MORE CIRCULARITY
LESS CARBON
-25% BY 2025

THE CARBON FOOTPRINT OF WASTE

NAVARRA

ACR+
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ZERO WASTE SCOTLAND

ACR+ is an international network of cities and regions sharing the aim of promoting a sustainable resource management and accelerating the transition towards a circular economy on their territories and beyond.

Circular economy calling for cooperation between all actors, ACR+ is open to other key players in the field of material resource management such as NGOs, academic institutions, consultancy, or private organisations.

Find out more at www.acrplus.org

Zero Waste Scotland exists to lead Scotland to use products and resources responsibly, focusing on where we can have the greatest impact on climate change.

Using evidence and insight, our goal is to inform policy, and motivate individuals and businesses to embrace the environmental, economic, and social benefits of a circular economy.

We are a not-for-profit environmental organisation, funded by the Scottish Government and European Regional Development Fund.

Find out more at www.zerowastescotland.org.uk/

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Research date: January – December 2021

Publication date: April 2022

Disclaimer:

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ACR+ 'MORE CIRCULARITY LESS CARBON' CAMPAIGN

ACR+ has partnered with its member Zero Waste Scotland to launch the 'More Circularity Less Carbon' campaign in November 2019 to reduce the carbon impact of municipal waste among its members by 25 per cent by 2025.

Zero Waste Scotland's Carbon Metric International (CMI) tool, developed from Scotland's ground-breaking Carbon Metric, enables ACR+ members to measure the carbon impact of their municipal waste, take effective actions to reduce it, and track their progress towards the 2025 target. A first cohort was organised in 2020, in which three ACR+ members collected data and analysed the carbon footprint of their municipal waste: the Brussels Region (BE), Pays de la Loire region (FR), and the city of Genoa (IT). This first cohort led to the publication of a cross-analysis that highlights similarities, differences, and potential improvements for the follow-up activities.

Navarra is one of the ACR+ members who joined cohort 2 to benefit from this project and received support use the CMI to quantify the whole-life carbon impacts of its municipal waste. The results are summarised in this report, which has three main objectives:

1. Enable Navarra to establish its 2025 carbon reduction target.
2. Provide a detailed breakdown of waste carbon impacts by materials and management process; and
3. Assess several carbon reduction scenarios that can help Navarra achieve its target.

ZERO WASTE SCOTLAND'S CARBON METRIC INTERNATIONAL

Zero Waste Scotland has developed a ground-breaking tool in the fight against global climate change. The Carbon Metric measures the whole-life carbon impacts of Scotland's waste, from resource extraction and manufacturing emissions right through to waste management emissions, regardless of where in the world these impacts occur (Figure 1).

"The Carbon Metric shows how reducing our waste, and managing what remains in a more sustainable way, is critical to the global fight against climate change."

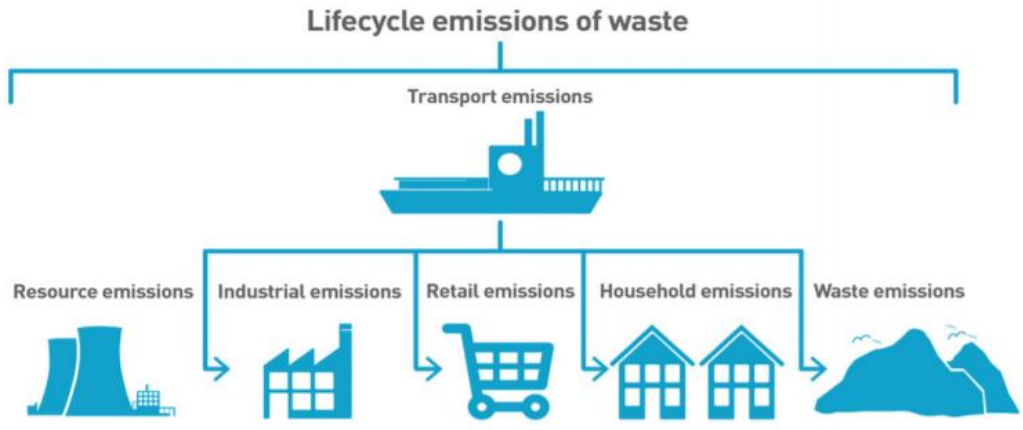


Figure 1 Schematic diagram presenting the lifecycle emissions of waste.

The Carbon Metric provides policymakers and business leaders with an alternative to weight-based waste measurement, allowing them to identify and focus specifically on those waste materials with the highest carbon impacts and greatest potential carbon savings. Scotland's 33% per capita food waste reduction target is an example of a policy informed by the Carbon Metric[1].

Further details on the Carbon Metric methodology can be found on Zero Waste Scotland's website[2].

The Carbon Metric could be adapted to Navarra' data thanks to the collaborative work between Zero Waste Scotland and ACR+.

METHOD & DATA SOURCE

The whole-life carbon impacts of **household waste** in Navarra were quantified in this report, based on 2019 data.

Stages covered in the analysis as follow:

- **Waste generated:** all waste generated by households in Navarra during the reporting year (i.e., 2019). Embodied carbon impacts linked to the production of material (resource extraction, manufacturing, and transport emissions) are included in this category. Impacts associated with the product's use are excluded.
- **Waste recycled:** all recycled (or reused) materials including biodegradable materials that have been composted or anaerobically digested. The analysis covers all activities linked to recycling waste, namely waste collection, sorting, recycling, and displacement benefits as recycled content substitutes virgin materials.
- **Waste landfilled:** all landfilled waste, including incinerator ash and any recycling and composting rejects that occur during collection, sorting or further treatment that are landfilled. The analysis covers the carbon impacts of waste collection and disposal.

More information on waste data used in the analysis, assumptions with regards to waste management operations in Navarra, and its limitations can be found in Appendix 1.

ABOUT NAVARRA

Navarra (Navarre) is one of the Spanish Chartered Communities and a geographically diverse region in northern Spain encompassing 272 municipalities (Figure 3). It has a population of 654,214 in 2019[3], and half of the inhabitants live in the metropolitan area of its capital, Pamplona.

Nafarroako Gobernua
Gobierno de Navarra

Figure 2 Logo of the Government of Navarra.

