APPENDIX A
LITERATURE SEARCH METHODS

A-1. Literature Search Methods

The literature review serves as the basis for this analysis. For the LCA portion of the review, the search queries (Table A-1) returned 3,159 peer-reviewed articles. Additional keyword searches (see Table A-5) were used to provide flexible searching for a variety of terms, as well as their frequency, in the titles and abstracts of the query results. We reviewed the titles and abstracts of all of the records in order to screen for relevance, selecting a subset for careful screening, and a final set of 247 articles for careful reading.

In addition to searching the peer-reviewed literature, we performed searches for non-peer-reviewed literature: reports and articles from governments, -governmental organization reports, and trade organizations. These searches were based on custom internet searches (e.g., restricting domains to ".edu" or ".gov"), finding non-peer-reviewed literature in the citations of the articles selected for review, and professional experience (i.e., contributors to this report drew upon their knowledge of the field to suggest additional sources). In all, 25 additional records were identified for careful reading.

Combining the results from the searches of peer-reviewed and non-peer-reviewed literature, all 272 records were reviewed. Twenty were excluded as being out of scope, leaving 252 articles and reports for inclusion in the study. All 252 references were screened for relevant content, which was used to provide pathway descriptions, discussions of drivers, and other qualitative text for this report. Ninety-two of these references provided data that could potentially be used for quantitative comparison; for these, the full text was reviewed, and documentation was developed describing their scope, results, and conclusions. Of these, 75 provided data based on LCA approaches. Of those, 47 provided useable data; data from 23 studies was used in both the inter- and intra-study analyses; 10 were used only in the interstudy, and 14 were used only in the intra-study. Table A-2 shows the disaggregation of these studies and data points by management pathway and environmental impact (note that individual studies can, and often do, address multiple pathways or impacts; therefore, the numbers in these tables cannot be summed). Forty-seven studies provide the ranking data summarized in Section 3.5.

Supplemental searches were performed on qualities of variety of soil amendments made by wasted food pathways. These searches (Table A-3) revealed 146 total results, of which 101 were unique. Screening resulted in 19 relevant articles for careful review.

A supplemental literature review was performed to the circularity assessment (Chapter 4). The search queries (Table A-4) returned 67 unique peer-reviewed articles. We reviewed the titles and abstracts of all the records to screen for relevance, selecting a subset for careful screening, and a final set of 20 articles for careful reading. Citations from within these articles were also scanned for relevance and reviewed if applicable. As with the initial literature review, we also performed searches for non-peer-reviewed literature, finding 6 additional references for careful reading.

A-1-1 Literature Queries and Keyword Searches

TABLE A-1. SUMMARY OF LCA LITERATURE SEARCH QUERIES, INCLUDING COUNTS OF UNIQUE RECORDS RETURNED (TOTAL UNIQUE = 3159)

Name	Source	Date	Number Unique	Total Results	Description	Search Terms
Q1	Web of Science	3/31/2021	264	264	Initial search: "food waste" as topic; pathway words in title, and LCA/environment words in title	TS="Food Waste" AND TI=(landfill OR donation OR upcycling OR "animal feed" OR unharvested OR compost* OR "anaerobic digestion" OR "aerobic digestion" OR co-digestion OR "land application" OR "wastewater treatment" OR incineration OR "controlled combustion" OR "waste-to-energy") AND TI=(environment* OR "soil health" OR LCA OR "life cycle assessment" OR "life cycle analysis", OR "water quality" OR eutrophication OR energy OR toxicity OR "greenhouse gas" OR "air emissions" OR "air pollution" OR "land use" OR "land occupation" OR "water use" OR "water consumption" OR "criteria air")
Q2	Web of Science	4/7/2021	393	503	Basic search revised: require some form of food waste in title, require something environmental in abstract, require some pathway or indicator in abstract	TI=("food waste" OR "food loss" OR "wasted food") AND AB=(environment* OR LCA OR "life cycle" or "lifecycle" or "life-cycle") AND AB=(landfill OR donation OR upcycling OR "animal feed" OR unharvested OR compost* OR "anaerobic digestion" OR "aerobic digestion" OR co-digestion OR "land application" OR "wastewater treatment" OR incineration OR "controlled combustion" OR "waste-to-energy" OR "soil health" OR "water quality" OR eutrophication OR energy OR toxicity OR "greenhouse gas" OR "air emissions" OR "air pollution" OR "land use" OR "land occupation" OR "water use" OR "water consumption" OR "criteria air")

Name	Source	Date	Number Unique	Total Results	Description	Search Terms
Q3	Web of Science	4/7/2021	346	891	initial search, with improved TI (with more stemming) improved environmental words (sustain, etc.) improved general (added pollution, recycling, etc.)	TI=("food waste*" OR "food loss*" OR "wasted food" OR "lost food") AND AB=(environment* OR LCA OR "life cycle" or "lifecycle" or "life-cycle" or resource* or sustain*) AND AB=("waste prevention" OR "waste management" OR pollut* OR recycl* OR landfill OR donation OR upcycling OR "animal feed" OR unharvested OR compost* OR "anaerobic digestion" OR "aerobic digestion" OR co-digestion OR "land application" OR "wastewater treatment" OR incineration OR "controlled combustion" OR "waste-to-energy" OR "soil health" OR biodivers* OR energy OR toxicity OR "land use" OR "land occupation" OR "water use" OR "water consumption" OR "water bod*" OR river OR lake OR "water quality" OR eutrophication OR "greenhouse gas" OR "air emissions" OR "air pollution" OR atmospher* OR "criteria air" OR climate)
Q4	Web of Science	4/8/2021	not used	1659	Basic search revised to a) exclude anaerobic digestion and compost (well-represented in results), and b) provide more terms that are higher specificity, c) split the impacts from the pathways, and d) use an OR for the two abstract searches.	TI=("food waste*" OR "food loss*" OR "wasted food" OR "lost food" OR “organic waste” OR “biowaste” OR “organic fraction” OR “bio-waste” OR “food-based”) AND (AB=(landfill OR donation OR "animal feed" OR "livestock feed" OR unharvested OR "soil incorporation" OR "land application" OR incineration OR combustion OR "waste-to-energy" OR "waste to energy" OR upcycling OR valorization OR valorisation OR carbonization OR carbonisation OR bioconversion OR pyrolysis OR gasification OR ferment) OR AB= ("soil health" OR biodivers* OR toxicity OR "land use" OR "land occupation" OR "water use" OR "water consumption" OR "water bod*" OR river OR lake OR "water quality" OR eutrophication OR "greenhouse gas" OR "air emissions" OR "air pollution" OR "criteria air" OR "climate change" OR "global warming")

Name	Source	Date	Number Unique	Total Results	Description	Search Terms
Q5	Web of Science	4/8/2021	403	932	Q4, but with Title more restrictive	TI=("food waste*" OR "food loss*" OR "wasted food" OR "lost food") AND (AB=(landfill OR donation OR "animal feed" OR "livestock feed" OR unharvested OR "soil incorporation" OR "land application" OR incineration OR combustion OR "waste-to-energy" OR "waste to energy" OR upcycling OR valorization OR valorisation OR carbonization OR carbonisation OR bioconversion OR pyrolysis OR gasification OR ferment) OR AB= ("soil health" OR biodivers* OR toxicity OR "land use" OR "land occupation" OR "water use" OR "water consumption" OR "water bod*" OR river OR lake OR "water quality" OR eutrophication OR "greenhouse gas" OR "air emissions" OR "air pollution" OR "criteria air" OR "climate change" OR "global warming")
PM4	PubMed	3/24/2021	3	26	Initial pubmed search; combination of searches 1,2,3 (see terms)	Search 1: landfill[Title] OR donation[Title] OR upcycling[Title] OR "animal feed"[Title] OR unharvested[Title] OR compost[Title] OR "anaerobic digestion"[Title] OR "aerobic digestion"[Title] OR co-digestion OR "land application"[Title] OR "wastewater treatment"[Title] OR incineration[Title] OR "controlled combustion"[Title] OR "waste-to-energy"[Title] Search 2: environment[Title] OR "soil health"[Title] OR LCA[Title] OR "life cycle assessment"[Title] OR "life cycle analysis"[Title], OR "water quality"[Title] OR eutrophication[Title] OR energy[Title] OR toxicity[Title] OR "greenhouse gas"[Title] OR "air emissions"[Title] OR "air pollution"[Title] OR "land use"[Title] OR "land occupation"[Title] OR "water use"[Title] OR "water consumption"[Title] OR "criteria air"[Title] Search 3: "food waste"[Title]
PM5	PubMed	3/24/2021	33	59	combination: searches 3 and 2	(see PM4)
PM6	PubMed	3/24/2021	349	383	combination: searches 3 and 1	(see PM4)

Name	Source	Date	Number Unique	Total Results	Description	Search Terms
PMQ2	PubMed	4/7/2021	23	189	Basic search revised: require some form of food waste in title, require something environmental in abstract, require some pathway or indicator in abstract. Combination of searches 1,2,3 in “Search Terms”	#3 Search: landfill[Title/Abstract] OR donation[Title/Abstract] OR upcycling[Title/Abstract] OR "animal feed"[Title/Abstract] OR unharvested[Title/Abstract] OR compost[Title/Abstract] OR "anaerobic digestion"[Title/Abstract] OR "aerobic digestion"[Title/Abstract] OR co-digestion OR "land application"[Title/Abstract] OR "wastewater treatment"[Title/Abstract] OR incineration[Title/Abstract] OR "controlled combustion"[Title/Abstract] OR "waste-to-energy"[Title/Abstract] OR "soil health"[Title/Abstract] OR "water quality"[Title/Abstract] OR eutrophication[Title/Abstract] OR energy[Title/Abstract] OR toxicity[Title/Abstract] OR "greenhouse gas"[Title/Abstract] OR "air emissions"[Title/Abstract] OR "air pollution"[Title/Abstract] OR "land use"[Title/Abstract] OR "land occupation"[Title/Abstract] OR "water use"[Title/Abstract] OR "water consumption"[Title/Abstract] OR "criteria air"[Title/Abstract] #1 Search: "food waste"[Title] OR "food loss"[Title] OR "wasted food"[Title] #2 Search: environment*[Title/Abstract] OR LCA[Title/Abstract] OR "life cycle"[Title/Abstract] OR lifecycle[Title/Abstract]
E1	Ebsco	3/24/2021	11	62	Basic search, with "food waste" as title, and pathway words in title, and LCA/environment words in title. Note quotes did not function well; application was a hit for 'landfill application'	"Food Waste" AND (landfill OR donation OR upcycling OR "animal feed" OR unharvested OR compost* OR "anaerobic digestion" OR "aerobic digestion" OR co-digestion OR "land application" OR "wastewater treatment" OR incineration OR "controlled combustion" OR "waste-to-energy") AND (environment* OR "soil health" OR LCA OR "life cycle assessment" OR "life cycle analysis", OR "water quality" OR eutrophication OR energy OR toxicity OR "greenhouse gas" OR "air emissions" OR "air pollution" OR "land use" OR "land occupation" OR "water use" OR "water consumption" OR "criteria air")
Q1_F1	Web of Science	3/29/2021	207	231	forward searches for 5 articles from Q1	
Q1_B1	Web of Science	3/29/2021	469	580	backward searches for 5 articles from Q1	

Name	Source	Date	Number Unique	Total Results	Description	Search Terms
Q1_2022	Web of Science	9/25/2022	76	93	Q1 + years = 2021-2023	… AND PY=(2021-2023)
Q2_2022	Web of Science	9/25/2022	219	263	Q2 + years = 2021-2023	… AND PY=(2021-2023)
Q3_2022	Web of Science		195	492	Q3 + years = 2021-2023	… AND PY=(2021-2023)
Q5_2022	Web of Science		168	461	Q5 + years = 2021-2023	… AND PY=(2021-2023)

TABLE A-2. NUMBERS OF STUDIES AND DATA POINTS, DISAGGREGATED BY MANAGEMENT PATHWAY AND ENVIRONMENTAL IMPACTS.

Management Pathway	Number of Studies	Number of Data Points
Source Reduction	4	17
Donation	5	17
Anaerobic Digestion	23	144
Animal Feed	5	21
Compost	18	68
Controlled Combustion / Incineration	19	72
Land application	1	5
Landfill	14	48
Sewer / Wastewater Treatment	3	7
Unharvested / Plowed In	1	1
Upcycling	-	-

Environmental Impact	Number of Studies	Number of Data Points
Acidification	18	57
Energy Demand	9	31
Eutrophication	20	92
GWP	35	168
Land Occupation	6	26
Water Consumption	9	26

TABLE A-3. SUMMARY OF WASTED FOOD-RELATED SOIL AMENDMENT SEARCH QUERIES, INCLUDING COUNTS OF UNIQUE RECORDS RETURNED (TOTAL UNIQUE = 101)

Source	Date	Number Unique	Total Results	Description	Search Terms
Web of Science	2/10/23	35	35	Initial search on carbon sequestration by digestate	((PY=(2010-2023)) AND AB=("carbon sequestration" OR "sequester carbon")) AND AB="digestate"
Science Direct	2/10/23	2	2	carbon sequestration by digestate	Title, abstract or key word: ("carbon sequestration" OR "sequester carbon") AND "digestate" Publication Year: 2010-2023
PubMed	2/10/23	1	11	carbon sequestration by digestate	Title/abstract: ("carbon sequestration" OR "sequester carbon") AND "digestate" Publication Date: 1/1/2010 to present
Web of Science	2/10/23	13	13	Initial search on digestate and soil health	((PY=(2010-2023)) AND AB=("soil health")) AND AB=(digestate)
Science Direct	2/10/23	0	5	digestate and soil health	Title, abstract or key word: "soil health” AND "digestate" Publication Year: 2010-2023
PubMed	2/10/23	0	5	digestate and soil health	Title/abstract: "soil health” AND "digestate" Publication Date: 1/1/2010 to present
Science Direct	2/15/23	12	12	Initial search on comparison of nutrient leaching from soil amendments	Title, abstract, keywords: "nutrient" AND “leach” AND "compost" AND ("digestate" OR "biosolids")
PubMed	2/15/23	4	6	comparison of nutrient leaching from soil amendments	leach*[Title/Abstract] AND nutrients[Title/Abstract] AND compost[Title/Abstract] AND (biosolids[Title/Abstract] OR digestate[Title/Abstract])
Web of Science	2/15/23	30	37	comparison of nutrient leaching from soil amendments	AB= leach* AND nutrients AND compost AND (biosolids OR digestate)
Science Direct	2/15/23	4	20	Initial search on biosolids*	Title, abstract, keywords: “soil" AND “health” AND "biosolids" AND "compost"

* Similar searches on Web of Science and PubMed did not reveal any unique and relevant sources

TABLE A-4. SUMMARY OF CIRCULARITY LITERATURE SEARCH QUERIES, INCLUDING COUNTS OF UNIQUE RECORDS RETURNED (TOTAL UNIQUE = 67)

Source	Date	Number Unique	Total Results	Description	Search Terms
Web of Science	10/14/22	51	51	Initial search for circularity literature	PY=(2014-2022) AND TI=circula* AND TI=(food OR organic) AND AB=food and AB=("animal feed" OR "compost" OR "anaerobic digestion" OR “land application” OR “wastewater treatment” OR incineration OR landfill OR “controlled combustion”) NOT DT=patent
Science Direct	10/14/22	8	32	Initial Science Direct search for circularity literature	Years: 2014 – 2022; Title, abstract, or author-specified keywords: Food AND (“animal feed” OR compost OR ‘anaerobic digestion” OR “land application” OR “wastewater treatment” OR incineration OR landfill OR “controlled combustion”); and Title: (circular OR circularity) AND (food OR organic)
PubMed	2/10/23	8	29	Initial PubMed search for circularity literature	(((((("2014/01/01"[Date - Publication] : "3000"[Date - Publication])) AND ("animal feed"[Title/Abstract] OR "compost"[Title/Abstract] OR "anaerobic digestion"[Title/Abstract] OR "land application"[Title/Abstract] OR "wastewater treatment"[Title/Abstract] OR incineration[Title/Abstract] OR landfill[Title/Abstract] OR "controlled combustion"[Title/Abstract])) AND (circular*[Title])) AND (food[Title] OR organic[Title])

TABLE A-5. KEYWORDS USED IN SCREENING OF LCA LITERATURE QUERY RESULTS. STEM SEARCHES ALLOW FOR ADDITION OF LETTERS TO THE SEARCH TERMS, EXACT SEARCHES REQUIRE NO ADDITIONAL CHARACTERS, AND REGEX SEARCHES PROVIDE ADDITIONAL FLEXIBILITY TO DEFINE CONSTRAINTS.

<table>
<tr><th>Full Name</th><th>Stem Search</th><th>Exact Search</th><th>Regex Search</th></tr>
<tr><td>Food Waste</td><td>food waste, food - waste, food loss, wasted food, waste food, lost food, fw, flw</td><td>FW, FLW</td><td>food waste|food-waste|food loss|wasted food|waste food|lost food|fw|flw</td></tr>
<tr><td>LCA</td><td>life cycle assessment, life cycle analysis, lifecycle assessment, lifecycle analysis, life - cycle assessment, life - cycle analysis</td><td>LCA</td><td></td></tr>
<tr><td>Food Waste LCA</td><td></td><td></td><td>(food waste|food - waste|food loss|wasted food|waste food|lost food|\bfw\b|\bflw\b).{0,10}(life cycle assessment|lifecycle assessment|life - cycle assessment|life cycle analysis|lifecycle analysis|life - cycle analysis|\bLCA\b)|(life cycle assessment|lifecycle assessment|life - cycle assessment|life cycle analysis|lifecycle analysis|life - cycle analysis|\bLCA\b).{0,10}(food waste|food - waste|food loss|wasted food|waste food|lost food|\bfw\b|\bflw\b)</td></tr>
<tr><td>Environment</td><td>environm</td><td></td><td></td></tr>
<tr><td>Sustain</td><td>sustain</td><td></td><td></td></tr>
<tr><td>Resources</td><td>resourc</td><td></td><td></td></tr>
<tr><td>Recycling</td><td>recycl</td><td></td><td></td></tr>
<tr><td>Pollut</td><td>pollut, contamin</td><td></td><td></td></tr>
<tr><td>Waste</td><td>waste prevention, waste management</td><td></td><td></td></tr>
<tr><td>Circular Economy</td><td>circular economy, circularity</td><td></td><td></td></tr>
<tr><td>TEA</td><td>techno- economic, technoeconomic</td><td>TEA</td><td></td></tr>
<tr><td>Source Reduction</td><td>source reduction</td><td></td><td></td></tr>
<tr><td>Unharvest / soil incorp.</td><td colspan="2">harvest, crop residue, stover, not harvest, plow in, plough in</td><td></td></tr>
<tr><td>Upcycling</td><td>upcycl, value - added surplus, value added surplus</td><td></td><td></td></tr>
<tr><td>Donation</td><td>donat</td><td></td><td></td></tr>
<tr><td>Animal feed</td><td colspan="2">Animal feed, animal ration, fish feed, livestock feed, livestock ration</td><td></td></tr>
<tr><td>Anaerobic Digestion</td><td>anaerobic digest</td><td>AD</td><td></td></tr>
<tr><td>Gasification</td><td>gasificat</td><td></td><td></td></tr>
<tr><td>Pyrolysis</td><td>pyrolysis</td><td></td><td></td></tr>
</table>

Full Name	Stem Search	Exact Search	Regex Search
Hydrothermal Carbonization			(hydrothermal).{0,5}(carbon)
Microbial Fuel Cell	microbial fuel cell		
Other Valorization	valorization, bioplastic, platform chemical, biochar		
Mechanical Biological Treatment	mechanical treatment, biological treatment		
Compost	compost		
Land Application	land application		
Wastewater treat.	wastewater treat	WRRF	
Controlled Combustion	combust, inciner		
Landfill	landfill, municpal solid waste	MSW	
Down the drain	disposer, kitchen sink, in - sink		
Landfill			(organic).{0,20}(solid waste|landfill|\bMSW\b)
Products	bioplastic, platform chemical		
Waste-energy	waste - energy, waste - to - energy, waste to energy, energy from waste, combustion, incineration		
Biochar	biochar		
Agricultural Wastes			(agricultur).{0,10}(waste)
Critera air pollut.	air pollut	CAP, HAP	
Biodiversity	biodiver		
Climate change	climate change, global warming	GWP	
Energy demand	energy demand		
Eutroph	eutroph		
Human health	human health, public health		
Land use	land use, land occupation, arable land		
Soil health	soil health		
Tox	toxic, ecotox, human-tox		
Water use	water use, water consumption, water demand		
Water quality	water quality, water pollution, polluted water		
Water	water bod, river, lake, ocean		

Full Name	Stem Search	Exact Search	Regex Search
Commercial	commerc, business		
Residential	residen, homeowner		
Production	food production, production of food		
Processing	processing		
China	China		
South Korea	South Korea		
European Union	European Union, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden	EU	
Europe (not EU)	Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Iceland, Kosovo, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia, San Marino, Serbia, Switzerland, Turkey, Ukraine, United Kingdom	UK	
United States	United States, America	U.S.	

