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Door-to-door paper waste collection: a case study of cost and ergonomics optimisation

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11 SUSTAINABLE CITIES
AND COMMUNITIES



12 RESPONSIBLE
CONSUMPTION
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A framework for sustainability assessment and prioritisation of urban waste prevention measures

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EVOLUTION OF THE URBAN WASTE MANAGEMENT SYSTEM IN THE EMILIA-ROMAGNA REGION

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Door-to-door waste collection: A framework for the socio – Economic evaluation and ergonomics optimisation

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AGENDA

LITERATURE REVIEW

MATERIALS AND METHOD

CASE STUDY

RESULTS

CONCLUSIONS

REFERENCES



LITERATURE REVIEW (1/3)

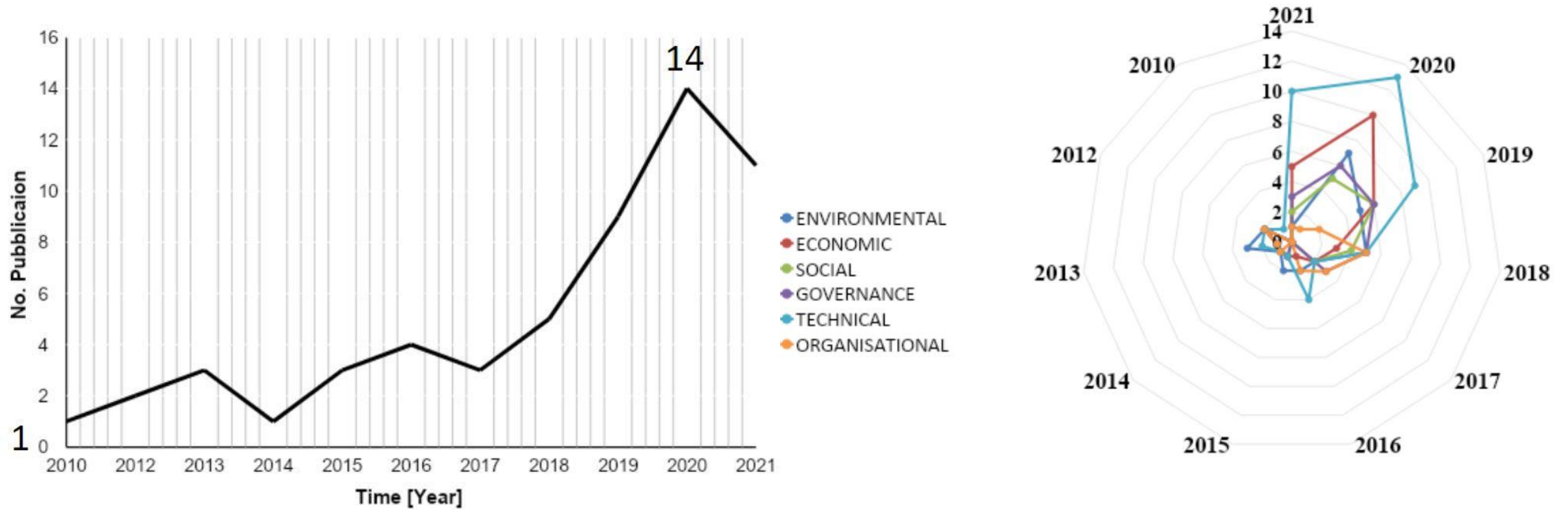


Figure 1. Overview of the number of publications over a time frame of 12 years (left), split into the sustainability aspects (right).



LITERATURE REVIEW (2/3)

A recent review on ergonomic interventions among waste collection workers cites **15 studies** on the occupational health, developed in **Europe** (Francis et al., 2019).

Specifically, questionnaires and medical examinations have reported:

- **musculoskeletal disorders (MSDs)** (Engkvist et al. 2011, Jozwiak et al., 2013, Francis et al., 2019)
- **liver disorders, Hepatitis A** (Dounias and Rachiotis, 2006; Rachiotis et al., 2016, Battini et al. 2018, Botti et al. 2020)
- **Hepatitis B** (Dounias et al., 2005)
- **respiratory problems** and **cardiovascular diseases** (Bünger et al., 2000, Athanasiou et al., 2010, Garrido et al., 2015, Vimercati et al., 2016).

National data from Italy show that **MSDs** are the main type of recognised Occupational Diseases and they have apparently stabilised since 2012, after growing continuously over recent years (EASHW, 2019).