[1] Scottish Government (2016) Making Things Last
[2] Zero Waste Scotland (2020) Carbon Metric Publications.
[3] Personal communications (ACR+ partners in Navarra)

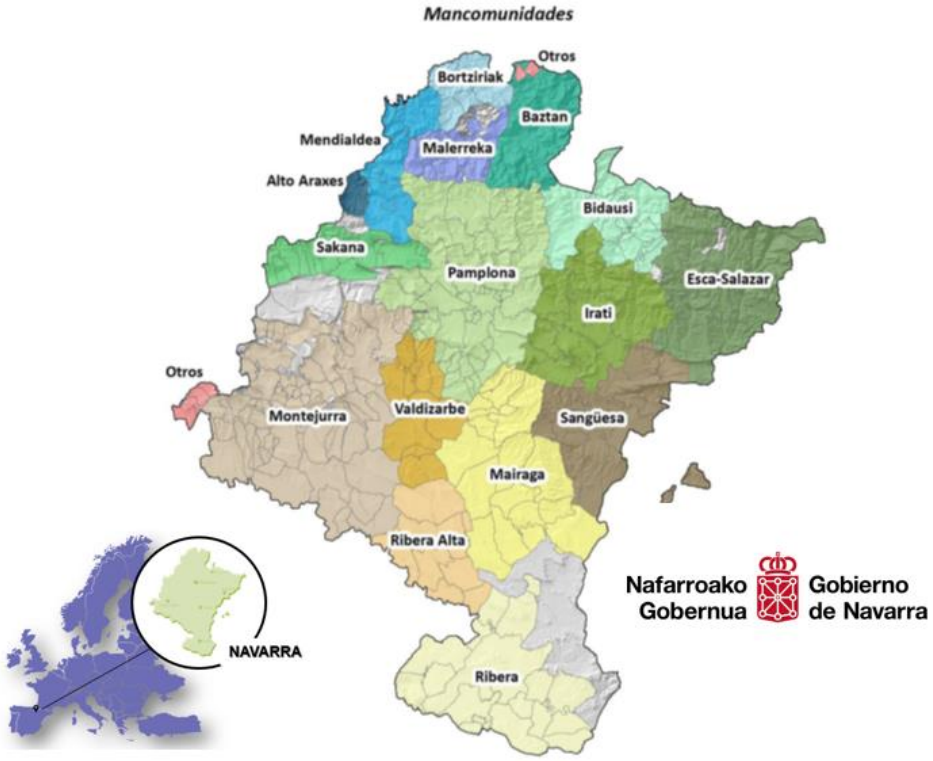


Figure 3 the Region of Navarra (source: navarra.es).

The total amount of municipal waste generated in Navarra in 2019 is approximately 285,000 tonnes, representing 434 kg/inh. This includes household waste and a share of commercial waste assimilated to household waste.

4.1 Collection

The composition of the household waste generated in Navarra is presented below.

Table 1 Breakdown of waste generated in Navarra in 2019.

Waste Category	Waste generated (tonnes)
Food waste	75,692
Paper and cardboard wastes	40,197
Garden wastes	34,192
Plastic wastes	31,389
Glass wastes	26,626
Health care and biological wastes	19,382
Household and similar wastes	15,274

Textile wastes	13,960
Wood wastes	9,385
Mixed ferrous and non-ferrous wastes	4,852
Mixed and undifferentiated materials	4,271
Discarded electronic equipment	3,670
Ferrous wastes	3,349
Mineral waste from C&D	775
Non-ferrous wastes	366
Spent solvents	100
Batteries wastes	82
Used oils	33
Chemical wastes	11
Grand Total	**283,605**

Waste collection is mostly done via road containers (bring bank system), that represent about 90% of the total collected quantities. A small part of the households and some commercial activities are collected door-to-door. Waste is sorted into 4 main fractions: food waste, paper and cardboard, glass packaging, and lightweight packaging (including plastic, metal, and Tetra Pak).

Bulky waste is collected on-demand, or in mobile and fixed civic amenity sites. There are also street containers for several specific fractions such as textiles, batteries, and used cooking oil.

4.2 Treatment and recycling

A breakdown of waste treatment and disposal route is shown in Figure 4. About half of the collected waste is sent to recycling, while the rest goes to landfilling. Incineration is not available in the region.

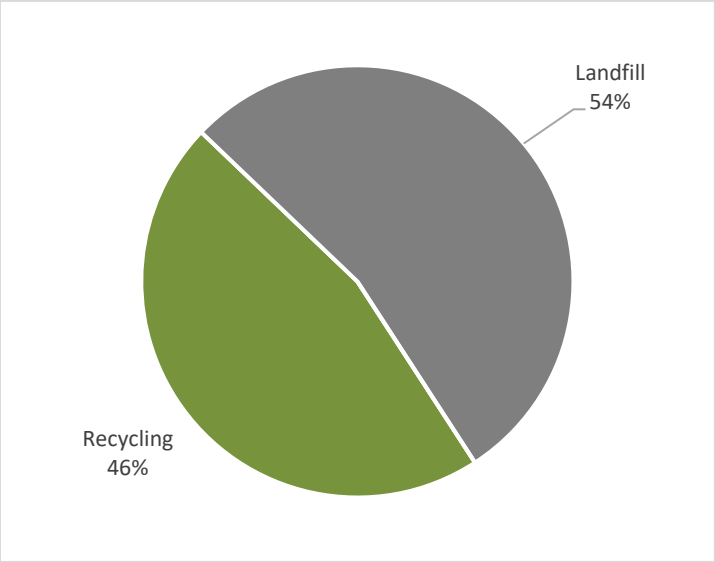


Figure 4 Final destination of household waste in 2019.

The treatment routes for the key waste streams are presented in the table below:

Waste stream	Treatment route
Residual waste	56% of residual waste is sent to three different landfilling sites. In one of them, most biogas is recovered as electricity, while the rest is sent to mechanical biological treatment followed by anaerobic digestion. The digestate is then sent to disposal.
Food waste	About 80% is sent to composting, while the rest is sent to anaerobic digestion, producing electricity, heat, and liquid and solid soil conditioner. About 25,000 tonnes of food waste is selectively collected, while about 7,000 tonnes are composted through home- or community composting.
Paper and cardboard waste	Navarra operates a dedicated collection service of paper and cardboard using street bins. This service includes commercial waste collected door-to-door in city centres.
Packaging waste	Plastic, metal, and Tetra Pak are collected in a commingled stream and sent to a sorting centre, with a reject rate of about 20%.
Glass packaging waste	All collected quantities are sent to close-loop (“bottle-to-bottle”) recycling. The contamination amounts to 2%.
Reuse	About 1,000 tonnes of waste is prepared for re-use: mostly furniture, clothes, EEE, and various household objects.