APPENDIX B
ENERGY, FERTILIZER, AND CARBON SEQUESTRATION OFFSETS

B-1. Energy

The following table documents energy production for electricity and heat in AD, incineration, landfill and WWT. The analysis showed that all or most facilities (some are vague) apply credits only on net energy production, as they should. This can be done in two ways, as documented in the Energy Recovery Modeling column of Table B-1. All values in the electricity column represent total electricity production, so when a net credit is applied, only a partial credit is documented. All studies take some credit for produced, exported electricity. Some studies take a credit for a portion of the heat that is sold, used for district heating, etc. Across the reviewed studies, incineration has the highest total median energy production (280 kWh/Mg wasted food (WF)); however, values in the table do not reflect onsite use, so net energy recovery cannot be determined from the extracted data. Median energy recovery for the AD pathway is 177 kWh/Mg WF. Fewer data points were identified for landfills and the values range widely.

Credit - Gross; Facility - Net	Full credit for all energy production and full impact for all energy consumption are included. Thus, there is a credit/impact only on the net difference.
Credit - Net; Facility - Net	Credit/impact based on net energy (production - consumption).

TABLE B-1. SUMMARY OF ENERGY CREDIT MODELING

Study	Pathway	Basis Unit (1 Mg)	Electricity Recovery		Heat Recovery		Energy Recovery Modeling	Note
			kWh	Credit Applied	kWh	Credit Applied		
Parry (2012)	AD	WF	421	TRUE	477	FALSE	Credit - Gross; Facility - Net	recovered heat was used to operate AD. The rest went unused.
Parry (2012)	WWT	WF	233	TRUE	271	FALSE	Credit - Gross; Facility - Net	
Parry 2012	Landfill	WF	224	TRUE	0	FALSE	Credit - Gross; Facility - Net	
Yoshida (2012)	AD	WF	191	Partial	0	FALSE	Credit - Gross; Facility - Net	Wet AD
Yoshida 2012	AD	WF	100	Partial	Not specified	TRUE	Credit - Gross; Facility - Net	Dry AD

Study	Pathway	Basis Unit (1 Mg)	Electricity Recovery		Heat Recovery		Energy Recovery Modeling	Note
			kWh	Credit Applied	kWh	Credit Applied		
Zhou (2022)	AD	WF	177	TRUE	0	FALSE	Credit - Gross; Facility - Net	"After purification, the biogas was sent to generating heat and electricity, and around 176.5 kWh/t WF was generated for energy recovery." Possible that some heat is included in recovered energy. Not clear.
González et al. (2020)	AD	WF	133	Partial	199	Partial	Credit - Net; Facility - Net	Values for CHP scenario; Assumes some heat is available for sale. This amount is credited.
Tong (2018)	Incineration	WF	157	Partial	0	FALSE	Credit - Gross; Facility - Net	Could not find values for AD.
Lee (2020)	AD	WF	163	TRUE	210	Not specified	Credit - Gross; Facility - Net	
Lee 2020	Incineration	WF	280	TRUE	601	Not specified	Credit - Gross; Facility - Net	
Pace (2018)	AD	Organic Waste	121	Partial	Not specified	FALSE	Credit - Net; Facility - Net	
Slorach (2020)	AD	WF	254	TRUE	0 for current scenario; 252 for future scenario	Partial	Credit - Gross; Facility - Net	
Mondello (2017)	Landfill	WF	166	TRUE	0	FALSE	Credit - Gross; Facility - Net	
Mondello 2017	Incineration	WF	564	TRUE	0	FALSE	Credit - Gross; Facility - Net	
Mondello 2017	AD	WF	175	TRUE	0	FALSE	Credit - Gross; Facility - Net	
Tian (2021)	AD	WF	385	TRUE	Not specified	FALSE	Credit - Gross; Facility - Net	centralized AD, scenario D.
Slorach et al. (2019b)	Incineration	WF	174	TRUE	0	FALSE	Credit - Net; Facility - Net	
Slorach et al. (2019b)	AD	WF	254	TRUE	476	FALSE	Credit - Net; Facility - Net	

Study	Pathway	Basis Unit (1 Mg)	Electricity Recovery		Heat Recovery		Energy Recovery Modeling	Note
			kWh	Credit Applied	kWh	Credit Applied		
Albizzati et al. (2021b)	Incineration	WF	500	TRUE	0	FALSE	Credit - Gross; Facility - Net	
Hoehn (2021)	Incineration	WF	138	TRUE	355	TRUE	Credit-Gross; Facility-Not specified	
Huang et al. (2022)	Incineration	WF	427	TRUE	Not specified	FALSE	Credit - Net; Facility - Net	
Huang et al. (2022)	Landfill	WF	33.9	TRUE	0	FALSE	Credit - Net; Facility - Net	

B-1-1 Fertilizer and CO_2 Sequestration

Looking across all studies (regardless of scope criteria), we identified 6 studies that report the magnitude of the GWP credit associated with carbon sequestration for the compost pathway and 8 studies for the AD pathway. At the same time, we reviewed studies to determine the range of magnitudes associated with avoided fertilizer production (for brevity and context we report them together here). Table B-2 and Table B-3 show the median, min and max credit values for each pathway for fertilizer and carbon sequestration credits. For the compost and AD pathways, respectively, we found 8 and 13 studies that report the magnitude of their modeled fertilizer credit. Table B-4 shows the carbon sequestration and fertilizer credits for individual studies-pathways. All studies that include both pathways attribute more carbon sequestration to compost than to AD. Among these studies, in absolute terms, the difference in magnitude between the two pathways is typically moderate (median difference = -10.3 kg CO_2eq difference/Mg wasted food). In relative terms, this difference amounts to 7% of median impact for the AD pathway and 23% of median impact for the compost pathway. This difference is consequential for the net impact of the compost pathway (i.e., it could switch from positive to negative). One study, Parry (2012), attributes a much greater estimate of carbon sequestration to the compost pathway as compared to AD.

TABLE B-2. GWP OF FERTILIZER AND CARBON SEQUESTRATION CREDITS (KG CO_2EQ/METRIC TON ORGANIC WASTE) FOR AD DIGESTATE

	Fertilizer Offset (n=13)	Carbon Sequestration (n=8)
Median	-26	-22
Min	-110	-80
Max	-3.2	-6.0

TABLE B-3: GWP OF FERTILIZER AND CARBON SEQUESTRATION CREDITS (KG CO_2EQ/METRIC TON ORGANIC WASTE) FOR COMPOST

	Fertilizer Offset (n=8)	Carbon Sequestration (n=6)
Median	-28	-94
Min	-50	-224
Max	-2.8	-10

Table 3-4 shows median values for pathway impacts with and without CO_2 sequestration (CO_2 Sequest = TRUE or FALSE) for AD, Compost, Land Application, Landfill, Unharvest, and WRRF. Note that these data overlap with, but do not match the data in Table B-2 and Table B-3, which required that offsets be explicitly reported. Table 3-4 simply requires that CO_2 sequestration be identified as either included or not. Nonetheless, all tables agree that the CO_2 sequestration offset reduces the GWP impact. Across pathways with data for both conditions, impacts with sequestration are higher than results without CO_2 sequestration. For AD and compost (looking across all tables), the shift is on the order of -50 to -200 kg CO_2eq / metric ton wasted food.

TABLE B-4: MAGNITUDE OF CARBON SEQUESTRATION AND AVOIDED FERTILIZER CREDITS (ALL RESULTS STANDARDIZED TO 1 METRIC TON OF THE DOCUMENTED BASIS UNIT)

Study	Pathway	Basis Unit	Fertilizer Nutrient Offset	Carbon Sequestration
			GWP (kg CO_2e)	GWP (kg CO_2e)
Yoshida (2012)	Compost	mixed organic waste	-2.82	-67.7
Yoshida (2012)	AD	mixed organic waste	-3.21	-60.9
Yoshida (2012)	AD	mixed organic waste	-9.18	-61.7
Levis and Barlaz (2011)	Compost	mixed organic waste	-11	-148
Hodge (2016)	Compost	mixed commercial wasted food (WF)	-14	-10
Hodge (2016)	AD	mixed commercial WF	-14	-6
Morelli et al. (2019)	Compost	WF	-16	-21.7
Morelli et al. (2019)	AD	WF	-6.0	-7.4
Schott (2016)	AD	WF	-67	Excluded
Morris et al. (2017)	Compost	WF	-50	-120
Morris et al. (2017)	AD	WF	-20	-80
Slorach et al. (2019a)	Compost	household WF	Minor	Excluded
Parry (2012)	Compost	WF	-48	-224
Parry (2012)	AD	WF	-53	-28
Ebner et al. (2015)	AD	industrial WF and manure	-8.2	-12.8
Tong et al. (2018)	AD	WF	-26	-15.4
Mondello (2017)	AD	WF	-42	Excluded
Mondello (2017)	Compost	WF	-40	Excluded
Tian et al. (2021)	AD	WF	-49	Excluded
Khosnevisan et al. (2018)	AD	mixed organic waste	-110	Excluded

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APPENDIX C
DESCRIPTION OF APPROACH TO COMPARE IMPACT METRICS

Consistency in reported impact category units enabled standardization of results across studies for the impact categories acidification, energy demand, eutrophication, GWP, land occupation, and water consumption. Variability in units prevented standardization of results for categories such as ecotoxicity, human toxicity, or smog formation. This section briefly describes the standardization approach.

C-1. Description of Approach to Compare Impact Metrics

Midpoint acidification is typically reported in units of Accumulated Exceedance (AE, i.e. mol H+ eq) or kg SO_2eq. Midpoint eutrophication is typically reported in either kg of nitrogen or phosphorus equivalents, but some methods, such as Impact 2002+ (Jolliet et al. 2003), do not include marine eutrophication, and other methods, such as ReCiPe 2008 (Goedkoop et al. 2013), classify freshwater and marine eutrophication separately. The EPA TRACI method (Bare 2011), however, combines the two types of eutrophication, reporting impacts in terms of kg nitrogen equivalents, based on stoichiometric conversions of algal biomass from the Redfield ratio (Redfield 1934). A broader discussion of acidification and eutrophication units across methods is provided in the LCIA Encyclopedia (Henderson 2015; van Zelm et al. 2015). In this study, we have harmonized acidification and eutrophication impacts to those used in the TRACI method, in order to account for the different units and the freshwater/marine modeling split. Table C-1, below, shows the conversion factors for acidification and eutrophication between a sampling of impact methods and TRACI. the impact methods shown are representative of the variety of units reported; Subsequent updates to some of the methods have been made (with little to no changes to global midpoint values, which are shown and used here), but many of the LCA studies reviewed have used older versions of methods.

Midpoint global warming potential is reported in terms of CO_2eq. However, as IPCC updates factors for GWP of substances, these factors can change in LCIA methods. No attempt was made to adjust for changes in these factors, as the relative magnitude of changes is restricted relative to scope, inventory data and other differences between studies.

Finally, midpoint land and water metrics are typically area and volume based, respectively, so no conversion between impact assessment methods is necessary.

TABLE C-1. SELECTED CHARACTERIZATION FACTORS FOR LCIA METHODS, ALONG WITH CONVERSION TO TRACI 2.1

Impact Method	Impact Category	Emission	Compartment	CF	Unit	TRACI 2.1 Impact Category	TRACI 2.1 Units	Conversion to TRACI 2.1
CML 2001	Acidification	SO_2	air	1.2	kg SO_2eq	Acidification	kg SO_2eq	0.833
CML 2001	Eutrophication	N	water	0.42	kg $PO_4^{(3-)}$eq	Eutrophication	kg Neq	2.349
CML 2001	Eutrophication	P	water	3.06	kg $PO_4^{(3-)}$eq	Eutrophication	kg Neq	2.382
CML 2001	Eutrophication	$PO_4^{(3-)}$	water	1	kg $PO_4^{(3-)}$eq	Eutrophication	kg Neq	2.380
ILCD 2011 Midpoint	Acidification	SO_2	air	1.31	mol H^+ eq	Acidification	kg SO_2eq	0.763
ILCD 2011 Midpoint	Freshwater Eutrophication	P	water	1	kg Peq	Eutrophication	kg Neq	7.290
ILCD 2011 Midpoint	Freshwater Eutrophication	$PO_4^{(3-)}$	water	0.33	kg Peq	Eutrophication	kg Neq	7.212
ILCD 2011 Midpoint	Marine Eutrophication	N	water	1	kg Neq	Eutrophication	kg Neq	0.986
Impact 2002+	Acidification	SO_2	air	1	kg SO_2eq	Acidification	kg SO_2eq	1.000
Impact 2002+	Eutrophication	N	water	0	kg $PO_4^{(3-)}$ P-lim	Eutrophication	kg Neq	0.986
Impact 2002+	Eutrophication	P	water	3.06	kg $PO_4^{(3-)}$ P-lim	Eutrophication	kg Neq	2.382
Impact 2002+	Eutrophication	$PO_4^{(3-)}$	water	1	kg $PO_4^{(3-)}$ P-lim	Eutrophication	kg Neq	2.380
ReCiPe 2008	Acidification	SO_2	air	1	kg SO_2eq	Acidification	kg SO_2eq	1.000
ReCiPe 2008	Freshwater Eutrophication	P	water	1	kg Peq	Eutrophication	kg Neq	7.290
ReCiPe 2008	Freshwater Eutrophication	$PO4^{(3-)}$	water	0.33	kg Peq	Eutrophication	kg Neq	7.212
ReCiPe 2008	Marine Eutrophication	N	water	1	kg Neq	Eutrophication	kg Neq	0.986
TRACI 2.1	Acidification	SO_2	air	1	kg SO_2eq	Acidification	kg SO_2eq	1.000
TRACI 2.1	Eutrophication	N	water	0.9864	kg Neq	Eutrophication	kg Neq	1.000
TRACI 2.1	Eutrophication	P	water	7.29	kg Neq	Eutrophication	kg Neq	1.000
TRACI 2.1	Eutrophication	$PO_4^{(3-)}$	water	2.38	kg Neq	Eutrophication	kg Neq	1.000

References and Notes for Table C-1:

- CML 2001: (Guinée et al. 2002)
- ILCD 2011: (Wolf et al. 2012). ILCD uses Accumulated Exceedance (Seppälä et al. 2006; Posch et al. 2008), with units of mol H+ eq.
- TRACI 2.1: (Bare 2011)
- ReCiPe 2008: (Goedkoop et al. 2013)
- Impact 2002+: (Jolliet et al. 2003)

APPENDIX D
EXTRACTED DATA VALUES

This section provides a table of data used in calculation of statistics for ranking, and in preparation of Figure 3-3 to Figure 3-8.

TABLE D-1. EXTRACTED DATA VALUES USED FOR INTER-STUDY COMPARISONS

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Acidification	Combust	incineration with electricity recovery	0.5	kg SO_2eq	Singapore	N.A.	Ahamed 2016
CED	Combust	incineration with electricity recovery	3530	MJ	Singapore	N.A.	Ahamed 2016
Eutrophication	Combust	incineration with electricity recovery	0.197	kg Neq	Singapore	N.A.	Ahamed 2016
GWP	Combust	incineration with electricity recovery	235	kg CO_2eq	Singapore	N.A.	Ahamed 2016
Eutrophication	Animal Feed	Wet	0.671	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Animal Feed	BSF	-0.0385	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Animal Feed	PC	0.148	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Animal Feed	Wet	3.43	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Animal Feed	BSF	0.0372	kg Neq	EU-27+1	N.A.	Albizzati 2021a

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Animal Feed	PC	2.19	kg Neq	EU-27+1	N.A.	Albizzati 2021a
GWP	Animal Feed	Wet	-76	kg CO_2eq	EU-27+1	N.A.	Albizzati 2021a
GWP	Animal Feed	BSF	17.1	kg CO_2eq	EU-27+1	N.A.	Albizzati 2021a
GWP	Animal Feed	PC	-210	kg CO_2eq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Compost	Centralized	0.158	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Compost	Home	1.09	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Compost	Centralized	4.88	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Compost	Home	7.29	kg Neq	EU-27+1	N.A.	Albizzati 2021a
GWP	Compost	Centralized	51	kg CO_2eq	EU-27+1	TRUE	Albizzati 2021a
GWP	Compost	Home	270	kg CO_2eq	EU-27+1	TRUE	Albizzati 2021a
Eutrophication	Donate	Base	-3.26	kg Neq	EU-27+1	N.A.	Albizzati 2021a
Eutrophication	Donate	Base	-1.31	kg Neq	EU-27+1	N.A.	Albizzati 2021a
GWP	Donate	Base	-1300	kg CO_2eq	EU-27+1	N.A.	Albizzati 2021a
GWP	AD	Baseline	123	kg CO_2eq	Europe	FALSE	Albizzati 2021b

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
GWP	Animal Feed	With avoided products (net result)	-329	kg CO_2eq	Europe	N.A.	Albizzati 2021b
GWP	Animal Feed	With avoided products (net result)	-385	kg CO_2eq	Europe	N.A.	Albizzati 2021b
GWP	Combust	Baseline	41.8	kg CO_2eq	Europe	N.A.	Albizzati 2021b
GWP	Compost	Baseline	152	kg CO_2eq	Europe	FALSE	Albizzati 2021b
GWP	Landfill	Baseline	2410	kg CO_2eq	Europe	FALSE	Albizzati 2021b
GWP	AD	Baseline	26.5	kg CO_2eq	Qatar	FALSE	Al-Rumaihi 2020
GWP	Compost	Baseline	128	kg CO_2eq	Qatar	FALSE	Al-Rumaihi 2020
GWP	AD	total food waste	-194	kg CO_2eq	Sweden	FALSE	Bernstad Saraiva Schott and Andersson 2015
GWP	Combust	total food waste	-82.8	kg CO_2eq	Sweden	N.A.	Bernstad Saraiva Schott and Andersson 2015
CED	Donate	Base	-6510	MJ	Sweden	N.A.	Eriksson 2017
GWP	Donate	Base	-574	kg CO_2eq	Sweden	N.A.	Eriksson 2017
CED	Upcycle	Base	-8240	MJ	Sweden	N.A.	Eriksson 2017
GWP	Upcycle	Base	-600	kg CO_2eq	Sweden	N.A.	Eriksson 2017
Acidification	Upcycle	Bread Additive	0.725	kg SO_2eq	Sweden	N.A.	Eriksson 2021
Acidification	Upcycle	Soup Additive	-2.29	kg SO_2eq	Sweden	N.A.	Eriksson 2021
Eutrophication	Upcycle	Bread Additive	0.948	kg Neq	Sweden	N.A.	Eriksson 2021