LITERATURE REVIEW (3/3)

Considering the waste collection systems, literature (Lu et al., 2020, Botti et al., 2020, Benito et al., 2021) agrees on selecting as **efficiency indicators** the:

- i) **cost of the service**
- ii) **tons of waste collected in the municipality**
- iii) **number of containers per collection route**
- iv) **frequency of collection**



MATERIALS AND METHOD (1/2)

Aspects	Object of the analysis	Selected indicators
Technical and ergonomic	Technical implications of reducing MMH of waste containers	Manual handling operations (MHO) as the number of operations needed to collect waste
Economic	Economic assessment of the service	Reduction of cost (RC) of the service
Social	Social analysis on the collection workers	Indicators included in the subcategory “workers” (UNEP, 2011)

Table 1. Overview of the technical, economic, and social aspects of the designed framework.



MATERIALS AND METHOD (2/2)

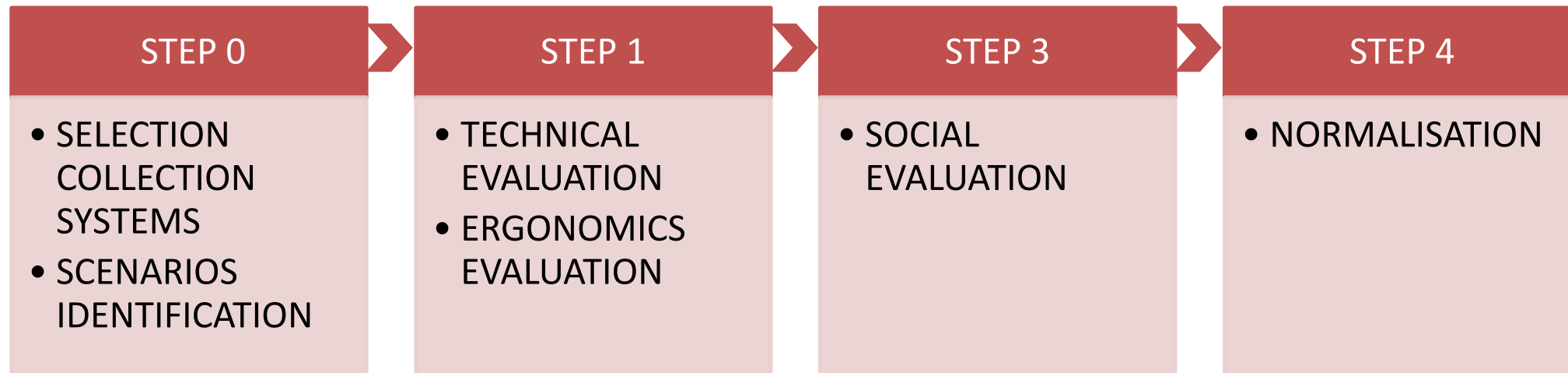


Figure 2. Overview of the four steps of the designed framework.



CASE STUDY (1 / 4)

- Door-to-door collection system: evaluation of **technical, ergonomics, economic,** and **social** aspects on workers' health and safety.
- Population: **4.459.477 inhabitants**
- Urban waste providers: **11 operators**
- Door-to-door system: **19 % separate collection**
- Amount of paper waste: **17 % waste**
= 86 kg / inhab.
- Sorted paper waste collection:
64 % paper waste

Emilia – Romagna Region (ARPAE, 2019)