5.1 Key findings

The carbon impacts of household waste in Navarra in 2019 were approximately 713,000 tonnes of carbon dioxide equivalent (tCO_2eq.), or 0.4 tCO_2eq./capita. Figure 5 shows that carbon saved through recycling was higher than carbon impacts of waste disposal (i.e., landfilling), meaning waste management activities (i.e., collection, treatment, and disposal) in Navarra are carbon negative. Embodied carbon impacts of waste material (i.e., the emissions generated by the extraction of resources, production, manufacturing, etc. of the corresponding products, labelled as "Generated" in Figure 5) are the highest contributor to the net carbon impacts of waste however, which is why waste prevention, in accordance with the waste hierarchy, always offers the greatest carbon savings. **Accounting for the full lifecycle impacts, Navarra's waste carbon intensity amounts to 2.5 tCO_2eq./tonne of waste.** This might be attributed to waste, in particular organic materials, being landfilled instead of recycled. In 2019, only 44% of food waste generated was recycled while the rest was sent to be landfilled.

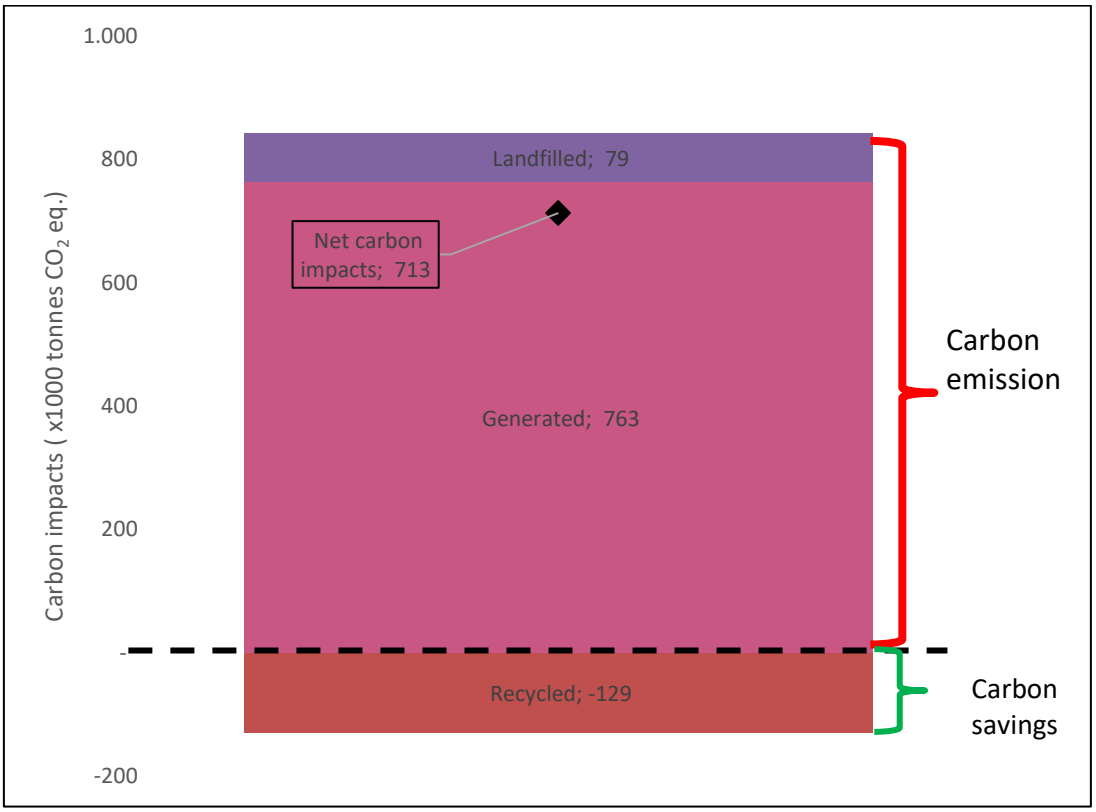


Figure 5 Breakdown of whole-life carbon impacts of waste by stage.

Figure 6 shows that food waste is the most significant fraction in terms of tonnage (nearly 76,000 tonnes) and associated with approximately 156,000 tonnes of CO_2. This is primarily due to the embodied carbon impacts of food products that end up discarded (carbon factor of food production is 2.41 tonne CO_2 eq. per tonne of food), and the significant amount of food waste landfilled as shown in Figure 7. Carbon impacts of landfilling food waste are approximately 23,400 tonne CO_2 eq.

Figure 6 also shows that textile waste is responsible for substantially higher carbon burdens when compared to the amount of textile waste generated.

Further carbon savings can be achieved by capturing more materials (e.g., plastics and healthcare waste[4]) for recycling (Figure 7). Overall, most carbon impacts are attributed to the production of materials (i.e., embodied impacts) in the first place as shown in Figure 8.

Landfilling has a noticeable impact for several waste fractions: food waste, paper and cardboard, healthcare waste (47% of which is composed of disposable nappies), and garden waste. Recycling enables relevant savings for several fractions: food waste (mainly recovered through anaerobic digestion with energy recovery), household waste (consisting for the most part of bulky waste such as furniture and mattresses), and glass waste (recycled in close loop). For all these fractions, diverting waste from landfilling to recycling might have an interesting potential to reduce the total carbon footprint. Focusing on biowaste (i.e., food waste and garden waste) might be relevant, considering that the current sorting rates are average.

For several other fractions, recycled quantities do not generate significant savings. This is the case of textile, whose preparation for re-use rate is only 6%, and plastic waste. For these fractions, focusing on prevention and re-use might prove more relevant. Another possibility would be to explore different recycling routes in particular for “other dense plastics” (representing 27% of the plastic waste), that could be associated with higher savings.

A detailed breakdown of waste tonnages and their impacts is available in Appendix 1 and 2 and can be used to identify areas for improvements in terms of both recycling rates and waste reduction.

[4] The composition of healthcare waste is assumed as follow: 47% disposable nappies, 44% pet excrement and bedding, 6% other absorbent hygiene products, and 3% potentially hazardous healthcare waste.