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Upcycle	Bread Additive	-0.109	kg Neq	Sweden	N.A.	Eriksson 2021
Eutrophication	Upcycle	Soup Additive	-0.496	kg Neq	Sweden	N.A.	Eriksson 2021
Eutrophication	Upcycle	Soup Additive	-4.14	kg Neq	Sweden	N.A.	Eriksson 2021
GWP	Upcycle	Bread Additive	68	kg CO_2eq	Sweden	N.A.	Eriksson 2021
GWP	Upcycle	Soup Additive	-450	kg CO_2eq	Sweden	N.A.	Eriksson 2021
Water Consumption	Upcycle	Bread Additive	-0.16	m^3 water	Sweden	N.A.	Eriksson 2021
Water Consumption	Upcycle	Soup Additive	-3	m^3 water	Sweden	N.A.	Eriksson 2021
GWP	AD	AD-LF -BU ; residuals to landfill; with beneficial units	-179	kg CO_2eq	United States	TRUE	Hodge 2016
GWP	AD	AD-WTE - BUresiduals to waste to energy incineration; with beneficial units	-130	kg CO_2eq	United States	TRUE	Hodge 2016
GWP	Combust	WTE - BU; beneficial units	-106	kg CO_2eq	United States	N.A.	Hodge 2016
GWP	Compost	AC-LF - BU; residuals to landfill; with beneficial units	-78	kg CO_2eq	United States	TRUE	Hodge 2016
GWP	Compost	AC-WTE; BU; residuals to waste to energy incineration; with beneficial units	-25	kg CO_2eq	United States	TRUE	Hodge 2016
GWP	Landfill	LF - BU; energy recovery	-10	kg CO_2eq	United States	TRUE	Hodge 2016
Eutrophication	Combust	Base	0.0000456	kg Neq	Spain	N.A.	Hoehn 2021

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Combust	Base	0.000986	kg Neq	Spain	N.A.	Hoehn 2021
Eutrophication	Compost	Base	0.000346	kg Neq	Spain	N.A.	Hoehn 2021
Eutrophication	Compost	Base	0.000197	kg Neq	Spain	N.A.	Hoehn 2021
Eutrophication	Landfill	Base	0.0219	kg Neq	Spain	N.A.	Hoehn 2021
Eutrophication	Landfill	Base	0.0076	kg Neq	Spain	N.A.	Hoehn 2021
Acidification	Combust	Base	-1	kg SO_2eq	China	N.A.	Huang 2022
Eutrophication	Combust	Base	0.365	kg Neq	China	N.A.	Huang 2022
GWP	Combust	Base	30	kg CO_2eq	China	N.A.	Huang 2022
Water Consumption	Combust	Base	-1.5	m^3 water	China	N.A.	Huang 2022
Acidification	Landfill	Base	12	kg SO_2eq	China	N.A.	Huang 2022
Eutrophication	Landfill	Base	0.219	kg Neq	China	N.A.	Huang 2022
GWP	Landfill	Base	590	kg CO_2eq	China	FALSE	Huang 2022
Water Consumption	Landfill	Base	0.5	m^3 water	China	N.A.	Huang 2022
CED	AD	Bio-1, Pre-treatment: biopulp AD with CHP	-13000	MJ	Denmark	N.A.	Khoshnevisan 2018

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
CED	AD	Bio-2, Pre-treatment: biopulp AD with electricity recovery and nutrient	-101	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Bio-3, Pre-treatment: biopulp AD with biogasoline and nutrientr recovery	-9640	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Sp-1, Pre-treatment: Screw press AD with CHP	-9530	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Sp-2, Pre-treatment: Screw press AD with electricity recovery and nutrient	-7470	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Sp-3, Pre-treatment: Screw press AD with biogasoline and nutrientr recovery	-7180	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Ds-1, Pre-treatment: Disc screen AD with CHP	-9320	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Ds-2, Pre-treatment: Disc screen AD with electricity recovery and nutrient	-6820	MJ	Denmark	N.A.	Khoshnevisan 2018
CED	AD	Ds-3, Pre-treatment: Disc screen AD with biogasoline and nutrientr recovery	-6470	MJ	Denmark	N.A.	Khoshnevisan 2018
GWP	AD	Bio-1, Pre-treatment: biopulp AD with CHP	-941	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Bio-2, Pre-treatment: biopulp AD with electricity recovery and nutrient	-672	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Bio-3, Pre-treatment: biopulp AD with biogasoline and nutrientr recovery	-333	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Sp-1, Pre-treatment: Screw press AD with CHP	-750	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Sp-2, Pre-treatment: Screw press AD with electricity recovery and nutrient	-562	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
GWP	AD	Sp-3, Pre-treatment: Screw press AD with biogasoline and nutrientr recovery	-327	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Ds-1, Pre-treatment: Disc screen AD with CHP	-758	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Ds-2, Pre-treatment: Disc screen AD with electricity recovery and nutrient	-532	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	AD	Ds-3, Pre-treatment: Disc screen AD with biogasoline and nutrientr recovery	-248	kg CO_2eq	Denmark	FALSE	Khoshnevisan 2018
GWP	Compost	Windrow compost	-148	kg CO_2eq	United States	TRUE	Levis 2011
GWP	Compost	ASP compost	-73	kg CO_2eq	United States	TRUE	Levis 2011
GWP	Compost	Gore compost	-102	kg CO_2eq	United States	TRUE	Levis 2011
GWP	Compost	In-vessel compost	-64	kg CO_2eq	United States	TRUE	Levis 2011
Acidification	Compost	S2- Aerated windrow composting	1.01	kg SO_2eq	Malaysia	N.A.	Lin 2022
Eutrophication	Compost	S2- Aerated windrow composting	-0.122	kg Neq	Malaysia	N.A.	Lin 2022
GWP	Compost	S2- Aerated windrow composting	463	kg CO_2eq	Malaysia	FALSE	Lin 2022
Acidification	AD	Anaerobic Digestion	0.203	kg SO_2eq	Germany	N.A.	Mayer 2020
Acidification	AD	AD + Incineration	0.0844	kg SO_2eq	Germany	N.A.	Mayer 2020
Eutrophication	AD	Anaerobic Digestion	-1.14	kg Neq	Germany	N.A.	Mayer 2020
Eutrophication	AD	Anaerobic Digestion	0.307	kg Neq	Germany	N.A.	Mayer 2020

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	AD	AD + Incineration	-0.712	kg Neq	Germany	N.A.	Mayer 2020
Eutrophication	AD	AD + Incineration	0.109	kg Neq	Germany	N.A.	Mayer 2020
GWP	AD	Anaerobic Digestion	-45.3	kg CO_2eq	Germany	FALSE	Mayer 2020
GWP	AD	AD + Incineration	-0.298	kg CO_2eq	Germany	FALSE	Mayer 2020
Acidification	Combust	Incineration	0.0427	kg SO_2eq	Germany	N.A.	Mayer 2020
Acidification	Combust	Incineration + drying	0.0894	kg SO_2eq	Germany	N.A.	Mayer 2020
Eutrophication	Combust	Incineration	-0.547	kg Neq	Germany	N.A.	Mayer 2020
Eutrophication	Combust	Incineration	0.153	kg Neq	Germany	N.A.	Mayer 2020
Eutrophication	Combust	Incineration + drying	-0.618	kg Neq	Germany	N.A.	Mayer 2020
Eutrophication	Combust	Incineration + drying	0.165	kg Neq	Germany	N.A.	Mayer 2020
GWP	Combust	Incineration	-55	kg CO_2eq	Germany	N.A.	Mayer 2020
GWP	Combust	Incineration + drying	-2.97	kg CO_2eq	Germany	N.A.	Mayer 2020
Acidification	AD	With avoided products	-0.23	kg SO_2eq	Italy	N.A.	Mondello 2017
CED	AD	With avoided products	-1660	MJ	Italy	N.A.	Mondello 2017
Eutrophication	AD	With avoided products	-0.0948	kg Neq	Italy	N.A.	Mondello 2017
GWP	AD	With avoided products	-299	kg CO_2eq	Italy	FALSE	Mondello 2017

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Land Occupation	AD	With avoided products	-0.14	m^2.yr	Italy	N.A.	Mondello 2017
Acidification	Animal Feed	With avoided products	-1.28	kg SO_2eq	Italy	N.A.	Mondello 2017
Eutrophication	Animal Feed	With avoided products	-0.45	kg Neq	Italy	N.A.	Mondello 2017
GWP	Animal Feed	With avoided products	-420	kg CO_2eq	Italy	N.A.	Mondello 2017
Acidification	Compost	With avoided products	0.38	kg SO_2eq	Italy	N.A.	Mondello 2017
Eutrophication	Compost	With avoided products	0.166	kg Neq	Italy	N.A.	Mondello 2017
GWP	Compost	With avoided products	59.3	kg CO_2eq	Italy	FALSE	Mondello 2017
Acidification	AD	Full-capacity base performance	-0.11	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
Acidification	AD	Full-capacity low performance	0.21	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
CED	AD	Full-capacity base performance	-7200	MJ	United States (Massachusetts)	N.A.	Morelli 2019
CED	AD	Full-capacity low performance	-3200	MJ	United States (Massachusetts)	N.A.	Morelli 2019
Eutrophication	AD	Full-capacity base performance	2.37	kg Neq	United States (Massachusetts)	N.A.	Morelli 2019
Eutrophication	AD	Full-capacity low performance	3.06	kg Neq	United States (Massachusetts)	N.A.	Morelli 2019

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
GWP	AD	Full-capacity base performance	-140	kg CO_2eq	United States (Massachusetts)	TRUE	Morelli 2019
GWP	AD	Full-capacity low performance	-30	kg CO_2eq	United States (Massachusetts)	TRUE	Morelli 2019
Acidification	Combust	Baseline	0.081	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
CED	Combust	Baseline	-960	MJ	United States (Massachusetts)	N.A.	Morelli 2019
Eutrophication	Combust	Baseline	0.00612	kg Neq	United States (Massachusetts)	N.A.	Morelli 2019
GWP	Combust	Baseline	-20	kg CO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
Acidification	Compost	Windrow base performance	1.2	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
Acidification	Compost	Windrow improved performance	0.5	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
Acidification	Compost	ASP improved performance	0.49	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
CED	Compost	Windrow base performance	290	MJ	United States (Massachusetts)	N.A.	Morelli 2019
CED	Compost	ASP base performance	540	MJ	United States (Massachusetts)	N.A.	Morelli 2019
CED	Compost	Windrow improved performance	220	MJ	United States (Massachusetts)	N.A.	Morelli 2019
CED	Compost	ASP improved performance	390	MJ	United States (Massachusetts)	N.A.	Morelli 2019

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Compost	Windrow base performance	0.937	kg Neq	United States (Massachusetts)	N.A.	Morelli 2019
Eutrophication	Compost	Windrow improved performance	0.661	kg Neq	United States (Massachusetts)	N.A.	Morelli 2019
GWP	Compost	Windrow base performance	100	kg CO_2eq	United States (Massachusetts)	TRUE	Morelli 2019
GWP	Compost	ASP base performance	70	kg CO_2eq	United States (Massachusetts)	TRUE	Morelli 2019
GWP	Compost	Windrow improved performance	-10	kg CO_2eq	United States (Massachusetts)	TRUE	Morelli 2019
Acidification	Landfill	Baseline	0.14	kg SO_2eq	United States (Massachusetts)	N.A.	Morelli 2019
CED	Landfill	Baseline	-200	MJ	United States (Massachusetts)	N.A.	Morelli 2019
Eutrophication	Landfill	Baseline	0.00848	kg Neq	United States (Massachusetts)	N.A.	Morelli 2019
GWP	Landfill	Baseline	320	kg CO_2eq	United States (Massachusetts)	FALSE	Morelli 2019
GWP	AD	Baseline	-170	kg CO_2eq	United States	TRUE	Morris 2017
GWP	Compost	Baseline	-50	kg CO_2eq	United States	TRUE	Morris 2017
GWP	Landfill	Baseline	30	kg CO_2eq	United States	TRUE	Morris 2017
GWP	WWTP	Baseline	100	kg CO_2eq	United States	TRUE	Morris 2017
Acidification	AD	AD (plus ~10% compost)	0	kg SO_2eq	Ireland	N.A.	Oldfield 2016

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	AD	AD (plus ~10% compost)	0	kg Neq	Ireland	N.A.	Oldfield 2016
GWP	AD	AD (plus ~10% compost)	-108	kg CO_2eq	Ireland	FALSE	Oldfield 2016
Acidification	Combust	Incineration	0.313	kg SO_2eq	Ireland	N.A.	Oldfield 2016
Eutrophication	Combust	Incineration	0.272	kg Neq	Ireland	N.A.	Oldfield 2016
GWP	Combust	Incineration	-18.7	kg CO_2eq	Ireland	N.A.	Oldfield 2016
Acidification	Compost	Composting	1.36	kg SO_2eq	Ireland	N.A.	Oldfield 2016
Eutrophication	Compost	Composting	0.884	kg Neq	Ireland	N.A.	Oldfield 2016
GWP	Compost	Composting	15	kg CO_2eq	Ireland	TRUE	Oldfield 2016
Acidification	Source Red.	Source reduction (plus compost, AD, or incineration)	-34.6	kg SO_2eq	Ireland	N.A.	Oldfield 2016
Eutrophication	Source Red.	Source reduction (plus compost, AD, or incineration)	-21.2	kg Neq	Ireland	N.A.	Oldfield 2016
GWP	Source Red.	Source reduction (plus compost, AD, or incineration)	-3550	kg CO_2eq	Ireland	N.A.	Oldfield 2016
Acidification	Donate	Average value of all scenarios	-57	kg SO_2eq	United States	N.A.	OR DEQ 2019
CED	Donate	Average value of all scenarios	-27300	MJ	United States	N.A.	OR DEQ 2019
Eutrophication	Donate	Average value of all scenarios	-36.9	kg Neq	United States	N.A.	OR DEQ 2019
GWP	Donate	Average value of all scenarios	-2760	kg CO_2eq	United States	N.A.	OR DEQ 2019

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Water Consumption	Donate	Average value of all scenarios	-398	m^3 water	United States	N.A.	OR DEQ 2019
GWP	AD	Energy and fertilizer displacement, CT = 200	26.4	kg CO_2eq	United States (Northern California)	FALSE	Pace 2018
GWP	AD	Energy and fertilizer displacement, CT = 350	18.9	kg CO_2eq	United States (Northern California)	FALSE	Pace 2018
GWP	AD	Energy and fertilizer displacement, CT = 500	15.3	kg CO_2eq	United States (Northern California)	FALSE	Pace 2018
GWP	AD	Energy and fertilizer displacement, CT = 650	11.7	kg CO_2eq	United States (Northern California)	FALSE	Pace 2018
GWP	AD	Energy and fertilizer displacement, CT = 800	8.1	kg CO_2eq	United States (Northern California)	FALSE	Pace 2018
GWP	AD	nonbiogenic only	-217	kg CO_2eq	United States	TRUE	Parry 2012
GWP	Compost	nonbiogenic only	83.1	kg CO_2eq	United States	TRUE	Parry 2012
GWP	Landfill	nonbiogenic only	508	kg CO_2eq	United States	TRUE	Parry 2012
GWP	WWTP	nonbiogenic only	279	kg CO_2eq	United States	TRUE	Parry 2012
Acidification	AD	Food residue	0.03	kg SO_2eq	Germany	N.A.	Poeschl 2012
Acidification	AD	Pomace	0.06	kg SO_2eq	Germany	N.A.	Poeschl 2012
Acidification	AD	Slaughterhouse waste	0.01	kg SO_2eq	Germany	N.A.	Poeschl 2012
Acidification	AD	Grease separator sludge	0.05	kg SO_2eq	Germany	N.A.	Poeschl 2012
Eutrophication	AD	Pomace	0	kg Neq	Germany	N.A.	Poeschl 2012

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	AD	Food residue	0.0888	kg Neq	Germany	N.A.	Poeschl 2012
Eutrophication	AD	Pomace	0.109	kg Neq	Germany	N.A.	Poeschl 2012
Eutrophication	AD	Slaughterhouse waste	0.0592	kg Neq	Germany	N.A.	Poeschl 2012
Eutrophication	AD	Grease separator sludge	0.0493	kg Neq	Germany	N.A.	Poeschl 2012
GWP	AD	Food residue	-51.7	kg CO_2eq	Germany	FALSE	Poeschl 2012
GWP	AD	Pomace	-85.5	kg CO_2eq	Germany	FALSE	Poeschl 2012
GWP	AD	Slaughterhouse waste	-50.6	kg CO_2eq	Germany	FALSE	Poeschl 2012
GWP	AD	Grease separator sludge	-26.4	kg CO_2eq	Germany	FALSE	Poeschl 2012
Land Occupation	AD	Pomace	0.66	m^2.yr	Germany	N.A.	Poeschl 2012
Land Occupation	AD	Food residue	3.8	m^2.yr	Germany	N.A.	Poeschl 2012
Land Occupation	AD	Pomace	3.58	m^2.yr	Germany	N.A.	Poeschl 2012
Land Occupation	AD	Slaughterhouse waste	2.12	m^2.yr	Germany	N.A.	Poeschl 2012
Land Occupation	AD	Slaughterhouse waste	0.42	m^2.yr	Germany	N.A.	Poeschl 2012
Land Occupation	AD	Grease separator sludge	2.05	m^2.yr	Germany	N.A.	Poeschl 2012

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Land Occupation	AD	Grease separator sludge	0.4	m^2.yr	Germany	N.A.	Poeschl 2012
Water Consumption	AD	Food residue	-0.73	m^3 water	Germany	N.A.	Poeschl 2012
Water Consumption	AD	Pomace	-0.89	m^3 water	Germany	N.A.	Poeschl 2012
Water Consumption	AD	Slaughterhouse waste	-0.48	m^3 water	Germany	N.A.	Poeschl 2012
Water Consumption	AD	Grease separator sludge	-0.31	m^3 water	Germany	N.A.	Poeschl 2012
GWP	AD	Farm	-76	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	AD	Foodservice	-243	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	AD	Manufacturing	-206	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	AD	Residential	-197	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	AD	Retail	-204	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	Animal Feed	Farm	-100	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Animal Feed	Foodservice	-222	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Animal Feed	Manufacturing	-176	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Animal Feed	Residential	-191	kg CO_2eq	Various	N.A.	ReFED 2023