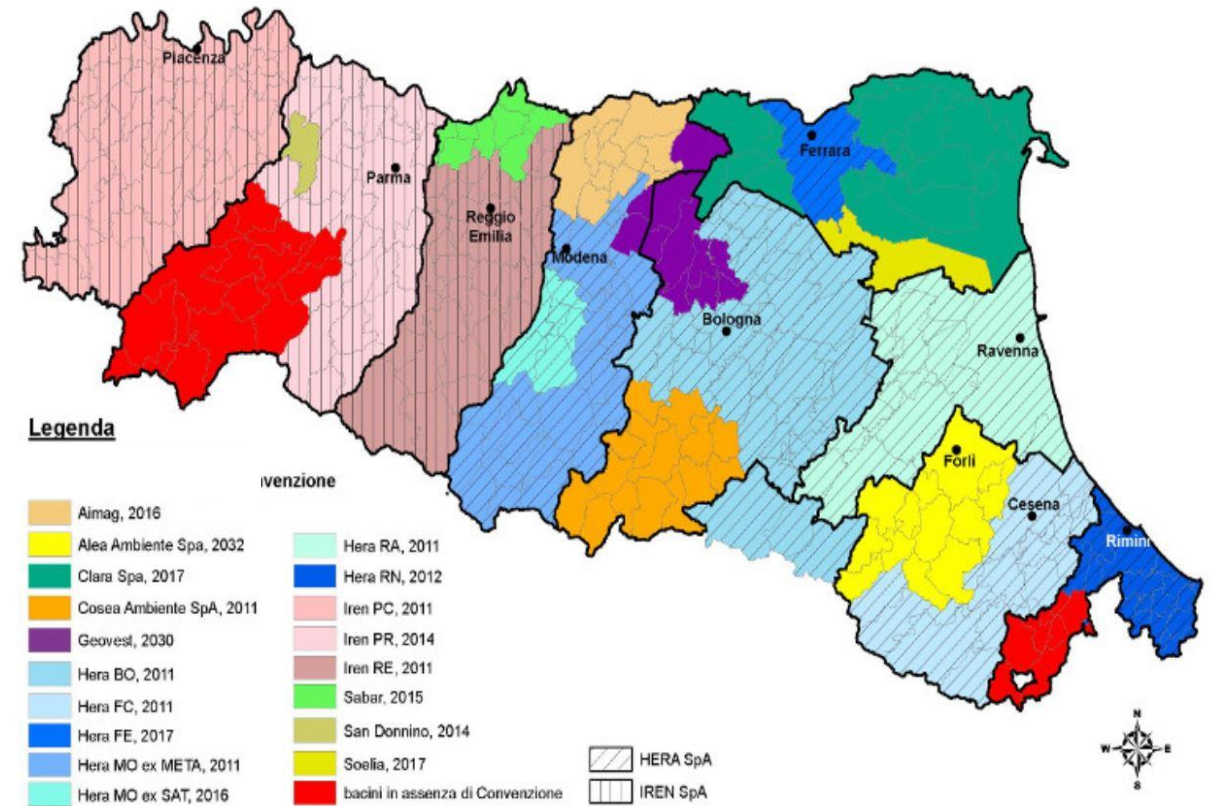


Figure 3. The 11 urban waste providers in Emilia Romagna Region (ATERSIR, 2021)



CASE STUDY (2 / 4)

Door-to-door collection systems of paper waste in GEOVEST Srl



40 **120** Litres capacity bins

- **Scenario 0** → 100% 40L
- **Scenario 10** → 100% switch 120L
- **Others** → 40L partially substituted by 120L

CASE STUDY (3 / 4)



Containers ty pology	Volume [l]	Height [cm]	Weight [kg]			Average number of container s per round	Colour	Limits (ISO 11228-1 ISO 11228-2)
			Initial	Vertical	Maintena nce			
A	40-litre capacity	48.7	-	16	-	0.7	Green	
B	120-litre capacity	94.5	13	-	6.5	0.4	Green	

Table 2. Ergonomic analysis: selected parameters of the selected systems.



CASE STUDY (4 / 4)

Parameter / Typology Bin	Unit	Typology A	Typology B
WSL	[min/day]	480	440
Breaks per day	[min/day]	30	30
Time to unload vehicle	[min/day]	15	15
Time to collect bins	[min/day]	73	83
Bin weight	[Kg]	5.7	17
No. Collected bins per day	[-]	219	125
Frequency of MMH operations	[-]	0.5	0.5
Total collected waste / worker	[Kg]	1.2	2.1

Table 3. Ergonomic analysis: selected parameters of each collection system.



RESULTS (1 / 3)

Parameter	Unit	Scenario 0	Scenario 5	Scenario 10
Time to collect bins	[min/day]	1	2	1 2
No. 40L capacity bins	[-]	313	0	157
No. 120L capacity bins	[-]	0	313	157
No. Household users with 40L	[-]	727	0	367
No. Household users with 120L	[-]	0	727	367
WSL	[min/day]	437	403	420
Cost	[Euro/min/CR]	389	359	374

Table 4. Economic analysis: results.



RESULTS (2 / 3)

Social topics and indicators	Scenario 0	Scenario 5	Scenario 10
Freedom of association and collective bargaining	+2	+2	+2
Child Labour	+2	+2	+2
Fair salary	+2	+2	+2
Working hours	+1	+1	+1
Forced Labour	+2	+2	+2
Equal opportunities/discrimination	+2	+2	+2
Health and safety	0	+1	+2
Total Social Impact	11	12	13
Economic topics and indicators	Scenario 0	Scenario 5	Scenario 10
Total cost of the service	6.220	5.980	5.739
Total cost of the service per inhabitants	19,9	9,1	18,3
Reduction of costs	-	0.8	1,6



Table 5. Social and economic analysis: results.