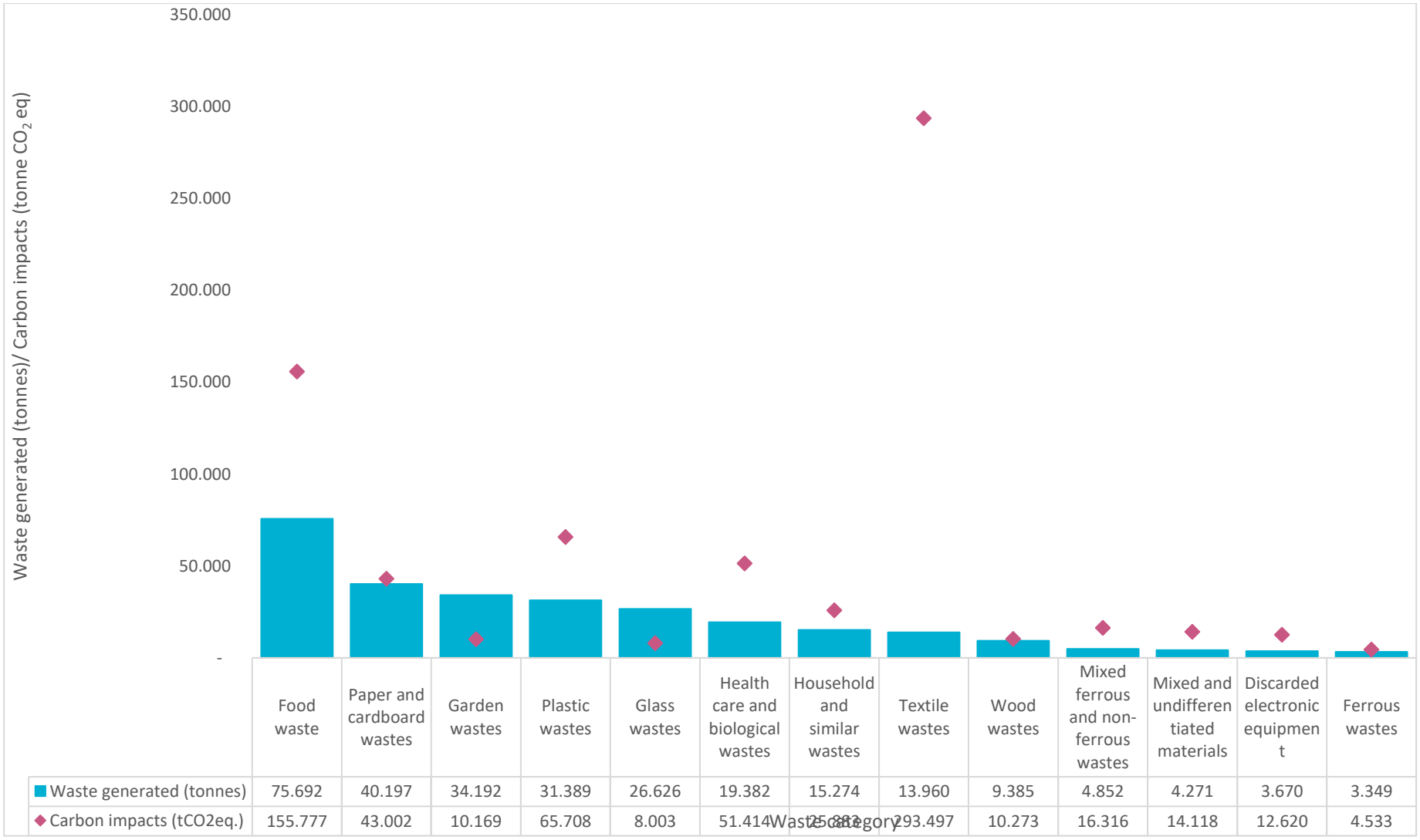
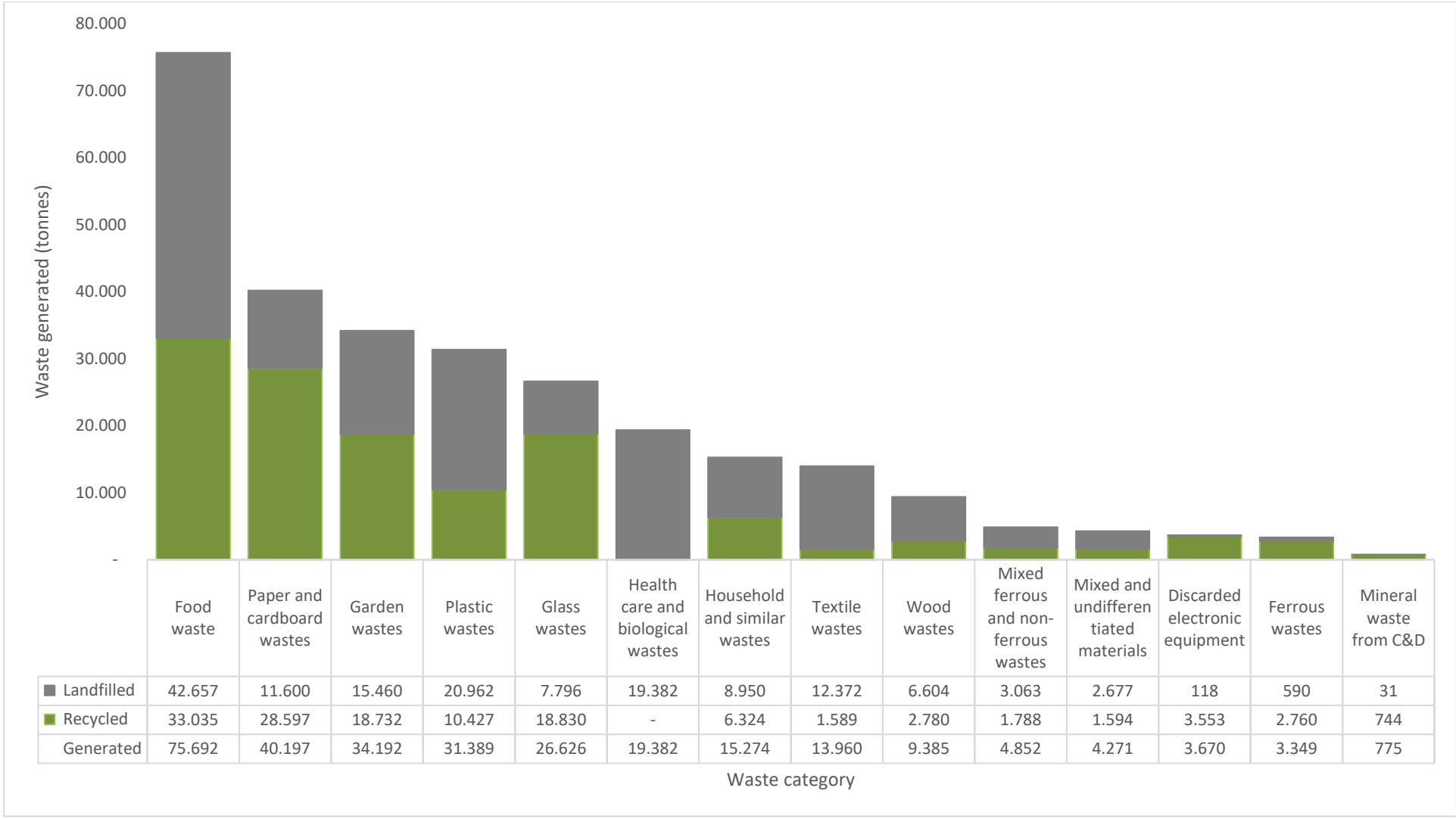
