criteria for Query 1 were:

- Studies excluding the use phase of textiles or presenting the use phase aggregated with the other life cycle phases
- Studies that do not include household consumers (this means that studies on textile use in hotels and hospitals are excluded)
- Studies not following LCA or material flow analysis (MFA) methodology

The first round of screening was done by checking abstracts and titles and any additional duplicates not identified by Endnote were removed. This resulted in a preliminary sample of 58 articles. The articles in the preliminary sample were then imported into Rayyan and assessed based on their methodology using the same exclusion criteria as for the initial screening. Any additional duplicates identified were also removed. This resulted in a final sample of 15 articles.

Query 2

The query ("apparel use" OR clothing OR textiles) AND ("LCA modelling" OR "life cycle assessment") AND ("consumer behavior" OR "consumer behaviour") was used and generated 18 articles via Web of Science and 329 via Science Direct (research articles and review articles). Six duplicates were identified in Endnote, resulting in 344 articles in the initial sample for Query 2. To limit the work burden in the initial sample screening, any duplicates in relation to Query 1 were also identified (n=92). The resulting initial sample for screening was 298 articles which was imported into Rayyan.

As we deemed the exclusion criteria for Query 1 too limited, the exclusion criteria for Query 2 were limited to:

- Studies not including the use phase of clothing

This resulted in 30 articles, of which two were duplicates that were not previously identified by Rayyan. The preliminary sample thus resulted in 29 articles. The methodology of these articles was then screened, resulting in a final sample of 20 articles. The methodology for selecting the articles for the review is illustrated in Figure 3.

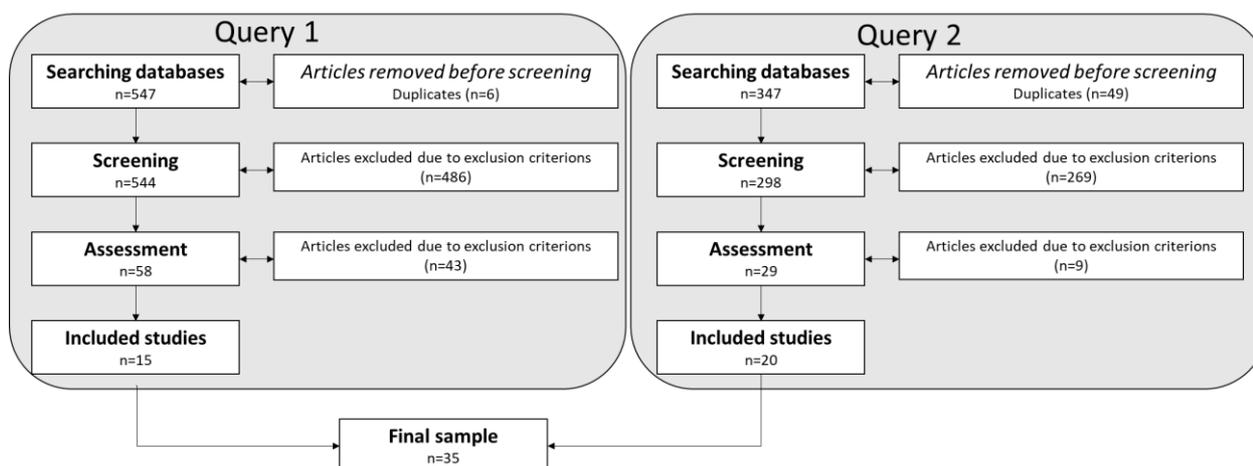


Figure 3: The outline of the methodology applied to identify the publications on clothing consumption and use to be included in the review

1.3. Food waste review

1.3.1. Publication year

The number of publications on quantification and environmental impact assessment of food waste per year is shown in Figure 4. Articles on environmental assessment of food waste published between 2010 and 2024 were reviewed. Only nine out of 50 of these articles were published prior to 2017. Thus, systematic research on food waste-related environmental assessments has only been expanded recently. The majority of publications on environmental assessment of food waste were published

between 2017 and 2022. This indicates an increased interest and growing importance of this research area.

As for food waste quantification, the publication dates of the selected articles range from 2013 to 2023. In the literature sample, this area of research has taken off in 2020, as an increase in publications is seen then. This increase continues up to the year of 2023.

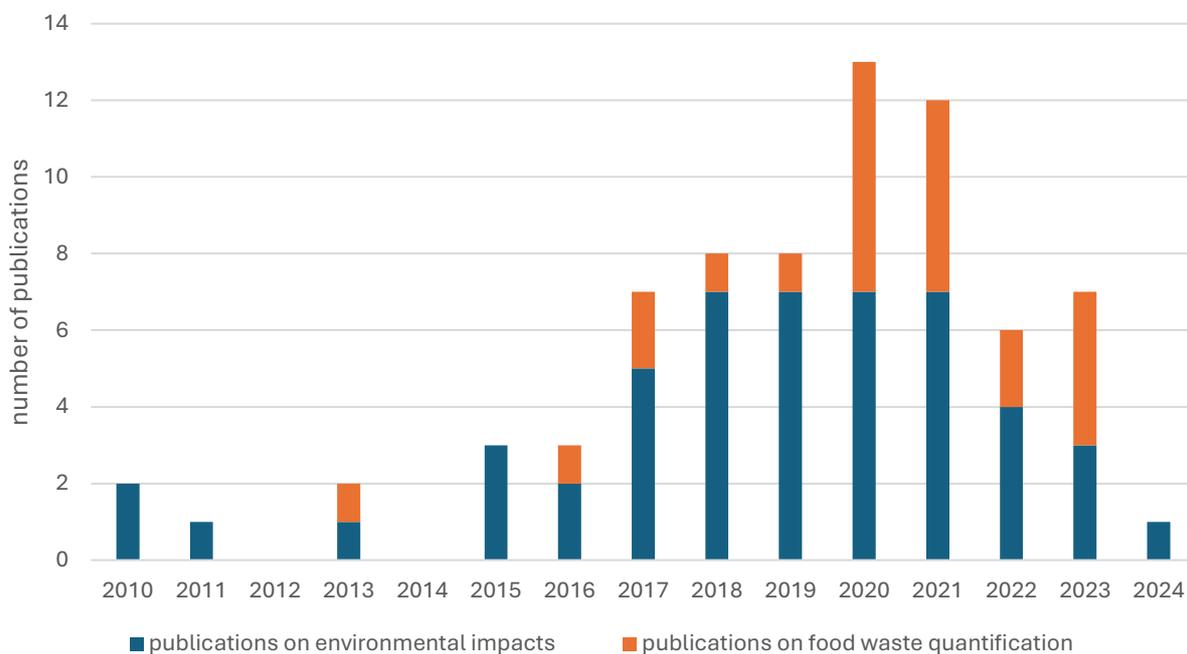


Figure 4: Number of publications on quantification and environmental impact assessment of food waste per year

1.3.2. Geographical scope

As shown in Figure 5, the geographical scope of the majority of articles on environmental impact assessment was Europe: United Kingdom (ten articles), the entire European Union (eight articles), Spain (four articles), Sweden (three articles), Denmark (two articles), Norway (two articles), Greece and the Netherlands (one article each). Asia is represented by China (five articles) and Japan (one article). The scope of the North American articles is either USA (six articles) or Canada (two articles). Five articles assessed the environmental impacts of food waste on an international scope. This means, that food

waste environmental impacts were either assessed in multiple countries simultaneously, or they were assessed on a global scale.

All countries are represented more or less equally in food waste quantification literature sample. These articles focused on Europe (UK, Spain, Sweden, Denmark, Lithuania, Czech Republic, Croatia, Germany, Greece, Italy, the Netherlands, Poland, Switzerland, Turkey or the entire EU), Asia (China, Japan, Korea, Vietnam), North America (USA, Canada), South America (Chile) or the Middle East (Iran). One publication deals with food waste quantification on an international level.

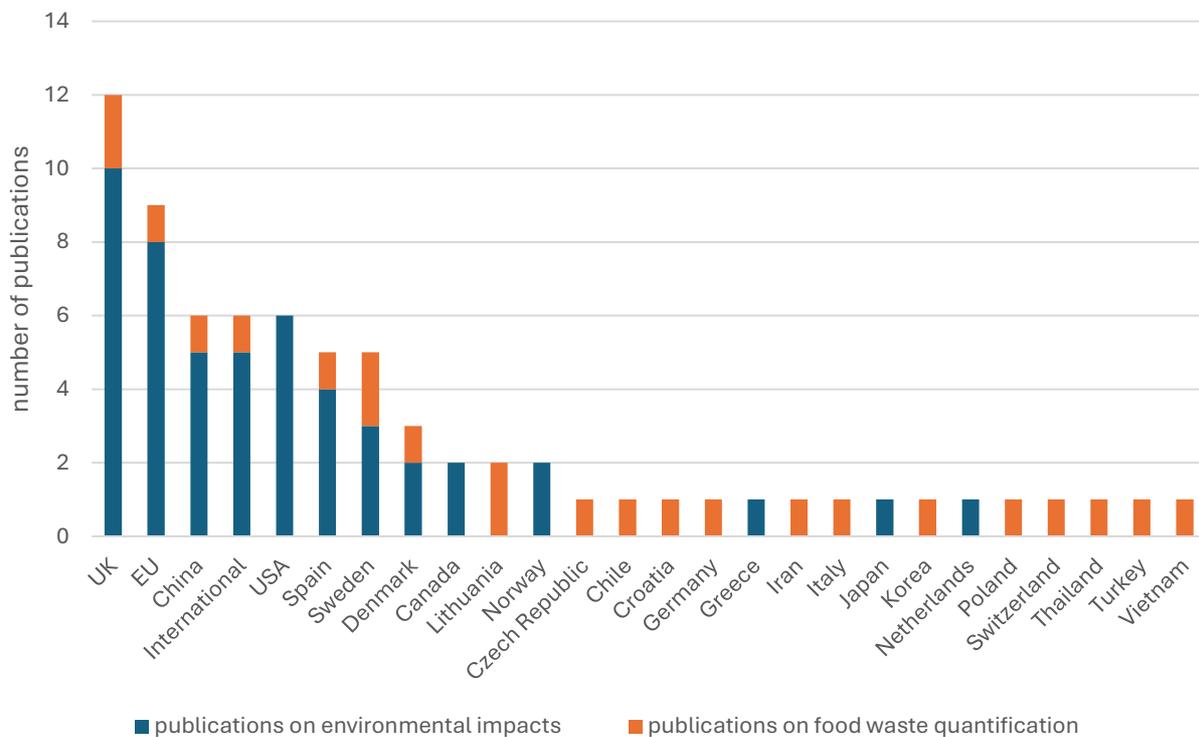


Figure 5: Geographical scope of the selected publications on food waste

1.3.3. Categorisation of food waste

Food waste is an important topic in research. While there is no universal definition for the term food waste (FUSIONS 2014a), the majority of publications analysed as part of this literature screening refer to the same common definitions of food waste:

- FAO (2013) defines food waste as food appropriate for human consumption which is being discarded, whether or not it is already expired or spoiled.
- FUSIONS (2014a) defines food waste as food and inedible parts of food which were removed from the supply chain to be recovered or disposed of.
- Gustavsson et al. (2013) lists the definition of food waste as food products which are fit for consumption but are discarded instead.

The consensus of these definitions is that food waste is food that is not consumed but disposed of. Household food waste is generated during storage (e.g., the expiry date was exceeded), meal preparation (e.g., cutting parts of vegetables) or leftovers from eating (FUSIONS 2014b). There is no universal classification system for food waste categorisation (FUSIONS 2014b). Barker et al. (2023) list multiple options for food waste categorisation, which are shown in Table 1.

Table 1: Options for food waste categorisation (Barker et al., 2023)

Basis for categorisation	Examples		
Avoidability	<ul style="list-style-type: none"> • Avoidable food waste • Unavoidable food waste • Potentially avoidable food waste 		
Degree of processing	<ul style="list-style-type: none"> • Unprocessed or minimally processed foods • Products extracted from natural foods (e.g., oils, fats, sugar) • Processed foods (e.g., canned products) • Ultra-processed foods (e.g., candy, ready meals) <p>This definition is based on the NOVA Food Classification system (Monteiro et al. 2016)</p>		
Food waste generation phase	<ul style="list-style-type: none"> • Preparation and serving • Consumption • Storage 		
Food group	<p>For example:</p> <table border="0"> <tr> <td data-bbox="518 1288 949 1624"> <ul style="list-style-type: none"> • Vegetables • Drinks • Bakery • Ready meals • Dairy • Eggs • Fruit </td> <td data-bbox="981 1243 1404 1624"> <ul style="list-style-type: none"> • Meat • Seafood • Sweets • Oil • Condiments • Staple foods • Cereals • Other </td> </tr> </table>	<ul style="list-style-type: none"> • Vegetables • Drinks • Bakery • Ready meals • Dairy • Eggs • Fruit 	<ul style="list-style-type: none"> • Meat • Seafood • Sweets • Oil • Condiments • Staple foods • Cereals • Other
<ul style="list-style-type: none"> • Vegetables • Drinks • Bakery • Ready meals • Dairy • Eggs • Fruit 	<ul style="list-style-type: none"> • Meat • Seafood • Sweets • Oil • Condiments • Staple foods • Cereals • Other 		

The majority of publications differentiate between avoidable and unavoidable food waste. Avoidable food waste consists of food, that could have been eaten at one point, while unavoidable food waste consists of inedible portions of food (Massow et al., 2019). 24 publications focus on the environmental impacts of

avoidable food waste. The environmental impacts of avoidable and unavoidable food waste are calculated separately in 18 studies. Eight publications also differentiate partially avoidable food waste.

A small number of publications only differentiated between cooking waste, leftovers of cooked dishes, untouched food as well as tea leaves and coffee grounds. Other publications also distinguish between processed and unprocessed food waste or between opened and unopened packaging and non-packaged food.

Food group-based waste categorisation is the most popular in the sample. However, there are different levels of aggregation. Some publications differentiate between different types of meat (e.g., beef, pork, poultry), while others consider meat as a single food waste stream. This is also the case for fruits and vegetables. Some publications also aggregate fish and meat or dairy and eggs to one single food waste category, while others assess these food groups as individual waste streams.

When categorising food waste by food group, FLW Protocol (2016a) recommends using standard codes for food products, such as the codes provided by the Codex Alimentarius General Standard for Food Additives (GSFA) system or the United Nations' Central Product Classification (CPC) system. WRAP (2009), which was referenced by multiple publications in the sample, used the following classification for their food waste assessment:

- Meat and fish
- Dairy and eggs
- Fresh vegetables and salads
- Fresh fruit
- Processed vegetables and salads
- Processed fruit
- Bakery
- Staple foods
- Oil and fat
- Meals (home-made and pre-prepared)

- Drinks
- Condiments, sauces, herbs and spices
- Cake and desserts
- Confectionery and snacks
- Other

1.3.4. Quantification of food waste

A total of 73 publications were screened for their methods used to quantify food waste. This included 50 publications on the environmental assessment of food waste and the additional 23 publications specifically focusing on food waste quantification. Figure 6 shows the identified food waste quantification methods and in how many publications they were used. The advantages and disadvantages of the identified methods are listed in Table 2.

