



UNIVERSITÀ DEGLI STUDI DI MILANO

DIPARTIMENTO DI SCIENZE AGRARIE E AMBIENTALI
DEPARTMENT OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Evaluating the Sustainability of Food Redistribution through Urban Food Hubs

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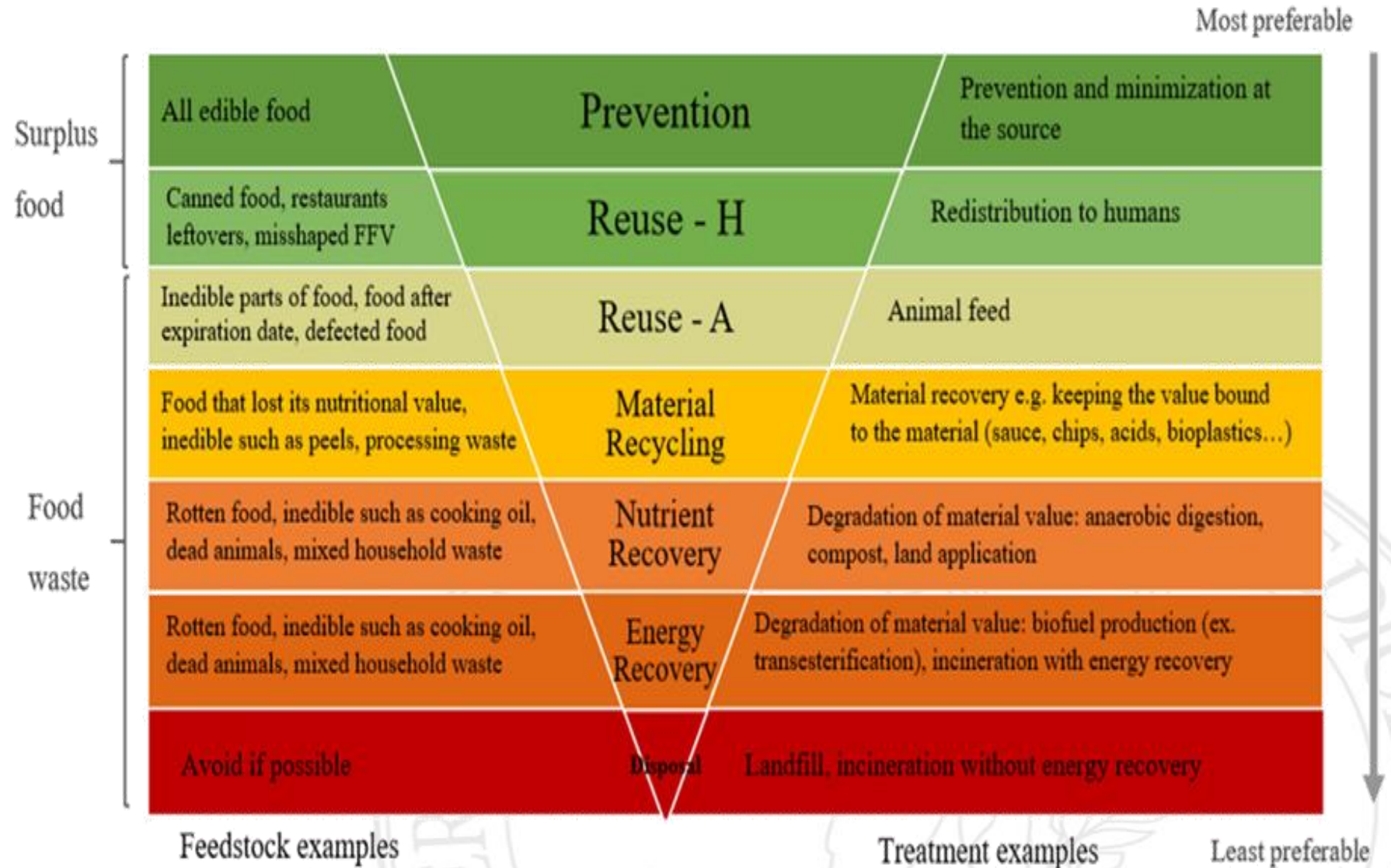
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Introduction

One third of the food produced globally, every year is wasted



Waste hierarchy pyramid. (Teigiserova et al., 2020)

Introduction

The greenhouse gas emissions associated with each waste management option and each food type.

Scenario/food product	Banana(kg CO ₂ e/kg food waste)	Chicken(kg CO ₂ e/kg food waste)	Lettuce(kg CO ₂ e/kg food waste)	Beef(kg CO ₂ e/kg food waste)	Bread(kg CO ₂ e/kg food waste)
Landfill	1.4	3.1	0.21	2.1	1.9
Incineration	0.10	-0.31	0.25	0.003	-0.67
Composting	0.043	0.043	0.043	0.043	0.043
Anaerobic digestion	-0.38	-0.26	-0.047	-0.67	-0.55
Animal feed	-0.011	-0.038	0.005	-0.030	-0.13
Donation	-0.12	-0.35	-0.013	-0.31	-0.61

The greenhouse gas emission associated with each waste management option ad each food type. (Eriksson et al., 2015).