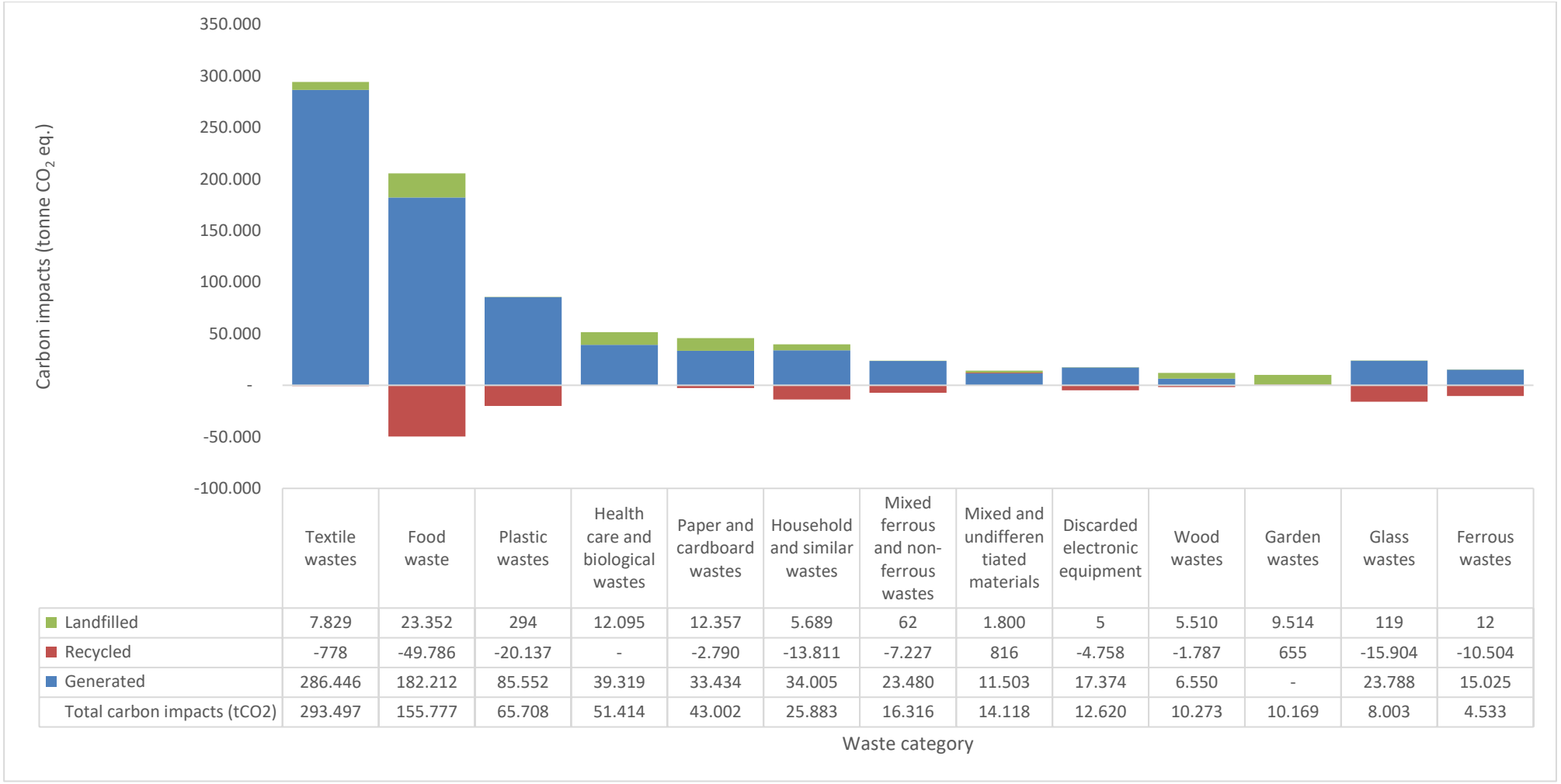


