

LCA of Digital Solutions for Municipal Services – The Case of Three Waste collection Services

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The need to combine digitalization and sustainability: “The Inclusive, Sustainable and Connected Society” and “The increase of waste flows”

Introduction:

More and more digital solutions are implemented on a municipality level. The potential to reduce time and reduce climate impact seems to be at hand. However, are digital solutions able to reduce time and climate impacts in general? The waste collection services are one of the municipality’s main services. For consumer there is no choice and much of the decisions are made on municipality level. In order to improve the service and the operation in a more sustainable manner, under the period of 2021 and 2023 three waste collection systems using Internet of things (IoT) and sensor services have been studied using Life Cycle Assessment (LCA) [1]:

- City centre waste collection system
- Textile waste collection system
- Recycling station waste collection system

Goal and research questions:

The scope of these studies are assessing the climate impacts of digital solutions for municipal services. The goal of this study is assessing the climate impacts of digital solutions in three waste collection systems: Waste collection (city centre), Textile collection and Recycling stations. The research questions are:

- What are the climate impacts from waste collection?
- How important are the climate impacts from the digital solutions compared to the waste collection systems?
- What are the social benefits of digital solutions?

The research project includes practical operations of digital solution for Municipal Services and includes the evaluation of environmental and the social benefits of digital solutions.

Material and method:

The material is based on three municipal waste collection. The service system includes the IoT system and waste system (Fig 1). The functional unit is one year of waste collection service with digital solutions (IoT). An actor based LCA method is used to discern the climate impacts from the stakeholders involved including digital service, the collection service and the citizen transport. The climate impacts are allocated to different actors in the waste collection chain. The reason for that is to elaborate on the service and the consumption part of the service.

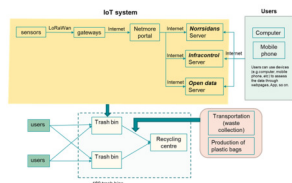


Figure 1: Service System includes the IoT system and the operation of the city waste collection system.

Product Service Systems (PSS):

Product Service systems (PSS) seldom include the consumer in the modelling of their system [2,3]. However, using IoT helps to discern consumer needs [4] as well as use-phase is important for climate impacts [5].

In the field of PSS, the system is captured as technical system with an eager interest for digitalisation and normative search for better service. However, how much is known about the use phase and the operation of such a service system and the consumer.

During normal operation, the central part of any municipality service is the transportation. In order to include the citizen and costumer, the Waste Service System has been described into the workflow from consumer to service provider: city centre waste collection, textile waste collection and recycling stations waste collection.

These were collected by the municipality in Sweden. In order to find out how transport can be reduced for waste collection by using digital solutions, the information have been gathered from the City of Södertälje in Sweden. At first glance, a reduction 25% reduced transport seemed to be possible.

The following functional units have been used: per kg collected city waste, per kg collected textile waste and per kg collected recycling stations waste (Fig 2 and 3).

Results:

The results for all three types of waste collection system show that the carbon footprint of the digital solution is neglectable (1-3% of climate impacts).

- In the case of city centre, the plastic bags do have the most important climate impacts (96%), while the transport depend on the type of fuel used (diesel or HVO).
- In the case of textile waste collection, the plastics bags and transport of citizens are most important, while the containers from recycling and textile stations are important.
- In the case of recycling stations, the most important climate impacts come from the transport of citizens.

From the service perspective, instead of saving climate impacts, the operation time is saved in waste collection service, that can be used for providing a better service.

From an actor perspective, the major climate impacts come from transport of the citizens to the collection system. The additional transport service developed by the municipality leads to reduced car transport and climate impacts from citizens.

Conclusion:

In conclusion, the actor-based method and are related to different stakeholders. The climate impacts and time allocated to the service becomes more and more important for waste management.

- The digital solution are neglectable compared to the waste collection system.
- Instead, the major climate impacts come from transport of the citizens to the collection system.
- Instead of reducing climate impacts, the digital solutions for municipal services lead to better service.

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Climate impact of textile waste collection with IoT system (t CO₂ eq per year)

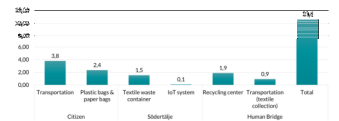


Figure 2: Climate impacts of textile waste collection with IoT system and actors involved.

Climate impact of waste collection recycling stations with IoT system (t CO₂ eq per year)

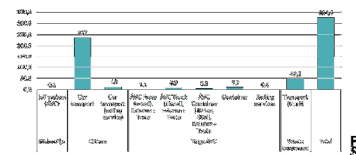


Figure 3: Climate impact of recycling stations with IoT system and actors involved.

- The environmental benefits of all three waste collection systems show that IoT system and sensors are neglectable compared to the waste collection. The major impacts come from the transportation of the citizens.
- The social benefits of digital solutions in different waste systems show that the operation provided by the municipality can be improved and the time saved can be used for “caring” services (gardening) as well as “transport” service from home (rolling service).



Figure 4: Waste collection service at Municipality

References:

[1] The Inclusive, Sustainable and Connected Society | RISE (2023): Life cycle assessment of IoT system in Södertälje - The case of textile waste collection and the municipality’s recycling stations. RISE report 2021:91. Life cycle assessment of Internet of Things(IoT) solution in Södertälje municipality – A smart waste collection system. RISE report 2023:16. [2] Tukker, A. (2004). Eight types of Product Service Systems. Bus. Strat. Env. 13, 246-260. [3] Catulli, M. et al (2017). Consuming use orientated product service systems. JCIProd 141, 1186-1193. [4] Wellsandt, S. et al. 2019. Life Cycle Management for Product-Service Systems. Springer. [5] Sarasini, S. et al. (2024). Reviewing the climatic impacts of product service systems. J of Cleaner Production, 452, 142119.