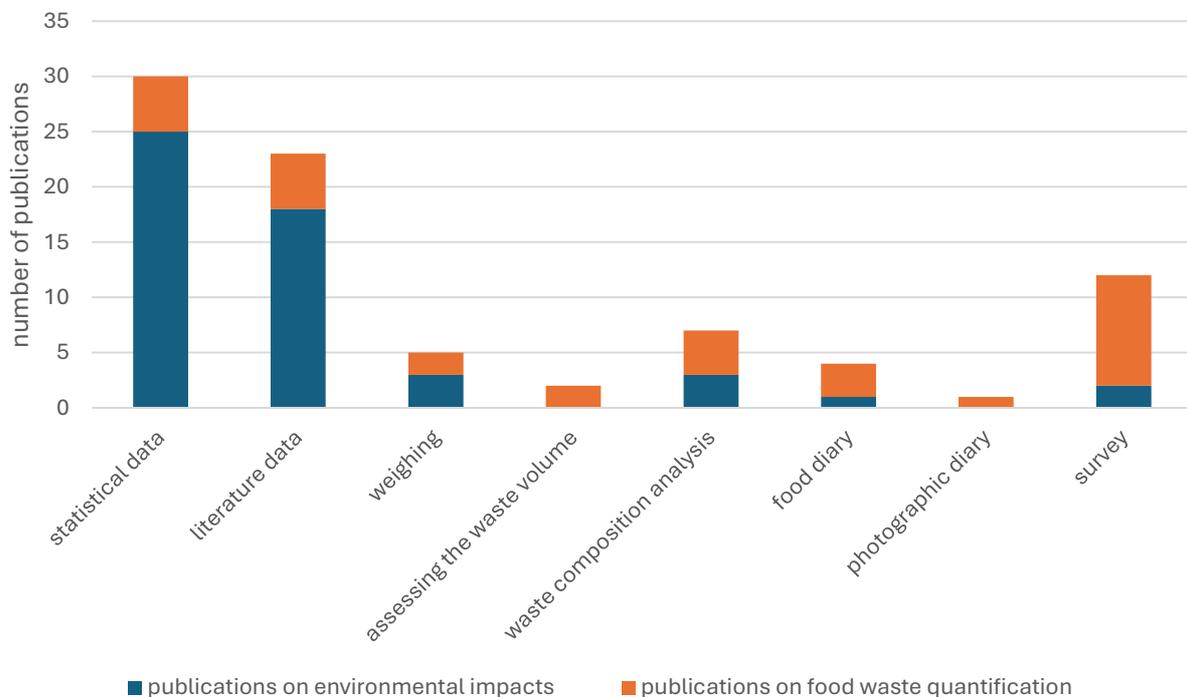


Figure 6: Identified food waste quantification methods and the number of their application in the literature sample

Food waste can be quantified through weighing with a weighing device (e.g., a scale). When weighing containers, the weight of the empty container must be taken into account (FLW Protocol 2016b). Weighing provides accurate data on food waste quantities. However, food waste weighing comes with effort and costs (e.g., for purchasing a scale, for logistics if the measurement is required at more than one location). The selection, calibration and proper use of the weighing device are key for an accurate data collection (FLW Protocol 2016b). In the literature sample, weighing was used to quantify food waste at hotels, restaurants or canteens (Beretta and Hellweg, 2019; Qian et al., 2022). Only one study (Manczarski et al., 2023) used this method for the quantification of household food waste (e.g., weighing the household's organic waste bins). Through weighing, only the total quantity of waste was measured. The waste composition was not assessed through this method. Instead, the food waste composition was taken from secondary data sources. Self-weighing of the food waste by the households is also possible. This is usually done in combination with a food diary (Abeliotis et al., 2015; Barker et al., 2023; Nováková et al., 2021).

The volume of food waste can be assessed through calibrated containers, water displacement or visual assessment. Then, the assessed volume is converted to weight. For this, density factors are used, which may lead to inaccuracies in the data collected (FLW Protocol 2016). In the literature sample, households were asked to take photographs of their food waste in the form of a photographic food diary (as an extension of a food diary). Two studies use these photographs to estimate the weight of household food waste (Barker et al., 2023; Ilakovac et al., 2020). This is done by estimating the volume of the food waste and then calculating its weight with data from the FAO/INFOODS Density Database.

Waste composition analysis is a method used to physically separate, weigh and categorise the individual food waste streams. The individual waste components are sorted and weighed. This way, very detailed food waste data can be collected. Food waste can be sorted into specific food categories (e.g., meat, vegetables). Other options for sorting categories (e.g., unopened vs. opened packaging). However, waste composition analysis is not suitable for all food waste streams. For example, materials which are poured down the drain are not captured by waste composition analysis (FLW Protocol 2016b).

FUSIONS (2014b) recommends a waste composition analysis in combination with a food diary to quantify household food waste. Waste composition analysis is the third most popular method to assess household food waste in the literature sample. The household waste is picked up and then separated into different

food waste categories, which are then weighed (Edjabou et al., 2016; Massow et al., 2019). household food waste can also be collected separately from the other household waste (e.g., in paper bags or in labelled plastic bins for each household) (Adelodun et al. 2021; Bernstad Saraiva Schott and Andersson 2015). Then, the separately collected food waste was picked up for the composition analysis.

Another option for food waste quantification by the households is the diary method. In diary research, the participants maintain a daily log of their food waste (FLW Protocol 2016b). In addition to the amount of food waste, other information, such as the type of food waste and reason for its disposal can be recorded. Furthermore, food waste that is disposed of via the sewer, home composted or fed to animals can also be captured this way (WRAP 2009). The food waste can be quantified through direct weighing, item counts (e.g., five apples) or volume-based measurements (e.g., with a measuring cup). Food diaries also provide the opportunity to collect qualitative data on food waste (e.g., the participant's views on food waste) (FLW Protocol 2016b). In the literature sample, four publications (Abeliotis et al., 2015; Giordano et al., 2022; Leverenz et al., 2021; Nováková et al., 2021) used the diary method to quantify household food waste.

In the context of household food waste, surveys can be used to collect data on food waste generation, food waste separation habits and food waste disposal practices. The key characteristic of surveys is, that their questioning is structured. The questionnaire can be directly distributed to the respondents or administered by an interviewer. For the purpose of food waste quantification, surveys are ideally used in combination with other methods (e.g., weighing, waste composition analysis, diary method) (FLW Protocol 2016b). In the literature sample, surveys are the second most popular method to assess household food waste quantities. In some publications, surveys were used in combination with other methods (e.g., weighing, waste composition analysis, diary method) (Adelodun et al., 2021; Giordano et al., 2022; Qian et al., 2022). Surveys can also be used to select a representative sample of participants (Adelodun et al., 2021; Barker et al., 2023; Edjabou et al., 2016). For this, the socio-demographic characteristics of the potential participants were assessed and a representative sample was selected on this basis.

Proxy data can be used if waste measurement is not practically feasible. These data can include national food waste data, food waste data for a specific sector or food waste data older than the assessment scope (FLW Protocol 2016b). Most of the reviewed publications, especially the publications mainly

focusing on the environmental assessment of food waste, did not collect any primary data and only used secondary data instead. The most common sources for secondary data in the sample were:

- Food waste statistics (e.g., FAO data, especially FAO food balance sheets, EU data)
- National databases (e.g., the Spanish database on food consumption and waste, the Chinese statistical yearbook, statistical data from US governmental organisations)
- Literature (e.g., data from WRAP reports, scientific literature)

Table 2: Advantages and disadvantages of the food waste quantification methods identified through literature screening (FLW Protocol 2016b)

Method	Advantages	Disadvantages
Weighing	<ul style="list-style-type: none"> • Accurate measurements • Little uncertainty about inventory data 	<ul style="list-style-type: none"> • High effort • Costs (e.g., for scale or for time required)
Assessing the waste volume	<ul style="list-style-type: none"> • Can be cheaper than weighing 	<ul style="list-style-type: none"> • Requires density factors to convert the volume to weight, which may lead to data inaccuracies
Waste composition analysis	<ul style="list-style-type: none"> • Accurate measurements 	<ul style="list-style-type: none"> • Costs • High level of expertise needed • Not suitable for certain waste streams (e.g., material poured down the drain)
Food diaries	<ul style="list-style-type: none"> • “Real time” records of food waste • Captures waste that is disposed of in the drain, fed to animals or home composted • Collecting qualitative information is possible 	<ul style="list-style-type: none"> • Risk that participants do not document all of their food waste • Risk that participants report incorrect food waste measurements • Social desirability bias
Surveys	<ul style="list-style-type: none"> • Low costs • Easy collection of useful additional information (e.g., respondent’s knowledge on food waste) 	<ul style="list-style-type: none"> • Risk of unreliable responses by the participant • Respondent may give responses that they think are desired • Should not be used as the only method to quantify food waste
Proxy data	<ul style="list-style-type: none"> • Low costs 	<ul style="list-style-type: none"> • Less accurate

1.3.5. Environmental assessment of food waste

A total of 50 publications were screened for the methodology used for the environmental assessment of food waste. As a result, an overview of the system boundaries, assessment methods and functional units used was created. This is further elaborated in the following subchapters.

1.3.5.1. System boundaries

Figure 7 shows the system boundaries used for the environmental impact assessment of household food waste. Eight publications calculated the cradle-to-gate impacts associated with food waste. These studies did not take into account the food waste disposal and focused mainly on dining facilities, retail stores or final food consumption. Only one of these eight studies was on household food waste.

Most publications took into account the entire life cycle of food waste (cradle-to-grave). Nine of these 30 publications focused on household food waste. The remaining cradle-to-grave publications assessed food waste impacts on the following levels: food service sector, food production, retail, municipality, national, global or an individual food product (e.g., ready meals).

The three gate-to-gate studies were conducted for retail, the food supply chain or on a global level. Five publications used the system boundary cradle-to-consumption. This means that all environmental impacts from resource extraction up to the consumption of the food were considered. These cradle-to-consumption studies mainly focused on households or dining facilities. One study assessed only the consumption-phase environmental impacts associated with food waste and one study calculated only the EoL impacts of food waste management.

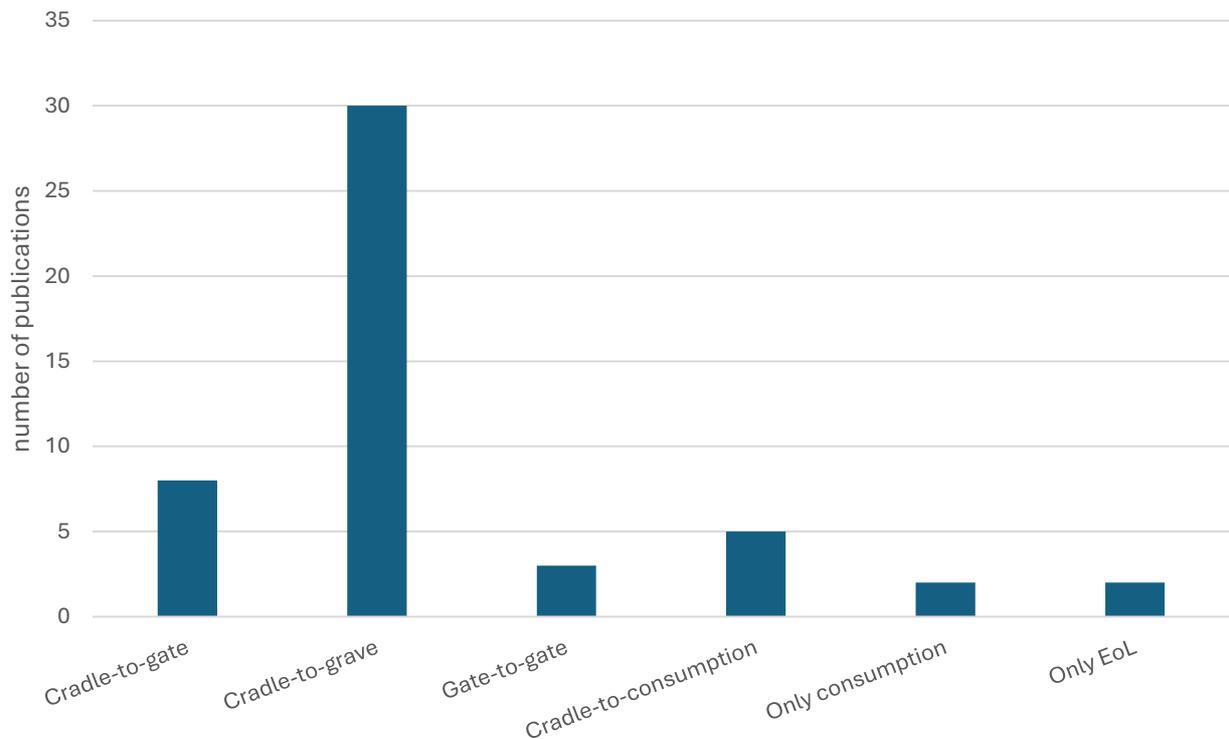


Figure 7: System boundaries for the environmental impact assessment of food waste

1.3.5.2. Environmental assessment methods

The identified environmental methods were grouped into five categories: life cycle-based methods, economic methods, hybrid methods, mathematical methods and statistical methods. Figure 8 shows how often the respective environmental assessment methods were used in the literature sample. Some studies used more than one single method and combined methods to broaden the scope of their assessment.

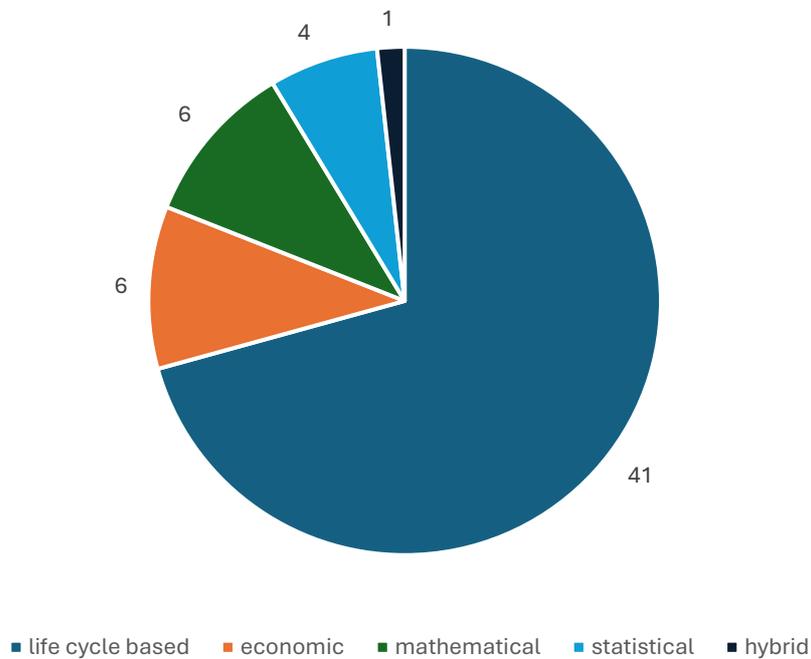


Figure 8: Number of publications in which the respective environmental assessment method was used for food waste

In the literature sample, 41 out of 50 studies used life cycle-based methods to assess environmental impacts of food waste. About half of them (22 publications) used LCA. Most LCA-studies in the literature sample conducted classic LCAs in accordance with ISO 14040/14044. Some studies conducted hybrid LCAs or combined LCA with other methods (e.g., life cycle costing (LCC), linear programming, environmentally extended input-output matrix, global equilibrium model). With the exception of three studies, the scope of all LCAs was cradle to grave.