Figure 6 Weight vs carbon impacts of key waste categories in Navarra.



	Food waste	Paper and cardboard wastes	Garden wastes	Plastic wastes	Glass wastes	Health care and biological wastes	Household and similar wastes	Textile wastes	Wood wastes	Mixed ferrous and non-ferrous wastes	Mixed and undifferentiated materials	Discarded electronic equipment	Ferrous wastes	Mineral waste from C&D
Landfilled	42.657	11.600	15.460	20.962	7.796	19.382	8.950	12.372	6.604	3.063	2.677	118	590	31
Recycled	33.035	28.597	18.732	10.427	18.830	-	6.324	1.589	2.780	1.788	1.594	3.553	2.760	744
Generated	75.692	40.197	34.192	31.389	26.626	19.382	15.274	13.960	9.385	4.852	4.271	3.670	3.349	775

Figure 7 Total tonnages of waste (key categories) in Navarra in 2019 by management route.



	Textile wastes	Food waste	Plastic wastes	Health care and biological wastes	Paper and cardboard wastes	Household and similar wastes	Mixed ferrous and non-ferrous wastes	Mixed and undifferentiated materials	Discarded electronic equipment	Wood wastes	Garden wastes	Glass wastes	Ferrous wastes
Landfilled	7.829	23.352	294	12.095	12.357	5.689	62	1.800	5	5.510	9.514	119	12
Recycled	-778	-49.786	-20.137	-	-2.790	-13.811	-7.227	816	-4.758	-1.787	655	-15.904	-10.504
Generated	286.446	182.212	85.552	39.319	33.434	34.005	23.480	11.503	17.374	6.550	-	23.788	15.025
Total carbon impacts (tCO2)	293.497	155.777	65.708	51.414	43.002	25.883	16.316	14.118	12.620	10.273	10.169	8.003	4.533

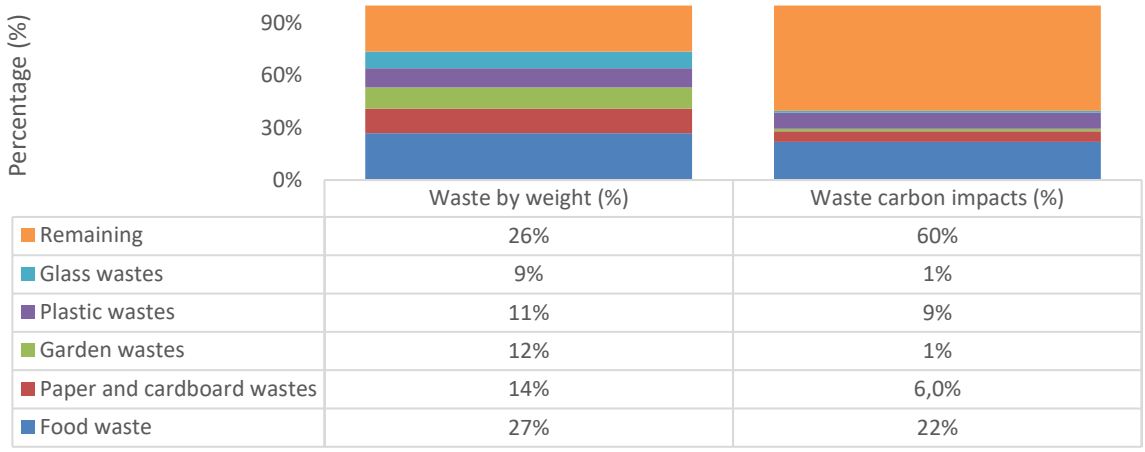
Waste category

Figure 8 Whole-life carbon impacts of key waste categories by management route.

5.2 The Top Five Waste Materials: Weight vs. Carbon Impacts

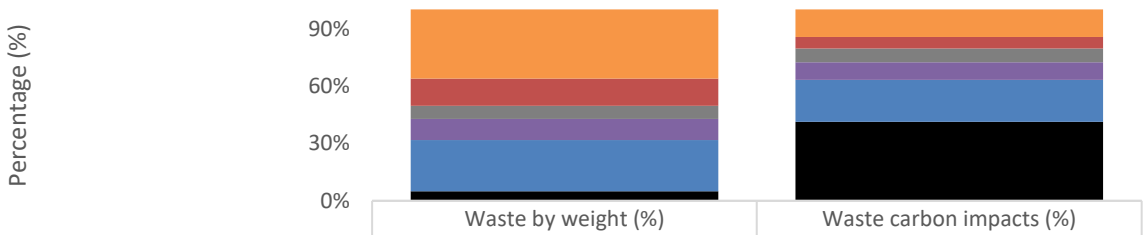
Many of the high tonnage materials in Navarra's waste streams have relatively low carbon impacts (e.g. glass waste accounts for 9% of total waste generated, but just 1% of total carbon impacts). To achieve the 2025 carbon savings target, focus should be placed on the most carbon intensive waste materials, such as **textile, food and plastic wastes.**

The top five waste materials by weight in 2019 accounted for 74% of Navarra's waste, but only 40% of its waste carbon impacts (Figure 9). On the other hand, the top five most carbon intensive waste materials accounted for 64% of the total weight, but 86% of waste carbon impacts (Figure 10). The waste category with the single greatest carbon impact is textile waste, which accounted for 5% of waste by weight but 41% of waste carbon impacts. Other carbon-intensive materials identified are plastic wastes, food wastes, paper & cardboard wastes, and healthcare waste.



	Waste by weight (%)	Waste carbon impacts (%)
Remaining	26%	60%
Glass wastes	9%	1%
Plastic wastes	11%	9%
Garden wastes	12%	1%
Paper and cardboard wastes	14%	6,0%
Food waste	27%	22%

Figure 9 Top five waste materials by weight and their associated carbon impacts.



	Waste by weight (%)	Waste carbon impacts (%)
Remaining	36%	14%
Paper and cardboard wastes	14%	6%
Health care and biological wastes	7%	7%
Plastic wastes	11%	9%
Food waste	27%	22%
Textile wastes	5%	41%

Figure 10 Top five waste materials by carbon impacts and their associated weight.

In addition to prioritising textile waste for waste prevention, re-use, and recycling, our analysis reveals that significant amount of food, and paper & cardboard wastes - both have high waste tonnages and significant carbon impacts - are disposed in landfills. Prioritising these categories in future policy interventions will not only reduce carbon impacts but also increase recycling rates in Navarra considerably.

It is also interesting to analyse the composition of these priority fractions, for which the Region of Navarra provided data. Among these fractions, specific products have a more significant impact, such as:

- Cotton-based fabrics for textiles;
- Meat-based product, which represents 19% of the food waste products;
- LDPE films represent a significant proportion of plastic waste and are not recycled.

Targeting these specific products might be relevant, as their individual contributions are quite significant.

5.3 Scenario analysis

Navarra must reduce its waste carbon impacts by approximately 178,000 tCO_2eq, to a total of 535,000 tCO_2eq by 2025, to achieve the 25% ACR+ target. A scenario analysis was carried out to investigate scenarios that Navarra might use to accomplish this, focusing on waste reduction.

Scenarios considered focus on the following carbon-intensive materials:

1. Textile waste;
2. Food waste;
3. Plastic wastes;
4. Paper and cardboard wastes;
5. Healthcare and biological waste

Table 2 lists scenarios considered in this analysis and their results, also presented in Figure 11.

Table 2 Summary of the scenario analysis results.