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
GWP	Animal Feed	Retail	-213	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Combust	Farm	996	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Combust	Foodservice	642	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Combust	Manufacturing	717	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Combust	Residential	737	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Combust	Retail	725	kg CO_2eq	Various	N.A.	ReFED 2023
GWP	Compost	Farm	37	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Compost	Foodservice	58.1	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Compost	Manufacturing	53.3	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Compost	Residential	52.2	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Compost	Retail	53.1	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Land App.	Farm	12.7	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	Land App.	Foodservice	29.6	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	Land App.	Manufacturing	25.1	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	Land App.	Residential	22.5	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	Land App.	Retail	21.8	kg CO_2eq	Various	FALSE	ReFED 2023

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
GWP	Landfill	Farm	328	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Landfill	Foodservice	834	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Landfill	Manufacturing	722	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Landfill	Residential	693	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Landfill	Retail	715	kg CO_2eq	Various	TRUE	ReFED 2023
GWP	Unharvest	Farm	47.4	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	WWTP	Farm	215	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	WWTP	Foodservice	572	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	WWTP	Manufacturing	493	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	WWTP	Residential	473	kg CO_2eq	Various	FALSE	ReFED 2023
GWP	WWTP	Retail	488	kg CO_2eq	Various	FALSE	ReFED 2023
Acidification	Combust	Baseline	-0.64	kg SO_2eq	Taiwan	N.A.	Shih 2021
CED	Combust	Baseline	-2070	MJ	Taiwan	N.A.	Shih 2021
Eutrophication	Combust	Baseline	-0.284	kg Neq	Taiwan	N.A.	Shih 2021
GWP	Combust	Baseline	493	kg CO_2eq	Taiwan	N.A.	Shih 2021
Land Occupation	Combust	Baseline	-1.04	m^2.yr	Taiwan	N.A.	Shih 2021
Acidification	Compost	Baseline	0.47	kg SO_2eq	Taiwan	N.A.	Shih 2021
CED	Compost	Baseline	894	MJ	Taiwan	N.A.	Shih 2021

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Compost	Baseline	0.261	kg Neq	Taiwan	N.A.	Shih 2021
GWP	Compost	Baseline	63.2	kg CO_2eq	Taiwan	FALSE	Shih 2021
Land Occupation	Compost	Baseline	0.27	m^2.yr	Taiwan	N.A.	Shih 2021
Acidification	AD	average value (10th and 90th also provided)	7.63	kg SO_2eq	United Kingdom	N.A.	Slorach 2019a
CED	AD	average value (10th and 90th also provided)	-1930	MJ	United Kingdom	N.A.	Slorach 2019a
Eutrophication	AD	average value (10th and 90th also provided)	-0.0846	kg Neq	United Kingdom	N.A.	Slorach 2019a
Eutrophication	AD	average value (10th and 90th also provided)	0.71	kg Neq	United Kingdom	N.A.	Slorach 2019a
GWP	AD	average value (10th and 90th also provided)	-31.6	kg CO_2eq	United Kingdom	FALSE	Slorach 2019a
Land Occupation	AD	average value (10th and 90th also provided)	0.6	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Land Occupation	AD	average value (10th and 90th also provided)	-0.21	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Water Consumption	AD	average value (10th and 90th also provided)	-274	m^3 water	United Kingdom	N.A.	Slorach 2019a
Acidification	Combust	average value (10th and 90th also provided)	0.39	kg SO_2eq	United Kingdom	N.A.	Slorach 2019a
CED	Combust	average value (10th and 90th also provided)	-900	MJ	United Kingdom	N.A.	Slorach 2019a
Eutrophication	Combust	average value (10th and 90th also provided)	0.0348	kg Neq	United Kingdom	N.A.	Slorach 2019a
Eutrophication	Combust	average value (10th and 90th also provided)	0.118	kg Neq	United Kingdom	N.A.	Slorach 2019a

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
GWP	Combust	average value (10th and 90th also provided)	-4.97	kg CO_2eq	United Kingdom	N.A.	Slorach 2019a
Land Occupation	Combust	average value (10th and 90th also provided)	-0.37	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Land Occupation	Combust	average value (10th and 90th also provided)	0.01	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Water Consumption	Combust	average value (10th and 90th also provided)	-149	m^3 water	United Kingdom	N.A.	Slorach 2019a
Acidification	Compost	average value (10th and 90th also provided)	10.1	kg SO_2eq	United Kingdom	N.A.	Slorach 2019a
CED	Compost	average value (10th and 90th also provided)	1310	MJ	United Kingdom	N.A.	Slorach 2019a
Eutrophication	Compost	average value (10th and 90th also provided)	-0.00642	kg Neq	United Kingdom	N.A.	Slorach 2019a
Eutrophication	Compost	average value (10th and 90th also provided)	0.385	kg Neq	United Kingdom	N.A.	Slorach 2019a
GWP	Compost	average value (10th and 90th also provided)	77.5	kg CO_2eq	United Kingdom	FALSE	Slorach 2019a
Land Occupation	Compost	average value (10th and 90th also provided)	4.08	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Land Occupation	Compost	average value (10th and 90th also provided)	-0.67	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Water Consumption	Compost	average value (10th and 90th also provided)	97.3	m^3 water	United Kingdom	N.A.	Slorach 2019a
Acidification	Landfill	average value (10th and 90th also provided)	0.24	kg SO_2eq	United Kingdom	N.A.	Slorach 2019a
CED	Landfill	average value (10th and 90th also provided)	140	MJ	United Kingdom	N.A.	Slorach 2019a
Eutrophication	Landfill	average value (10th and 90th also provided)	0.0204	kg Neq	United Kingdom	N.A.	Slorach 2019a

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Landfill	average value (10th and 90th also provided)	7.32	kg Neq	United Kingdom	N.A.	Slorach 2019a
GWP	Landfill	average value (10th and 90th also provided)	195	kg CO_2eq	United Kingdom	TRUE	Slorach 2019a
Land Occupation	Landfill	average value (10th and 90th also provided)	0.79	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Land Occupation	Landfill	average value (10th and 90th also provided)	3.85	m^2.yr	United Kingdom	N.A.	Slorach 2019a
Water Consumption	Landfill	average value (10th and 90th also provided)	-39.4	m^3 water	United Kingdom	N.A.	Slorach 2019a
Acidification	AD	Baseline	7.6	kg SO_2eq	United Kingdom	N.A.	Slorach 2019b
CED	AD	Baseline	-1990	MJ	United Kingdom	N.A.	Slorach 2019b
Eutrophication	AD	Baseline	-0.101	kg Neq	United Kingdom	N.A.	Slorach 2019b
Eutrophication	AD	Baseline	0.69	kg Neq	United Kingdom	N.A.	Slorach 2019b
GWP	AD	Baseline	-39	kg CO_2eq	United Kingdom	FALSE	Slorach 2019b
Land Occupation	AD	Baseline	0.6	m^2.yr	United Kingdom	N.A.	Slorach 2019b
Land Occupation	AD	Baseline	-0.23	m^2.yr	United Kingdom	N.A.	Slorach 2019b
Water Consumption	AD	Baseline	-249	m^3 water	United Kingdom	N.A.	Slorach 2019b
Acidification	Combust	Baseline	0.4	kg SO_2eq	United Kingdom	N.A.	Slorach 2019b
CED	Combust	Baseline	-940	MJ	United Kingdom	N.A.	Slorach 2019b

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Combust	Baseline	0.0241	kg Neq	United Kingdom	N.A.	Slorach 2019b
Eutrophication	Combust	Baseline	0.0986	kg Neq	United Kingdom	N.A.	Slorach 2019b
GWP	Combust	Baseline	-10	kg CO_2eq	United Kingdom	N.A.	Slorach 2019b
Land Occupation	Combust	Baseline	-0.04	m^2.yr	United Kingdom	N.A.	Slorach 2019b
Land Occupation	Combust	Baseline	-0.005	m^2.yr	United Kingdom	N.A.	Slorach 2019b
Water Consumption	Combust	Baseline	-133	m^3 water	United Kingdom	N.A.	Slorach 2019b
Acidification	Landfill	Baseline	0.2	kg SO_2eq	United Kingdom	N.A.	Slorach 2019b
CED	Landfill	Baseline	120	MJ	United Kingdom	N.A.	Slorach 2019b
Eutrophication	Landfill	Baseline	0.0168	kg Neq	United Kingdom	N.A.	Slorach 2019b
Eutrophication	Landfill	Baseline	7.3	kg Neq	United Kingdom	N.A.	Slorach 2019b
GWP	Landfill	Baseline	193	kg CO_2eq	United Kingdom	TRUE	Slorach 2019b
Land Occupation	Landfill	Baseline	0.1	m^2.yr	United Kingdom	N.A.	Slorach 2019b
Land Occupation	Landfill	Baseline	3.84	m^2.yr	United Kingdom	N.A.	Slorach 2019b
Water Consumption	Landfill	Baseline	-33	m^3 water	United Kingdom	N.A.	Slorach 2019b

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	Donate	80% donation with avoided emissions and 20% landfilling with energy recovery	-0.892	kg Neq	Brazil	N.A.	Sulis 2021
GWP	Donate	80% donation with avoided emissions and 20% landfilling with energy recovery	-325	kg CO_2eq	Brazil	N.A.	Sulis 2021
Water Consumption	Donate	80% donation with avoided emissions and 20% landfilling with energy recovery	-69	m^3 water	Brazil	N.A.	Sulis 2021
Acidification	Landfill	With energy recovery	1.2	kg SO_2eq	Brazil	N.A.	Sulis 2021
Eutrophication	Landfill	With energy recovery	0.0219	kg Neq	Brazil	N.A.	Sulis 2021
GWP	Landfill	With energy recovery	175	kg CO_2eq	Brazil	FALSE	Sulis 2021
Water Consumption	Landfill	With energy recovery	-3.5	m^3 water	Brazil	N.A.	Sulis 2021
GWP	Donate	base	-400	kg CO_2eq	Sweden	N.A.	Sundin 2022
Acidification	AD	Decentralized AD, biogas to electricity	0.275	kg SO_2eq	Singapore	N.A.	Tian 2021
Acidification	AD	Decentralized AD, biogas to cook fuel	0.119	kg SO_2eq	Singapore	N.A.	Tian 2021
Acidification	AD	Centralized AD, biogas to electricity	0.309	kg SO_2eq	Singapore	N.A.	Tian 2021
Acidification	AD	Centralized AD, biogas to transport fuel	-0.0989	kg SO_2eq	Singapore	N.A.	Tian 2021
Eutrophication	AD	Decentralized AD, biogas to electricity	0.0698	kg Neq	Singapore	N.A.	Tian 2021
Eutrophication	AD	Decentralized AD, biogas to cook fuel	0.0625	kg Neq	Singapore	N.A.	Tian 2021
Eutrophication	AD	Centralized AD, biogas to electricity	0.0955	kg Neq	Singapore	N.A.	Tian 2021

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Eutrophication	AD	Centralized AD, biogas to transport fuel	0.0853	kg Neq	Singapore	N.A.	Tian 2021
Eutrophication	AD	Decentralized AD, biogas to electricity	0.953	kg Neq	Singapore	N.A.	Tian 2021
GWP	AD	Decentralized AD, biogas to electricity	-72.8	kg CO_2eq	Singapore	FALSE	Tian 2021
GWP	AD	Decentralized AD, biogas to cook fuel	-238	kg CO_2eq	Singapore	FALSE	Tian 2021
GWP	AD	Centralized AD, biogas to electricity	-81.4	kg CO_2eq	Singapore	FALSE	Tian 2021
GWP	AD	Centralized AD, biogas to transport fuel	-137	kg CO_2eq	Singapore	FALSE	Tian 2021
Water Consumption	AD	Decentralized AD, biogas to electricity	0.0508	m^3 water	Singapore	N.A.	Tian 2021
Water Consumption	AD	Decentralized AD, biogas to cook fuel	0.311	m^3 water	Singapore	N.A.	Tian 2021
Water Consumption	AD	Centralized AD, biogas to electricity	0.0662	m^3 water	Singapore	N.A.	Tian 2021
Water Consumption	AD	Centralized AD, biogas to transport fuel	0.282	m^3 water	Singapore	N.A.	Tian 2021
Acidification	Combust	Base	0.0873	kg SO_2eq	Singapore	N.A.	Tian 2021
Eutrophication	Combust	Base	0.0153	kg Neq	Singapore	N.A.	Tian 2021
Eutrophication	Combust	Base	0.00155	kg Neq	Singapore	N.A.	Tian 2021
GWP	Combust	Base	-29.2	kg CO_2eq	Singapore	N.A.	Tian 2021
Water Consumption	Combust	Base	0.0213	m^3 water	Singapore	N.A.	Tian 2021

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
Acidification	AD	Baseline	-0.169	kg SO_2eq	Singapore	N.A.	Tong 2018
Acidification	AD	Baseline	-0.0901	kg SO_2eq	Singapore	N.A.	Tong 2018
Eutrophication	AD	Baseline	0.0948	kg Neq	Singapore	N.A.	Tong 2018
Eutrophication	AD	Baseline	0.163	kg Neq	Singapore	N.A.	Tong 2018
GWP	AD	Baseline	94.1	kg CO_2eq	Singapore	TRUE	Tong 2018
GWP	AD	Baseline	38.5	kg CO_2eq	Singapore	TRUE	Tong 2018
Acidification	Combust	Baseline	-0.0864	kg SO_2eq	Singapore	N.A.	Tong 2018
Eutrophication	Combust	Baseline	0.0837	kg Neq	Singapore	N.A.	Tong 2018
GWP	Combust	Baseline	107	kg CO_2eq	Singapore	N.A.	Tong 2018
GWP	AD	Net emissions; with curing	-66.1	kg CO_2eq	Various	TRUE	U.S. EPA 2020b
GWP	AD	Net emissions; with direct application	-154	kg CO_2eq	Various	TRUE	U.S. EPA 2020b
GWP	AD	Net emissions; with curing	-44.1	kg CO_2eq	Various	TRUE	U.S. EPA 2020b
GWP	AD	Net emissions; with direct application	-110	kg CO_2eq	Various	TRUE	U.S. EPA 2020b
GWP	Combust	Net emissions	-143	kg CO_2eq	Various	N.A.	U.S. EPA 2020b
GWP	Compost	Net emissions	-132	kg CO_2eq	Various	TRUE	U.S. EPA 2020b
GWP	Landfill	Net emissions	551	kg CO_2eq	Various	TRUE	U.S. EPA 2020b
GWP	Source Red.	Net emissions	-4030	kg CO_2eq	Various	N.A.	U.S. EPA 2020c

Impact	Pathway	Scenario	Result	Unit (per metric ton wasted food)	Geography	CO_2 Sequestration	Citation
CED	Source Red.	Baseline	-14700	MJ	United States	N.A.	U.S. EPA 2021c
CED	Source Red.	Baseline	-33100	MJ	United States	N.A.	U.S. EPA 2021c
GWP	Source Red.	Baseline	-1250	kg CO_2eq	United States	N.A.	U.S. EPA 2021c
GWP	Source Red.	Baseline	-3040	kg CO_2eq	United States	N.A.	U.S. EPA 2021c
Land Occupation	Source Red.	Baseline	-1560	m^2.yr	United States	N.A.	U.S. EPA 2021c
Land Occupation	Source Red.	Baseline	-7310	m^2.yr	United States	N.A.	U.S. EPA 2021c
Water Consumption	Source Red.	Baseline	-113	m^3 water	United States	N.A.	U.S. EPA 2021c
Water Consumption	Source Red.	Baseline	-298	m^3 water	United States	N.A.	U.S. EPA 2021c

TABLE D-2. EXTRACTED DATA VALUES USED FOR INTRA-STUDY RANKINGS

Non-standardized impact results are presented per the listed functional unit and units. In cells with multiple values listed, multiple pathway scenario impact results are averaged to establish the pathway ranking. Rank 1 = Best performance. Higher numbers are associated with higher impact. Numbers do not always start at 1 as additional pathways (not included in the report) are sometimes ranked as well. The first set of pathway columns are the data used to establish rankings; the second set are the rankings. WF = wasted food.

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Eutrophication	0.02				0.08		Ahamed 2016	1 tonne WF	kg PO$_4$eq	Singapore		1				2		Eutrophication Potential
Acidification	0.04				0.50		Ahamed 2016	1 tonne WF	kg SO$_2$eq	Singapore		1				2		Acidification
GWP	-1.5				2.4E+2		Ahamed 2016	1 tonne WF	kg CO$_2$eq	Singapore		1				2		Global Warming Potential
GWP		-3.3E+2				2.4E+3	Albizzati 2021b	1 metric ton of WF processed	kg CO$_2$eq	Europe	Wet Animal Feed		1				2	Global Warming Potential
GWP		-3.3E+2			42		Albizzati 2021b	1 metric ton of WF processed	kg CO$_2$eq	Europe	Wet Animal Feed		1			2		Global Warming Potential
GWP		-3.3E+2		1.5E+2			Albizzati 2021b	1 metric ton of WF processed	kg CO$_2$eq	Europe	Wet Animal Feed		1		2			Global Warming Potential
GWP	1.2E+2	-3.3E+2					Albizzati 2021b	1 metric ton of WF processed	kg CO$_2$eq	Europe	Wet Animal Feed	2	1					Global Warming Potential
GWP			1			2	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1			2	Global Warming Potential
GWP			1		2		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1		2		Global Warming Potential
GWP			1	2			Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1	2			Global Warming Potential
GWP	2		1				Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed	2		1				Global Warming Potential
GWP	1.2E+2			1.5E+2	42	2.4E+3	Albizzati 2021b	WF processing	kg CO$_2$eq	Europe	Traditional Pathways	1			1	1	2	Global Warming Potential
Human Toxicity		1				2	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1				2	Human toxicity, cancer
Human Toxicity		1			2		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1			2		Human toxicity, cancer
Human Toxicity		1		1			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		1			Human toxicity, cancer
Human Toxicity	1	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	1	1					Human toxicity, cancer
Human Toxicity			1			2	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1			2	Human toxicity, cancer

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Human Toxicity			1		2		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1		2		Human toxicity, cancer
Human Toxicity	1			1	2	2	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	1			1	2	2	Human toxicity, cancer
Human Toxicity		2				1	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2				1	Human Toxicity, non-cancer
Human Toxicity		2			1		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2			1		Human Toxicity, non-cancer
Human Toxicity		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Human Toxicity, non-cancer
Human Toxicity	1	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	1	1					Human Toxicity, non-cancer
Human Toxicity			2			1	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			2			1	Human Toxicity, non-cancer
Human Toxicity			2		1		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			2		1		Human Toxicity, non-cancer
Human Toxicity	3			4	1	2	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	3			4	1	2	Human Toxicity, non-cancer
Particulate matter formation		1				2	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1				2	Particulate matter formation
Particulate matter formation		1			2		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1			2		Particulate matter formation
Particulate matter formation		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Particulate matter formation
Particulate matter formation	2	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	2	1					Particulate matter formation
Particulate matter formation			1			2	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1			2	Particulate matter formation
Particulate matter formation			1		2		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1		2		Particulate matter formation
Particulate matter formation	2		1				Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed	2		1				Particulate matter formation