All life cycle-based environmental assessments which did not perform the four mandatory steps of LCA were summarised under the term “footprint method”. This also includes studies which use emission factors from LCAs and multiply them by the process input values. Footprint methods were applied in 18 publications. With the exception of one study, all of them calculated the food waste-related carbon footprint. The water footprint of food waste was calculated in two studies. Footprints concerning land use, eutrophication and acidification were only found in one publication. Most of the footprints were calculated either for cradle-to-grave, followed by cradle-to-gate.

While the vast majority of publications used life cycle-based methods for environmental assessment of food waste, other methods were identified as well. However, these were only used once or twice on average in the entire food waste literature sample. These methods include cost-benefit analysis, equilibrium modelling and life cycle costing (LCC). These methods mainly focus on economic aspects, such as costs of food waste (e.g., costs of waste collection and disposal, cost of personnel time for waste management) (Mattsson et al., 2018), macroeconomic rebound effects of food waste prevention (Albizzati et al., 2022), the impact of price changes along the food supply chain on food waste generation (Cattaneo et al., 2021) as well as internal and external costs (e.g., market price, externalities of pollutants or transport) (Albizzati et al., 2021). To quantify environmental impacts, these methods were only applied in combination with a life cycle-based approach like LCA or the footprint method.

Besides economic methods, statistical and mathematical methods like the Bayesian belief network, system dynamics modelling, linear programming and multi-layer substance flow analysis were also identified. These studies assess the relationship between socioeconomic key variables (e.g., household income, household size, education level) and food waste generation (Song et al., 2018), socioeconomic impacts of different food waste management options (Parsa et al., 2024), the nutritional and economic costs of food loss and waste along the supply chain (Vazquez-Rowe et al., 2020), as well as the implications of food waste strategies on biomass, energy and nutrient cycles (Hamilton et al., 2015).

Hybrid methods, which are a combination of environmental, economic, statistical or mathematical models, were identified as well. These include a ranking method, based on combined monetary and environmental indicators (Dreyer et al., 2019), a counterfactual environmental footprint analysis quantifying the impact of food loss and waste reductions (Osei-Owusu et al., 2022) and an environmentally extended input-output analysis. The environmentally extended input-output analysis is used to assess the environmental impacts of changes in food waste (Read et al., 2020; Read and Muth, 2021; Usubiaga et al., 2018) or to assess the rebound effect of customer emission reduction measures (Albizzati et al., 2022).

1.3.5.3. Functional unit

The functional units identified in the food waste literature sample are shown in Table 3. Half of the assessed publications used a functional unit based on the amount of waste (e.g., total amount of national food waste, average amount of food waste per person). Eight publications based their assessment on the functional unit of the management of one unit of food waste. A food consumption-based functional unit (e.g., consumption of one unit of food) was used in five publications. This took into account the amount of food waste per unit of consumed food. Ten publications used a food production-based functional unit (e.g., one unit of food produced, total national amount of produced food, one unit of a specific product). Again, this took into account the amount of food waste per unit of produced food. Three studies based their functional unit on the calorie content of food. The functional unit would either be the amount needed to meet the calorie requirement of an average person or simply one calorie of food. One study defined the functional unit as the total amount of avoided national food waste. Three studies used to functional units in their assessment: one waste management-based and one food production-based functional unit.

Table 3: Overview of identified functional units used for the environmental assessment of food waste

Categorisation	Examples	Number of publications
Amount of food waste	<ul style="list-style-type: none"> • Total amount of food waste (either on national level, city level, in retail or in food service) • Average amount of food waste per person and year • Average amount of food waste per household and year • Amount of food waste per meal • Amount of avoided food waste 	26
Waste management	<ul style="list-style-type: none"> • Management of one unit of food waste 	8
Food consumption	<ul style="list-style-type: none"> • One unit of food consumed • Total food consumption (on a national level) 	5
Food production	<ul style="list-style-type: none"> • Production of one unit of food • One unit of a certain product (e.g., a ready meal, fruits and vegetables) 	10
Calorie uptake	<ul style="list-style-type: none"> • Average calorie requirement of one person (per day or per year) 	3
Food waste reduction	<ul style="list-style-type: none"> • Total amount of avoided national food waste 	1

1.3.5.4. Impact categories

Regarding the environmental impact categories, 43 out of 50 publications assessed the greenhouse gas emissions or carbon footprint, which is referred to as global warming potential in Figure 9. This highlights the importance of global warming potential in regards to the environmental impact assessment of food waste. The second most used impact category is water use, which was used in 21 studies. The impact categories land use, eutrophication, acidification, resource use, energy use, ecotoxicity, photochemical ozone formation, human health and particulate matter were each used between 9 and 13 times in the literature sample.

Three studies assessed nutrient-specific indicators. Niu et al. (2022) assessed the nitrogen footprint and phosphorus footprint (in combination with carbon footprint and water footprint) of edible food waste in selected Chinese provinces. In addition to acidification, ecotoxicity, global warming potential, human toxicity and photochemical ozone formation, Gentil et al. (2011) also assessed the nutrient enrichment associated with treatment of food waste. Hamilton et al. (2015) quantified implication of food waste strategies on the national energy and phosphorus cycles in Norway.



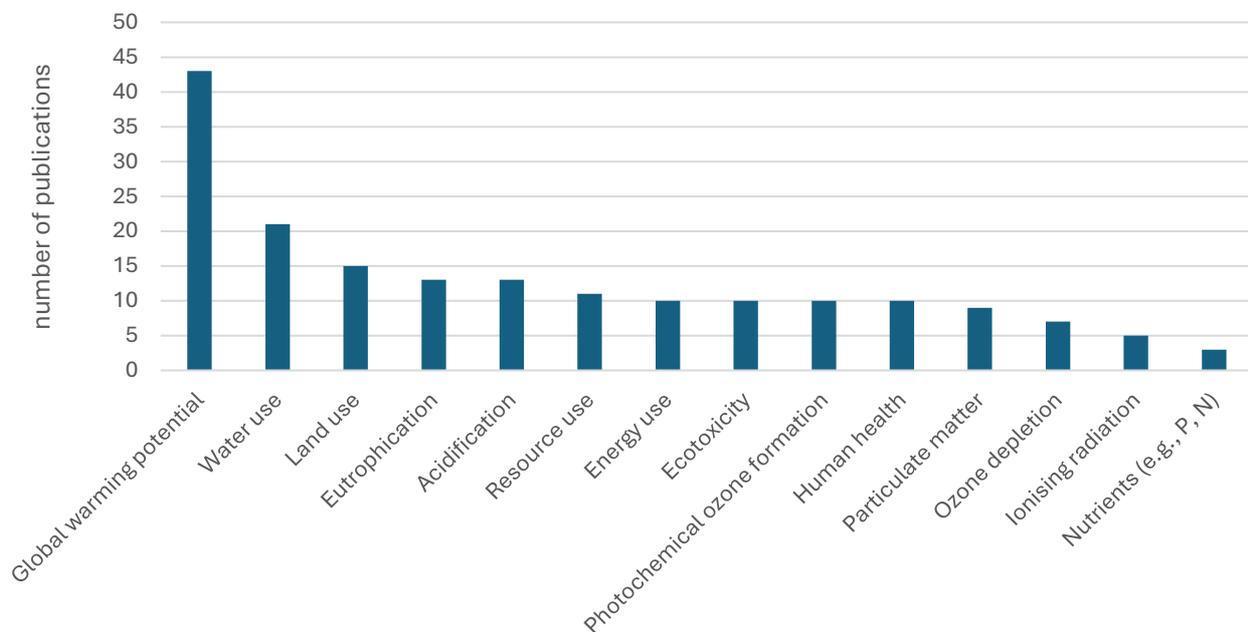


Figure 9: The impact categories and indicators assessed in the studies on environmental impacts of food waste in the final literature sample

In general, most studies either assessed only the food waste-related carbon emissions or the entire set of midpoint environmental impact categories common in LCA, as recommended by the Product Environmental Footprint. These impact categories are used in the most commonly used LCA impact assessment methods (e.g., ReCiPe, Environmental Footprint, CML) and consist of:

- Global warming potential
- Stratospheric ozone depletion
- Human toxicity (cancer and non-cancer)
- Particulate matter formation
- Photochemical ozone formation
- Ecotoxicity
- Acidification
- Eutrophication (freshwater, marine, terrestrial)

- Ionising radiation
- Land use
- Water use
- Resource use (fossil, mineral and metals)

In the literature sample, the emission factors for quantifying environmental impacts were either taken from relevant scientific publications or LCA databases. The LCA database used most often in the literature sample is Ecoinvent. Other databases that were used are Agri-footprint, the Danish LCA food database, the LCA database created by the Barilla Center for Food and Nutrition.

1.4. Domestic consumption and use of clothing review

1.4.1. Publication year

Figure 10 shows the number of publications per year for the final literature sample. Results show that there has been a constant increase in publications, indicating an increased interest in the research area of environmental assessment of clothing consumption and use.

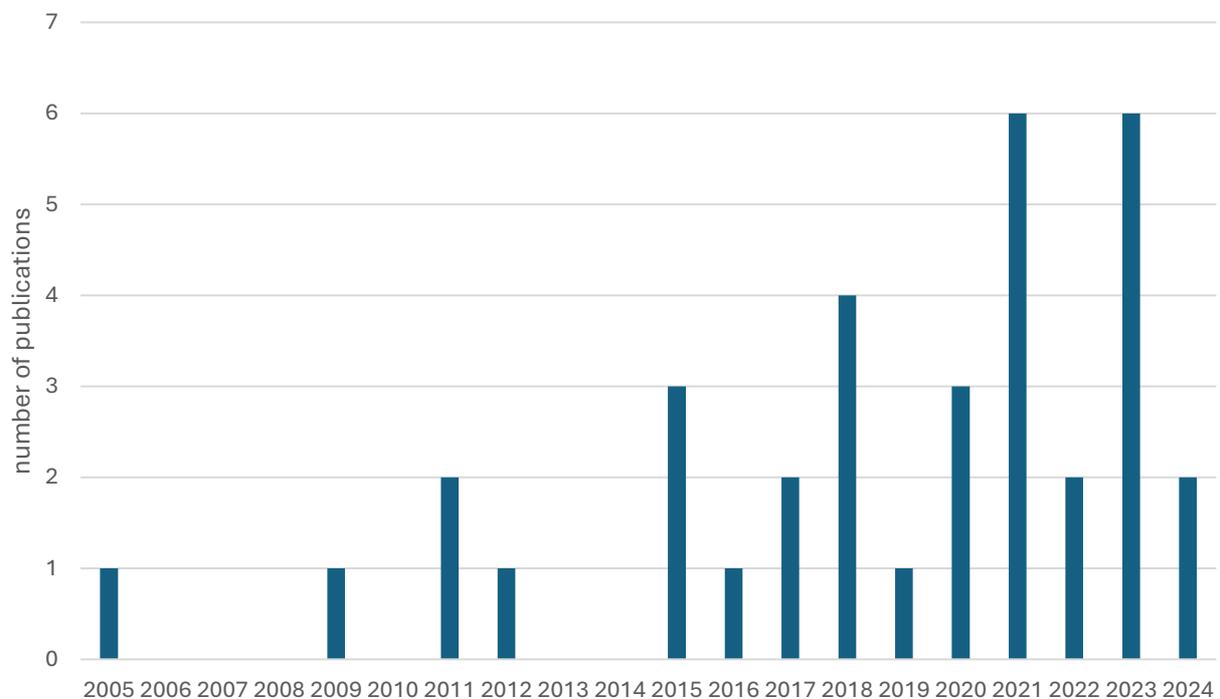


Figure 10: The number of publications on environmental assessment of clothing consumption and use per year

1.4.2. Geographical setting of use phase

Figure 11 shows the distribution of the studies’ geographical setting of the clothing use phase. Results show that the most common geographical setting of the use phase are Germany and Japan (six studies respectively), followed by Sweden, China, and the USA (five studies respectively). On the importance of the geographical setting of the study, Sohn et al. (2021) write that the selection of geographical settings is important as there are regional differences in purchasing patterns, washing practices and dryer ownership. This statement is confirmed by Nautiyal et al. (2023), who compared the washing and disposal practice of apparel in New Zealand to those in other countries. They conclude that there are significant differences between countries, which underlines the need for country specific data in LCAs of clothing consumption and use. The importance of regionalised data is also mentioned by Piontek et al. (2020) and Piontek and Müller (2018), but in the context of product service systems, where for example transportation and laundry practices have a large influence on the results.

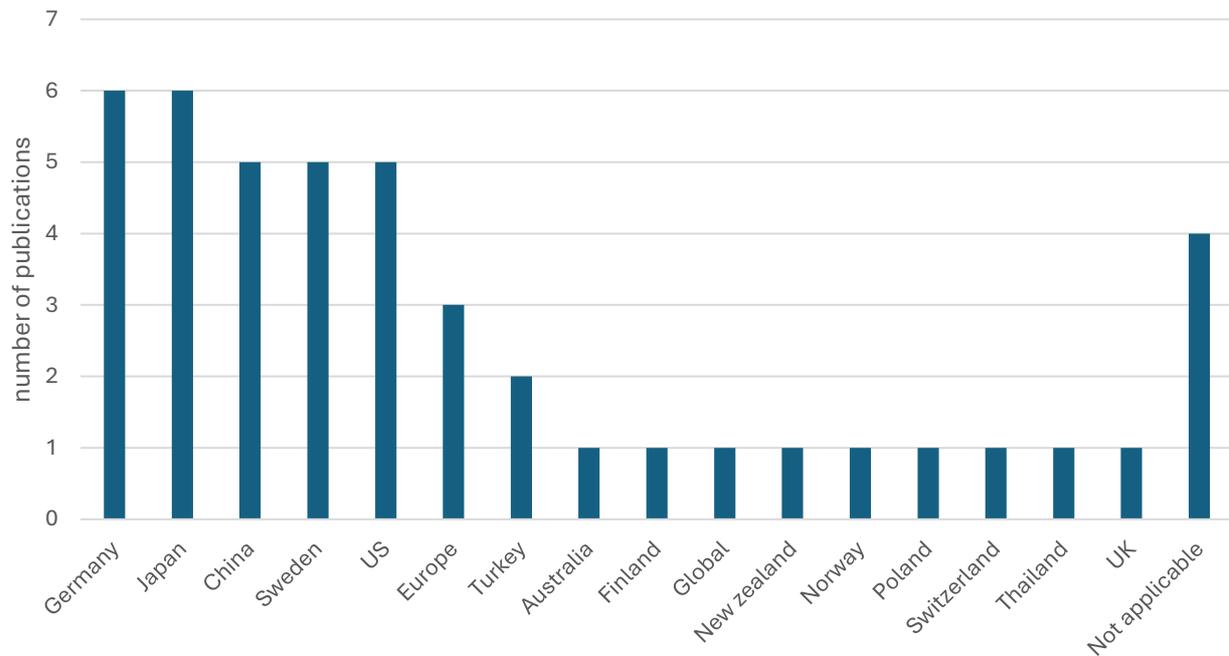


Figure 11: The distribution of the geographical setting for the clothing use phase in the literature sample.

1.4.3. System boundaries

Figure 12 shows the distribution of the system boundaries of the included studies. The category *not applicable* is primarily related to review studies which do not explicitly state the system boundaries. The results show that all studies include the consumption and use stages of the garment. The majority of the studies include the production phase, however a minority excludes it. While the exclusion of the production stage might be in line with the scope of the specific study, not including the production stage could lead to sub-optimisation of the system. This is because different clothing items are related to different environmental impacts, for example depending on differences in fibre types, fabric production (e.g., weaving or knitting), wet processing (e.g., the dyeing technology used), confectioning (e.g., more complex garments require more energy) and the energy (e.g., fossil or renewable) used in these processes. The different clothing items do also influence the washing patterns and duration of product life span, and consequently, their environmental impacts (Schmutz et al., 2021).