Scope

To assess the environmental, economic and social impacts associated with the recovery of surplus food and its redistribution for human consumption through the model of urban food hubs



Materials and Methods



New service: donation as a strategy for the valorization and management of surplus food from GDO

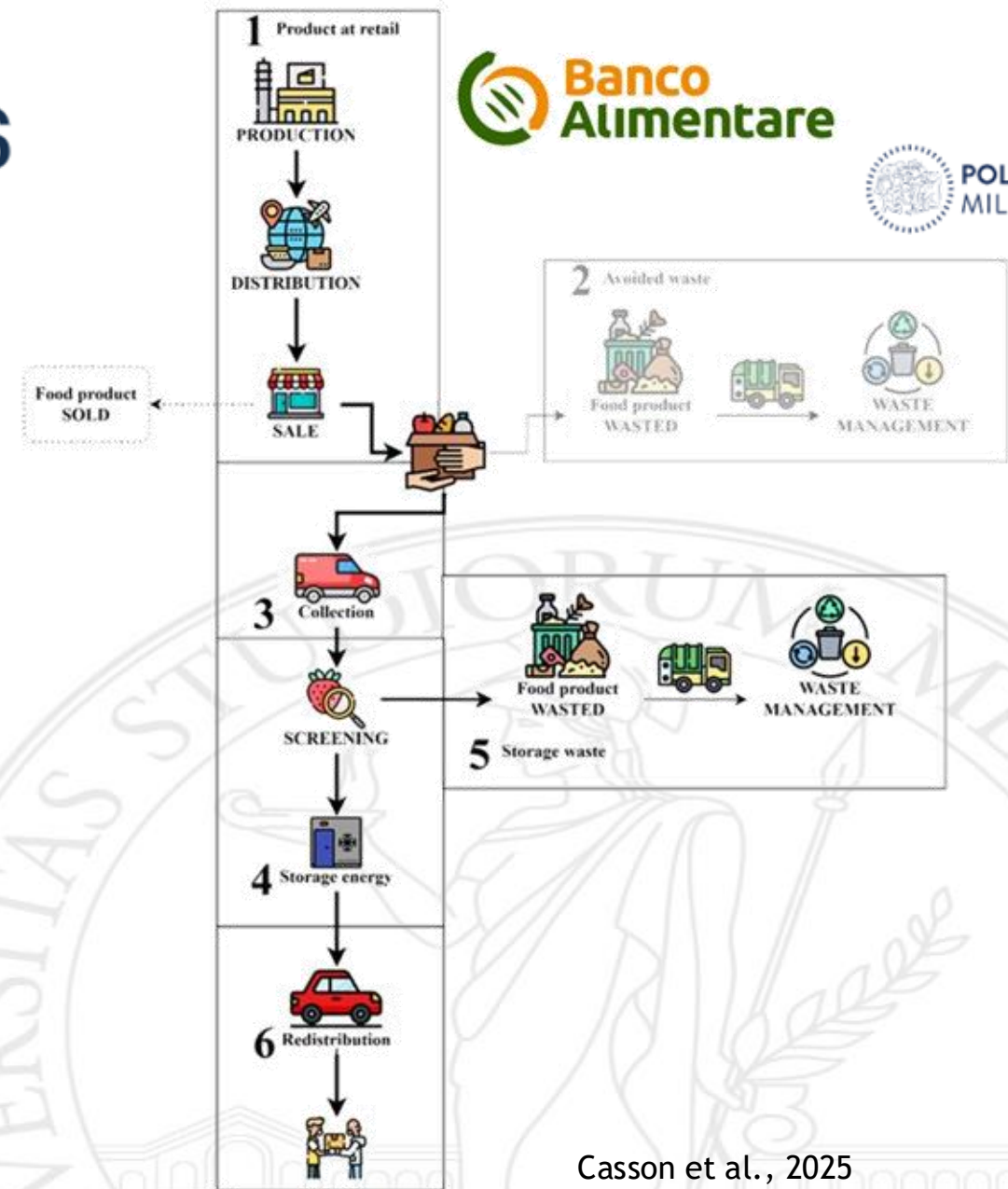
Hubs: Lambrate and Isola (31 months)

Functional unit: service provided by one hub in an average year.

-Environmental Impact (LCA): Simapro (ISO 14040:2021; ISO 14044:2021)