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Particulate matter formation	1			2	1	1	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	1			2	1	1	Particulate matter formation
Acidification		2				1	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2				1	Acidification, terrestrial
Acidification		2			1		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2			1		Acidification, terrestrial
Acidification		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Acidification, terrestrial
Acidification	2	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	2	1					Acidification, terrestrial
Acidification			2			1	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			2			1	Acidification, terrestrial
Acidification			2		1		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			2		1		Acidification, terrestrial
Acidification			1	2			Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1	2			Acidification, terrestrial
Acidification	2		1				Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed	2		1				Acidification, terrestrial
Acidification	3			4	1	2	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	3			4	1	2	Acidification, terrestrial
Eutrophication		2				1	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2				1	Eutrophication, terrestrial
Eutrophication		2			1		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2			1		Eutrophication, terrestrial
Eutrophication		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Eutrophication, terrestrial
Eutrophication	2	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	2	1					Eutrophication, terrestrial
Eutrophication			1	2			Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1	2			Eutrophication, terrestrial
Eutrophication	2		1				Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed	2		1				Eutrophication, terrestrial
Eutrophication	2			3	1	1	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	2			3	1	1	Eutrophication, terrestrial
Eutrophication		2				1	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2				1	Eutrophication, marine
Eutrophication		2			1		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		2			1		Eutrophication, marine
Eutrophication		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Eutrophication, marine
Eutrophication	2	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	2	1					Eutrophication, marine

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Eutrophication			1			2	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1			2	Eutrophication, marine
Eutrophication			1		2		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1		2		Eutrophication, marine
Eutrophication			1	2			Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1	2			Eutrophication, marine
Eutrophication	2		1				Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed	2		1				Eutrophication, marine
Eutrophication	3			2	1	1	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	3			2	1	1	Eutrophication, marine
Eutrophication		1				2	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1				2	Eutrophication, freshwater
Eutrophication		1			2		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1			2		Eutrophication, freshwater
Eutrophication		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Eutrophication, freshwater
Eutrophication	2	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	2	1					Eutrophication, freshwater
Eutrophication			1			2	Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1			2	Eutrophication, freshwater
Eutrophication			1		2		Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1		2		Eutrophication, freshwater
Eutrophication			1	2			Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1	2			Eutrophication, freshwater
Eutrophication	2		1				Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed	2		1				Eutrophication, freshwater
Eutrophication	1			2	1	1	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	1			2	1	1	Eutrophication, freshwater
Ecotoxicity		1				2	Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1				2	Ecotoxicity, freshwater
Ecotoxicity		1			2		Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1			2		Ecotoxicity, freshwater
Ecotoxicity		1		2			Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed		1		2			Ecotoxicity, freshwater
Ecotoxicity	2	1					Albizzati 2021b	7.9 kg WF	relative ranking	Europe	Wet Animal Feed	2	1					Ecotoxicity, freshwater
Ecotoxicity			1	2			Albizzati 2021b	10.4 kg WF	relative ranking	Europe	Dry Animal Feed			1	2			Ecotoxicity, freshwater

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Ecotoxicity	1			2	1	1	Albizzati 2021b	WF processing	relative ranking	Europe	Traditional Pathways	1			2	1	1	Ecotoxicity, freshwater
GWP	81, 22	-76	-210, 17	51, 270			Albizzati 2021a	1 ton post-process WF	kg CO_2eq	Europe		3	2	1	4			GWP
Eutrophication	1, 1	0.68	-0.04, 0.15	0.16, 1.1			Albizzati 2021a	1 ton post-process WF	kg Neq	Europe		4	3	1	2			Marine Eutrophication
Eutrophication	0.7, 0.71	0.47	0.01, 0.3	0.67, 1			Albizzati 2021a	1 ton post-process WF	kg Peq	Europe		3	2	1	4			Freshwater eutrophication
GWP	27			1.3E+2			Al-Rumaihi 2020	metric ton WF	kg CO_2eq	Qatar		1			2			Global Warming Potential
Human Toxicity	2			1			Al-Rumaihi 2020	metric ton WF	relative ranking	Qatar		2			1			Human Toxicity
Eutrophication	2			1			Al-Rumaihi 2020	metric ton WF	relative ranking	Qatar	Moderate difference	2			1			Eutrophication
Acidification	2			1			Al-Rumaihi 2020	metric ton WF	relative ranking	Qatar	Moderate difference	2			1			Acidification
GWP	0.36, 0.28			0.40	-0.15, -0.2		Benavente 2017	kg two-phase olive mill waste (TPOMW)	kg CO_2eq	Spain	B1 = composting B2 = Anaerobic digestion B3 = Anaerobic digestion T1 = combustion T2 = combustion	2			3	1		Global Warming Potential
Acidification	4.2E-3, 1.8E-03			4.2E-3	-3.0E-03, -2.2E-03		Benavente 2017	kg two-phase olive mill waste (TPOMW)	Accumulated Exceedance	Spain		2			3	1		Acidification
Eutrophication	6.6E-03, 3.0E-03			7.4E-3	-3.7E-03, -3.0E-03, -2.2E-03		Benavente 2017	kg two-phase olive mill waste (TPOMW)	Accumulated Exceedance	Spain		2			3	1		Eutrophication, terrestrial
Eutrophication	-0.4E-04, -0.4E-04			-3.0E-4	0, 0		Benavente 2017	kg two-phase olive mill waste (TPOMW)	kg Peq	Spain		2			1	3		Freshwater Eutrophication
Eutrophication	1.5E-03, 1.2E-03			3.5E-3	-0.3E-03, -0.2E-03		Benavente 2017	kg two-phase olive mill waste (TPOMW)	kg Neq	Spain		2			3	1		Eutrophication, marine

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Ecotoxicity	4.2E-01, 4.2E-01			4.0	0, 0		Benavente 2017	kg two-phase olive mill waste (TPOMW)	CTUe	Spain		2			3	1		Ecotoxicity
Human Toxicity	3.2E-10, 3E-10			5.5E-9	-1E-10, -0.8E-10		Benavente 2017	kg two-phase olive mill waste (TPOMW)	CTUh	Spain		2			3	1		Human toxicity, cancer
Human Toxicity	5E-7, 5E-7			7.6E-6	0, 0		Benavente 2017	kg two-phase olive mill waste (TPOMW)	CTUh	Spain		2			3	1		Human Toxicity, non-cancer
GWP	-3.0E+2				-3.6E+2		Clavreul 2012	1 tonne of organic kitchen waste	kg CO_2eq	Denmark		2				1		Global Warming Potential
GWP		61	2.0E+2	1.2E+2		1.0E+3	Dou 2018	1 tonne food waste	kg CO_2eq	South Korea	From Kim and Kim 2010		1	3	2		4	Global Warming Potential
GWP	-1.8E+2			-78	-1.1E+2	-25	Hodge 2016	1000 kg mixed waste (58% food waste, 42% non-food waste)	kg CO_2eq	United States		1			3	2	4	Global Warming Potential
Eutrophication	2.0E-4			4.8E-5	6.3E-6	3.0E-3	Hoehn 2021	1 metric ton of WF treated	kg Peq	Spain		3			2	1	4	Freshwater eutrophication
Eutrophication	1.8E-5			2.0E-4	1.0E-3	7.7E-3	Hoehn 2021	1 metric ton of WF treated	kg Neq	Spain		1			2	3	4	Marine eutrophication
GWP	-10, 120				30	5.9E+2	Huang 2022	1 metric ton (wet basis) of collected and treated food waste	kg CO_2eq	China		2				1	3	Climate change
Acidification	0.5, -0.5				-1.0	12	Huang 2022	1 metric ton (wet basis) of collected and treated food waste	kg SO_2eq	China		2				1	3	Terrestrial acidification potential

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Eutrophication	0, 0.01				0.05	0.03	Huang 2022	1 metric ton (wet basis) of collected and treated food waste	kg Peq	China		1				3	2	Freshwater eutrophication potential
Particulate matter formation	0, 0.05				-0.50	0.05	Huang 2022	1 metric ton (wet basis) of collected and treated food waste	kg PM$_{2.5}$eq	China		2				1	3	Particulate matter formation potential
GWP				88		4.9E+2	Keng 2020	1 metric ton organic waste (food + landscape)	kg CO$_2$eq	Malaysia	minor difference				1		2	Global Warming Potential
Acidification				0.75		0.07	Keng 2020	1 metric ton organic waste (food + landscape)	kg SO$_2$eq	Malaysia	moderate difference				2		1	Acidification
Eutrophication				0.05		6.7	Keng 2020	1 metric ton organic waste (food + landscape)	kg Neq	Malaysia	moderate difference				1		2	Eutrophication
Human Toxicity				8.0E-10		2.2E-5	Keng 2020	1 metric ton organic waste (food + landscape)	CTUh	Malaysia	moderate difference				1		2	Human Toxicity, cancer
Human Toxicity				1.5E-4		1.5E-3	Keng 2020	1 metric ton organic waste (food + landscape)	CTUh	Malaysia	moderate difference				1		2	Human Toxicity, non-cancer
Particulate matter formation				0.05		5.1E-3	Keng 2020	1 metric ton organic waste (food + landscape)	kg PM$_{2.5}$eq	Malaysia	moderate difference				2		1	Particulate Matter Formation Potential

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Ecotoxicity				1.5E+2		1.1E+5	Keng 2020	1 metric ton organic waste (food + landscape)	CTUe	Malaysia	major difference				1		2	Ecotoxicity
GWP	-4.0E+2			-148, -73, -102, -64		1140, -25, -235, -5	Levis 2011	1000 kg of food waste plus 550 kg of branches	kg CO_2eq			1			3,4,5,6		2,7,8,9	Global Warming Potential
GWP	-2.9E-3, -1.2E-4, -6.5E-6		-3.3E-3	4.3E-4		1.1E-3, -6.7E-4	Lin 2022	1 tonne of WF (wet basis)	DALY	Malaysia		2,4,5		1	6		3,7	Global Warming Potential
Particulate matter formation	-4.3E-4, 8.5E-7, -1E-5		-2.3E-4	7.0E-5		5.4E-5, -9.8E-5	Lin 2022	1 tonne of WF (wet basis)	DALY	Malaysia		1,4,5		2	7		3,6	Fine particulate matter formation
Human Toxicity	-2.2E-3, 1.4E-5, -4E-5		-1.3E-4	-2.5E-4		1.9E-6, -6.8E-4	Lin 2022	1 tonne of WF (wet basis)	DALY	Malaysia		1,5,7		4	3		2,6	Human carcinogenic toxicity
Human Toxicity	-7.3E-3, 1.4E-5, -2.2E-4		-1.2E-3	-3.7E-3		2.7E2, -2.1E-3	Lin 2022	1 tonne of WF (wet basis)	DALY	Malaysia		1,5,6		4	2		3,7	Human non-carcinogenic toxicity
Acidification	-1.9E-7, -1.6E-8, -2.1E-8		-7.0E-8	2.2E-7		1.5E-7, 4.5E-8	Lin 2022	1 tonne of WF (wet basis)	species.yr	Malaysia		1,3,4		2	7		5,6	Terrestrial acidification
Eutrophication	-7.7E-8, 4.0E-9, 9.6E-10		-1.7E-8	-7.6E-9		3.1E-9, -2.5E-8	Lin 2022	1 tonne of WF (wet basis)	species.yr	Malaysia		1,5,7		3	4		2,6	Freshwater eutrophication
Eutrophication	-1.3E-11, 4.9E-14, -1.5E-13		-4.1E-10	-9.3E-12		0, -4.1E-12	Lin 2022	1 tonne of WF (wet basis)	species.yr	Malaysia		2,5,7		1	3		4,6	Marine eutrophication
Ecotoxicity	-1.3E-9, -7E-12, -8.4E-11		-2.9E-9	-2.1E-9		1.2E-24, -4.2E-10	Lin 2022	1 tonne of WF (wet basis)	species.yr	Malaysia		3,5,6		1	2		4,6	Terrestrial ecotoxicity
Ecotoxicity	-2.6E-9, -8.8E-11, -1.0E-10		-2.5E-9	-1.4E-9		6.6E-9, -7.7E-10	Lin 2022	1 tonne of WF (wet basis)	species.yr	Malaysia		1,5,6		2	3		4,7	Freshwater ecotoxicity
Ecotoxicity	-4.2E-6, 3.84E-8, -1.1E-7		-7.2E-7	-2.0E-6		1.5E-5, -1.2E-6	Lin 2022	1 tonne of WF (wet basis)	species.yr	Malaysia		1,5,6		4	2		3,7	Marine ecotoxicity
GWP	-.045, -2.9E-5				-.055, -3E-3		Mayer 2020	kg OF-MSW	kg CO_2eq	Germany		3				2		Global Warming Potential

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Ecotoxicity	-0.02					-	Opatokun 2017	1 kg food waste	g 1,4 DB eq	Australia		1					2	Terrestrial ecotoxicity
Eutrophication	-1.14, -0.71				-0.55, -0.06		Mayer 2020	kg OF-MSW	kg Peq	Germany		1,2				3,4		Freshwater eutrophication
Human Toxicity	-0.034, -0.039				-0.01, -0.016		Mayer 2020	kg OF-MSW	kg 1,4 DCBeq	Germany		1,2				3,4		Human toxicity
Ecotoxicity	-0.17					0.12	Opatokun 2017	1 kg food waste	g 1,4 DB eq	Australia		1					2	Freshwater ecotoxicity
Eutrophication	3.1E-4 1.1E-4				1.6E-4 1.7E-4		Mayer 2020	kg OF-MSW	kg Neq	Germany		1,4				2,3		Marine eutrophication
Particulate matter formation	4.8E-5 5.8E-5				5.5E-5 7.6E-5		Mayer 2020	kg OF-MSW	kg PM_{10}eq	Germany		1,3				2,4		Particulate Matter Formation Potential
Acidification	2.0E-4 8.4E-5				4.3E-5 8.9E-5		Mayer 2020	kg OF-MSW	kg SO_2eq	Germany		2,4				1,3		Terrestrial acidification
Ecotoxicity	-0.20					0.07	Opatokun 2017	1 kg food waste	g 1,4 DB eq	Australia		1					2	Marine ecotoxicity
Acidification	-0.23		-1.3	0.38	-0.74	1.5	Mondello 2017	1 tonne of food waste	kg SO_2eq	Italy	With avoided products	3		1	4	2	5	Acidification
Eutrophication	-0.04		-0.19	0.07	-0.14	0.75	Mondello 2017	1 tonne of food waste	kg PO_4eq	Italy	With avoided products	3		1	4	2	5	Eutrophication
GWP	-3.0E+2		-4.2E+2	59	4.9E+2	1.1E+3	Mondello 2017	1 tonne of food waste	kg CO_2eq	Italy	With avoided products	2		1	3	4	5	Global Warming Potential
Ecotoxicity	-4.8				1.4	3.0	Slorach 2019b	1 tonne WF	g 1,4 DB eq	United Kingdom		1				2	3	Terrestrial ecotoxicity
Ecotoxicity	-5.2			3.8	1.2	2.9	Slorach 2019a	1 metric ton household food waste	g 1,4 DB eq	United Kingdom		1			4	2	3	Terrestrial ecotoxicity
Ecotoxicity	-4.2			-0.27	-0.34		Slorach 2020	1 tonne of household food waste	g 1,4 DB eq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	1			3	2		Terrestrial ecotoxicity
Human Toxicity	-11					3.4	Opatokun 2017	1 kg food waste	g 1,4 DBeq	Australia		1					2	Human toxicity
Eutrophication	0.002, 0.003			0.001, 0.001	6.2E-6	8.6E-6	Morelli 2019	1 kg food waste	kg Neq	United States		4			3	1	2	Eutrophication

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
GWP	-0.14, -0.03			0.10, -0.01, 0.07	-0.02	0.32	Morelli 2019	1 kg food waste	kg CO_2eq	United States		1			3	2	4	Global Warming Potential
Acidification	-1.1E-4, 2.1E-4			1.2E-3, 5E-4, 4.9E-4	8.1E-5	1.4E-4	Morelli 2019	1 kg food waste	kg SO_2eq	United States		1			4	2	3	Acidification Potential
Particulate matter formation	2.5E-5, 4.0E-7			2.8E-5, 2.8E-5, 7.4E-6, 7.4E-6	2.9E-6	7.5E-6	Morelli 2019	1 kg food waste	kg $PM_{2.5}$eq	United States		1			4	2	3	Particulate Matter Formation
GWP	-0.17			-0.05		0.52	Morris 2014	1 kg food waste	kg CO_2eq	United States		1			2		3	Global Warming Potential
GWP	-0.17			-0.05		0.03	Morris 2017	1 kg food waste	kg CO_2eq	United States		1			2		3	Global Warming Potential
GWP				4.5E+2		6.5E+2	Mu 2017	1 tonne fresh matter in food waste	kg CO_2eq	United States					1		2	Global Warming Potential
Acidification				2.4		0.47	Mu 2017	1 tonne fresh matter in food waste	kg SO_2eq	United States					2		1	Acidification
Eutrophication				-4.4		1.3	Mu 2017	1 tonne fresh matter in food waste	kg Neq	United States					1		2	Eutrophication Potential
Human Toxicity				4.0E-4		1.2E-6	Mu 2017	1 tonne fresh matter in food waste	CTUh	United States					2		1	Human Toxicity, non-cancer
Human Toxicity				2.3E-5		1.6E-7	Mu 2017	1 tonne fresh matter in food waste	CTUh	United States					2		1	Human Toxicity, cancer
Particulate matter formation				0.02		0.12	Mu 2017	1 tonne fresh matter in food waste	kg $PM_{2.5}$eq	United States					1		2	Human Health (respiratory)
Ecotoxicity				2.5E+3		13	Mu 2017	1 tonne fresh matter in food waste	CTUe	United States					2		1	Ecotoxicity
GWP	-70, -215, -260			1.1E+2		3.5E+2	Murphy 2006	1 metric ton food scraps	kg CO_2eq	Ireland		1,2,3			4		5	Global Warming Potential
GWP	-1.4E+8			1.9E+7	-2.4E+7	5.7E+8	Oldfield 2016	1,267,749 tonnes WF	kg CO_2eq	Ireland		1			3	2	4	Global Warming Potential

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Acidification	0			1.7E+6	4.0E+5	5.3E+5	Oldfield 2016	1,267,749 tonnes WF	kg SO_2eq	Ireland		1			4	2	3	Acidification Potential
Eutrophication	0			4.7E+5	1.5E+5	1.5E+6	Oldfield 2016	1,267,749 tonnes WF	kg PO_4eq	Ireland		1			3	2	4	Eutrophication Potential
GWP				2	1		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Manfredi et al. 2011				2	1		Global Warming Potential
GWP					1	2	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Andersen et al 2012					1	2	Global Warming Potential
GWP				1		2	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Lundie et al.				1		2	Global Warming Potential
GWP	-7.6E+2					5.0E+2	Opatokun 2017	1 kg food waste	g CO_2eq	Australia		1					2	Global Warming Potential
Acidification	-1.3					0.08	Opatokun 2017	1 kg food waste	g SO_2eq	Australia		1					2	Terrestrial acidification
Eutrophication	-0.21					0.01	Opatokun 2017	1 kg food waste	g Peq	Australia		1					2	Freshwater eutrophication
Eutrophication	-2.9					2.8	Opatokun 2017	1 kg food waste	g Neq	Australia		1					2	Marine eutrophication
Human Toxicity	-33		5.3	2.1	-42	69	Mondello 2017	1 tonne of food waste	kg 1,4 DBeq	Italy	With avoided products	2		4	3	1	5	Human toxicity
Particulate matter formation	-0.39					0.03	Opatokun 2017	1 kg food waste	g PM_{10}eq	Australia		1					2	Particle matter formation
Ecotoxicity	0.68		3.8	7.4	-27	42	Mondello 2017	1 tonne of food waste	kg 1,4 DBeq	Italy	With avoided products	2		3	4	1	5	Freshwater ecotoxicity
Ecotoxicity	-1.7E+3		1.2E+4	1.6E+4	-6.6E+4	1.0E+5	Mondello 2017	1 tonne of food waste	kg 1,4 DBeq	Italy	With avoided products	2		3	4	1	5	Marine ecotoxicity
Ecotoxicity	-0.15		0.06	-	-0.98	0.52	Mondello 2017	1 tonne of food waste	kg 1,4 DBeq	Italy	With avoided products	2		4	3	1	5	Terrestrial ecotoxicity
GWP	-9.4E+2			3.6E+2		2.2E+3	Parry 2012	3930 tons food waste	short ton CO_2eq	United States	only non-biogenic	1			2		3	Global Warming Potential
GWP	38	2.1	40	2.8E+2			Salemdeeb 2017	1 metric ton municipal food waste	kg CO_2eq	United Kingdom		2	1	3	4			Global Warming Potential
Human Toxicity	1.2E-4	-1.0E-4	-9.4E-5	1.2E-4			Salemdeeb 2017	1 metric ton municipal food waste	CTU	United Kingdom		3	1	2	3			Human Toxicity, non-cancer
Eutrophication	1.9	-1.7	-1.4	1.9			Salemdeeb 2017	1 metric ton	kg Neq	United Kingdom		3	1	2	3			Eutrophication, marine