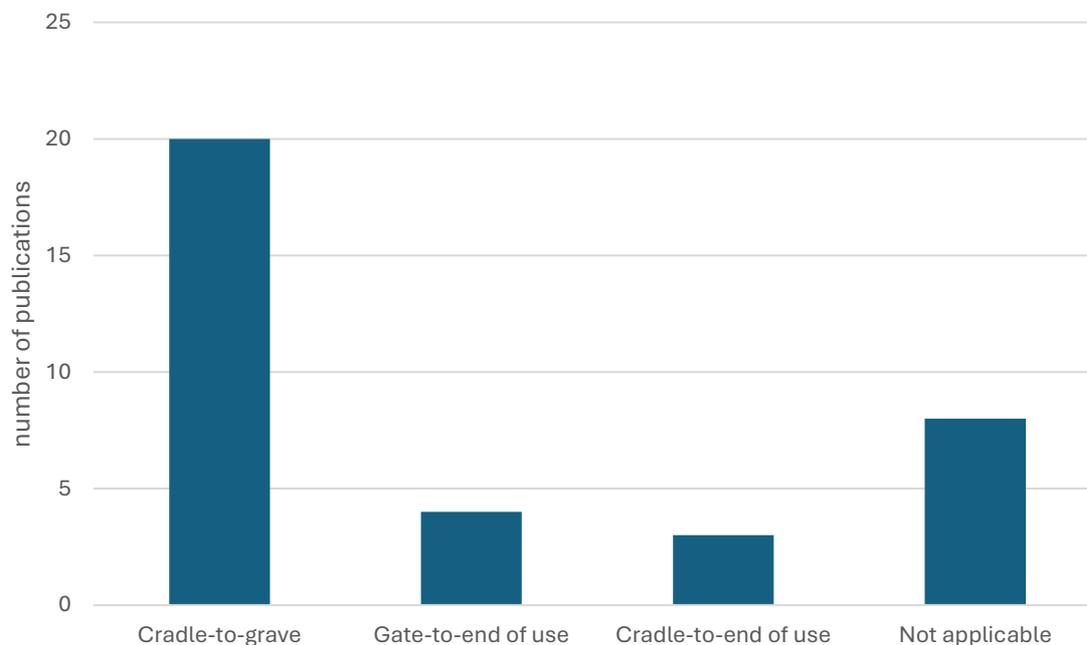


Figure 12: The system boundaries of the studies on clothing consumption and use in the final literature sample

1.4.4. Data collection method

Of the included studies, only eight collect primary data via surveys or interviews. Most of the included studies collect their data using literature, statistics or supplier data. Some of these studies do however collect data from literature, which is based on surveys, but the creation of specific questionnaires appropriate for the study in question is uncommon. In most of the questionnaires, it is not clear what exactly is measured.

1.4.5. Functional unit

Of the 35 studies included in the review, 28 are following an LCA approach or use some other method to quantify the environmental impacts of domestic clothing consumption or different means of clothing use, the latter including laundry activities. The LCA articles were divided based on four overarching themes: product service system (includes, for example, clothing libraries), laundry (the process of cleaning and drying clothes), clothing items (typically cradle-to-grave assessments of one/several clothing items), and

finally, clothing consumption (purchasing and use of clothing). The reason behind this division is to be able to capture all aspects of a holistic functional unit on household clothing consumption and use. Table 4 shows the included LCA studies, and the functional unit applied in the study.

Table 4: The life cycle assessment articles on clothing consumption and use, divided into four different main themes, and the applied functional unit

Main theme	Query #	Article	Functional unit
Product service system	1	Böckin et al. (2022)	100,000 Euro per month, from consumer transactions of jackets
	1	Mora-Sojo et al. (2023)	One year of Norwegian’s household’s apparel needs met by acquisition
	1	Zamani et al. (2017)	1 average use of each of the three garments: 1 100% cotton T-shirt, a pair of 98% cotton and 2% elastane jeans, and a 100% polyester dress
	2	Piontek et al. (2020)	Wearing of a certain garment
	2	Johnson and Plepys (2021)	3 different functional units: one average use, 4 years of consumer needs, user dress needs for 4 years satisfied by purchasing
Laundry	1	Moon et al. (2020)	Per person per year
	1	Amasawa et al. (2018)	One year of laundry activities per household
	1	Ryberg et al. (2018)	Doing 34.4 billion washes per year of 4.5 kg normally soiled dry fabric at medium water hardness with a model liquid detergent
	2	Fidan et al. (2024)	9 kg of clothing that was washed in a washing machine
	2	Yamaguchi et al. (2011)	A washing machine (with 9 years of service)
Clothing item	1	Horn et al. (2023)	One use of a polyester T-shirt
	1	Moazzem et al. (2021)	The use of 1 kg cotton knit dyed t-shirt and the use of 1-kilogram polyester knit dyed jacket

Main theme	Query #	Article	Functional unit
	1	Roos et al. (2016)	A T-shirt, a pair of jeans, a dress, a jacket and one garment for the public sector: a hospital uniform
	2	Luo et al. (2022)	A pair of conventional 100% cotton jeans
	2	Schmutz et al. (2021)	A knitted cotton t-shirt of 154 g (representing an average weight) having a life span of 44 cycles
	2	Temizel-Sekeryan and Hicks (2021)	145 g silver enabled PES textiles (indicates men's t-shirt with a large size) during its lifetime of 100 laundering cycles
	2	Baydar et al. (2015)	1,000 items of knitted and dyed cotton T-shirts
	2	Manda et al. (2015)	1 T-shirt being worn 100 times
	2	Zhang et al. (2015)	A piece of 100% cotton short sleeved T-shirt
	2	Walser et al. (2011)	1 T-shirt
	2	Steinberger et al. (2009)	100 days of a garment being worn (100 days, or once a week for 2 years or every two days for 2 seasons)

Main theme	Query #	Article	Functional unit
Clothing consumption	1	Moon (2024)	Per item/unit
	2	Long et al. (2023)	Not clear: "in the past 12 months, how much did you spend on online shopping?"
	2	Sohn et al. (2021)	Jeans or T-shirt provisioning for one consumer over one year
	2	Zhang et al. (2021)	Unclear: emissions from urban and rural residents
	2	Piontek et al. (2019)	1 year of varied clothes
	2	Bin and Dowlatabadi (2005)	US household 1997

Table 4 shows that there is a large diversity among the functional units used in the LCAs on clothing consumption and use. Fourteen of the functional units are related to a clear reference flow, such as a pair of jeans or 1,000 items of knitted and dyed cotton T-shirts. Of these, only four functional units also include the life span of the product (for example washing cycles or times being worn). This leads to difficulties in capturing all consumer behaviour in the use phase. Klepp et al. (2020) provide guidance on different means of capturing clothing life spans: The number of years, number of wears, the number of users and the number of cleaning cycles. They write that the different units provide different understandings and comes with both drawbacks and benefits, and that the choice of measure (or combination of measures) depends on the scope of the study. They conclude that both the number of wears for all users as well as the service life span are important. They mean that the number of wears is the best measure for regular clothing and number of years is most suited for clothes intended for special occasions.

A difficulty when assessing the use phase of domestic use of clothing is that it includes many different parameters such as consumption, laundry and any use of product service systems such as clothing rentals (as are shown in Table 4). This means that it is important to find a functional unit that captures all of these activities. Klepp et al. (2020) state for example that the ideal functional unit for assessing clothing life span should be based on a combination of the number of wears and duration in use by all owners. They were however not sure on how to capture this. Another aspect to consider when choosing the

functional unit is the main driver of the system. In this case, Mora-Sojo et al. (2023) identify clothing consumption rather than the need of owning or using garments. While they do not specify what they mean with the need for clothing consumption, the study focuses on the influence of different means for increasing circularity in the Norwegian clothing system. This includes clothing rental services and buying second hand clothing. However, we argue that using the driver of clothing consumption as the basis for the functional unit can however be troublesome. This is because it does not allow for fair comparisons with circularity measures that do not include consumption of new or second-hand clothes (e.g., shopping), such as mending of clothes.

1.4.6. Allocation

Whenever there is reuse of clothing (buying second hand or donating), there will be the need for allocation between the first and second life cycle. Sohn et al. (2021) handle this by allocating all production-induced environmental impacts to the first life cycle of the clothing item, when the respective clothing item is made available for a second life. The second life cycle of the clothing item is instead allocated the processes needed for making the item available for second hand. This is often referred to as the cut-off approach. Likewise, Mora-Sojo et al. (2023) applied the cut-off approach in their study. This choice of method is also in line with guidelines such as the Greenhouse Gas protocol provided by the World Business Council for Sustainable Development and World Resource Institute (2011), who state that the cut-off approach is appropriate to use in situations when the market for the recycled material is saturated. An alternative approach is provided by Moon (2024), who calculate the greenhouse gas emissions reduction potential by subtracting greenhouse gas emissions from new clothing (with the same functionality as second hand clothing) from the greenhouse gas emissions of the second hand clothing. This approach is not in line with allocation methods available in guidelines such as ISO 14044 standards (International Organization for Standardization 2006), the Greenhouse Gas Protocol (British Standards Institute 2011) or the Product Environmental Footprint guidelines (European Commission 2018). Instead, it is an unconventional approach to account for benefits and burdens that come from reusing old clothes rather than producing new ones.

1.4.7. Impact assessment categories

Figure 13 shows that the most used midpoint indicator is climate impact, followed by water use. This is reasonable, as the use of clothing includes laundry practices which are closely related to energy use (and resulting climate impact) and water consumption. Both indicators are also important for the production phase, as cotton, for example, requires water and energy for cultivation, as well as large amounts of energy for yarn production (La Rosa and Grammatikos, 2019). This pattern also follows what we expect from traditional LCA studies: a strong focus on climate impact, with the addition of some well-established impact assessment categories (water use, eutrophication, and acidification). Notably, the climate impact correlates very well with acidification and eutrophication, and photochemical ozone creation potential, as was shown by Janssen et al. (2016) for ethanol production. This means that, in some cases, little additional information is added by including all four of these.

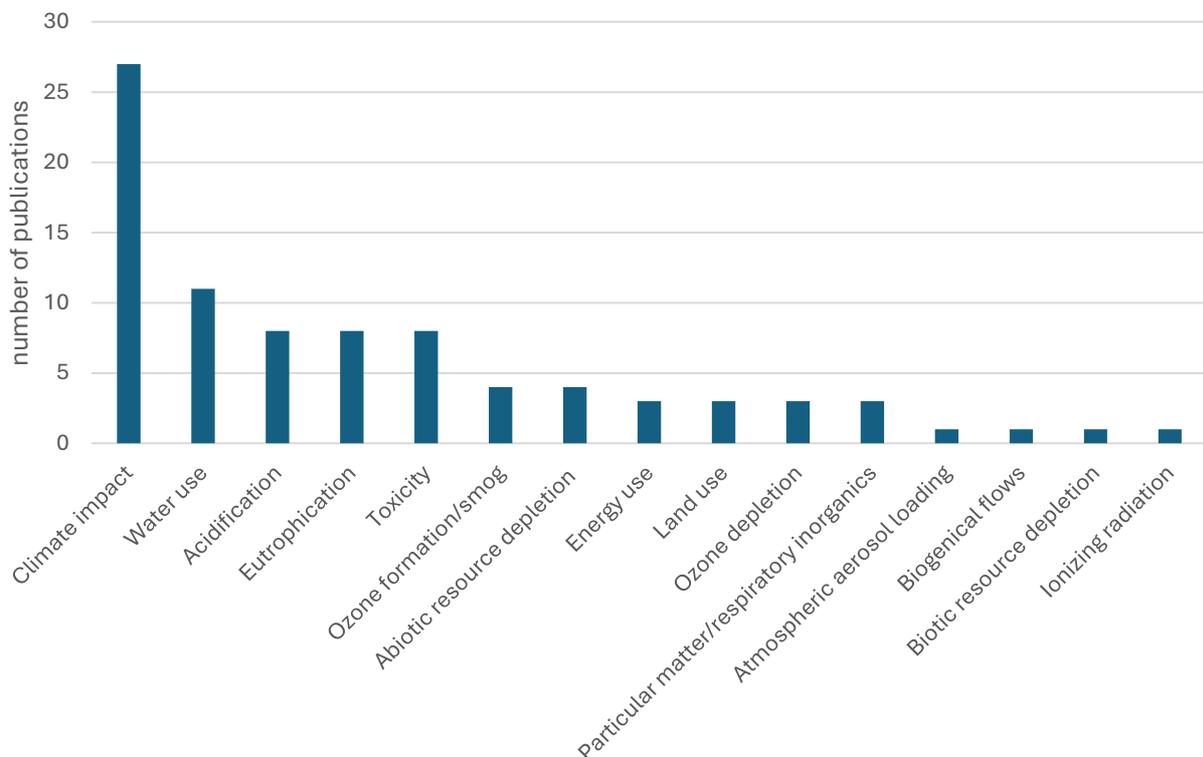


Figure 13: The distribution of the use of different midpoint life cycle impact assessment indicators in the environmental assessment of domestic clothing consumption and use

While we initially were surprised by the low number of studies including energy use, some of the energy use inventory is captured by the abiotic resource depletion category (depending on how it was presented in the reviewed article). Another unexpected outcome of the review was the low number of articles including toxicity. Note that we grouped toxicity into one category, meaning that if one study assessed many different types of toxicity (say freshwater toxicity and human toxicity), this is only accounted for once. Generally, toxicity is a challenging impact category to consider as its outcome depends on the quality of the foreground inventory, the quality of the inventory for the background system (database data), but also the characterisation factors available (Roos et al., 2019). For future LCAs on clothing consumption and use, we suggest expanding the impact categories from the most common ones in Figure 13 to also include less commonly used impact categories, such as land use and toxicity, to avoid problem shifting in the assessment.

1.5. Conclusions on food waste and clothing consumption and use

1.5.1. Food waste conclusions

Based on the systematic literature review, the following conclusions were drawn for the quantification of food waste and its environmental impact for the CARE project:

- A standardised definition of "food waste" at the start of the CARE project is important. It must be precisely defined what is included in the term food waste (e.g., avoidable, partially avoidable and unavoidable food waste).
- There are no universal guidelines for the categorisation of food waste. A categorisation based on avoidability, degree of processing, generation phase and food group is possible (see Table 1). The categorisation according to the various food groups (see WRAP 2009) has proven to be useful in the literature. Different degrees of aggregation of the food waste streams (e.g., either just "meat" or "beef", "pork" and "chicken") are possible as well.
- As for food waste quantification, most of the selected publications rely on secondary data for this. Data collection through surveys or waste composition analysis are also popular in the literature

sample. However, FUSIONS (2014b) recommends a waste composition analysis in combination with a food diary for assessing household food waste quantities. The advantage of waste composition analysis is the high accuracy of measurements. Food diaries also capture food waste disposed of through pouring down the drain, home composting or feeding to animals (FLW Protocol 2016b).