RESULTS (3 / 3)

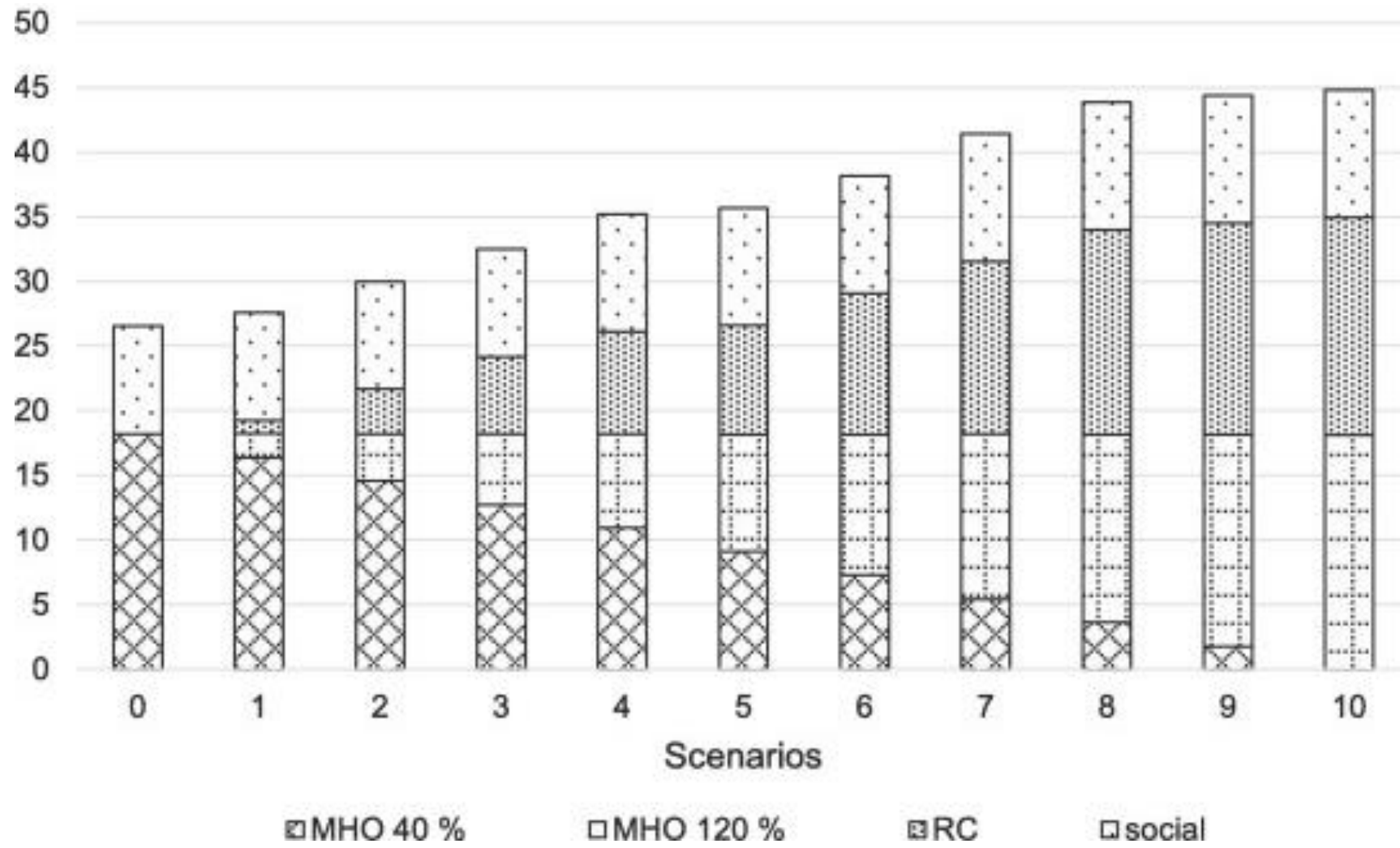


Table 5. Normalised value: results.



CONCLUSIONS

- Waste collection characteristics impact workers' health and safety
- The selected case study of a technical intervention in a door-to-door collection scheme is used for the development of a theoretical framework for increasing sustainability
- Ergonomics evaluation is not widely implemented for evaluating the implications of the waste collection systems.
- Ergonomics intervention on wheeled containers reduces the musculoskeletal disorders.



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