-Economic Impact: Annual net economic benefit analysis

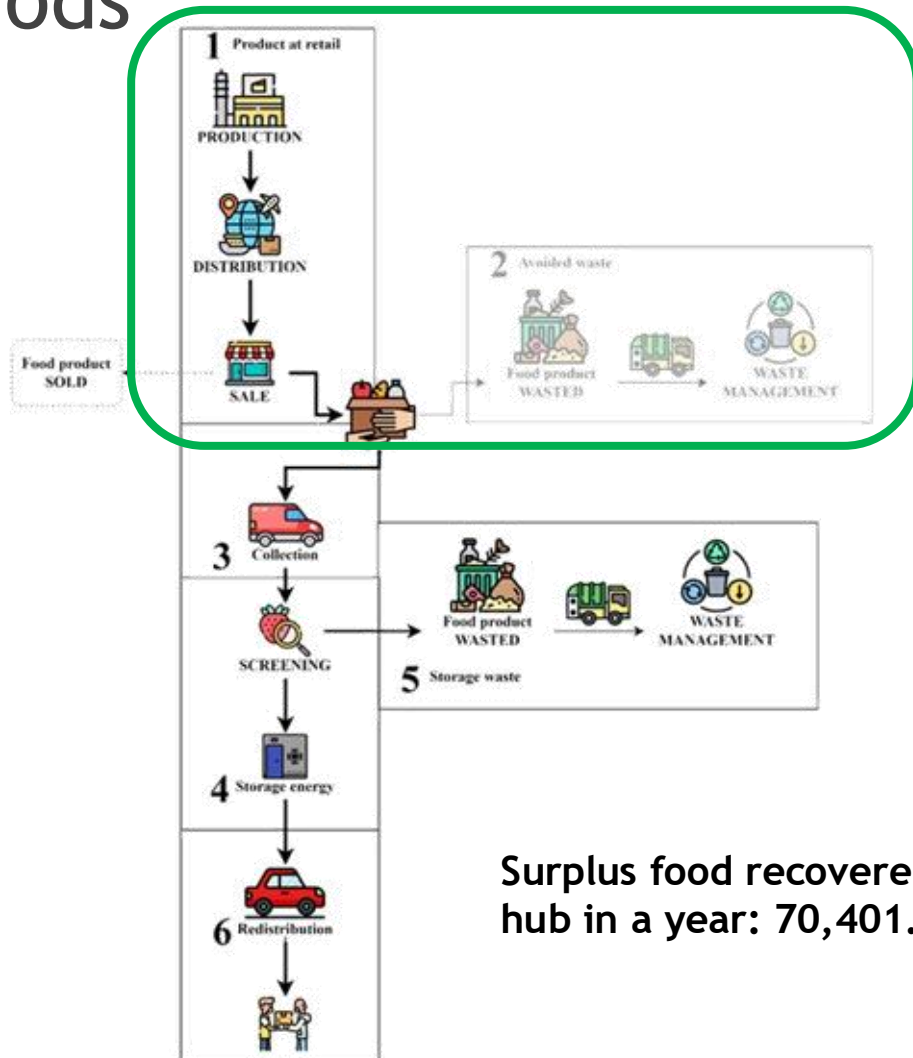
-Social Impact: Social sustainability indicators evaluation



Casson et al., 2025



Materials and Methods

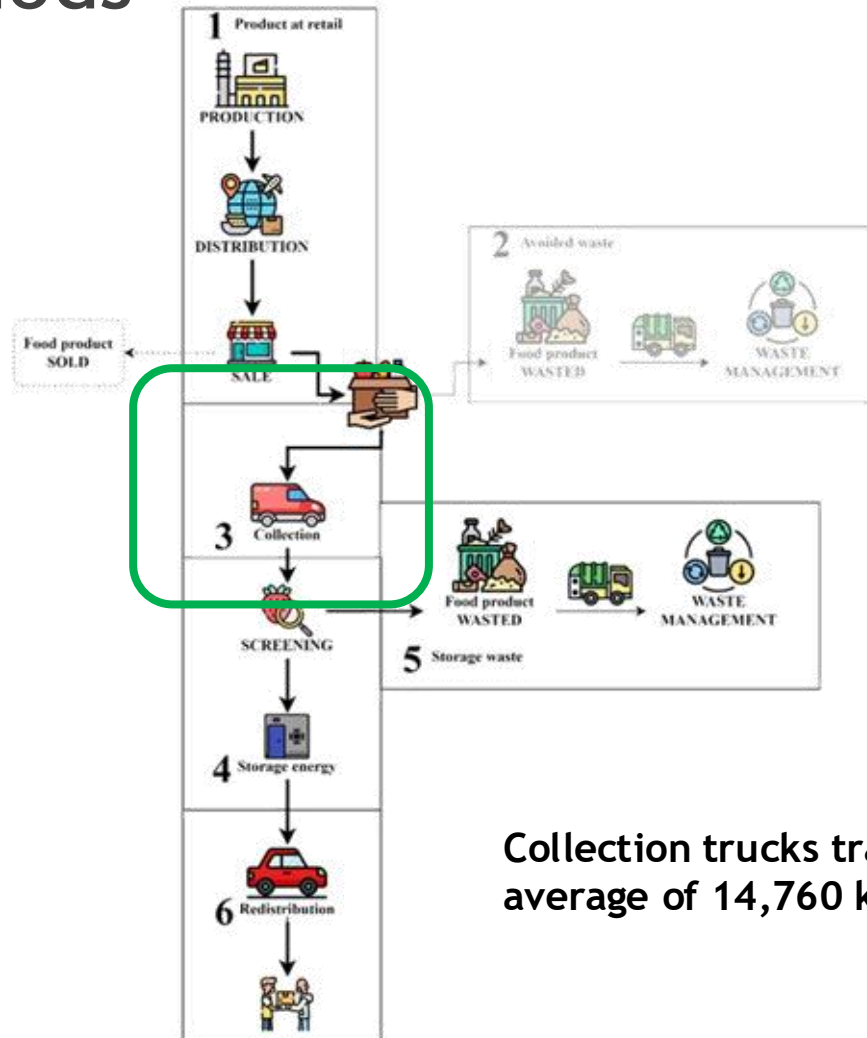


Surplus food recovered by one hub in a year: 70,401.68 kg

Environmental impact: carbon credits from recovering surplus food and from the avoided waste.

Economic impact: the surplus donated represented an economic credit. It is represented by the average sale price reported by retailers, and the savings related to the avoided food waste management for the retailer.