- The majority of publications used a life cycle-based method like LCA or footprint method to assess the environmental impacts of food waste. Thus, LCA and footprint method can be considered state of the art in terms of life cycle-based environmental assessment methods. Although other methods have been identified, their main focus were mostly socio-economic and not environmental aspects. To compensate for this, these methods were often combined with LCA or the footprint method. This further emphasises the importance of LCA and the footprint method for environmental assessment.
- A cradle-to-grave system boundary was used most frequently in the literature sample. This makes sense, as an environmental assessment of food waste should also include the EoL.
- Functional units based on the amount of food waste (e.g., total amount of food waste per household or per person) were the most popular in the literature sample (see Table 3).
- The most frequently used impact categories were global warming potential, followed by water use, land use, eutrophication and acidification. However, in order to represent the overall environmental impacts, indicators for human toxicity, particulate matter formation, ecotoxicity and resource consumption, among others, should also be included. These aspects are covered, for example, by the indicators of the Environmental Footprint (EF) impact assessment method.

1.5.2. Clothing consumption and use conclusion

Regarding clothing consumption and use, the following conclusions were derived from the results of the literature review:

- Primary data on clothing consumption and laundry habits needs to be collected within the CARE project, which can be done through questionnaires, interviews or self-assessments. In addition to clothing consumption quantities, data collection should also include the type of fabric, as this will have a large influence on the end results. Inventory data should also be provided grouped into the different regions of the households, to capture any differences between these.

- As the type of fabric used in the clothes has a large influence on the clothing production impacts and also some on the impacts from the use phase, the system boundaries should consider at least cradle-to-end-of-use stage.
- There is no consensus on what a useful functional unit for assessing the environmental impacts of domestic use of clothing is. Effort should be put into defining this for the CARE project.
- The choice of impact categories should be expanded from the commonly applied impact categories to include also land use and toxicity, given that high quality inventory data can be acquired.



2. Part 2: Sustainable well-being indicators

2.1. Introduction to Part 2

Part 2 of this deliverable presents the process and results of screening assessment methods used in literature related to sustainable well-being. This screening was conducted by researchers at Tampere University (TAU). The literature review is complemented with insights from a researcher workshop organised in February 2024. This workshop brought together Finnish sustainable well-being researchers to discuss and share their views and experiences on measuring sustainable well-being at the household level. The objective of both the literature review and the workshop was to build knowledge that will contribute to selecting suitable indicators for assessing well-being effects in participating households within the CARE project. The chosen data collection protocols, including indicators for sustainable well-being and living conditions¹, will be further developed in CARE task 1.2 and reported as part of deliverable D1.2 Evaluation method and data collection protocol (due M17 in May 2025).

2.2. Sustainable well-being in CARE

Sustainable well-being has been defined as “human well-being in the context of nature” (Hirvilammi 2015, p.83). It involves thriving within planetary boundaries: ensuring a just and safe space for humanity and promoting both individual and collective welfare with the least possible environmental impact (Gough, 2017, p. 86).

Efforts to develop sustainable well-being metrics have progressed mainly at the societal level, driven by the need for more comprehensive indicators that complement or replace gross domestic product. In CARE, sustainable well-being approach is applied at the individual and household level, concentrating on the effects of changing consumption practices in food waste and clothing. This means that the concept

¹ Taking into account the timeframe for producing this deliverable, the deliverable focuses on reporting the review of sustainable well-being indicators. Choosing the indicators for living conditions are more straightforward, and will be done later in task 1.2. In general, it should be noted that in the countries from where households participate in CARE interventions (Finland, Sweden, Norway, Germany, and Estonia), the living conditions are quite well developed. However, in this deliverable, any implications regarding measuring living conditions are discussed when presenting the results of the sustainable well-being workshop.

of well-being is not used to assess societal system's ability to produce well-being in a sustainable way, but it is seen as something that households can contribute to by making their consumption practices more circular.

In CARE, the sustainability part of sustainable well-being is mainly outlined as environmental sustainability. This derives from the premises of circular consumption, that emphasises reducing resource use and keeping materials and products in use as long as possible (Rabiu & Jaeger-Erben, 2022). However, the environmental sustainability of circular consumption is always more or less linked to the questions of social and economic sustainability. The temporal perspective to sustainable well-being in CARE is restricted to the project's duration, and in the scope of the CARE project, it is not possible to examine long-term impacts. .

In the CARE project, sustainable well-being indicators will be used in assessments conducted before and after the pilots. When promoting circular consumption, our goal is not to compromise sustainable well-being and living conditions. In the best-case scenario, the transition to sustainable circular consumption practices can even enhance sustainable well-being by alleviating anxiety related to climate change, reducing excess of material possessions, saving money in household budgets, creating more storage space at home, improving skills in food waste management and fostering care for clothes. The transition can also increase perceived behavioural control related to consumer responsibilities in sustainable living or a sense of belonging to a community.

2.3. Literature on measuring sustainable well-being

The purpose of reviewing literature related to sustainable well-being was twofold: first, to establish a foundation for assessing well-being effects in participating households within the CARE project, and second, to enhance the conceptual understanding of TAU researchers and highlight relevant issues for discussion in the researcher workshop. As mentioned in the introduction to Part 2, this literature review, combined with insights from the researcher workshop, contributes to the selection of suitable indicators for sustainable well-being in CARE project.

2.3.1. Method for the mapping review

This literature review presented in Part 2 follows a narrative approach. It addresses a broad research focus by screening sustainable well-being literature and involves selective data collection without a fully systematic protocol. Specifically, this method can be called a mapping review, which categorises existing literature and assesses its quality to find insights for further research (Grant and Booth, 2009). The chosen approach served the CARE project by identifying narrower practice-relevant questions related to assessing sustainable well-being in households. Given that there is no unified and extensive body of literature focused on sustainable well-being indicators, a systematic review would have been challenging, if not impossible, to conduct.

The methodology for the mapping review proceeded as follows: 1) testing keywords to gain a general understanding of which sustainable practices, dimensions and measurements of well-being are commonly addressed in literature; 2) categorising the literature found using the most comprehensive keywords/search terms relevant to the project's contexts; and 3) closely examining and interpreting findings, with a focus on reviewing papers that explicitly discussed well-being within the context of sustainable consumption practices and included indicators for eudaimonic well-being.

The review data was collected by TAU researchers in January and February 2024. It included articles from peer-reviewed, scholarly journals. The databases used were Google Scholar and EBSCO (Academic Search Ultimate). The following search words were used in the initial searches:

- Sustainability (and consumption): “sustainable consumption”, “circular economy”, “circular economy practices”, “circular practices”, “circular consumption”, “environmentally-friendly behaviour”, “ecologically responsible behaviour”, “ecologically sustainable behaviour”, “pro-environmental behaviour”, “pro-environmental consumption”, anticonsumption, minimalism, “green consumption”
- Well-being: well-being (or well-being or wellbeing), “sustainable well-being” (or well-being or wellbeing), “subjective well-being” (or well-being or wellbeing), eudaimonic, hedonic, life-satisfaction
- Clothing: “sustainable fashion consumption”, “clothing consumption”, sustainable AND well-being (or well-being or wellbeing) AND clothes (or clothing or fashion), well-being (or well-being or wellbeing) AND fashion (or clothing or textile)

- Food: “sustainable food consumption”, “food waste”, “food waste reduction”, “food waste management”, “food waste” AND well-being (or well-being or wellbeing), “food storage” AND well-being (or well-being or wellbeing), “food preparation” AND well-being (or well-being or wellbeing), food AND well-being (or well-being or wellbeing)

The next chapter introduces the conceptual overview and the well-being indicators that seemed to be most commonly utilised in the sustainability context.

2.3.2. Conceptual overview

As a result of the review, two common theoretical approaches were identified in well-being research: the needs-based and the capability-based approach. This section introduces the theoretical and conceptual background of sustainable well-being, including the most frequently used well-being measures.

2.3.2.1. Needs-based and capability-based approach

The development of sustainable well-being measurement stems from indicators designed for societal-level decision-making, often used alongside or in place of gross domestic product. These indicators are often appointed to two distinct theoretical approaches:

- *The needs-based approach*: This perspective views well-being in relation to the fulfilment of material and non-material needs. In current sustainable well-being research, the most widely applied needs-based theory seems to be the HDLB model (Having, Doing, Loving, Being) proposed by Allardt (1993) (see also Helne and Hirvilammi, 2015). The HDLB model considers sustainable well-being from multiple perspectives: 1) Having: Satisfaction of material needs such as food, water, energy, housing, and basic utilities. 2) Doing: Meaningful activities that individuals engage in voluntarily. 3) Loving: The need for connection with other people and the environment. 4) Being: A healthy physical, emotional, and spiritual existence and fulfilling life. Another frequently cited needs-based work is the Human scale development (Max-Neef 1991) describing nine interrelated, non-hierarchical and universal needs: subsistence, protection, affection, understanding, participation, leisure, creation, identity, and freedom (pp. 44 –49).

- *The capability approach*: This approach emphasises an individual's capabilities – their real opportunities to achieve well-being. Rather than focusing solely on needs, the capability approach considers what people can actually do and be. It assesses the freedom and agency individuals have to lead lives they value. (Sen 2013) For example, ten core human capabilities have been listed including life; bodily health; bodily integrity; senses, imagination and thought; emotions; practical reason; affiliation; other species; play; and political and material control over one's environment (Nussbaum 2005). This approach has been seen as problematic from the sustainable well-being viewpoint because it emphasises the individual's freedom to define valuable doings and beings. Contrary to this, the needs-based approach questions the individual (and potentially unsustainable) "wants" as a basis of well-being (Helne and Hirvilammi, 2015).

2.3.2.2. Hedonic, eudaimonic and social measures

Well-being measures are commonly categorised into hedonic and eudaimonic traditions within well-being studies (Ryan and Deci, 2001). This distinction also applies in contexts such as reducing consumption (Vollebregt et al., 2024).

The hedonic approach defines well-being through subjective well-being such as pleasure, positive affect or happiness (Ryan and Deci, 2001). The most common hedonic well-being measure seems to be the Subjective Well-Being (SWB) measure by Diener (1984), which includes measures for life satisfaction, and for positive and negative affect. Satisfaction with life is measured with items (different number of items depending on the version adapted) assessed with scales from strongly agree to strongly disagree (SWLS) (Diener et al., 1985). Examples of items are "The conditions of my life are excellent", "I am satisfied with my life", and "In most ways, my life is close to my ideal." Affective dimensions are usually measured using emotion items lists such as the Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988) or its variants. Respondents rate emotions or feelings from 'not at all' to 'extremely so'. The number of listed emotions (the original scale has two 10-item mood scales) and the evaluation time span vary across studies.

Other hedonic scales identified, for example in the context of reducing consumption, include Subjective Happiness Scale and Orientation to Happiness Scale (Vollebregt et al., 2024, table 1). Diener et al. (2010) have also developed another scale for positive and negative affects: 12-item Scale of Positive and

Negative Experience (SPANE) that captures feelings beyond high arousal feelings (e.g., content, grateful).

Studies in different fields of consumption often employ hedonic and subjective well-being measures (Sirgy, 2021). While these measures are widely used and tested, some argue that they primarily focus on individual preferences and human desires, potentially overlooking other crucial aspects related to sustainability (Hirvilammi, 2015; Moynat et al., 2022).

The eudaimonic approach centres on psychological well-being and defines well-being more broadly in terms of the fully functioning person. It emphasises self-realisation and the search for meaning in life (Ryan and Deci, 2001). One of the most popular measurement scales for eudaimonic well-being is Ryff's Scales of Psychological Well-being (PWB) (Ryff and Keyes, 1995). It includes six dimensions: self-acceptance, positive relations with others, autonomy, environmental mastery, purpose in life, and personal growth. In both the original 42-item scale and in a shortened 18-item scale, respondents evaluate items using options from strongly agree to strongly disagree. Examples of items include "I think it is important to have new experiences that challenge how I think about myself and the world" (personal growth), "In general, I feel I am in charge of the situation in which I live" (environmental mastery) and "Maintaining close relationships has been difficult and frustrating for me" (positive relations with others). Another scale relevant to sustainable consumption is the 8-item Flourishing Scale which assesses aspects ranging from positive relationships to feelings of competence and having meaning and purpose in life (Diener et al., 2010). Respondents rate each item on a 1–7 scale, ranging from strong disagreement to strong agreement.

While less frequently used, certain scales have been identified in the context of reducing consumption. These include the Psychological Distress Scale, Personal Well-being Index, and Subjective Vitality Scale (Vollebregt et al., 2024).

The eudaimonic perspective often encompasses items and dimensions related to social relations. Some authors (e.g., Herziger et al., 2020; Seegebarth et al. 2016) have specifically emphasised social well-being in the context of sustainable consumption. One example of a relevant scale is Keyes's Social Well-being scale (Keyes 1998), which includes five dimensions: social integration, social contribution, social coherence, social actualisation and social acceptance. The shorter version of this scale consists of 15 statements, such as: "I feel close to other people in my community" (integration), "I have something

valuable to give to the world” (contribution) and “The world is becoming a better place for everyone” (actualisation). Respondents rate these statements on a scale ranging from strongly agree to strongly disagree.

2.3.3. Measuring sustainable well-being in the context of sustainable consumption

In addition to the diverse concepts and terminology related to well-being measurements, sustainable consumption encompasses several dimensions. Common forms of sustainable consumption include green buying (e.g., reusable items, electric cars), sharing economy, second-hand purchases, recycling and substituting (e.g., choosing a train ride over a flight). Sustainable consumption is also part of broader pro-environmental or ecological behaviour. Synonyms used in literature include “green”, “eco-friendly”, and “environmental behaviour” (Vollebregt et al., 2024). Within the CARE project, the specific focus lies on a specific form of sustainable consumption – circular consumption, which emphasises the environmental aspect. Circular consumption manifests in everyday consumption practices which aim “to reduce resource consumption and to keep materials and products in use as long as possible” (Rabiu and Jaeger-Erben, 2022, p. 2). However, given that research on circular consumption practices is still in its infancy (see Rabiu and Jaeger-Erben, 2022), this review primarily considers relevant literature related to the broader concept of sustainable consumption.

Guillen-Royo (2019) explains that “sustainable consumption is generally defined in terms of ‘behaviour’ or ‘lifestyle’, which may overlap with the meaning of ‘practice’ but generally concern purchases (e.g., buying water-saving devices) or activities (e.g., recycling)” (p. 1114). Lorek and Spangenberg (2014) distinguish between weak and strong perspectives on sustainable consumption. They argue that weak (technology and market based) approaches are not sufficient to prevent the environmental and societal disasters ahead caused by current economic development. Instead, they advocate for a strong sustainable consumption perspective, which focuses more on patterns and behaviours in consumption and on a structural reform in societies. In the weak sustainability discourse technological and organisational solutions are prioritised and human-made substitutes are seen as an option to natural resources (Guillen-Royo, 2019).

Examples of concrete sustainable practices by individuals following this dichotomy could be for example recycling (weak measure) and changing dietary practices like reducing the intake of meat and fish (strong

measure) (Guillen-Royo, 2019). According to growing research literature, neither of these sustainable consumption types seem to influence well-being negatively. In fact, as stated by Kasser (2017): “regular engagement in pro-ecological behaviours is positively correlated with personal well-being” (p. 1). However, there is no full consensus on the well-being effects of sustainable consumption. In their review, Vollebregt et al. (2024) found that consumption reductions impacted hedonic well-being more negatively than eudaimonic well-being. They conclude that the difference may be due to variation in consumers and their values and needs. Some individuals seek immediate gratification and short-term comfort. They might find sustainable consumption efforts such as reducing consumption too time and effort consuming. On the other hand, there are consumers who value long-term goals and have a different worldview. They may find happiness from partaking in sustainable practices because they think it also helps others and the environment.