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
								municipal food waste										
Ecotoxicity	3.0E+2	-2.8E+2	-2.2E+2	3.0E+2			Salemdeeb 2017	1 metric ton municipal food waste	CTU	United Kingdom		4	1	2	3			Ecotoxicity
Acidification	2.1	-1.0	-0.65	1.6			Salemdeeb 2017	1 metric ton municipal food waste	Accumulated Exceedance	United Kingdom		4	1	2	3			Acidification
Human Toxicity	9.3E-7	-2.8E-7	-1.3E-7	1.1E-6			Salemdeeb 2017	1 metric ton municipal food waste	CTU	United Kingdom		3	1	2	4			Human Toxicity, cancer
Eutrophication	0.03	-0.03	-0.02	0.03			Salemdeeb 2017	1 metric ton municipal food waste	kg Peq	United Kingdom		3	1	2	4			Eutrophication, freshwater
Particulate matter formation	0.09	-0.05	-0.02	0.08			Salemdeeb 2017	1 metric ton municipal food waste	kg $PM_{2.5}$eq	United Kingdom		4	1	2	3			Particulate Matter Formation Potential
Eutrophication	9.5	-4.4	-3.3	7.0			Salemdeeb 2017	1 metric ton municipal food waste	Accumulated Exceedance	United Kingdom		4	1	2	3			Eutrophication, terrestrial
GWP	-1.9E+2				-83		Bernstad Saraiva Schott and Andersson 2015	metric ton currently generated food waste	kg CO_2eq	Sweden		1				2		Global Warming Potential
GWP	1					2	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Sanscartier et al. 2012	1					2	Global Warming Potential
GWP	1			2			Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Colon et al. 2012	1			2			Global Warming Potential
GWP					1	2	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Manfredi et al. 2011					1	2	Global Warming Potential
GWP				2	1		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Andersen et al 2012				2	1		Global Warming Potential
GWP	2			1			Bernstad Saraiva Schott 2016	Food waste	relative ranking	Various	Lundie et al.	2			1			Global Warming Potential

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
								management										
GWP	2				3		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Assefa et al	1				2		Global Warming Potential
GWP	1			2			Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Boldrin et al 2011	1			2			Global Warming Potential
GWP	2			3		1	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Kong et al. 2012	2			3		1	Global Warming Potential
GWP	2				1		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Kirkeby et al. 2006	2				1		Global Warming Potential
GWP				1		2	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Kim and Kim, 2010				1		2	Global Warming Potential
GWP	1			2			Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Bernstad and la Cour Jansen, 2001	1			2			Global Warming Potential
GWP	2				1		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Fruergaard and Astrup 2010	2				1		Global Warming Potential
GWP	1			2		3	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Aye and Widjaya, 2005	1			2		3	Global Warming Potential
GWP	2			1		3	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Blengini et al. 2008	2			1		3	Global Warming Potential
GWP	1			2	3		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Diggelman and Ham 2003	1			2	3		Global Warming Potential
GWP	1			2	3		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Khoo et al. 2010	1			2	3		Global Warming Potential
GWP				1	2		Bernstad Saraiva Schott 2016	Food waste	relative ranking	Various	Lee et al. 2007; if				1	2		Global Warming Potential

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
								management			biogenic CO$_2$ is included							
GWP				2	1		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Lee et al. 2007; if biogenic CO$_2$ is included				2	1		Global Warming Potential
GWP	1					2	Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Hamelin et al. 2013	1					2	Global Warming Potential
Acidification	-0.13			0.47	-0.64	1.5	Shih 2021	1 metric ton kitchen waste	kg SO$_2$eq	Taiwan		2			3	1	4	Acidification
Eutrophication	-0.03			0.11	-0.12	0.83	Shih 2021	1 metric ton kitchen waste	kg PO$_4$eq	Taiwan		2			3	1	4	Eutrophication
GWP	-2.9E+2			63	4.9E+2	1.2E+3	Shih 2021	1 metric ton kitchen waste	kg CO$_2$eq	Taiwan		1			2	3	4	Global Warming
Human Toxicity	-29			2.8	-41	71	Shih 2021	1 metric ton kitchen waste	kg 1,4 DBeq	Taiwan		2			3	1	4	Human Toxicity
Ecotoxicity	0.82			7.9	-27	43	Shih 2021	1 metric ton kitchen waste	kg 1,4 DBeq	Taiwan		2			3	1	4	Fresh Water Aquatic Ecotoxicity
Ecotoxicity	-1.7E+3			1.6E+4	-6.6E+4	1.0E+5	Shih 2021	1 metric ton kitchen waste	kg 1,4 DBeq	Taiwan		2			3	1	4	Marine Aquatic Ecotoxicity
Ecotoxicity	-0.08			0.07	-0.87	0.64	Shih 2021	1 metric ton kitchen waste	kg 1,4 DBeq	Taiwan		2			3	1	4	Terrestrial Ecotoxicity
GWP	-39				-10	1.9E+2	Slorach 2019b	1 tonne WF	kg CO$_2$eq	United Kingdom		1				2	3	Global Warming Potential
Human Toxicity	-22				-0.70	4.3	Slorach 2019b	1 tonne WF	kg 1,4 DBeq	United Kingdom		1				2	3	Human toxicity
Eutrophication	-14				2.3	3.3	Slorach 2019b	1 tonne WF	g Peq	United Kingdom		1				3	2	Freshwater eutrophication
Acidification	7.6				0.40	0.20	Slorach 2019b	1 tonne WF	kg SO$_2$eq	United Kingdom		3				2	1	Terrestrial acidification
Ecotoxicity	-3.3				-1.5	-0.04	Slorach 2019b	1 tonne WF	kg 1,4 DBeq	United Kingdom		1				2	3	Freshwater ecotoxicity
Ecotoxicity	-3.0				-1.4	-0.10	Slorach 2019b	1 tonne WF	kg 1,4 DBeq	United Kingdom		1				2	3	Marine ecotoxicity
Ecotoxicity	-3.9			1.4	-1.9	-0.18	Slorach 2019a	1 metric ton household food waste	kg 1,4 DBeq	United Kingdom		1			4	2	3	Freshwater ecotoxicity

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Eutrophication	0.70				0.10	7.4	Slorach 2019b	1 tonne WF	kg Neq	United Kingdom		2				1	3	Marine eutrophication
Particulate matter formation	0.99				0.17	0.10	Slorach 2019b	1 tonne WF	kg PM_{10}eq	United Kingdom		3				2	1	Particulate matter formation
GWP	-32			78	-5.0	2.0E+2	Slorach 2019a	1 metric ton household food waste	kg CO_2eq	United Kingdom		1			3	2	4	Global Warming Potential
Ecotoxicity	-3.5			1.3	-1.7	-0.23	Slorach 2019a	1 metric ton household food waste	kg 1,4 DBeq	United Kingdom		1			4	2	3	Marine ecotoxicity
Human Toxicity	-22			4.5	-0.19	4.5	Slorach 2019a	1 metric ton household food waste	kg 1,4 DBeq	United Kingdom		1			3	2	4	Human toxicity
Ecotoxicity	-0.58			-0.13	-0.25		Slorach 2020	1 tonne of household food waste	kg 1,4 DBeq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	1			3	2		Freshwater ecotoxicity
Ecotoxicity	-0.55			-0.12	-0.23		Slorach 2020	1 tonne of household food waste	kg 1,4 DBeq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	1			3	2		Marine ecotoxicity
Eutrophication	-12			-0.88	4.8	2.8	Slorach 2019a	1 metric ton household food waste	g Peq	United Kingdom		1			2	4	3	Freshwater Eutrophication
Eutrophication	0.72			0.39	0.12	7.4	Slorach 2019a	1 metric ton household food waste	kg Neq	United Kingdom		3			2	1	4	Marine Eutrophication

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Acidification	7.6			10	0.39	0.24	Slorach 2019a	1 metric ton household food waste	kg SO_2eq	United Kingdom		3			4	2	1	Terrestrial Acidification
Particulate matter formation	1.0			1.4	0.18	0.11	Slorach 2019a	1 metric ton household food waste	kg PM_{10}eq	United Kingdom		3			4	2	1	Particulate Matter Formation
GWP	9.6			44	42		Slorach 2020	1 tonne of household food waste	kg CO_2eq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	1			3	2		Global warming potential
Human Toxicity	-8.1			-0.09	0.33		Slorach 2020	1 tonne of household food waste	kg 1,4 DBeq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	1			2	2		Human toxicity
Human Toxicity	-21					-21	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg 1,4 DBeq	China		1					2	Human toxicity
Ecotoxicity	-0.42					-0.37	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg 1,4 DBeq	China		1					2	Freshwater ecotoxicity
Ecotoxicity	-0.43					-0.37	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg 1,4 DBeq	China		1					2	Marine ecotoxicity

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Eutrophication	-4.3			2.1	6.1		Slorach 2020	1 tonne of household food waste	g Peq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	1			2	3		Freshwater eutrophication
Eutrophication	0.73			0.64	0.92		Slorach 2020	1 tonne of household food waste	kg Neq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	2			1	3		Marine eutrophication
Acidification	7.5			5.1	1.9		Slorach 2020	1 tonne of household food waste	kg SO_2eq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	3			2	1		Terrestrial acidification
Particulate matter formation	0.99			0.51	0.36	1.0	Slorach 2020	1 tonne of household food waste	kg PM_{10}eq	United Kingdom	Scenarios include mix of management practices. AD = Scenario 4 (92%), Incineration = Scenario 1 (74%), Compost = scenario 3, Landfill = Current/BAU	3			2	1		Particulate matter formation

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
GWP	1				2		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Bernstad and la Cour Jansen, 2001	1				2		Global Warming Potential
GWP	1				2		Bernstad Saraiva Schott 2016	Food waste management	relative ranking	Various	Hamelin et al. 2013	1				2		Global Warming Potential
GWP	-72.8, -238, -81.4, -137				-29		Tian 2021	Disposal of 1-ton WF generated from local food centre	kg CO_2eq	Singapore		1				2		GWP
Eutrophication	0.01				2.0E-3		Tian 2021	Disposal of 1-ton WF generated from local food centre	kg Peq	Singapore		2				1		Freshwater eutrophication
Eutrophication	0.97				1.5E-3		Tian 2021	Disposal of 1-ton WF generated from local food centre	kg Neq	Singapore		2				1		Marine eutrophication
Acidification	0.28, 0.12, 0.31, -0.1				0.09		Tian 2021	Disposal of 1-ton WF generated from local food centre	kg SO_2eq	Singapore		2				1		Terrestrial acidification
Acidification	-169, -26				-86		Tong 2018	1000 tonnes food waste	kg SO_2eq	Singapore		1,3				2		Acidification
Eutrophication	40, 73				35		Tong 2018	1000 tonnes food waste	kg PO_4eq	Singapore		2,3				1		Eutrophication
Ecotoxicity	7.2E-3, 3.9E-3				1.0E-2, 9.7E-3		Mayer 2020	kg OF-MSW	kg 1,4 DCBeq	Germany		1,2				3,4		Freshwater ecotoxicity
GWP	94100, 92500				1.1E+5		Tong 2018	1000 tonnes food waste	kg CO_2eq	Singapore		1,2				2		Global Warming Potential
Ecotoxicity	0.007, 0.004				0.01, 0.009		Mayer 2020	kg OF-MSW	kg 1,4 DCBeq	Germany		1,2				3,4		Marine ecotoxicity
Ecotoxicity	6.7E-5 6.2E-6				6.4E-6 8.2E-6		Mayer 2020	kg OF-MSW	kg 1,4 DCBeq	Germany		1,4				2,3		Terrestrial ecotoxicity

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Ecotoxicity	-11300, -1960				-8.9E+2		Tong 2018	1000 tonnes food waste	kg DCBeq	Singapore		1,2				3		Freshwater ecotoxicity
GWP	-0.14			-0.12	-0.13	0.50	U.S. EPA 2020b	short ton of food waste	MT CO_2eq	United States	wet AD, direct application	1			3	2	4	Global Warming Potential
GWP	-0.06			-0.12	-0.13	0.50	U.S. EPA 2020b	short ton of food waste	MT CO_2eq	United States	alternate ranking. Wet AD with curing	3			2	1	4	Global Warming Potential
GWP	-0.10			-0.12	-0.13	0.50	U.S. EPA 2020b	short ton of food waste	MT CO_2eq	United States	Dry AD Direct application	3			2	1	4	Global Warming Potential
GWP	-0.04			-0.12	-0.13	0.50	U.S. EPA 2020b	short ton of food waste	MT CO_2eq	United States	Dry AD with Curing	3			2	1	4	Global Warming Potential
GWP	-3.7E+2					-3.3E+2	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg CO_2eq	China		1					2	Global Warming Potential
Human Toxicity	-25500, -4470				-1.3E+2		Tong 2018	1000 tonnes food waste	kg DCBeq	Singapore		1,2				3		Human toxicity
Particulate matter formation	-0.66					-0.48	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg PM_{10}eq	China		1					2	Particulate matter formation
Acidification	-1.8					-1.4	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg SO_2eq	China		1					2	Terrestrial acidification
Eutrophication	-0.01					-9.4E-3	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg Peq	China		1					2	Freshwater eutrophication
Eutrophication	-0.36					-0.19	Xu 2015	Management of 1 tonne of Food Waste Volatile Solids	kg Neq	China		1					2	Marine eutrophication

Standard Impact Category	Anaerobic Digestion	Wet Feed	Dry Feed	Compost	Controlled combustion	Landfill	Source Report	Functional Unit	Units	Geography	Note	Anaerobic Digestion, Rank	Wet Feed, Rank	Dry Feed, Rank	Compost, Rank	Controlled combustion, Rank	Landfill, Rank	Original impact category
Ecotoxicity	-4.1E7 -9.4E6				-4.0E+6		Tong 2018	1000 tonnes food waste	kg DCBeq	Singapore		1,2				3		Marine ecotoxicity
Ecotoxicity	-336, 44.8				65		Tong 2018	1000 tonnes food waste	kg DCBeq	Singapore		1,2				3		Terrestrial ecotoxicity
Acidification	0.20				0.50	0.34	Zhang 2019	1 metric ton of food waste	kg SO$_2$eq	China		1				3	2	Acidification
Eutrophication	0.11				0.10	0.30	Zhang 2019	1 metric ton of food waste	kg Peq	China		2				1	3	Eutrophication
Ecotoxicity	0.34				0.03	0.02	Zhang 2019	1 metric ton of food waste	kg DCBeq	China		3				2	1	Freshwater ecotoxicity
GWP	2.7E+2				7.6E+2	5.9E+2	Zhang 2019	1 metric ton of food waste	kg CO$_2$eq	China		1				3	2	Global Warming Potential
Human Toxicity	0.60				1.6	0.32	Zhang 2019	1 metric ton of food waste	kg DCBeq	China		2				3	1	Human toxicity
Ecotoxicity	53				67	4.9	Zhang 2019	1 metric ton of food waste	kg DCBeq	China		2				3	1	Marine ecotoxicity
Ecotoxicity	0.10				0.22	0.01	Zhang 2019	1 metric ton of food waste	kg DCBeq	China		2				3	1	Terrestrial ecotoxicity
GWP	-37			89			Zhou 2022	one ton of WF	kg CO$_2$eq	China		1			2			GWP
Acidification	0.10			0.61			Zhou 2022	one ton of WF	kg SO$_2$eq	China		1			2			Acidification
Eutrophication	0.24			1.6			Zhou 2022	one ton of WF	kg NO$_3$eq	China		1			2			Nutrient Enrichment
GWP	-0.18	-0.17		0.05	0.67	0.63	ReFED 2023	Ton of food waste	MT CO$_2$eq	Various		1	2		3	5	4	GWP
GWP	-0.07	-0.09		0.03	0.90	0.30	ReFED 2023	Ton of food waste	MT CO$_2$eq	Various		2	1		3	5	4	GWP
GWP	-0.22	-0.20		0.05	0.58	0.76	ReFED 2023	Ton of food waste	MT CO$_2$eq	Various		1	2		3	4	5	GWP
GWP	-0.18	-0.19		0.05	0.66	0.65	ReFED 2023	Ton of food waste	MT CO$_2$eq	Various		2	1		3	5	4	GWP

APPENDIX E
OTHER EMERGING PATHWAYS

The following sections provide a discussion of emerging pathways for wasted food management. Given that these technologies are in development, they were not included in the main analysis.

E-1. Hydrothermal Carbonization

Hydrothermal carbonization (HTC) is the conversion of watery slurry of organic material into carbon-rich hydrochar under moderate temperature and pressure (Mayer et al. 2019). The HTC process can operate with a variety of wet organic feedstocks including wasted food, green waste, digestate and the organic fraction of MSW (OFMSW) (Owsianiak et al. 2016). In the HTC process wasted food can be co-treated with non-wasted food (e.g., packaging), but the presence of packaging material in the waste stream has been found to drive environmental impacts (Berge et al. 2015).

Figure E-1 shows a system diagram for the HTC wasted food management pathway. Pre-treatment steps include moisture adjustment, sorting, mixing/shredding and chemical addition. Hydrochar is cooled, de-watered and combusted in a boiler or CHP system to recover heat and electrical energy. Liquid effluent resulting from the dewatering process may require advanced wastewater treatment due to high nutrient content or the presence of contaminants (Mayer et al. 2019).