Materials and Methods



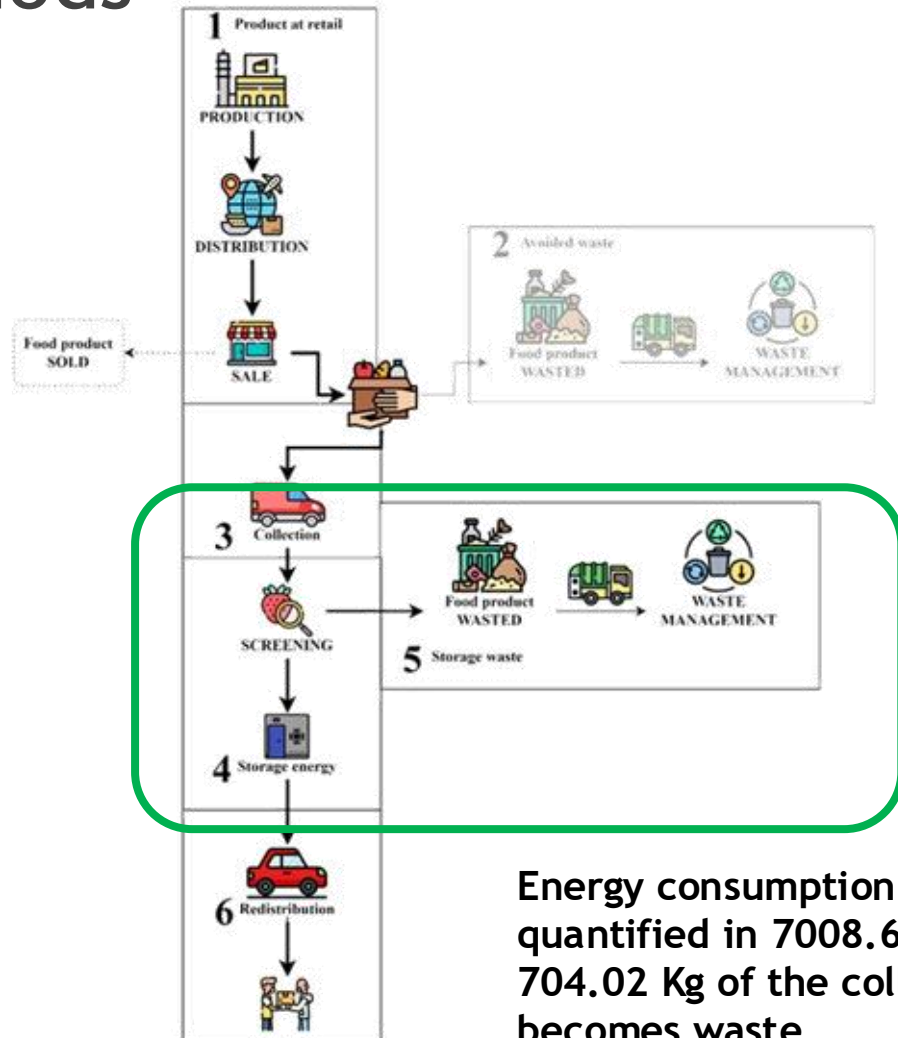
Collection trucks travel an average of 14,760 km/year

Collection is performed once a week.

Environmental impact: For each collection round, the corresponding emissions were calculated, considering the use of refrigerated transport.

Economic impact: the Automobile Club d'Italia (ACI) platform was used to estimate the average cost per km for the vehicle used, yielding a value of 0.36 €/km.

Materials and Methods



Energy consumption was quantified in 7008.62 kWh/year. 704.02 Kg of the collected food becomes waste.

Storage - energy.

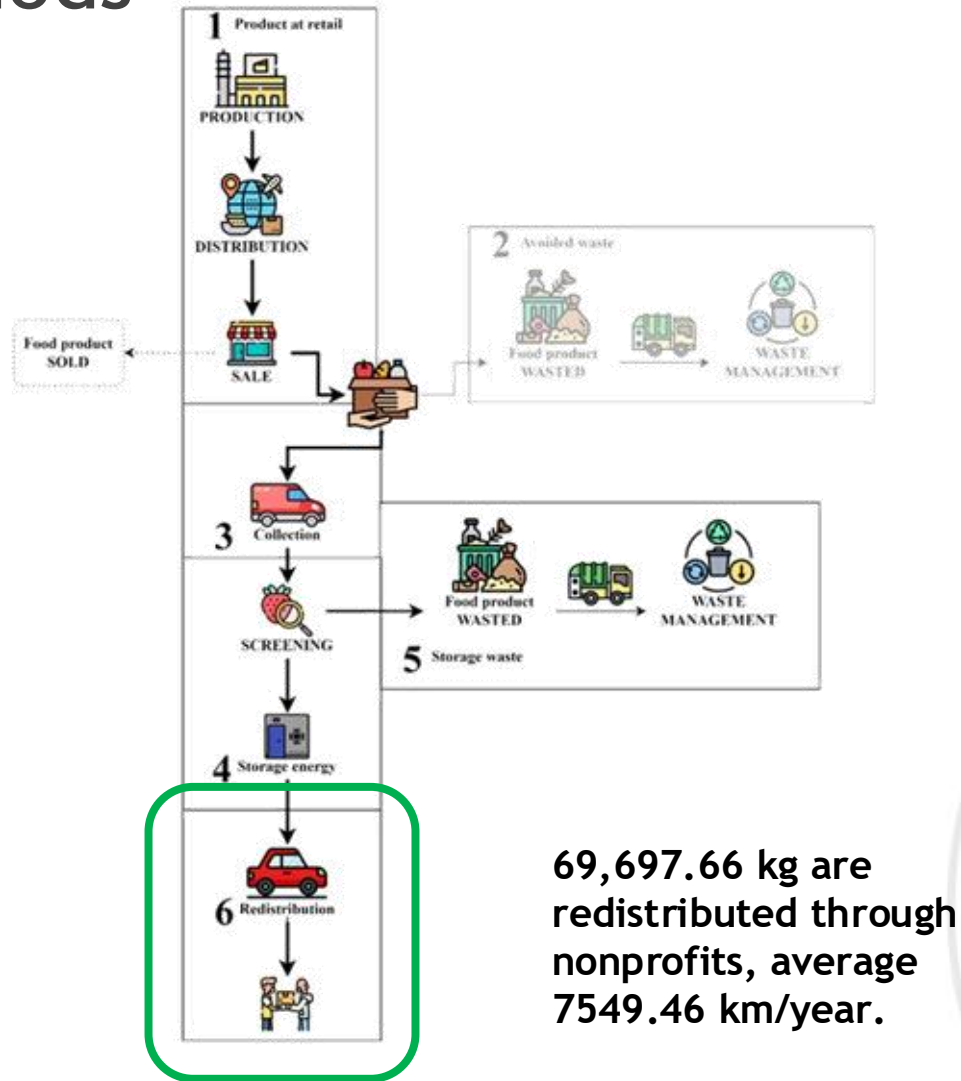
Environmental impact: obtained from energy bills of the hubs