The measuring of sustainable consumption varies considerably from analyses on the ecological footprint of households to individuals’ engagement in practices and behaviours defined as sustainable (Guillen-Royo, 2019). These behaviours are measured by questionnaires or scales under titles such as pro-environmental behaviour, sustainable behaviour, pro-environmental activities, ecological behaviour or green behaviour (see summary in Carrero et al., 2020, table 1) and they consist of questions relating for example to energy efficiency, saving water, buying organic food and environmentally-friendly products, avoiding eating meat, recycling, composting, environmental activism, favouring public transportation and reusing and repairing items (Schmitt et al., 2018; Whitmarsh and O’Neill, 2010).

Next, the review will focus on literature regarding sustainable well-being and sustainable consumption practices in the context of food and clothing.

2.3.4. Measuring sustainable well-being in the context of food and clothing

Based on the conceptual understanding outlined above, the TAU researchers began to search for studies that applied various indicators to measure sustainable well-being specifically within the domains of food and clothing. As described by Gough and Thomas (2017), mapping is a tool to “distinguish different perspectives or practices that have been studied” (p. 57). The primary goal at this stage was not to conduct an integrative systematic review, but rather to establish foundational knowledge regarding

sustainable well-being and identify potential indicators relevant to sustainable consumption practices related to food and clothing.

After the first stage of the review, the research team selected peer-reviewed papers with high impact (frequently cited) that explicitly addressed well-being and sustainable consumption practices. During this stage, the TAU research team collectively discussed the results from the first stage. Ultimately, the team decided to focus the mapping review on eudaimonic well-being within the context of the CARE project's sustainable consumption perspectives (specifically related to food and clothing). As previously mentioned, eudaimonic approaches to well-being are considered more suitable for addressing sustainability (Moynat et al., 2022). Notably, the majority of sustainable well-being research predominantly employed various subjective well-being measurements, while eudaimonic perspectives remained relatively scarce.

The most common hedonic measurement found was the Satisfaction with Life Scale (e.g., Boujbel and d'Astous, 2012, Kaida and Kaida, 2016, Pfeiler and Egloff, 2020, van den Berg et al., 2010). Additionally, the Scale of Positive and Negative Experience was utilised in a study examining the impact of style and clothing orientations on well-being (Nielsen et al., 2023). The few studies with an eudaimonic perspective utilised the Psychological Well-being (PWB) Scale (Carrero et al., 2020) and assessed emotional well-being (flourishing) (Issock Issock et al., 2023; Kang et al., 2021). Some studies combined eudaimonic and hedonic measures (e.g., Apaolaza et al., 2018; Bharucha et al., 2020; Guillen-Royo, 2019; Issock Issock et al., 2023).

Notably, studies that examined both well-being and sustainable consumption did not explicitly address or name consumption practices as 'circular consumption'. Research on the well-being effects of food waste reduction and sustainable (or circular) clothing consumption remains scarce or non-existent.

In the context of food, well-being effects have primarily been studied from the perspective of healthy and sustainable diets. These are not necessarily related to circular consumption. Examples include research on organic food consumption (Apaolaza et al., 2018; Issock Issock et al., 2023) and vegetarian diets (Pfeiler and Egloff, 2020). Locally produced food and related practices, such as allotment gardening or food acquisition from farmers markets, have also been associated with well-being (Bharucha et al., 2020; van den Berg et al., 2010). A more general concept of food well-being has been developed (Block et al.,

2011). A qualitative study by Mugel et al. (2019) includes the food waste avoidance process as contributing to food well-being.

The relationship between sustainable clothing consumption and well-being remains relatively unexplored, particularly from the eudaimonic well-being perspective. Existing research often relies on subjective well-being indicators, such as assessing the psychological impact of wearing sustainable versus non-sustainable clothing (Tassell et al., 2022). Notably, it seems that there is a lack of a coherent metric defining what constitutes sustainable clothing consumption. Liu et al. (2022) studied how slow fashion consumption relates to consumer well-being. They used components of both hedonic and eudaimonic well-being perspectives. Slow fashion is seen as a counteraction to fast fashion and means a deliberate shift from quantity to quality, and balancing fashion expression with durability and long-term engagement. Fast fashion, on the other hand, is associated with a 'materialistic' orientation and compulsive buying tendencies, which often lead to negative impacts on well-being (Liu et al., 2022; Silvera et al., 2008). In their study, Nielsen et al. (2023) further differentiated between style-oriented and fashion-oriented clothing consumption, linking fashion orientation to materialistic values. They also employed subjective well-being scaled to measure well-being. Additionally, some earlier research has examined the rejection of materialism through voluntary simplicity and minimalism and how these lifestyles affect well-being (e.g., Lloyd and Pennington, 2020). Another qualitative study has shown that minimalism and reducing clothing quantities can positively impact individuals' lives (Vladimirova, 2021).

2.3.5. Reflections from the literature to CARE project

First, the results of the mapping review support our initial idea in the planning stage of CARE to assess sustainable well-being based on the needs-based well-being theory. Recognising the somewhat universal nature of needs - beyond individual judgement - allows the CARE project to address the inherent discrepancy between a human-centred well-being concept and environmental sustainability. In addition, the four dimensions of having, doing, loving and being align well with practices involved in transitioning to circular modes of consumption. Everyday household practices and their material infrastructures fulfil the needs for having and doing, while skills and shared cultural meanings address the needs for loving and being.

Second, according to recent studies, the CARE project needs to take into account the importance of including indicators that measure both hedonic, eudaimonic and social dimensions of well-being. While some decline in material well-being may occur in the short term when households adopt circular practices, this may be compensated by enhancements in other dimensions of well-being.

The CARE project adheres to the practice theoretical approach when designing pilots for households. Social practice theories view human social action as taking place through “practices”, which consist of interconnected elements: materials, meanings, and competencies (Shove and Pantzar, 2005; Suski et al., 2021). Changing elements within everyday consumption practices – such as providing households with new materials and tools for clothing care or developing their competencies in food management – may have varying impacts on well-being. For instance, learning new skills may initially be time-consuming, but can lead to feelings of personal growth over time (see e.g., Närvänen et al., 2024). To capture this multidimensional perspective in CARE well-being assessments, indicators beyond hedonic well-being are needed.

Third, there is no single well-being scale that comprehensively covers all dimensions specifically validated for the contexts of food waste and sustainable clothing consumption. As a result, the CARE project adopts a pragmatic approach by combining indicators that have been empirically tested in other contexts and/or utilised in previous studies related to sustainable consumption. The primary goal of well-being measurement in CARE is to assess interventions rather than to develop or test entirely new measures.

Fourth, only a few researchers have studied the well-being effects of changing consumption practices toward circularity. The challenge in the CARE project is that the current indicators will most likely show us the aggregate well-being impact of all the changes during the interventions rather than the impacts of a single intervention or a single change in consumption practices. To address this, qualitative interview data can complement the quantitative assessment.

2.4. Researcher workshop

In February 2024, CARE researchers of TAU organised a researcher workshop that brought together Finnish sustainable well-being researchers to explore their perspectives in the context of circular economy. The workshop had two primary goals 1) complementing the knowledge of sustainable well-

being indicators from earlier literature and 2) engaging in dialogue with fellow researchers and research projects in sustainable well-being.

2.4.1. Workshop participants

The relevant ongoing and previous research projects related to sustainable well-being indicators were identified already in the application phase of CARE project. TAU researchers contacted researchers in two other projects on sustainable well-being currently running at TAU (ToBe² and ORSI³ projects) and invited them to contribute their suggestions regarding the workshop agenda, schedule and relevant participants. Participants were invited using a snowball sampling method, with researchers freely sharing invitations within their networks. They were asked to forward the invitation to other researchers that might have expertise on measuring sustainable well-being at the household level.

While the option for online participation was offered, only two potential participants expressed a preference for this format. Consequently, the workshop was held onsite only at Tampere University.

Eleven sustainable well-being researchers interested in circular economy participated in the workshop. They represented eight different universities or institutions: Tampere University, Lappeenranta-Lahti University of Technology LUT, University of Jyväskylä, BIOS Research Unit, Natural Resources Institute Finland, Finnish Institute for Health and Welfare, Sciences Po Paris, and Finnish Environment Institute. Their perspectives to sustainable well-being varied and different disciplines were covered, for example social politics, organisational sciences and environmental sciences.

2.4.2. Organising the workshop

The workshop took place in February 2024 onsite at Tampere University. The workshop commenced with an introduction to the CARE project and its alignment with the workshop's objectives. All participants received a privacy notice and information sheet about the workshop. Participants signed the informed

² ToBe project – 'Towards an economy for sustainable well-being: Integrated policies and transformative indicators' – is a Horizon Europe project running in 2023–2026.

³ ORSI project – 'Towards Eco-Welfare State: Orchestrating for Systemic Impact' is funded by the Strategic Research Council at the Research Council of Finland, running in 2019–2025.

consent form. Next, all participants introduced themselves shortly. The workshop was not filmed or recorded, but written notes and photos were taken.

The workshop was structured around three themes and discussion rounds: 1) Potential well-being effects for households, 2) Indicators or metrics for sustainable well-being and 3) Best practices for studying sustainable well-being. The following sections provide a detailed account of the progress and the conversations that unfolded around these themes.

2.4.2.1. Theme 1: Potential well-being effects

Participants engaged in an ideation phase where they wrote down on post-it notes their answers to the question: “What kinds of well-being effects there are or could be for households when adopting sustainable lifestyles/practices?” Notably, this phase did not adhere to any predefined framework from literature. Instead, participants could freely draw upon their theoretical backgrounds and everyday experiences. Given that household participation in the interventions of CARE project is voluntary, the TAU researchers encouraged participants to concentrate on voluntary change rather than forced change (e.g., through legislation). Participants were reminded that the workshop focused on circular consumption and environmental sustainability.

After the initial ideation phase, participants were asked to consider the specificity of the well-being effects they had listed on their post-it notes in different contexts of sustainable consumption. They sorted these effects into four consumption categories from the CARE project: 1) relevant to food waste, 2) relevant to clothing, 3) relevant to both food waste and clothing and 4) not relevant to food waste or clothing.

The majority of well-being effects (28 post-its) were deemed relevant to both reducing food waste and making clothing consumption more sustainable in households. Well-being effects specifically related to sustainable clothing consumption (five post-its) included perspectives on material relations and materialism, which play a less central role in the context of food waste. For instance, the positive well-being impact of keeping one’s favourite clothes longer was highlighted, and the balance between intrinsic and extrinsic values may impact well-being. Additionally, one well-being effect was exclusively relevant to food waste (one post-it), emphasising health benefits as a by-product of more sustainable eating habits. Interestingly, no well-being effects were considered irrelevant in both food and clothing contexts.

To facilitate further discussions, the workshop facilitator intuitively grouped the well-being effects in both contexts under four themes: 'social', 'psychological', 'meaningful action' and 'time/money'. Subsequently, an open discussion led to the inclusion of dimensions related to 'ethical concerns linked to well-being' (doing good, gender equality, and sufficient material well-being) and 'environmental effects'.

2.4.2.2. Theme 2: Indicators or metrics for sustainable well-being

In the next phase of the workshop, participants were asked to write down their answers on post-it notes in response to the question: "What kind of indicators or metrics could be used to measure these well-being effects in the context of food waste / circular clothing consumption (or both)?" (see Figure 14). The level, maturity or details of indicators were not limited. Subsequently, the post-its describing well-being indicators and measures were collected next to those from the previous phase.

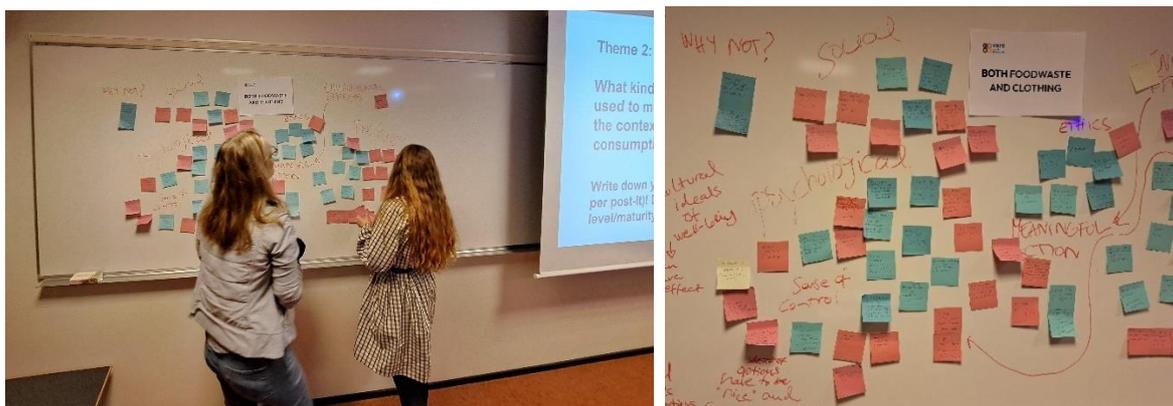


Figure 14: Researcher workshop participants working on Theme 2 (©TAU/Martta Vänskä)

Most of the well-being indicators (39 post-its) were again considered as relevant to both reducing food waste and making clothing consumption more sustainable in households. The indicators relevant only either to food waste (four post-its) or clothing contexts (three post-its) contained objective measurements of the amount of food waste or purchased/repaired clothing.

The discussion on indicators raised the question that "sustainable" in sustainable well-being is challenging to measure using households' subjective evaluations. For instance, the amount of food waste is easier to perceive, but the broader environmental impacts are more difficult to observe in daily life.

Another point in the discussion was related to time and how it affects experienced well-being. Initially, changing to circular consumption habits requires time and energy, but as competences related to the practice improve, it can ultimately make life easier. Time can also be reflected in the indicators – is your time spent better than before?

2.4.2.3. Theme 3: Best practices for studying sustainable well-being

As part of the workshop's wrap-up discussion, participants shared their previous experiences and key learnings related to measuring sustainable well-being. The discussion began by a participant pointing out that respondents' values, cultural ideals of well-being and their understanding of well-being significantly influence their evaluations. An essential question emerged: Do people recognise the connection between environmental well-being and their own well-being? In comparison studies across different countries, cultural differences also play a role in how households assess their actions and the effects on well-being. The criteria for selecting households to participate in studies and interventions were also discussed. For example, income level can significantly impact how individuals experience well-being effects. Households with lower income may perceive their sustainable practices as undervalued and struggle to envision what well-being truly means. Conversely, changing consumption habits might be more manageable for families with higher income, resulting in smaller well-being effects.

The workshop concluded with a networking lunch, fostering future collaboration and ongoing research dialogue. Participants willingly shared their names and contact details with other participants. After the event, TAU researchers shared the contact details, written notes and a compilation of all the post-it notes generated during the event. Participants were encouraged to provide further input, including tips, comments and additional readings.

2.4.3. Reflections from the workshop to CARE project

First, the workshop produced dimensions of sustainable well-being that were familiar from previous literature and theories reviewed during the earlier phase. Notably, the results reinforced the importance of incorporating eudaimonic and social dimensions to the well-being indicators in the CARE project.