Scenario number	Description	Total carbon impacts (Tonnes CO_2eq.)	Reduction rate (%)
Scenario 0	Business as usual	712,800	-
Scenario 1	5 targeted materials - 20% reduction	591,000	-17%
Scenario 2	Textile (30%), food waste (30%), remaining target materials (20%)	546,000	-24%
Scenario 3	Textile (40%), food waste (25%), remaining target materials (20%)	524,500	-26%
Scenario 4	All materials (25%)	534,632	-25%

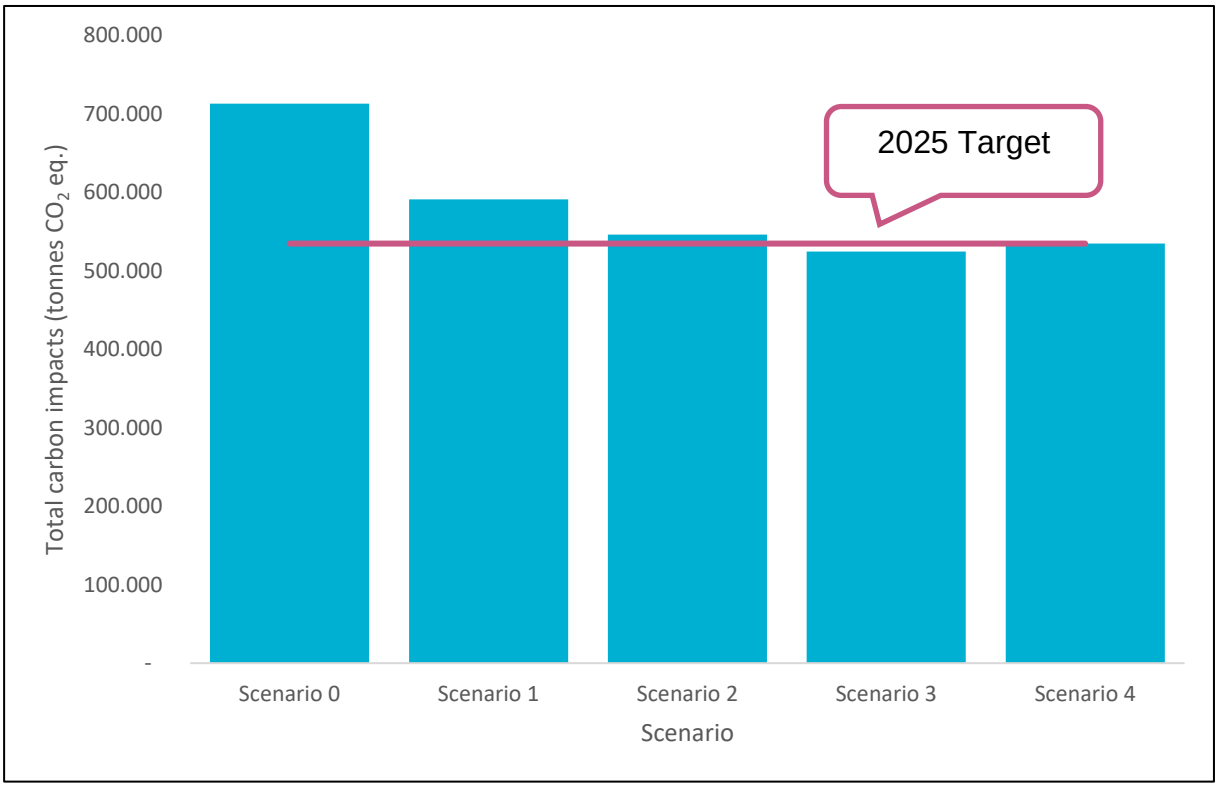


Figure 11 Results of the scenario analysis.

Results, presented in Figure 11, suggest that Navarra can meet the 2025 carbon reduction target by adopting one of the following strategies:

1. Reduce the amount of textile by 40% and food waste by 25%, and other targeted waste materials (i.e., plastics, paper and cardboard, and healthcare waste) by 20%; or
2. Introduce a waste reduction target of 25% for **all** materials.

It is worth mentioning that our analysis is based on waste reduction strategies without considering any improvements in recycling activities (diverting materials from landfilling to recycling). What is more, we only looked at several scenarios that prioritise waste reduction over improvements in waste disposal and treatment activities, considering that waste reduction is the most impactful way to mitigate carbon emissions. Navarra seems to have a great opportunity to increase recycling rates, in particular for food waste as only 44% of food waste is currently recycled (see Appendix 1). Moreover, our analysis shows that nearly 43,000 and 15,500 tonnes of food and garden waste are still landfilled and hence contributing to carbon impacts. Diverting these tonnages for recycling would ultimately lead to high carbon savings. For example, diverting 50% of food and garden waste from landfilling to recycling is expected to achieve carbon savings in the region of 50,000 tonnes.

The availability of data remains a limitation to this study despite Navarra's efforts to gather as much data as possible. Data gaps have been addressed by using default assumptions based

on the Scottish Carbon Metric[5]. Assumptions made by the analysis team include substitution rate (amount of virgin material offset by recycling), the composition of mixed waste stream (e.g., residual waste), and upstream transport assumptions.

It is also strongly recommended to undertake further work to gather Navarra's specific granular data, in particular for high-carbon materials such as food and textile wastes. This will help the analysis team to develop bespoke carbon factors to accurately quantify the carbon impacts of waste generated and managed in the region.

CONCLUSION

The 2019 carbon impacts of household waste in Navarra are assessed by the Carbon Metric at approximately 713,000 tonnes of carbon dioxide equivalent (tCO_2eq.), or 0.4 tCO_2eq per capita.

To achieve a 25% reduction by 2025 as part of the ACR+ 'More Circularity Less Carbon' campaign, the region must reduce its waste carbon impacts by approximately 178,000 tCO_2eq, to a total of 535,000 tCO_2eq by 2025.

Several scenarios, that focus on waste prevention measures, have been investigated in this report to explore pathways for Navarra to achieve the 2025 target. It seems that significant efforts on waste reduction will be necessary to do so, addressing key fractions such as textiles, food, and plastic wastes.

Follow-up activities might include further investigation on the actual composition of carbon intensive materials as discussed previously and current management routes of the top 5 targeted materials, as well as the identification of actions and policies that could contribute to reach the aforementioned reduction targets. Moreover, a comparison with the analysis carried out for the other participants to the MCLC campaign will help to put the figures obtained in perspective.