Economic impact: the national average cost per kWh was used for the economic evaluation.

Storage: waste.

1% of recovered food becomes waste after the hub's quality checks at the hubs. Through the municipal waste management system, waste collection trucks travel an average of 30 km and deliver food products for treatment (50 % composted and 50 % biogas).

Materials and Methods

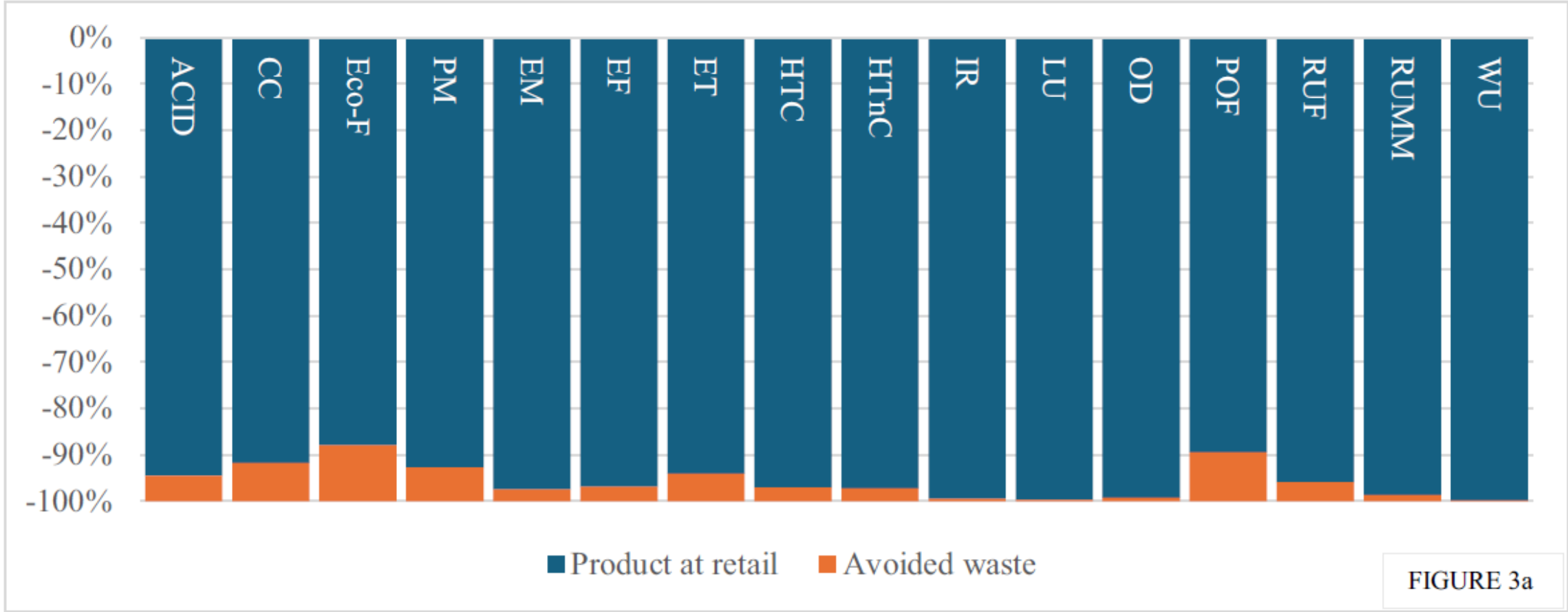


Environmental impact: the average distance covered by front-line organizations was calculated through Google Maps, and transport was modelled using representative data of petrol-powered and diesel-powered cars (Euro 5), based on data from the Ecoinvent 3.10 database