Second, the sorting task conducted during the workshop indicated that most well-being effects are not context-specific to a particular type of consumption. Consequently, in the CARE project, we can mainly utilise the same subjective well-being indicators for both consumption contexts (food waste and clothing). While many ideas aligned with existing literature, some novel ideas emerged (i.e., that were not in focus in the reviewed literature). For instance, discussions touched upon how time is perceived within participating households and how work related to circular practices is distributed across genders. Moving forward, the CARE project needs to carefully consider whether (and to what extent) context-specific measures, such as health effects (in the context of food waste) or well-being impacts stemming from material relations (in the context of clothing) should be included in the indicators.

Third, the workshop discussions provided valuable input for planning CARE pilots and establishing household recruitment criteria. For example, it is crucial to consider the diverse effects of income level to evaluations of sustainability and well-being. In the CARE pilots, we aim for a heterogeneous sample that includes households from various socio-economic backgrounds. However, we note that – also from the point-of-view of well-being – recruiting households with the lowest income might be challenging. Furthermore, a key consideration emerged regarding whether the well-being indicators should be country-specific or allow for cross-country comparisons. Comparisons between countries are not central to the CARE project and the limited number of households from each country (15–30) makes robust quantitative comparisons challenging to implement. Nevertheless, qualitative data collected during CARE (e.g., household interviews) can provide valuable insights into well-being effects in each country.

Fourth, the workshop revealed challenges that need to be addressed when measuring the sustainable well-being of households. For example, to mitigate the problems related to subjectivity, CARE will incorporate well-being measures that extend beyond subjective evaluations, for example the time spent on caring and organising clothes. Measuring environmental sustainability is addressed in CARE project by conducting well-being measurement in parallel with environmental assessment based on life cycle analysis. The workshop emphasised the importance of continuing the dialogue initiated in this task and within this deliverable.

2.5. Key implications on sustainable well-being

Table 5 summarises the key implications for the CARE project from literature and workshop.

Table 5: Key implications from literature and the researcher workshop regarding sustainable well-being indicators

Sustainable well-being measurement in CARE project should...	Support from literature	Support from workshop
build on needs-based well-being theory.	X	
see sustainable well-being multidimensional and consisting of hedonic, eudaimonic and social dimensions.	X	X
build on a combination of indicators empirically tested or utilised in previous studies related to sustainable consumption.	X	
use both context-specific and general well-being indicators for the consumption contexts under study (food waste and clothing).		X
have well-being measures that do not rely only on subjective evaluations.		X

The work related to the sustainable well-being indicators continues in task 1.2 where the data collection protocol for CARE will be developed together with fellow researchers within the CARE project and the local partners who implement the household pilots. During this collaborative process, feedback on the chosen well-being indicators will be requested also from the workshop participants and possibly also from

other relevant researchers who could not attend the workshop. The data collection encompasses both sustainable well-being and living condition. These data are to be collected from households together with environmental assessment data, including data on material efficiency, food waste or wardrobe audits. As part of Task 1.2., the measures for living conditions will be chosen. The CARE project should carefully choose measures that are relevant and aligned with the sustainable well-being indicators. The comprehensive data collection protocol will be finished in CARE project by M17 (May 2025).

3. Final conclusions

In conclusion, the review report on impact assessment for the CARE project has shed light on crucial aspects related to environmental impacts in the context of household food waste and domestic clothing consumption, as well as sustainable well-being indicators. Through an extensive literature review and analysis, several key findings have emerged that will be used to guide the future direction of the project.

One of the primary findings is the importance of clear definitions and categorisations for quantifying food waste accurately. The report underscores the significance of utilising methods such as waste composition analysis and food diaries to provide precise measurements of food waste quantities in households. Waste composition analysis allows to assess not only the amount of food waste generated, but also the different types of food waste. Food diaries also make it possible to record how and why food waste is disposed of, enabling a more nuanced understanding of food waste behaviours. The literature review has shown that LCA and the footprint method are the state of the art in terms of environmental impact assessment of food waste. Most assessments use a cradle-to-grave system boundary and a functional unit based on the amount of food waste (e.g., total amount of food waste per household or per person).

Primary data on clothing consumption and laundry habits needs to be collected for the environmental impact assessment of clothing. This can be done through interviews, questionnaires or self-assessments. In addition to clothing quantities, data on the type of fabric should also be collected. It is evident that the production stage of clothing items plays a significant role in determining their environmental impacts. Factors such as fibre types, fabric production methods, dyeing technologies and energy sources used during production all contribute to the overall sustainability profile of clothing items. Therefore, it is essential for the system boundaries of studies to encompass at least the cradle-to-end-of-use stage to capture these diverse impacts effectively. Furthermore, the report highlights the importance of defining a

useful functional unit for assessing the environmental impacts of domestic clothing use. Efforts should be directed towards establishing a consensus on this matter within the CARE project to ensure accurate and meaningful assessments. Additionally, expanding the choice of impact categories to include land use and toxicity is recommended, provided that high-quality inventory data can be obtained. This broader set of impact categories will offer a more comprehensive understanding of the environmental implications of household clothing consumption and use.

In terms of sustainable well-being, this report highlights that it is important to build on a needs-based well-being theory and to account for the multidimensionality of sustainable well-being, as it consists of hedonic, eudaimonic and social dimensions. Furthermore, building on a combination of indicators which were empirically tested or utilised in previous studies related to sustainable consumption will benefit the CARE project. It is recommended to use both context-specific and general well-being indicators for the consumption contexts of household food waste and clothing. Additionally, the well-being measures should not rely only on subjective evaluations.

In conclusion, the insights and recommendations provided in this review report serve as valuable guidance for the CARE project as it progresses towards achieving its goals of promoting sustainability in household food waste and domestic clothing consumption. By considering the multifaceted environmental impacts and embracing sustainable well-being principles, the project can make meaningful contributions to a more sustainable future.



References

- Abeliotis K, Lasaridi K, Costarelli V *et al* (2015) The implications of food waste generation on climate change: The case of Greece. *SUSTAINABLE PRODUCTION AND CONSUMPTION* 3:8–14. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84945958019&doi=10.1016%2fj.spc.2015.06.006&partnerID=40&md5=6fc6702d13341a302f5af09a54227a11>
- Adelodun B, Kim SH, Choi KS (2021) Assessment of food waste generation and composition among Korean households using novel sampling and statistical approaches. *WASTE MANAGEMENT* 122:71–80
- Albizzati PF, Rocchi P, Cai M *et al* (2022) Rebound effects of food waste prevention: Environmental impacts. *WASTE MANAGEMENT* 153:138–146
- Albizzati PF, Tonini D, Astrup TF (2021) A Quantitative Sustainability Assessment of Food Waste Management in the European Union. *Environmental science & technology* 55:16099–16109
- Allardt E (1993) Having, Loving, Being: An Alternative to the Swedish Model of Welfare Research. In: Nussbaum M, Sen A (eds) *The Quality of Life*. Oxford University Press, pp 88–94
- Allwood JM, Laursen SE, de Rodríguez CM *et al* (2006) Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom. Technical annex
- Amasawa E, Suzuki Y, Moon D *et al* (2018) Designing Interventions for Behavioral Shifts toward Product Sharing: The Case of Laundry Activities in Japan. *SUSTAINABILITY* 10:2687
- Apaolaza V, Hartmann P, D'Souza C *et al* (2018) Eat organic – Feel good? The relationship between organic food consumption, health concern and subjective wellbeing. *Food Quality and Preference* 63:51–62
- Barker H, Shaw PJ, Richards B *et al* (2023) Towards Sustainable Food Systems: Exploring Household Food Waste by Photographic Diary in Relation to Unprocessed, Processed and Ultra-Processed Food. *SUSTAINABILITY* 15. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85148017868&doi=10.3390%2fsu15032051&partnerID=40&md5=4ddb076a3eb1280f495ad639c544b633>
- Baydar G, Ciliz N, Mammadov A (2015) Life cycle assessment of cotton textile products in Turkey. *Resources, Conservation and Recycling* 104:213–223
- Beretta C, Hellweg S (2019) Potential environmental benefits from food waste prevention in the food service sector. *RESOURCES CONSERVATION AND RECYCLING* 147:169–178
- Bernstad Saraiva Schott A, Andersson T (2015) Food waste minimization from a life-cycle perspective. *JOURNAL OF ENVIRONMENTAL MANAGEMENT* 147:219–226
- Bharucha ZP, Weinstein N, Watson D *et al* (2020) Participation in local food projects is associated with better psychological well-being: evidence from the East of England. *Journal of public health (Oxford, England)* 42:e187–e197
- Bin S, Dowlatabadi H (2005) Consumer lifestyle approach to US energy use and the related CO2 emissions. *Energy Policy* 33:197–208
- Block LG, Grier SA, Childers TL *et al* (2011) From Nutrients to Nurturance: A Conceptual Introduction to Food Well-Being. *Journal of Public Policy & Marketing* 30:5–13
- Böckin D, Goffetti G, Baumann H *et al* (2022) Business model life cycle assessment: A method for analysing the environmental performance of business. *SUSTAINABLE PRODUCTION AND CONSUMPTION* 32:112–124
- Boujbel L, d'Astous A (2012) Voluntary simplicity and life satisfaction: Exploring the mediating role of consumption desires. *J of Consumer Behaviour* 11:487–494

- British Standards Institute (2011) PAS 2050:2011-Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. Available via <https://knowledge.bsigroup.com/products/specification-for-the-assessment-of-the-life-cycle-greenhouse-gas-emissions-of-goods-and-services?version=standard>. Accessed 6 Mar 2024
- Carrero I, Valor C, Redondo R (2020) Do All Dimensions of Sustainable Consumption Lead to Psychological Well-Being? Empirical Evidence from Young Consumers. *J Agric Environ Ethics* 33:145–170
- Cattaneo A, Federighi G, Vaz S (2021) The environmental impact of reducing food loss and waste: A critical assessment. *Food Policy* 98. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85084196323&doi=10.1016%2fj.foodpol.2020.101890&partnerID=40&md5=70c9a5b626d2f2cc267d55bec2bf4692>
- Diener E (1984) Subjective well-being. *Psychological Bulletin* 95:542–575
- Diener E, Emmons RA, Larsen RJ *et al* (1985) The Satisfaction With Life Scale. *Journal of personality assessment* 49:71–75
- Diener E, Wirtz D, Tov W *et al* (2010) New Well-being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings. *Soc Indic Res* 97:143–156
- Dreyer HC, Dukovska-Popovska I, Yu Q *et al* (2019) A ranking method for prioritising retail store food waste based on monetary and environmental impacts. *JOURNAL OF CLEANER PRODUCTION* 210:505–517
- Edjabou ME, Petersen C, Scheutz C *et al* (2016) Food waste from Danish households: Generation and composition. *WASTE MANAGEMENT* 52:256–268. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84977992518&doi=10.1016%2fj.wasman.2016.03.032&partnerID=40&md5=39b6e6221d550a5014bed52f002947cb>
- European Commission (2018) PEF CR Guidance document, -Guidance for the development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3. Available via https://green-business.ec.europa.eu/environmental-footprint-methods_en. Accessed 6 Mar 2024
- European Commission (2022) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Strategy for Sustainable and Circular Textiles. Publications Office of the European Union, Brussels
- FAO (2013) Food wastage footprint. Impacts on natural resources, summary report. Food and Agriculture Organization of the United Nations, Rome
- Fidan FŞ, Aydoğan E, Uzal N (2024) The selection of washing machine programs with fuzzy dematel and moora-ratio multi-criteria decision-making methods considering environmental and cost criteria. *Desalination and Water Treatment*
- FLW Protocol (2016a) Food Loss and Waste Accounting and Reporting Standard. https://www.flwprotocol.org/wp-content/uploads/2017/05/FLW_Standard_final_2016.pdf
- FLW Protocol (2016b) Guidance on FLW Quantification Methods. Supplement to the Food Loss and Waste (FLW) Accounting and Reporting Standard, Version 1.0. https://flwprotocol.org/wp-content/uploads/2016/05/FLW_Protocol_Guidance_on_FLW_Quantification_Methods.pdf
- FUSIONS (2014a) FUSIONS Definitional Framework for Food Waste
- FUSIONS (2014b) Standard approach on quantitative techniques to be used to estimate food waste levels. Ostfold Research, Research Report 21.14
- FUSIONS (2016) Food waste quantification manual to monitor food waste amounts and progression. <https://www.eu-fusions.org/phocadownload/Publications/FUSIONS%20Food%20Waste%20Quantification%20Manual.pdf>

- Gentil EC, Gallo D, Christensen TH (2011) Environmental evaluation of municipal waste prevention. *WASTE MANAGEMENT* 31:2371–2379
- Giordano C, Graziano P, Lazzarini M *et al* (2022) Sustainable Community Movement Organisations and household food waste: The missing link in urban food policies? *Cities* 122. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85122658656&doi=10.1016%2fj.cities.2021.103473&partnerID=40&md5=62f4b7006c6001b98429b409f978b62c>
- Gough D, Thomas J (2017) Commonality and diversity in reviews. In: Gough D, Oliver S, Thomas J (eds) *An introduction to systematic reviews*. Sage, pp 43–70
- Gough I (2017) *Heat, greed and human need. Climate change, capitalism and sustainable wellbeing*. Edward Elgar Publishing, Cheltenham, UK, Northampton, MA, USA
- Grant MJ, Booth A (2009) A typology of reviews: an analysis of 14 review types and associated methodologies. *Health information and libraries journal* 26:91–108
- Guillen-Royo M (2019) Sustainable consumption and wellbeing: Does on-line shopping matter? *JOURNAL OF CLEANER PRODUCTION* 229:1112–1124
- Gustavsson J, Cederberg C, Sonesson U (2011) Global food losses and food waste. Extent, causes and prevention; study conducted for the International Congress Save Food! at Interpack 2011, [16 - 17 May], Düsseldorf, Germany. Food and Agriculture Organization of the United Nations, Rome
- Gustavsson J, Cederberg C, Sonesson U *et al* (2013) *The methodology of the FAO study: “Global Food Losses and Food Waste - extent, causes and prevention”*- FAO, 2011
- Gwozdz W, Steensen Nielsen K, Müller T (2017) An Environmental Perspective on Clothing Consumption: Consumer Segments and Their Behavioral Patterns. *SUSTAINABILITY* 9:762
- Hamilton HA, Peverill MS, Müller DB *et al* (2015) Assessment of Food Waste Prevention and Recycling Strategies Using a Multilayer Systems Approach. *Environmental science & technology* 49:13937–13945
- Helne T, Hirvilammi T (2015) Wellbeing and Sustainability: A Relational Approach. *Sustainable Development* 23:167–175
- Herziger A, Claborn KA, Brooks JS (2020) Is There Hope for the Double Dividend? How Social Context Can Shape Synergies and Tradeoffs between Sustainable Consumption and Well-Being. *Ecological Economics* 176:106736
- Hirvilammi T (2015) *In search of sustainable wellbeing: Integrating ecological issues into wellbeing research*. Doctoral dissertation, University of Helsinki
- Horn S, Mölsä KM, Sorvari J *et al* (2023) Environmental sustainability assessment of a polyester T-shirt - Comparison of circularity strategies. *SCIENCE OF THE TOTAL ENVIRONMENT* 884:163821
- Ilakovac B, Voca N, Pezo L *et al* (2020) Quantification and determination of household food waste and its relation to sociodemographic characteristics in Croatia. *WASTE MANAGEMENT* 102:231–240. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85074293494&doi=10.1016%2fj.wasman.2019.10.042&partnerID=40&md5=c7db9daf6e8ad3418861024b20ee2a98>
- International Organization for Standardization (2006) *Environmental management — Life cycle assessment — Requirements and guidelines (ISO Standard No. 14044:2006)*. Available via <https://www.iso.org/obp/ui/#iso:std:iso:14044:ed-1:v1:en>. Accessed 6 Mar 2024
- Issock PB, Mpinganjira M, Roberts-Lombard M (2023) Beyond sustainable consumption practices: Linking organic food consumption to hedonic and eudaimonic well-being. *Appetite* 188:106633
- Janssen M, Xiros C, Tillman A-M (2016) Life cycle impacts of ethanol production from spruce wood chips under high-gravity conditions. *Biotechnology for biofuels* 9:53