[5] Zero Waste Scotland (2020) The Carbon Footprint of Scotland's Waste Technical Report [Online]. Available at: www.zerowastescotland.org.uk/

APPENDICES

Appendix 1 Total amount of waste generated in Navarra (2019). Unit: tonnes

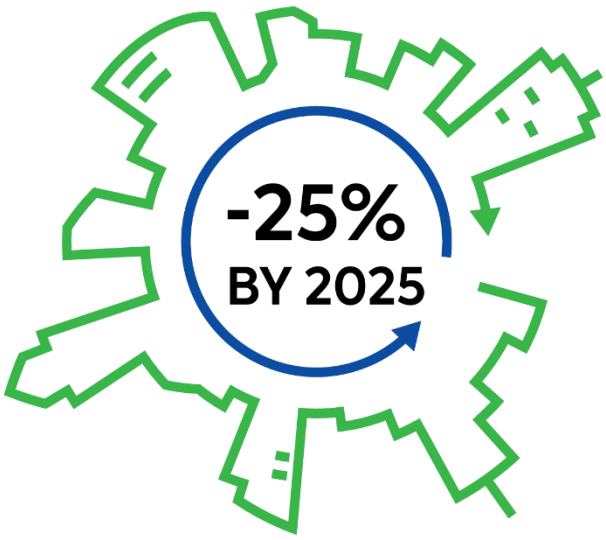
Waste category	Generated	Recycled	Incinerated	Landfilled
Acid, alkaline or saline wastes	-	-	-	-
Food waste	75,692	33,035	-	42,657
Animal faeces, urine and manure	-	-	-	-
Batteries wastes	82	82	-	-
Chemical wastes	11	11	-	0
Combustion wastes	-	-	-	-
Common sludges	-	-	-	-
Discarded electronic equipment	3,670	3,553	-	118
Discarded vehicles	-	-	-	-
Dredging spoils	-	-	-	-
Glass wastes	26,626	18,830	-	7,796
Health care and biological wastes	19,382	-	-	19,382
Household and similar wastes	15,274	6,324	-	8,950
Industrial effluent sludges	-	-	-	-
Ferrous wastes	3,349	2,760	-	590
Mixed ferrous and non-ferrous wastes	4,852	1,788	-	3,063
Non-ferrous wastes	366	362	-	3
Mineral waste from C&D	775	744	-	31
Mineral wastes from waste treatment and stabilised wastes	-	-	-	-
Mixed and undifferentiated materials	4,271	1,594	-	2,677
Other mineral wastes	-	-	-	-
Paper and cardboard wastes	40,197	28,597	-	11,600
Plastic wastes	31,389	10,427	-	20,962
Spent solvents	100	96	-	4
Textile wastes	13,960	1,589	-	12,372
Used oils	33	32	-	1
Garden wastes	34,192	18,732	-	15,460
Waste containing PCB	-	-	-	-
Wood wastes	9,385	2,780	-	6,604
Grand Total	**283,605**	**131,335**	**-**	**152,271**

Appendix 2 Whole-life carbon impacts of waste generated in Navarra (2019).

	Unit: tonne CO2 eq.			
Waste category	**Generated**	**Recycled**	**Incinerated**	**Landfilled**
Acid, alkaline, or saline wastes	0	0	-	0
Food waste	182,212	-49,786	-	23,352
Animal faeces, urine, and manure	0	0	-	0
Batteries wastes	466	-76	-	0
Chemical wastes	13	45	-	0
Combustion wastes	0	0	-	0
Common sludges	0	0	-	0
Discarded electronic equipment	17,374	-4,758	-	5
Discarded vehicles	0	0	-	0
Dredging spoils	0	0	-	0
Glass wastes	23,788	-15,904	-	119
Health care and biological wastes	39,319	0	-	12,095
Household and similar wastes	34,005	-13,811	-	5,689
Industrial effluent sludges	0	0	-	0
Ferrous wastes	15,025	-10,504	-	12
Mixed ferrous and non-ferrous wastes	23,480	-7,227	-	62
Non-ferrous wastes	3,661	-2,980	-	0
Mineral waste from C&D	283	4	-	0
Mineral wastes from waste treatment and stabilised wastes	0	0	-	0
Mixed and undifferentiated materials	11,503	816	-	1,800
Other mineral wastes	0	0	-	0
Paper and cardboard wastes	33,434	-2,790	-	12,357
Plastic wastes	85,552	-20,137	-	294
Rubber wastes	0	0	-	0
Sludges and liquid wastes from waste treatment	0	0	-	0
Soils	0	0	-	0
Sorting residues	0	0	-	0
Spent solvents	97	0	-	0
Textile wastes	286,446	-778	-	7,829
Used oils	40	-22	-	0
Garden wastes	0	655	-	9,514
Waste containing PCB	0	0	-	0
Wood wastes	6,550	-1,787	-	5,510
Grand Total	**763,248**	**-129,042**	-	**78,636**

Appendix 3 Carbon factors for of household waste generated in Navarra (2019).

Waste category	Unit: tonne CO2 eq. per tonne of waste			
	Generated	Recycled	Incinerated	Landfilled
Acid, alkaline, or saline wastes	2.01	0.00	N/A	0.00
Food waste	2.41	-1.51	N/A	0.55
Animal faeces, urine, and manure	0.00	0.00	N/A	0.00
Batteries wastes	5.69	-0.92	N/A	0.10
Chemical wastes	1.16	4.20	N/A	0.12
Combustion wastes	0.00	0.00	N/A	0.01
Common sludges	0.00	0.00	N/A	0.00
Discarded electronic equipment	4.73	-1.34	N/A	0.04
Discarded vehicles	6.57	-2.24	N/A	0.00
Dredging spoils	0.00	0.00	N/A	0.00
Glass wastes	0.89	-0.84	N/A	0.02
Health care and biological wastes	2.03	0.00	N/A	0.62
Household and similar wastes	2.23	-2.18	N/A	0.64
Industrial effluent sludges	0.00	0.00	N/A	0.00
Ferrous wastes	4.49	-3.81	N/A	0.02
Mixed ferrous and non-ferrous wastes	4.84	-4.04	N/A	0.02
Non-ferrous wastes	10.01	-8.22	N/A	0.02
Mineral waste from C&D	0.37	0.00	N/A	0.01
Mineral wastes from waste treatment and stabilised wastes	0.00	0.00	N/A	0.00
Mixed and undifferentiated materials	2.69	0.51	N/A	0.67
Other mineral wastes	0.00	0.00	N/A	0.00
Paper and cardboard wastes	0.83	-0.10	N/A	1.07
Plastic wastes	2.73	-1.93	N/A	0.01
Rubber wastes	2.76	-1.28	N/A	0.01
Sludges and liquid wastes from waste treatment	0.00	0.00	N/A	0.00
Soils	0.01	0.00	N/A	0.02
Sorting residues	0.00	0.00	N/A	0.57
Spent solvents	0.97	0.00	N/A	0.00
Textile wastes	20.52	-0.49	N/A	0.63
Used oils	1.22	-0.70	N/A	0.00
Garden wastes	0.00	0.03	N/A	0.62
Waste containing PCB	0.00	0.00	N/A	0.00
Wood wastes	0.70	-0.64	N/A	0.83



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