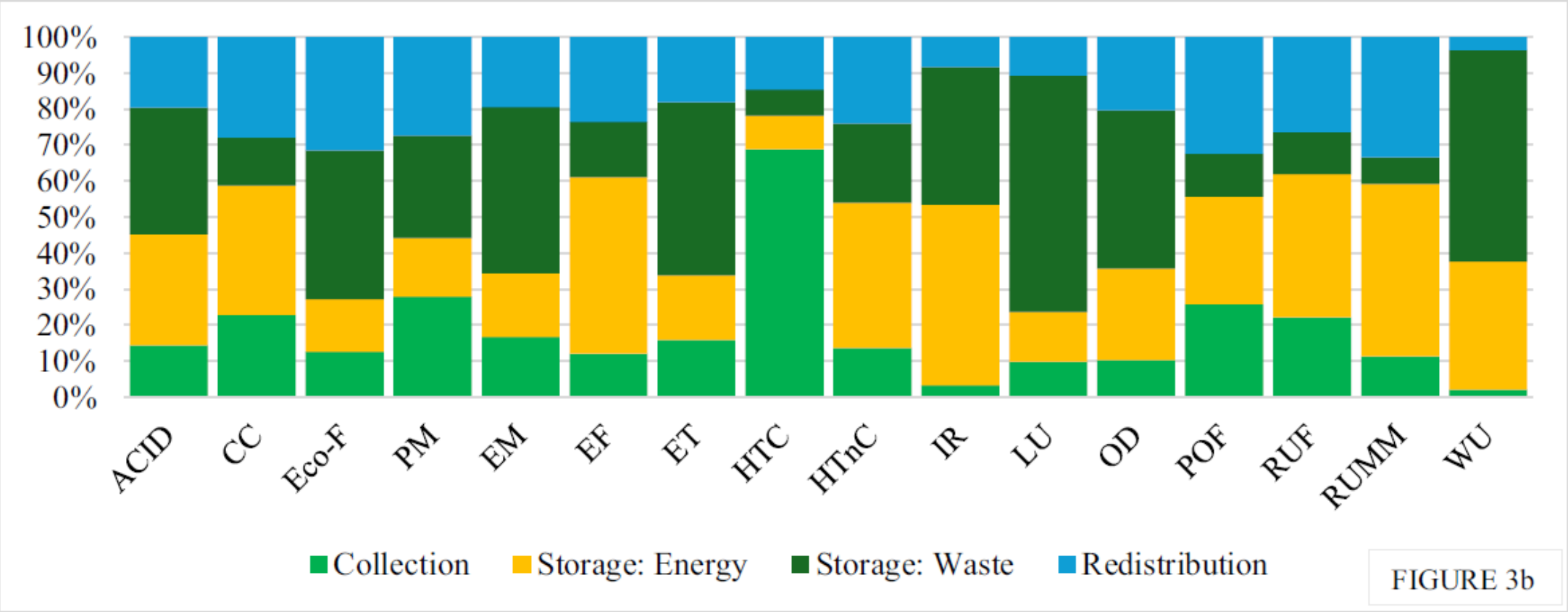
Economic Impact: modelled using ACI tables and an average of 0.45 €/km was identified as cost.

Social impact: 500 g of food is identified as an equivalent dish by the Italian Reference Nutrient Intake Levels (LARN). This value was used as a reference for the calculation of the social impact

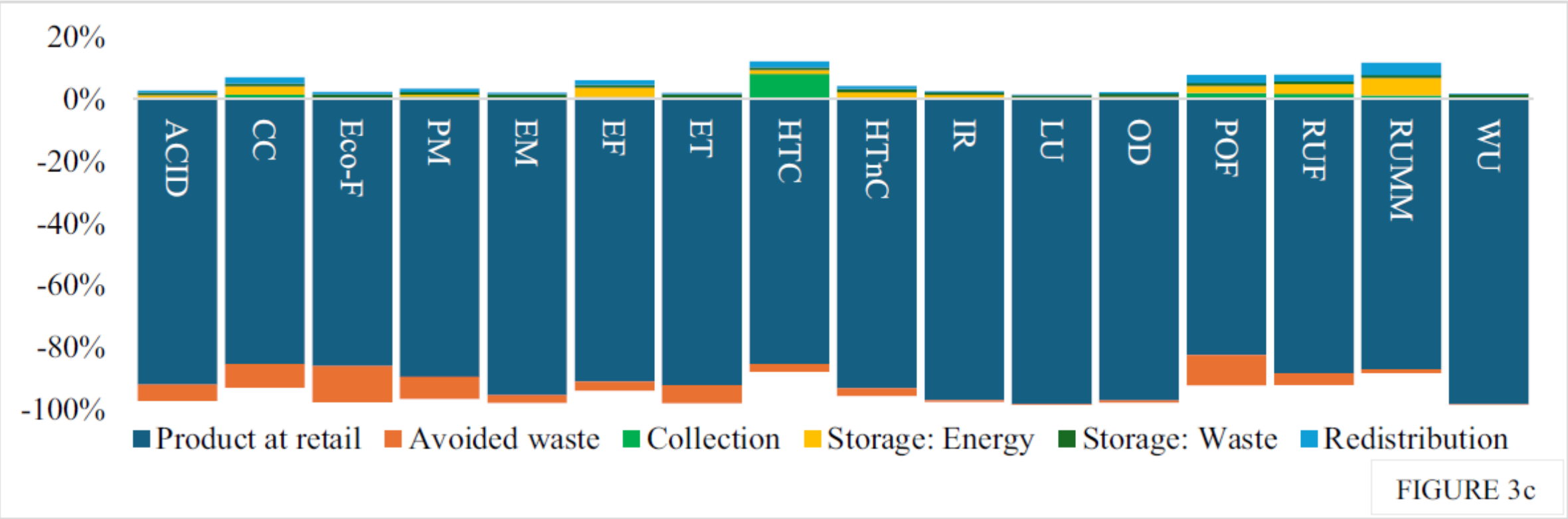
Results: Environmental Impact (credits)



Results: Environmental Impact (debts)



Results: Environmental Impact



On average, one food hub in a year saves **107 t CO₂ eq** (CC), $3.19 \times 10^5 \text{ m}^3$ deprived WU and 7.06×10^6 Points (Pt) LU

Results: Economic Impact

Economic impact assessment expressed per functional unit. The last row reports the overall balance (benefits minus costs).