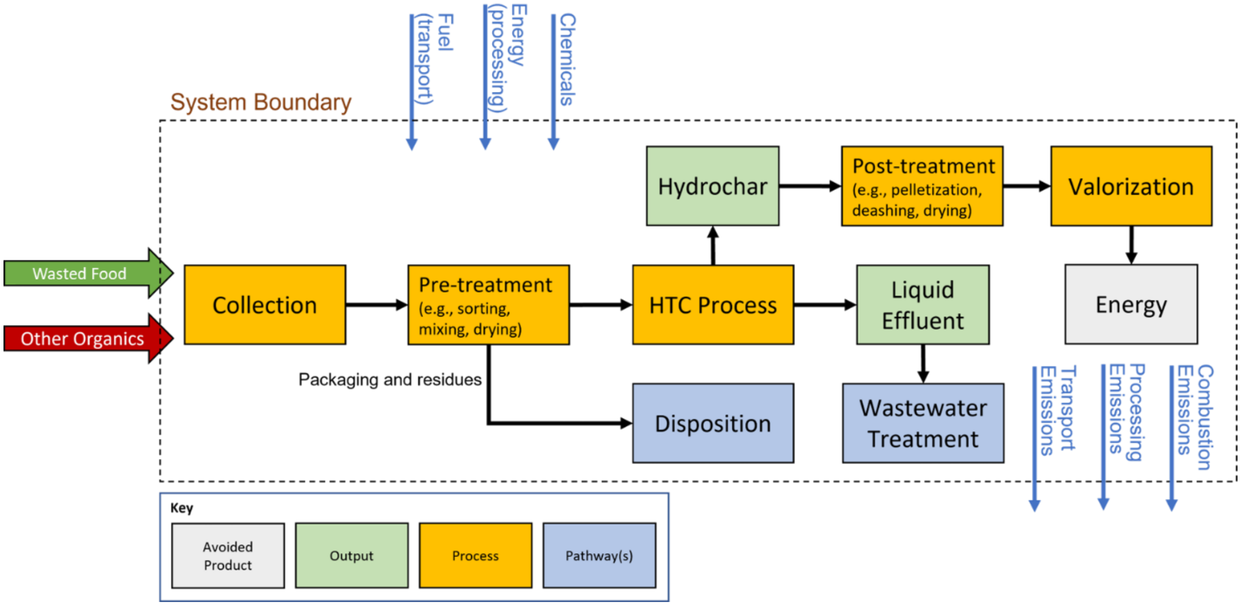

FIGURE E-1. DIAGRAM OF WASTED FOOD HYDROTHERMAL CARBONIZATION

E-1-1 Process Operation

During HTC, food waste is fed into a reactor where heat (around 180−250°C) and pressure (around 10-20 bar) remove moisture from the biomass (Owsianiak et al. 2016) . Despite the temperature and pressure requirements, Berge et al. (2015) found that energy demand for the provision of heat had a “fairly negligible impact on the system”. An LCA of wasted food HTC found that operation of the HTC process contributed minimally to gross environmental impact across 15 impact categories (Owsianiak et al. 2016). Pumping of wet biowaste and drying and pelletization of hydrochar was analyzed separately from reactor operation and was a larger source of environmental impact (Owsianiak et al. 2016).

E-1-2 Process Emissions

The main products of HTC are hydrochar, non condensible gases leading to process air emissions (SO_2, NO_x, CO, CO_2, etc.) and water containing inorganic and organic compounds including trace metals such as chromium, arsenic, nickel, mercury and cadmium (Owsianiak et al. 2016). The HTC process can accept wasted food with moderate amounts of packaging contamination. Global warming impact of the process was found to increase significantly when 40% of incoming feedstock mass was packaging, due to the presence of fossil carbon in these materials (e.g., plastic packaging) (Berge et al. 2015).

E-1-3 Liquid Effluent Treatment

Hydrochar dewatering leads to the production of liquid effluent. This liquid may require treatment prior to discharge. Advanced treatment processes, such as reverse osmosis can be used to concentrate the effluent, which is then diluted to reduce its metal concentration for safe use as a fertilizer (Owsianiak et al. 2016).

E-1-4 Hydrochar Valorization

Hydrochar can be combusted to produce energy after pre-processing. The first stage of the hydrochar preparation process involves the separation of liquids and solids from the carbonization process in HTC. Afterwards, the solids are dried and any water remaining in the hydrochar must be evaporated before the hydrochar can be burned for energy. Global warming potential was found to be sensitive to the electricity demand of hydrochar drying (Berge et al. 2015). Hydrochar is a coal-like material that is typically transported to coal-fired power plants to substitute coal-based electricity. Hydrochar combustion has been shown to be a large contributor to smog and terrestrial eutrophication impact, but it was found that avoided energy production produced environmental benefits for the GWP and acidification impact categories. Acidification and GWP impact were found to be sensitive to the electrical efficiency of hydrochar energy recovery (Berge et al. 2015).

TABLE E-1. HTC: ENVIRONMENTAL DRIVERS

Source of Environmental Impact	Environmental impact may be driven by packaging materials in wasted food.
Source of Environmental Impact	Hydrochar drying has high energy demand.
Source of Environmental Impact	Hydrochar combustion emits CAPs.
Source of Environmental Impact	Wastewater treatment of liquid effluent.
Source of Environmental Benefit	Hydrochar combustion displaces production and use of fossil energy.
Source of Environmental Benefit	Use of liquid effluent as fertilizer displaces conventional fertilizer production.
Options to Reduce Impact	Optimize hydrochar energy recovery.
Options to Reduce Impact	Additional pre-treatment sorting to remove packaging material from incoming wasted food and reduce global warming impact.
Additional Considerations	Environmental impacts associated with liquid-phase emissions decrease with the increasing presence of packaging material.[65]

E-2. Pyrolysis, Torrefaction and Gasification

Pyrolysis, torrefaction and gasification are all thermochemical processes where organic materials are converted in a controlled, low-oxygen environment to biochar (torrefaction), bio-oil (pyrolysis), synthesis gas (gasification), and associated gases and tar. The resulting biofuels can be further processed to produce gasoline, diesel, naphtha and refined industrial chemicals (U. Lee et al. 2017). In the case of gasification, the initial pyrolytic gases are further reacted with a gasifying agent to produce syngas (Mayer et al. 2019). Torrefaction is a mild pyrolytic process in which biochar is the primary energy product.

Commercial-scale application of pyrolysis, torrefaction, and gasification for wasted food management is nascent. Globally, there are facilities specializing in MSW gasification (Seo et al. 2018, 2), which is expected to include wasted food.

Pyrolysis, Torrefaction, and Gasification: Associated Process Steps		
Types	**Allothermal**	Use of outside fuel sources to meet the heat requirement.
	Autothermal	Combustion of internal feedstock to meet the heat requirement.

Figure E-2 shows a system diagram for the wasted food pathways centered on pyrolysis, torrefaction and gasification. Potential pre-treatment steps include drying, shredding and chemical addition (Mayer et al. 2019) . Bio-oil and synthesis gas (syngas) are the primary outputs of the pyrolysis and gasification management pathways and can be used either for energy production or undergo further processing to replace fossil-based feedstocks in the chemical industry. Produced fuel gas can be flared or used to provide process heat or other energy products. Biochar is a high carbon solid byproduct and can be used as a soil amendment (replacing peat), combusted to produce energy or disposed of in a landfill. Biochar can also be used as an additive in cement mortar to improve strength.

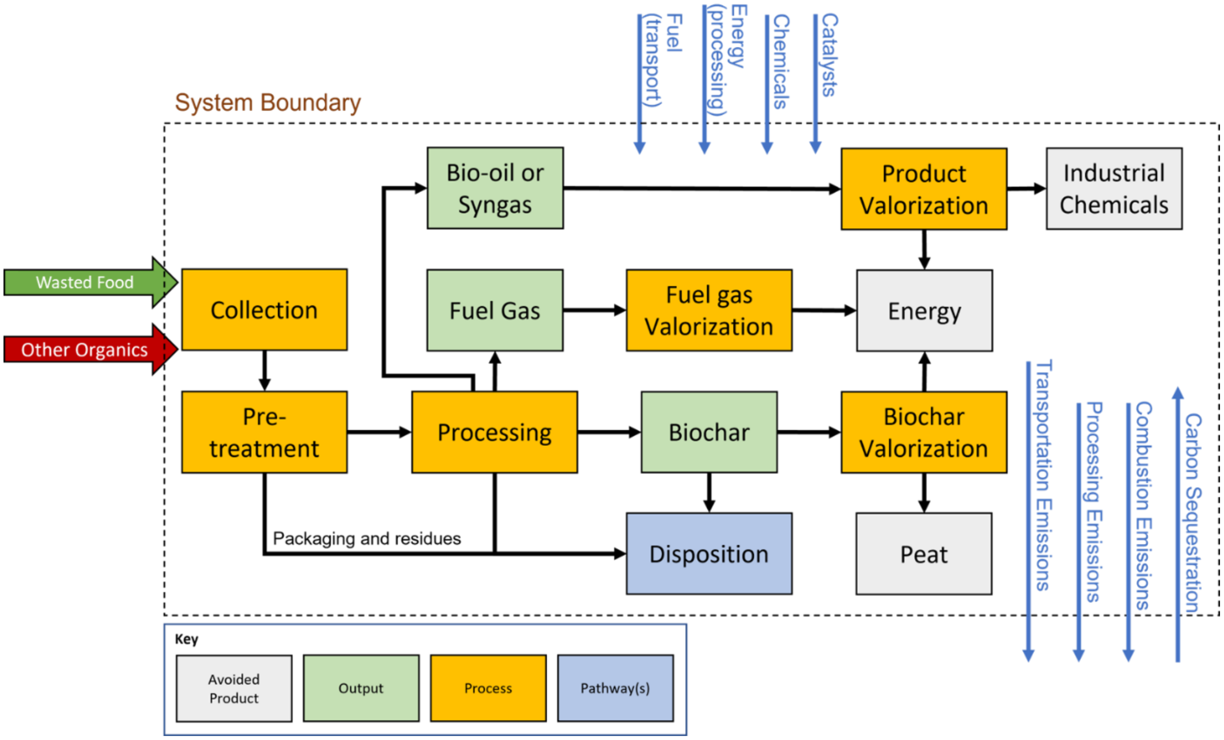

FIGURE E-2. DIAGRAM OF WASTED FOOD PYROLYSIS, TORREFACTION OR GASIFICATION

E-2-1 Process Operation

Torrefaction, gasification and pyrolysis are similar thermochemical processes that produce bio-fuels in low oxygen environments. During torrefaction, wasted food is introduced into a furnace and the heating temperature and nitrogen flowrate are adjusted to maximize biochar and energy output (Pahla et al. 2017).

Gasification involves the partial oxidation of food waste at high temperatures in gasifiers with a gasifying agent such as air, steam or oxygen until the organic matter is converted into syngas, a mixture of H, CO, CO_2, water, and hydrocarbons (Trabold and Babbitt 2018). Prior to the gasification process, Wasted Food requires processing to the designated particle size through methods such as sorting, shredding, grinding, drying and pelletization. These processes require additional energy use which contribute to the overall environmental impact of gasification (Nayak and Bhushan 2019).

Pyrolysis occurs at lower temperatures than gasification and requires heating wasted food without an oxidizing agent. This process creates biochar, bio-oils and gaseous products (Trabold and Babbitt 2018).[66]

E-2-2 Process Emissions

Pyrolysis produces non-condensable gaseous products such as H, CO, CO_2, methane, and C2H6. These emissions contribute to the environmental impact of the pyrolysis process. Gasification emissions include ash, tars, unburnt char, alkali, metal compounds, S, N, carbonyl sulfide, ammonia and hydrogen cyanide, which contribute to the overall life cycle impact of gasification (Trabold and Babbitt 2018).

E-2-3 Bio-oil and Syngas Valorization

Pyrolysis bio-oil and gasification syngas can be transformed into biofuels by removing oxygen through catalytic treatment and hydrogenation. Syngas produced by gasification is frequently used for heat generation and stationary power. The produced syngas from gasification must be cleaned before being used for heat generation or power. Syngas can undergo further processing (e.g., catalytic conversion) to manufacture liquid fuels or chemical intermediates. Bio-oil (e.g., naphtha) can also be used as a feedstock or intermediary in the chemical and flavor industry (Trabold and Babbitt 2018).

E-2-4 Biochar Use and Disposal

Biochar produced by pyrolysis, torrefaction and gasification is an excellent soil amendment providing a variety of benefits such as acidity mediation, cation exchange capacity and water and nutrient retention. Biochar improves soil and crop health and boosts crop yields by immobilizing some organic pollutants and trace metals (Xiong et al. 2019) . Biochar can also be ground into powder and used in cement mortar to adsorb water and improve strength (Xiong et al. 2019).

TABLE E-2. PYROLYSIS, TORREFACTION AND GASIFICATION: ENVIRONMENTAL DRIVERS

Source of Environmental Impact	Air emissions from processing (e.g., fuel gas).
Source of Environmental Impact	Process energy demand.
Source of Environmental Impact	Landfill or incineration of biochar.
Source of Environmental Impact	Waste management (e.g. ash from gasification).
Source of Environmental Benefit	Use of biochar for beneficial purposes such as a soil amendment or cement mixture additive.
	Fuel gas can be recovered and used for internal energy purposes. Excess fuel gas can also be recovered and sold for energy purposes.

Options to Reduce Impact	Optimize recovery of biochar for beneficial use.
Other Considerations	Processing conditions (e.g., temperature, residence time) impact bio-product yields.

E-3. Other Industrial Uses

For the understudied industrial use pathways (pyrolysis, gasification, HTC, etc.), it is not currently possible to draw robust conclusions about their environmental performance relative to other wasted food pathways. This is due both to the limited amount of research that considers these pathways and the wide range of technologies that fall in this broad category.

- For the pyrolysis and gasification pathways, no impact data were identified that met the basic scope criteria.
- Berge et al. (2015) is the only source of impact data for HTC that met basic scope criteria. Data from this study indicates acidification and GWP benefits that place HTC in the middle of other end-of-life pathways.
- More research is needed for these pathways as they are brought to commercial scale and pursue operational efficiency to optimize environmental performance in the lower end of the identified range.

Given the wide breadth of bio-based products that could ultimately be produced from the industrial use pathways, a wide range of performance outcomes are to be expected. The primary benefit of the industrial use pathways is their potential to avoid the production of non-renewable and resource intensive products such as electricity, diesel and virgin plastic resins. However, these pathways are also resource intensive and the realized net benefit depends on the balance of production and avoided product impacts.

E-3-1 Rendering

Rendering is the process of processing and heat treating unused portions of livestock carcasses and used cooking oil to produce fat and a protein-rich solids. Thus, this pathway applies to specific wasted food streams.

Figure E-3 shows a system diagram for rendering. The central component of the rendering process is heat treatment (e.g. at temperatures >115°C for >40 minutes). Heat treatment yields two main streams, one of proteinaceous solids, and the other of fatty liquid. Following additional processing of these two streams, major destinations for rendered material are livestock/aquaculture/pet feed, fuel, fertilizer, and industrial chemicals, although the output of rendering can be used in other products such as personal care products (Wilkinson and Meeker 2021). Rendered fat can be used directly in a variety of products (e.g., detergents, lubricants) or can be further processed.

Some of the local environmental concerns specific to rendering include microbiological safety, odors, and liquid effluents. With respect to the livestock carcass waste stream, microbiological safety is of concern: heat treatment of rendering does inactivate bacteria, viruses, and protozoa, but there has been concern about transmissible spongiform encephalopathy (TSE) in animal feed products, and the European Union requires that portions of the livestock carcass (brain, spinal cord) be incinerated (Gwyther et al. 2011). Rendering does produce odors, though a large fraction of these can be controlled with washing, with a higher degree of reduction from air cleaning technologies such as scrubbers. Liquid wastes such as oils and greases require treatment at on-site or local wastewater treatment facilities (Gwyther et al. 2011).

Our review found only one LCA study that included rendering (Corona et al. 2020), and the review of (Shurson 2020) identified very limited environmental data. Therefore, this pathway requires further study before it can be assessed quantitatively or compared to other pathways. For ReFED, Corona et al. (2020) model protein displacing soybean for feed production, biodiesel displacing conventional diesel production (and combustion), and bioglycerin displacing conventional glycerin. As documented in ReFED, the performance of rendering appears similar to that of AD. However, Gwyther et al. (2011) suggest that anaerobic digestion or other technologies may have advantages, among them environmental, over rendering.

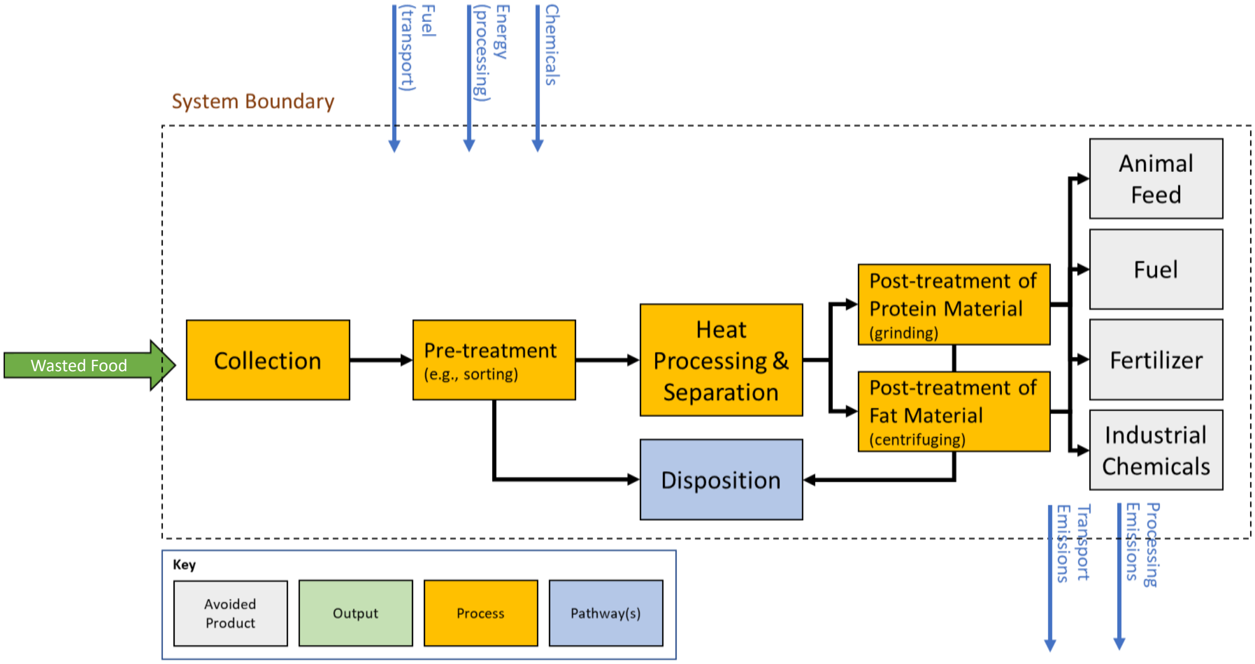

FIGURE E-3. DIAGRAM OF WASTED FOOD RENDERING

Source of Environmental Impact	Energy for heat processing; transport.
Source of Environmental Benefit	Displacement of production of livestock/aquaculture/pet feed, fuel, fertilizer, and industrial chemicals.
Options to Reduce Impact	Optimize recovery of protein and fat.

APPENDIX F
ENDNOTES

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[1] World Resources Institute (WRI), Consumer Goods Forum (CGF), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), Waste and Resources Action Programme (WRAP), World Business Council for Sustainable Development (WBCSD).

[2] The term ‘water resource recovery facility’, WRRF, is used in this report to refer to wastewater treatment plants to highlight focuses on the resources that could be recovered. The term ‘wastewater treatment’ is used in this report to refer to the process of treating wastewater at the WRRF. For example, within the sewer/WWT pathway not all facilities receiving wasted food will have anaerobic digestion, so the more general term is preferred. Other forms of energy or resource recovery can occur at WRRFs, that may qualify them as WRRFs, but these practices are outside the scope of this document.

[3] Damiani (2021) places the impact of beef production at more than 28 kg CO2e/kg, on average, whereas rice production results in one-tenth the GWP impacts of beef (2.7 kg CO2e/kg).