- Johnson E, Plepys A (2021) Product-Service Systems and Sustainability: Analysing the Environmental Impacts of Rental Clothing. SUSTAINABILITY 13:2118
- Kaida N, Kaida K (2016) Pro-environmental behavior correlates with present and future subjective well-being. Environ Dev Sustain 18:111–127
- Kang J, Martinez CM, Johnson C (2021) Minimalism as a sustainable lifestyle: Its behavioral representations and contributions to emotional well-being. SUSTAINABLE PRODUCTION AND CONSUMPTION 27:802–813
- Kasser T (2017) Living both well and sustainably: a review of the literature, with some reflections on future research, interventions and policy. Philosophical transactions. Series A, Mathematical, physical, and engineering sciences 375
- Keyes CL (1998) Social Well-Being. Social Psychology Quarterly 61:121
- Kleinhüchelkotten S, Neitzke H-P, Schmidt N (2018) Bewertung der Nachhaltigkeit von Innovationen entlang der textilen Kette. InNaBe-Projektbericht 7.1
- Klepp IG, Laitala K, Wiedemann S (2020) Clothing Lifespans: What Should Be Measured and How. SUSTAINABILITY 12:6219
- La Rosa, Grammatikos (2019) Comparative Life Cycle Assessment of Cotton and Other Natural Fibers for Textile Applications. Fibers 7:101
- Leverenz D, Schneider F, Schmidt T *et al* (2021) Food Waste Generation in Germany in the Scope of European Legal Requirements for Monitoring and Reporting. SUSTAINABILITY 13
- an Liu, Baines E, Ku L (2022) Slow Fashion Is Positively Linked to Consumers' Well-Being: Evidence from an Online Questionnaire Study in China. SUSTAINABILITY 14:13990
- Lloyd K, Pennington W (2020) Towards a Theory of Minimalism and Wellbeing. Int J Appl Posit Psychol 5:121–136
- Long Y, Chen G, Wang Y (2023) Carbon footprint of residents' online consumption in China. ENVIRONMENTAL IMPACT ASSESSMENT REVIEW 103:107228
- Lorek S, Spangenberg JH (2014) Sustainable consumption within a sustainable economy – beyond green growth and green economies. JOURNAL OF CLEANER PRODUCTION 63:33–44
- Luo Y, Wu X, Ding X (2022) Carbon and water footprints assessment of cotton jeans using the method based on modularity: A full life cycle perspective. JOURNAL OF CLEANER PRODUCTION 332:130042
- Manczarski P, Rolewicz-Kalinska A, Lelicinska-Serafin K (2023) Quantitative Analysis of Household Food Waste Collection in Warsaw: Assessing Efficiency and Waste Minimization. SUSTAINABILITY 15
- Manda BM, Worrell E, Patel MK (2015) Prospective life cycle assessment of an antibacterial T-shirt and supporting business decisions to create value. Resources, Conservation and Recycling 103:47–57
- Massow M von, Parizeau K, Gallant M *et al* (2019) Valuing the Multiple Impacts of Household Food Waste. Front. Nutr. 6:143. <https://www.frontiersin.org/articles/10.3389/fnut.2019.00143/full>
- Mattsson L, Williams H, Berghel J (2018) Waste of fresh fruit and vegetables at retailers in Sweden - Measuring and calculation of mass, economic cost and climate impact. RESOURCES CONSERVATION AND RECYCLING 130:118–126
- Max-Neef M (1991) Human scale development: Conception, application, and further reflections. The Apex Express
- Moazzem S, Crossin E, Daver F *et al* (2021) Assessing environmental impact reduction opportunities through life cycle assessment of apparel products. SUSTAINABLE PRODUCTION AND CONSUMPTION 28:663–674

- Moon D (2024) Promoting sustainable practices: Exploring secondhand clothing consumption patterns and reductions in greenhouse gas emissions in Japan. *SUSTAINABLE PRODUCTION AND CONSUMPTION* 45:294–305
- Moon D, Amasawa E, Hirao M (2020) Consumer Motivation and Environmental Impact of Laundry Machine-Sharing: Analysis of Surveys in Tokyo and Bangkok. *SUSTAINABILITY* 12:9756
- Mora-Sojo MC, Krych K, Pettersen JB (2023) Evaluating the current Norwegian clothing system and a circular alternative. *Resources, Conservation and Recycling* 197:107109
- Moynat O, Volden J, Sahakian M (2022) How do COVID-19 lockdown practices relate to sustainable well-being? Lessons from Oslo and Geneva. *Sustainability: Science, Practice and Policy* 18:309–324
- Mugel O, Gurviez P, Decrop A (2019) Eudaimonia Around the Kitchen: A Hermeneutic Approach to Understanding Food Well-Being in Consumers' Lived Experiences. *Journal of Public Policy & Marketing* 38:280–295
- Närvänen E, Fuentes C, Mesiranta N (2024) The Assembling of Circular Consumption. In: Lehtimäki H, Aarikka-Stenroos L, Jokinen A et al (eds) *The Routledge handbook of catalysts for a sustainable circular economy*. Routledge, Abingdon, Oxon, New York, NY, pp 535–549
- Nautiyal M, Hunting A, Joseph F et al (2023) Examining Practices of Apparel Use and End of Life in New Zealand. *SUSTAINABILITY* 15:5141
- Nielsen KS, Joanes T, Webb D et al (2023) Exploring the psychological characteristics of style and fashion clothing orientations. *JCM* 40:897–910
- Niinimäki K, Peters G, Dahlbo H et al (2020) The environmental price of fast fashion. *Nat Rev Earth Environ* 1:189–200
- Niu ZT, Ng SJ, Li B et al (2022) Food waste and its embedded resources loss: A provincial level analysis of China. *SCIENCE OF THE TOTAL ENVIRONMENT* 823
- Nováková P, Hák T, Janoušková S (2021) An analysis of food waste in czech households—a contribution to the international reporting effort. *Foods* 10. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85104928954&doi=10.3390%2ffoods10040875&partnerID=40&md5=24da3d7c316eafd2e3739708dfec2c7d>
- Nussbaum M (2005) Wellbeing, contracts and capabilities. In: Manderson L (ed) *Rethinking Wellbeing*. Griffin Press, pp 45–68
- Osei-Owusu AK, Towa E, Thomsen M (2022) Exploring the pathways towards the mitigation of the environmental impacts of food consumption. *SCIENCE OF THE TOTAL ENVIRONMENT* 806
- Parsa A, van de Wiel M, Schmutz U et al (2024) Balancing people, planet, and profit in urban food waste management. *SUSTAINABLE PRODUCTION AND CONSUMPTION* 45:203–215. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85182901542&doi=10.1016%2fj.spc.2024.01.003&partnerID=40&md5=2582845aa3ea2274372df7969e36ec09>
- Pfeiler TM, Egloff B (2020) Do vegetarians feel bad? Examining the association between eating vegetarian and subjective well-being in two representative samples. *Food Quality and Preference* 86:104018
- Piontek FM, Amasawa E, Kimita K (2020) Environmental implication of casual wear rental services: Case of Japan and Germany. *Procedia CIRP* 90:724–729
- Piontek FM, Müller M (2018) Literature Reviews: Life Cycle Assessment in the Context of Product-Service Systems and the Textile Industry. *Procedia CIRP* 69:758–763
- Piontek FM, Rapaport M, Müller M (2019) One year of Clothing Consumption of a German Female Consumer. *Procedia CIRP* 80:417–421

- Qian L, Rao Q, Liu H *et al* (2022) Food waste and associated carbon footprint: evidence from Chinese universities. *Ecosystem Health and Sustainability* 8.
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-85139419743&doi=10.1080%2f20964129.2022.2130094&partnerID=40&md5=48d96e00f21b9aacc1dba93d80d7b0da>
- Rabiu MK, Jaeger-Erben M (2022) Appropriation and routinisation of circular consumer practices: A review of current knowledge in the circular economy literature. *Cleaner and Responsible Consumption* 7:100081
- Read QD, Brown S, Cuéllar AD *et al* (2020) Assessing the environmental impacts of halving food loss and waste along the food supply chain. *SCIENCE OF THE TOTAL ENVIRONMENT* 712
- Read QD, Muth MK (2021) Cost-effectiveness of four food waste interventions: Is food waste reduction a "win-win?". *RESOURCES CONSERVATION AND RECYCLING* 168
- Roos S, Jönsson C, Posner S *et al* (2019) An inventory framework for inclusion of textile chemicals in life cycle assessment. *Int J Life Cycle Assess* 24:838–847
- Roos S, Zamani B, Sandin G *et al* (2016) A life cycle assessment (LCA)-based approach to guiding an industry sector towards sustainability: the case of the Swedish apparel sector. *JOURNAL OF CLEANER PRODUCTION* 133:691–700
- Ryan RM, Deci EL (2001) On happiness and human potentials: a review of research on hedonic and eudaimonic well-being. *Annual review of psychology* 52:141–166
- Ryberg MW, Owsianiak M, Clavreul J *et al* (2018) How to bring absolute sustainability into decision-making: An industry case study using a Planetary Boundary-based methodology. *SCIENCE OF THE TOTAL ENVIRONMENT* 634:1406–1416
- Ryff CD, Keyes CL (1995) The structure of psychological well-being revisited. *Journal of personality and social psychology* 69:719–727
- Scherhauser S, Moates G, Hartikainen H *et al* (2018) Environmental impacts of food waste in Europe. *WASTE MANAGEMENT* 77:98–113.
<https://www.sciencedirect.com/science/article/pii/S0956053X18302617>
- Schmitt MT, Aknin LB, Axsen J *et al* (2018) Unpacking the Relationships Between Pro-environmental Behavior, Life Satisfaction, and Perceived Ecological Threat. *Ecological Economics* 143:130–140
- Schmutz M, Hirschier R, Som C (2021) Factors Allowing Users to Influence the Environmental Performance of Their T-Shirt. *SUSTAINABILITY* 13:2498
- SDG12 (2022) Aktivitätenliste | SDG12. Available via
https://sdg12.de/de/aktivitaeten?field_unterziel_target_id%5B%5D=13. Accessed 1 Mar 2024
- Seegebarth B, Peyer M, Balderjahn I *et al* (2016) The Sustainability Roots of Anticonsumption Lifestyles and Initial Insights Regarding Their Effects on Consumers' Well - Being. *Journal of Consumer Affairs* 50:68-99
- Sen A (2013) The Ends and Means of Sustainability. *Journal of Human Development and Capabilities* 14:6–20
- Shove E, Pantzar M (2005) Consumers, Producers and Practices. *Journal of Consumer Culture* 5:43–64
- Silvera DH, Lavack AM, Kropp F (2008) Impulse buying: the role of affect, social influence, and subjective wellbeing. *JCM* 25:23–33
- Sirgy MJ (2021) Macromarketing Metrics of Consumer Well-Being: An Update. *Journal of Macromarketing* 41:124–131
- Sohn J, Nielsen KS, Birkved M *et al* (2021) The environmental impacts of clothing: Evidence from United States and three European countries. *SUSTAINABLE PRODUCTION AND CONSUMPTION* 27:2153–2164

- Song G, Semakula HM, Fullana-I-Palmer P (2018) Chinese household food waste and its' climatic burden driven by urbanization: A Bayesian Belief Network modelling for reduction possibilities in the context of global efforts. *JOURNAL OF CLEANER PRODUCTION* 202:916–924.
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-85052975906&doi=10.1016%2fj.jclepro.2018.08.233&partnerID=40&md5=29e9e463c401f09de2e3c62e3e0ef40f>
- Steinberger JK, Friot D, Jolliet O *et al* (2009) A spatially explicit life cycle inventory of the global textile chain. *Int J Life Cycle Assess* 14:443–455
- Suski P, Speck M, Liedtke C (2021) Promoting sustainable consumption with LCA – A social practice based perspective. *JOURNAL OF CLEANER PRODUCTION* 283:125234
- Tassell C, Bardey A, Schat A (2022) How to wear happiness: Impact of wearing clothing labelled sustainable or fast fashion on subjective well-being. *International Journal of Sustainable Fashion & Textiles* 1:63–80
- Temizel-Sekeryan S, Hicks AL (2021) Cradle-to-grave environmental impact assessment of silver enabled t-shirts: Do nano-specific impacts exceed non nano-specific emissions? *NanoImpact* 22:100319
- Usubiaga A, Butnar I, Schepelmann P (2018) Wasting Food, Wasting Resources: Potential Environmental Savings Through Food Waste Reductions. *JOURNAL OF INDUSTRIAL ECOLOGY* 22:574–584
- van den Berg AE, van Winsum-Westra M, Vries S de *et al* (2010) Allotment gardening and health: a comparative survey among allotment gardeners and their neighbors without an allotment. *Environmental health : a global access science source* 9:74
- Vazquez-Rowe I, Laso J, Margallo M *et al* (2020) Food loss and waste metrics: a proposed nutritional cost footprint linking linear programming and life cycle assessment. *INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT* 25:1197–1209
- Vladimirova K (2021) Consumption corridors in fashion: deliberations on upper consumption limits in minimalist fashion challenges. *Sustainability: Science, Practice and Policy* 17:102–116
- Vollebregt M, Mugge R, Thürridl C *et al* (2024) Reducing without losing: Reduced consumption and its implications for well-being. *SUSTAINABLE PRODUCTION AND CONSUMPTION* 45:91–103
- Walser T, Demou E, Lang DJ *et al* (2011) Prospective environmental life cycle assessment of nanosilver T-shirts. *Environmental science & technology* 45:4570–4578
- Watson D, Clark LA, Tellegen A (1988) Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology* 54:1063–1070
- Whitmarsh L, O'Neill S (2010) Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *Journal of Environmental Psychology* 30:305–314
- World Business Council for Sustainable Development and World Resource Institute (2011) Greenhouse Gas Protocol: Product Life Cycle Accounting and Reporting Standard.
https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf
- WRAP (2009) Household food and drink waste in the UK. Final report. Wastes & Resources Action Programme (WRAP), Banbury
- Yamaguchi Y, Seii E, Itagaki M *et al* (2011) Evaluation of domestic washing in Japan using life cycle assessment (LCA). *Int J Consumer Studies* 35:243–253
- Zamani B, Sandin G, Peters GM (2017) Life cycle assessment of clothing libraries: can collaborative consumption reduce the environmental impact of fast fashion? *JOURNAL OF CLEANER PRODUCTION* 162:1368–1375

Zhang M, Ding S, Pang J *et al* (2021) The effect of indirect household energy consumption on PM 2.5 emission in China: An analysis based on CLA method. JOURNAL OF ENVIRONMENTAL MANAGEMENT 279:111531

Zhang Y, Liu X, Xiao R *et al* (2015) Life cycle assessment of cotton T-shirts in China. Int J Life Cycle Assess 20:994–1004



Project partners