		2022		2023		2024	
		Isola	Lambrate	Isola	Lambrate	Isola	Lambrate
Benefits							
Product class	Unit of measure						
Various dry	€	7704.40	7286.57	8115.12	7123.48	5034.82	2218.00
Bread	€	76,559.56	72,407.60	56,128.10	67,700.48	42,862.62	49,082.27
Bakery	€	32,898.00	31,113.89	26,860.96	33,762.96	17,295.60	17,652.88
Fruit & vegetables	€	138,573.81	131,058.72	86,890.50	168,794.28	81,117.50	73,293.07
Meat	€	32,131.13	30,388.60	30,342.08	23,641.85	24,270.27	11,982.28
Fish	€	1445.71	1367.30	2056.98	202.33	1028.49	505.82
Cooked food	€	40,315.33	38,128.96	14,363.71	33,563.27	9114.40	51,072.98
Dairy	€	31,453.95	29,748.15	37,686.27	18,858.23	21,116.63	10,241.29
A. Total	€	361,081.88	341,499.79	262,443.72	353,646.90	201,840.33	216,048.59
Avoided cost category							
Waste management avoided unitary costs	€/kg	0.12	0.12	0.12	0.12	0.12	0.12
B. Waste management avoided costs	€	8999.16	8511.12	6375.00	9610.92	5261.76	4891.08
Costs							
Cost category	Unit of measure						
Collection – Unitary vehicle cost	€/km	0.36	0.36	0.36	0.36	0.36	0.36
Distances covered	Km	14,640	14,880	14,640	14,880	8540	8680
C. Collection– Vehicle cost	€	5270.40	5356.80	5270.40	5356.80	3074.40	3124.80
D. Collection – Driver cost	€	16,000	16,000	16,000	16,000	9333	9333
Storage – Unitary electricity costs	€/kWh	0.7	0.7	0.38	0.38	0.37	0.37
Electricity consumption	kWh	7008	7008	7008	7008	4088	4088
E. Storage – Electricity cost	€	4905.60	4905.60	2663.04	2663.04	1512.56	1512.56
Redistribution – Unitary vehicle cost	€/km	0.45	0.45	0.45	0.45	0.45	0.45
Distances covered	Km	6730	8369	6730	8369	3926	4882
F. Redistribution-Vehicle cost	€	3028.50	3766.05	3028.50	3766.05	1766.63	2196.86
TOTAL COSTS	€	29,204.50	30,028.45	26,961.94	27,785.89	15,686.92	16,167.56
Economic balance (A + B-C-D-E-F)	€	340,876.54	319,982.46	241,856.78	335,471.93	191,415.17	204,772.11



Results: Social Impact

Table 6

Social impact assessment expressed per functional unit.

	2022		2023		2024	
	Isola	Lambrate	Isola	Lambrate	Isola	Lambrate
						Product class
<i>Dry/various</i>	1608	1521	1694	1487	1051	463
<i>Bread</i>	13,159	12,445	9647	11,636	7367	8436
<i>Bakery</i>	2026	1916	1654	2079	1065	1087
<i>Fruit and vegetables</i>	46,879	44,337	29,395	57,103	27,442	24,795
<i>Meat</i>	3784	3578	3573	2784	2858	1411
<i>Fish</i>	86	81	122	12	61	30
<i>Cooked food</i>	2243	2121	799	1867	507	2841
<i>Dairy</i>	5209	4926	6241	3123	3497	1696
<i>Total</i>	74,993	70,926	53,125	80,091	43,848	40,759
<i>Waste</i>	750	709	531	801	438	408
Net redistributed	74,243	70,217	52,594	79,290	43,410	40,351
Equivalent meals	148,486	140,433	105,188	158,580	86,819	80,703
Beneficiaries	3800	2200	3800	2200	3800	2200
Meals per beneficiary	39.01	63.83	27.64	72.08	22.81	36.68

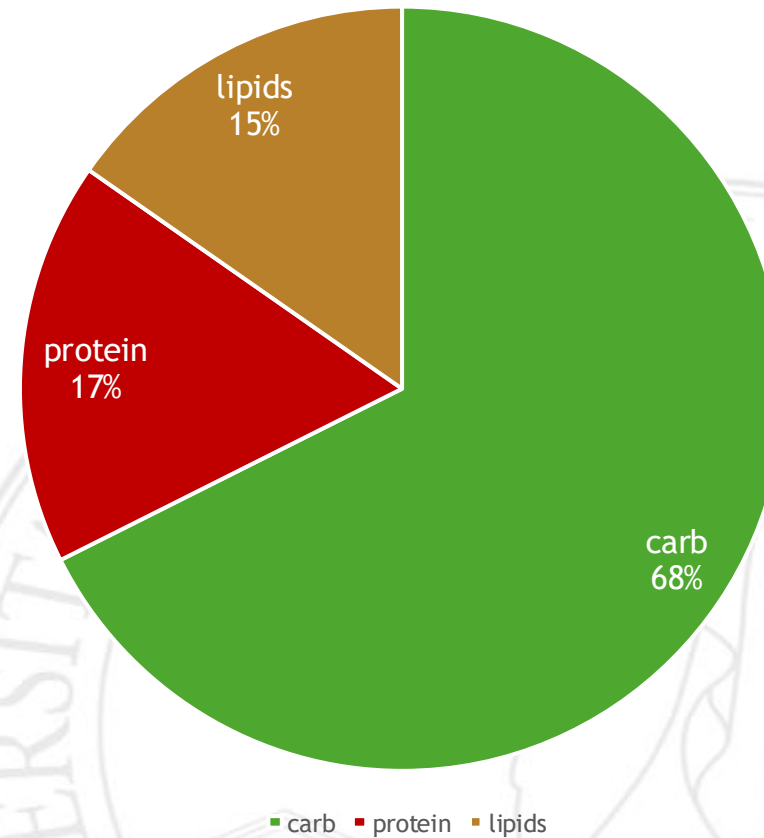


Results: Social Impact

LARN values :