[4] Eriksson and Spångberg (2017) considered the conversion of nonmarketable fruits and vegetables into chutney. They looked at five different fruits and vegetables (apples, bananas, oranges, peppers, and tomatoes) and evaluated only GWP (kg CO2e/kg wasted food) and energy demand (MJ/kg wasted food). The analysis considered avoided production of fresh fruits and vegetables. Production intensities varied from 0.4 kg CO2e and 5 MJ for an apple to 1 kg CO2e and 15 MJ for a pepper, and thus the net impact was between -0.4 and -1 kg CO2e and between -5 and -15 MJ for the upcycling of the apple and pepper. Additionally, several processes were essentially cancelled by their opposites: processing and avoided processing, glass jar production and avoided glass jar production, transportation to supermarket and avoided transportation to supermarket.

[5] Eriksson et al. (2021) investigated changing broccoli harvesting practices to collect leaves and broccoli heads that fall outside the quality norms and are typically left behind. The leaves were considered for use in bread (displacing wheat flour) and broccoli soup (displacing imported broccoli powder), while the heads were considered for sliced broccoli. For all three scenarios, additional harvesting steps were negligible. Transportation was similar to that required for regular broccoli. The displacement of other products was a major contributor to overall impacts. In the case of bread, the displacement of wheat flour did not offset drying, so the net impact was 0.075 kg CO2e/kg broccoli. However, the soup and sliced broccoli displaced products with higher impacts, leading to net negative impact (-0.45 to -0.35 kg CO2eq/kg broccoli).

[6] For example, cows are often raised for milk and meat, but the leather produced from their hides is not treated as impact-free. In the case of upcycling, broccoli is generally cultivated for its florets, and the leaves are wasted food. As wasted food, broccoli leaf production is impact-free. However, if broccoli leaves were to become a regular substitute for wheat flour, they might cease to be classified as upcycled, and then they would no longer be considered impact-free. A study of broccoli leaves found that the leaves had higher environmental production impacts than wheat flour (Eriksson et al. 2021).

[7] Co-digestion of signficant quantities of wasted food with sludge from wastewater treatment operations may materially affect the composition and associated benefits and impacts of biosolids processing and use. The Biosolids Emissions Assessment Model (BEAM), was developed by the Canadian Council of

Ministers of the Environment, to estimate GHG emissions associated with biosolids management . Applicability of this model to biosolids generated from a co-digestion process is unknown.

[8] About 1,265 of the roughly 16,000 WRRFs in the United States process biosolids with AD, and roughly 10% of those facilities co-digest source-separated wasted food with biosolids (ASCE 2021; U.S. EPA 2023b). Co-digestion of food waste along with wastewater solids has been shown to increase biogas production, with fats, oils, and grease providing some of the greatest biogas benefits (Parry 2014).

[9] A U.S. EPA report of case studies of WRRFs adding wasted food (FOG, residential, commercial, and industrial) as co-digestate showed increases in biogas production ranging from 40% to 300% (U.S. EPA 2014b).

[10] The ratio of produced energy to input energy (termed the energy ratio) is sometimes used to quantify net energy production. Research cited by Khoshnevisan et al. (2018) reports that biogas plants typically have an energy ratio of between 2 and 6. In their own analysis, energy ratios varied from 3.1 to 5.2.

[11] A review of sustainable approaches to wasted food management summarizes nine studies that provide evidence of improved methane yields, enhanced process stability, or increased volatile solids reduction when wasted food is co-digested with green waste, biosolids, animal manure, and other organic materials (Paritosh et al. 2017).

[12] Many reviewed studies specify either single- or two-stage digestion processes, but do not go into detail on why a specific reactor type was chosen. Ahamed et al. (2016) state clearly that “conventional single-stage reactors are not suitable for food waste,” and the study relies instead on a two-stage technology that is expected to increase process stability and yield more methane. Ahamed’s analysis looks at digestion of pure wasted food, while many other studies co-digest wasted food with other organic materials. Tiwary et al. (2015) go into greater detail, describing that methanogenic organisms struggle to deal with the rapid drop in pH that accompanies hydrolysis when highly degradable materials such as wasted food are introduced directly into single-stage reactors. Separation of these reactions within multi-stage reactors can increase biological stability and process performance. Alternatively, co-digestion of highly degradable materials with more stable organic materials can circumvent this issue but limits the quantity of wasted food that can be processed in each facility.

[13] Instances in which it may not be appropriate to assign an avoided burden credit for the full quantity of energy produced include, for example, situations where there is no market for produced heat or where biogas has historically been used to provide heat for AD (i.e., baseline is not natural gas combustion).

[14] Al-Rumaihi et al. (2020) showed that GWP results are sensitive to changes in CHP output, with a 30% increase in heat and electricity production leading to a greater than 100% decrease in impact potential (i.e., a net benefit).

[15] A few studies examine disposal of digestate by incineration (Chiu and Lo 2018; Tong et al. 2018) or in a landfill (Righi et al. 2013).

[16] One study states that 30% to 50% of total nitrogen can be lost as ammonia within six hours of application, though incorporation into soil may reduce losses by 85%. Nitrate leaching is also of concern, with losses of up to 15% of applied nitrogen from autumn applications (Nicholson et al. 2017).

[17] Slorach et al. (2019a) report that there is not a significant difference in the production of biogas between mesophilic and thermophilic reactors, but that thermophilic reactors can have twice the energy consumption. Tiwary et al. (2015) come to a different conclusion, finding that thermophilic reactors do have greater biogas production.

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[18] A consequential analysis of animal feed, composting, and AD found that the lower eutrophication, toxicity, and acidification impacts of wet and dry feed are largely due to avoiding conventional animal feed production (Salemdeeb et al. 2017).

[19] Albizzati et al. (2021b) consider avoided reference products for their wet and protein-concentrated animal feed pathways, which are maize grain and soybean-based, respectively. When compared to the gross impact of animal feed production and alternative management pathways, the reference product avoids considerable environmental burdens for several impact categories including human toxicity, cancer, particulate matter formation, global warming, ionizing radiation, photochemical ozone formation, eutrophication, and freshwater ecotoxicity.

[20] Thakali et al. (2022) studied the effect of source and regulatory requirements on the type and amount of contamination in food wastes intended for composting. Source separated food wastes generated from locations that were required by regulation to separate food waste from packaging and other non-food contaminants had lower levels of physical contamination than food wastes from locations that voluntarily separated. Chemical contaminates across both regulated and unregulated sources include zinc, copper, halogenated organics, and PFAS.

[21] A review of methane emissions found that typically between 1% and 4% of carbon entering a compost pile is released as methane (Ermolaev et al. 2014). A separate review of laboratory and field studies found that 2.7% of carbon is released as methane (Pardo et al. 2015). A review by Cerda et al. (2018) identified that between 0.03 and 71.4 kg methane are released per ton wasted food during composting. Accurate measurement of compost gaseous emissions can be difficult, given emission gradients at different locations in the pile (Büyüksönmez 2012).

[22] Levis and Barlaz (2011) performed a sensitivity analysis that looked at the fraction of carbon in compost feedstock that was liberated during biodegradation. The analysis considered loss of between 40% and 83% of initial carbon, with strong linear increases in GWP across all considered composting technologies as the fraction of carbon loss increased. Increasing carbon loss during composting increases process methane emissions while decreasing long-term carbon storage.

[23] An analysis of high and low emission scenarios for home composting systems (Quirós et al. 2014) illustrates the variable impacts of compost process emissions. In the high emission scenario, process emissions dominate all other operational impacts (energy, tools, and collection) for the acidification, eutrophication, and GWP categories. Energy-related inventory categories and ozone depletion are not influenced by compost process emissions. In the low emissions scenarios, process emissions still dominate for GWP, but the magnitude of impact is reduced. The contribution of process emissions to acidification and eutrophication is reduced dramatically in the low emission scenario and is similar in magnitude to impacts associated with infrastructure and energy consumption.

[24] The interplay of the various bacterial communities that compost organic waste is complex, and thus it can be straightforward to optimize for a single emission but difficult to optimize across emissions. For example, a review of strategies to minimize NH_3 emissions identified several approaches: 1) adjusting pH, 2) adjusting C:N ratios (e.g., through initial adjustment or co-composting a green waste that has a high C:N ratio), 3) adding absorbents (e.g., zeolite or biochar), 4) struvite precipitation (with additional adjustment of salinity), 5) adjusting nitrification, or 6) adjusting aeration rates and pressures (Wang et al. 2018; Wang and Zeng 2018).

[25] The studies that explicitly state their assumptions related to carbon sequestration assume that between 10% and 15% of land-applied carbon is sequestered (Levis and Barlaz 2011; Yoshida et al. 2012).

Whether or not the carbon in compost is assumed to be sequestered has a strong impact on results, potentially shifting net GWP emissions from positive to negative (Levis and Barlaz 2011; Silver et al. 2018).

[26] Wasted food is a good source of nitrogen and phosphorus in composting systems, can help establish ideal C/N, ratios in compost systems and leads to finished compost products with benefits both as a soil conditioner and as a replacement for chemical fertilizers.

[27] Energy use has been found to be a major contributor of gross emissions of nitrogen oxides and sulfur oxides in ASP and bioreactor compost systems (Levis and Barlaz 2011). The analysis shows considerably less gross impact associated with windrow composting energy demand, which is dominated by windrow turning.

[28] Carbon dioxide, ammonia, methane, nitrous oxide, and VOCs constitute 99% of total emissions; further detail is provided in Quirós et al. (2014).

[29] Increasing aeration through pile turning and bulking agents decreased emissions of both methane and nitrogen dioxide, according to a review of management approaches (Pardo et al. 2015) and laboratory-scale experiments (Yang et al. 2013). Experiments by the California Natural Resources Agency also confirm the importance of maintaining aeration to limit methanogenesis (Silver et al. 2018). A study of GHG emissions from home-scale composting systems came to an alternate conclusion: that fewer mixing events led to reduced methane emissions, while increased temperature led to increased emissions (Ermolaev et al. 2014). Other authors, cited in the Ermolaev study, had a similar finding and attributed their result partly to the release during turning events of methane trapped within the pile. Oxidation of methane to carbon dioxide near the pile's surface, by methanogenic bacteria, could also explain part of the finding that reduced mixing leads to less GHG emissions (Jäckel et al. 2005).

[30] An analysis of a community-scale composting system showed a moderate to major (10% to >30%) reduction in gross impact for GWP, acidification, smog formation, and ozone depletion as a result of avoided nitrogen fertilizer production. Carcinogenic toxicity impact most strongly benefited from the avoided fertilizer production, with the avoided impact of fertilizer production leading to nearly net zero impact (Keng et al. 2020). Results for a wasted food aerobic composting system showed moderate to major reductions in gross GWP and minor to moderate reductions in gross energy demand due to avoided fertilizer production (Morris et al. 2017). An analysis of wasted food composting that included windrow, ASP, Gore and bioreactor compost systems identified moderate reductions in gross GWP for all systems as a result of avoided fertilizer production (Levis and Barlaz 2011). Other authors have identified only minor environmental benefits associated with avoided fertilizer production for GWP (Righi et al. 2013).

[31] The rate of compost application should be calibrated to consider all other nutrient sources such as legumes and chemical fertilizers, to avoid over-fertilization. Spreading equipment should be capable of metering compost application to avoid over-applying. Compost should not be applied when soil is frozen, and other best management practices related to organic amendment applications, such as manure, should be followed (NRCS and Agricultural BMP Task Force 2017).

[32] Food waste is a high-moisture waste product. It should be mixed with a dry, high-carbon material to absorb moisture and provide structure to the compost pile necessary for aeration and odor control. The ideal C:N ratio at the time of pile formation is 30:1 with a moisture content of 50% to 70% (Risse and Faucette 2017).

[33] See Trabold and Babbitt (2018) or Mayer et al.(2019)for more information.

[34] Some food seasonings have high chlorine levels, which are related to dioxin production potential.

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[35] This statement refers to net impacts, which include olive production and olive oil processing in this analysis.

[36] Oily food waste is high in carbon (C:N ratio of 90:1) and can immobilize nitrogen in the soil, affecting crop yields if sufficient nitrogen is not available.

[37] The high carbon content of oily food waste can immobilize nitrate in the soil, prevent leaching, and make that nitrogen available for subsequent crops through re-mineralization, thus avoiding the need for additional fertilization.

[38] Of the reviewed studies that investigate land-applied wasted food, most indicate that direct application can benefit soil health, provide nutrients, and boost crop yields, but only if carefully managed temporally and co-applied with other organic wastes or inorganic fertilizers (Kumar et al. 2009; San Miguel et al. 2012).

[39] wasted food "must be applied at or below agronomic rates, and nuisance conditions (such as odors and flies) and negative impacts on surface and ground waters must be minimized" (Belcher and Aldrich 2006).

[40] Batuecas et al. (2019) commented on the risk that groundwater and surface water pollution could result from application of olive waste to agricultural fields, and a separate study on applying palm oil processing residues raised similar concerns (Embrandiri et al. 2012).

[41] "Landfill gas contains many different gases. Methane and carbon dioxide make up 90% to 98% of landfill gas. The remaining 2% to 10% includes nitrogen, oxygen, ammonia, sulfides, hydrogen and various other gases" (NYSDOH 2019).

[42] U.S. EPA's Waste Reduction Model (WARM) suggests that under "moderate" moisture conditions, an appropriate decay rate for food waste is 0.14 yr-1. For paper and wood products, under similar conditions, decay rates vary between 0.02 and 0.12 yr-1, with higher values indicating more rapid decomposition. Yard trimmings have an average decay rate under moderate moisture conditions of 0.2 yr-1.

[43] For example, lipids were calculated to contribute 59% to 70% of methane potential for a variety of food wastes in anaerobic environments, though there is a potential for lipids to inhibit methanogens (Lopez et al. 2016). The authors note the need for further research to clarify the role of lipids in wasted food decomposition.

[44] Reasonable ranges for decay rate and oxidation factor selection may lead to wasted food emissions varying from 0.23 to 0.71 MTCO$_2$e (metric tons of CO$_2$ equivalent) per ton of food waste (CARB 2017).

[45] Some studies suggest that typical EPA decay rates are too low (Wang et al. 2013), which would lead to underestimation of the portion of methane produced early in the landfill's life, before the installation of robust LFG capture systems.

[46] The carbon storage potentials of other commonly landfilled organic materials such as cardboard, newspaper, grass, and dimensional lumber were estimated to be 55%, 84%, 53%, and 88%, respectively (U.S. EPA 2020b).

[47] One study that modeled the landfill as "a 'dry tomb' where microbial activity is suppressed" assumed that 43% of landfilled carbon was sequestered (Yoshida et al. 2012). This value is considerably higher than the 16% estimate provided by WARM and is unlikely to apply in moist regions. Additional research has shown that landfill degradation is more limited in arid regions (Jain et al. 2021).

[48] Landfill leachate is the predominant contributor to eutrophication potential in several studies (Edwards et al. 2017; Lee et al. 2020; Slorach et al. 2020).

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[49] Lee et al. (2017) found that when their LCA model was altered to increase LFG collection in the early stages of cell development, GHG emissions could be reduced by 27% compared to a less aggressive gas collection strategy.

[50] The authors noted that use of these factors was uncertain but was based on the best available information at the time.

[51] Zan et al. (2020) suggested that just 6% of the total COD in wasted food is degraded over a 4-hour sewer residence time. For comparison, direct GHG emissions from landfilling wasted food are approximately 16–30+ times greater than these marginal additional sewer emissions from added wasted food (Zan et al. 2020). In the U.S. context, this 6% figure may overestimate actual sewer emissions, given that a GIS-based analysis simulating the residence time of 3,422 U.S. sewer systems found that the median residence time of wastewater is approximately 3.3 hours (as opposed to Zan et al.'s 4-hour basis), with larger municipalities having longer residence times (Kapo et al. 2017).

[52] About 1,265 of the roughly 16,000 WRRFs in the United States process biosolids with AD (ASCE 2021; U.S. EPA 2023b).

[53] Concern that additional wasted food in sewers will drive solids deposition and clogging has not been universally borne out (Bolzonella et al. 2003). Further study and decision support tools are needed to navigate potential trade-offs between wasted food conveyance and sewer performance. For instance, various studies of long-term impacts have shown that, when high-specific-gravity wasted food (e.g., bones and egg shells) and/or FOG-rich wasted food are excluded, marginal additional sewer deposits from wasted food are small and have a minor impact on sewer performance (Mattsson et al. 2015). Mattsson et al. (2014) used cameras to monitor the effects of food waste disposers on small-diameter residential pipes across three Swedish municipalities. Despite disposer usage correlating with more deposits, especially in pipe segments with sags or gentle slopes, these deposits were small and appeared to have a minor impact on sewer performance (Mattsson et al. 2014).

[54] Source separation requires separate collection and transportation infrastructure that is not currently available in all communities, and sewage collection avoids hygiene and odor problems that can arise during other forms of collection and transportation (Kaur et al. 2019).

[55] A survey of local municipal authorities and waste management operators revealed that organizations providing organic feedstocks to AD operators can expect to meet contamination requirements of less than 5% on a total weight basis (Ogden et al. 2022).

[56] The animal feed pathway can address contamination concerns through preprocessing. Vermicomposting can recover the value of the food waste (in this case nutritional value) by transferring it to a different carrier (like fly larvae), avoiding the issue of feeding animals food waste with physical contaminants (Nick Hacheney and Sally Brown 2017).

[57] Heterogenous wasted food feedstocks can be difficult to formulate for appropriate animal nutrition.

[58] In a 2019 survey of composters in California, 48% reported that contaminated waste streams limit their ability to accept wasted food (CalRecycle 2019). Regulations governing commercial composting facilities in Washington State limit physical contamination in compost piles to less than 1% of wet weight with a plastic content of not more than 0.25% (State of Washington 2019).

[59] https://www.epa.gov/air-emissions-factors-and-quantification/emissions-estimation-tools

[60] Their reported values range from -4300, -3090, -162 and +536 kg CO2e when preventing (source reduction), donating, digesting and landfilling 1 metric ton of wasted food, respectively. The source

reduction pathway receives a credit for avoiding food production, as does food donation. The AD and landfilling options do not receive this credit. Stated differently, the wasted food collected for donation comes with a negative carbon footprint, so that additional transportation and other processing may produce some GHG emissions but leaves the overall pathway with a large, net negative carbon footprint. Food waste enters the AD and landfilling pathways with a neutral (zero) carbon footprint, given its status as a waste product. These modeling options describe the convention, used in this report, to compare wasted food pathways to source reduction, wherein source reduction/donation have a virtual net negative impact while wasted food enters other pathways burden free (i.e. neutral environmental impact).

[61] An analysis of AD, composting, controlled combustion, and landfilling of wasted food found that management pathways have small GWP impacts (and potentials to reduce impact) compared to food production (Slorach et al. 2020).

[62] In 2021, over 65% of landfilled waste was sent to facilities with active energy recovery projects, and nearly 50% of collected LFG was sent for energy recovery (U.S. EPA 2022a).

[63] Including 4% used as alternative daily cover for landfills

[64] Excluding scenarios where cover crops are harvested for bio-energy.

[65] Toxicity and eutrophication impacts were found to decrease with the increasing presence of packaging material as these impacts are dominated by liquid emissions, produced during hydrochar dewatering, which are not produced by low-moisture, packaging materials (Berge et al. 2015).

[66] Research has shown that slow pyrolysis, with its lower temperatures and slower heating rates, tends to produce more biochar and less bio-oil because of longer residence times with slower heating delays decomposition (Trabold and Babbitt 2018).