- Carbohydrates: 45-60%
- Proteins: 10-20%
- Lipids: 25-35%

calories distribution



Results:

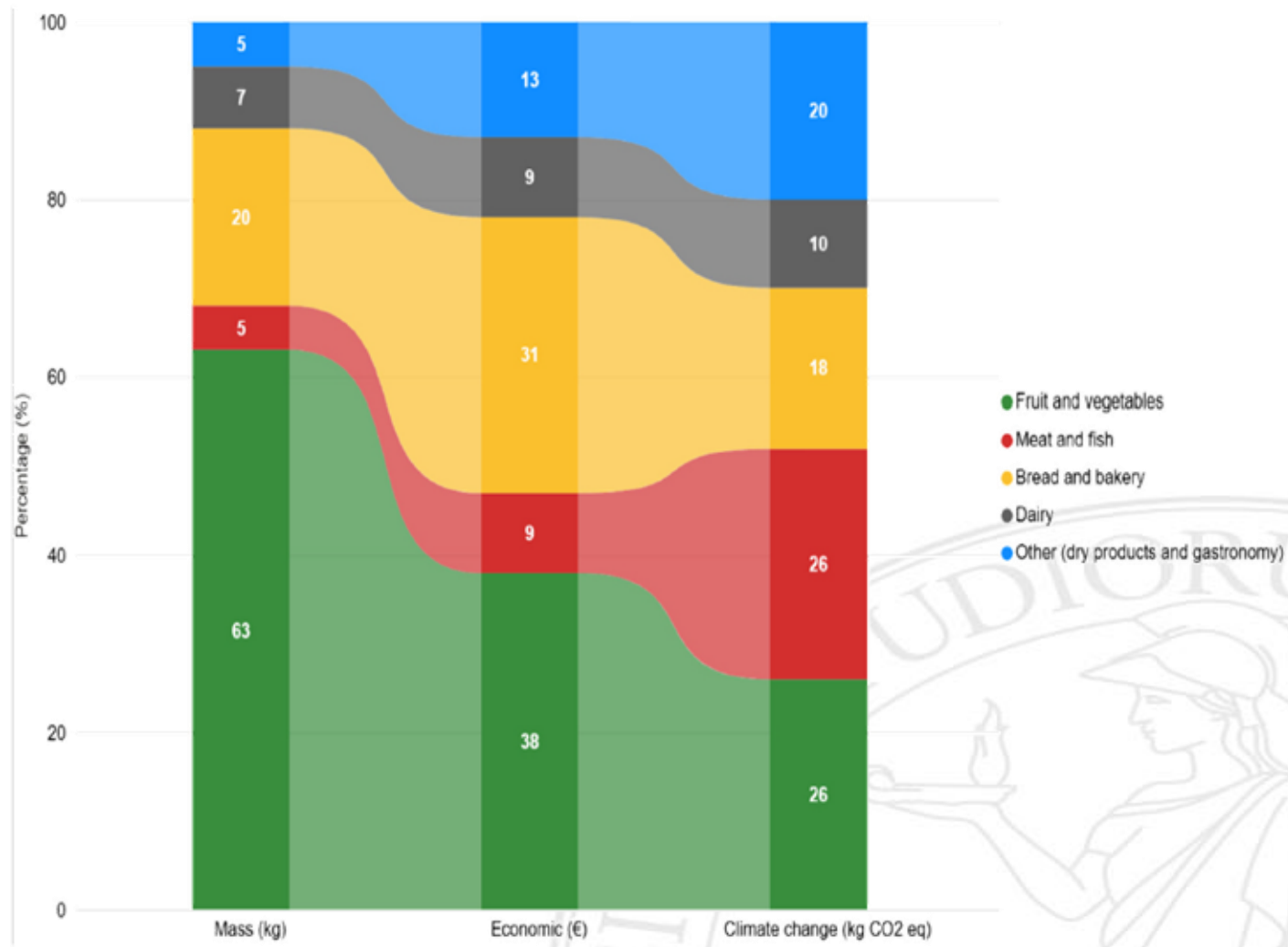


Fig. 5. Recovered and redistributed food from the food hubs: Meal composition, recovered economic value, contribution to climate change for each aggregated food category as per functional unit.

The first part of the graph shows the distribution in terms of mass, showing the percentage composition of an average meal. The second part shows the percentage contribution of each aggregated food category regarding the economic credits recovered. The third part shows the environmental credits for each aggregated food category, referring to Climate Change only. Percentages are rounded to the closest integer value.

Conclusion:

Summary of main environmental, economic and social sustainability indicators. Every indicator is expressed per functional unit.

Sustainability dimension	Key indicators
<i>Environmental</i>	107 t of CO ₂ eq credits Positive outcomes across all categories of environmental impact
<i>Economic</i>	336,109 € in redistributed food products 316,331 € in net economic value generated The ratio between economic value recovered and total costs equal to 11.91 (12.21 when including savings in waste management costs)
<i>Social</i>	More than 3000 beneficiaries served 69.7 t recovered, equivalent to 139,395 meals redistributed (46.5 per beneficiary)



Future perspective

- Educate children
- Optimize transportation phases of the new service
- Create a network, between the hubs, based on macronutrient.



Thanks for your attention.

