

Socioeconomic Life Cycle Assessment of the Food Loss and Waste Management Strategies in Spain: A Regionalized Approach

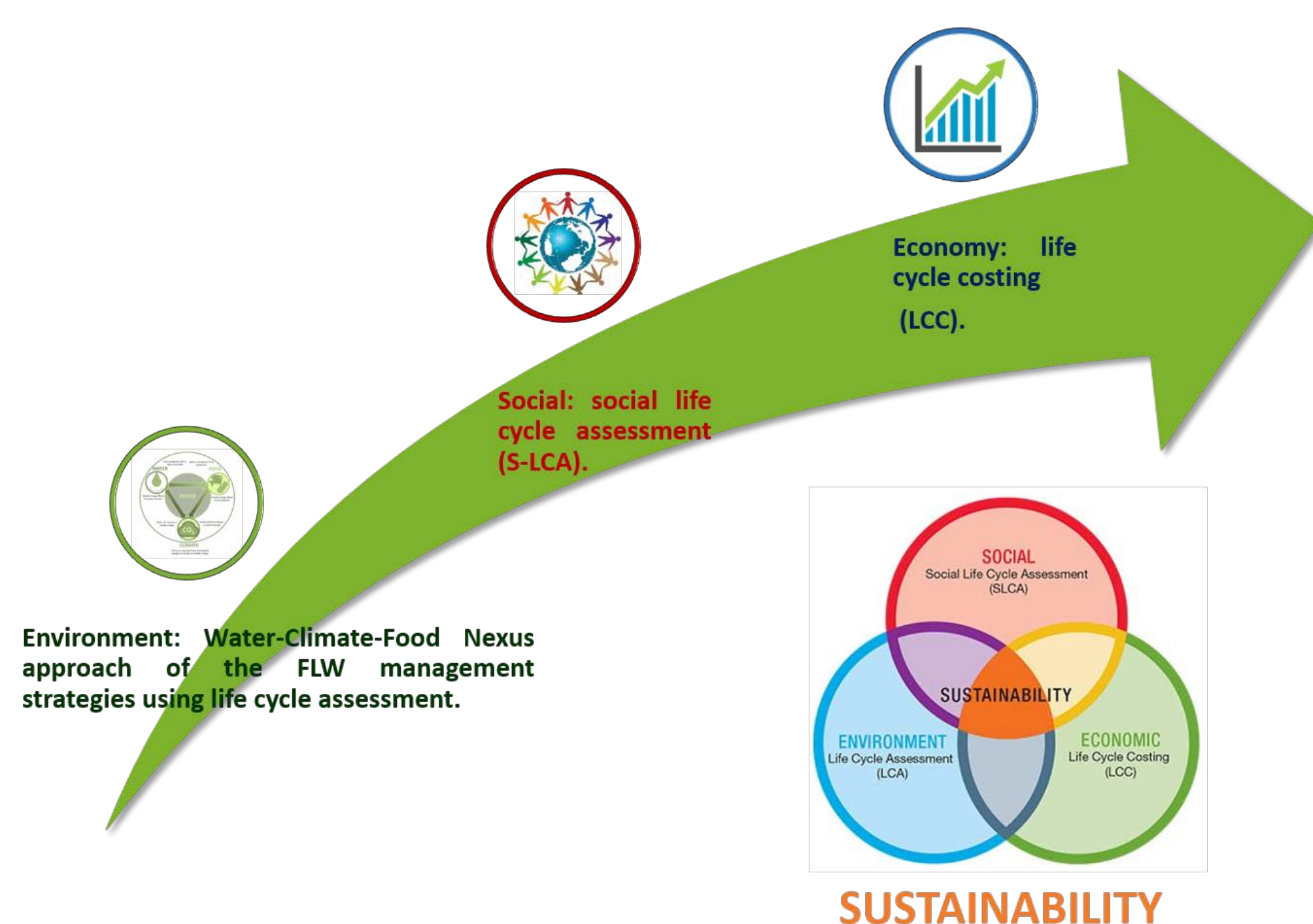
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1. MOTIVATION

Food loss and waste (FLW) prevention and a properly management represents a societal imperative need to achieve a transition of food systems towards a circular economy. In this sense, life cycle approaches provide policy-relevant and consistent assessment for the evaluation of the environmental impacts of FLW generation and management. To assess the economic cost of FLW, the Life Cycle Costing (LCC) methodology is being increasingly used to develop analyzes combining environmental and socio-economic aspects. Studies including the three pillars of Sustainability, i.e., environmental, social and economic impacts, are needed. In this framework, in Spain and important fraction of the FLW generated is still landfilled. The rest is managed in the 10 existing incineration plants, or in mechanical-biological treatment stations, based on aerobic composting or anaerobic digestion systems. There is a needed to determine the best strategies for FLW management searching for a zero FLW-to-landfill horizon.



3. LIFE CYCLE COSTING ASSESSMENT

The prices of four different FLW management options are being assessed: i) landfill, ii) incineration (thermal treatment), iii) aerobic composting, and iv) anaerobic digestion. Additionally, the existing taxes at any FLW management option and Spanish region, the national and European landfill restrictions, the transport costs, and the projected evolution of the carbon emission prices until 2040, are tabulated. The social assessment will be included by quantifying the generated or maintained local employees. The system boundaries includes all the edible FLW generated along the entire food supply chain.

DIFFERENT CONSIDERED COSTS FOR THE ESTIMATIONS

| | Management (€/T) | Electricity (€/T) | Compost/ digestate (€/ T input) | Transport-C (€/T) | Transport-D (€/T) |
|---------------------|------------------|-------------------|---------------------------------|-------------------|-------------------|
| Aerobic composting | 24.00 | 0 | 5.18 | 40 | 20 |
| Anaerobic digestion | 72.20 | 33.39 | 19.41 | 40 | 20 |
| Landfill | 38.68 | 0 | 0 | 40 | 20 |
| Incineration | Specific data* | 27.44 | 0 | 40 | 20 |
| MBT (Ac) | 58.87 | 0 | 5.18 | 40 | 20 |
| MBT (Ad) | 59.97 | 33.39 | 19.41 | 40 | 20 |

5. ON-GOING RESEARCH

The study aims to link the assessment of the best environmental, social and economic sustainable paths of the Spanish food sector, for providing a holistic approach when developing regionalized FLW management policies in Spain.

It is intended to present a first approximation to a LCC assessment including and linking social and economic aspects to a framework where a previously environmental assessment was done. Nevertheless, future work should consider other factors such as the quantifying the managed quantities including the inedible parts of FLW. Other potentially emerging management options such as gasification or pyrolysis, must be taken into account. Moreover, it will be important to internalize other environmental impact costs, such as the carbon emission costs assessed in this work. Additionally, it would be interesting to analyze the best management strategies at municipal level, assessing the 8,112 municipalities existing in Spain.

Finally, efforts in the coming years must be focused on increasing the amounts of waste that are collected separately, reducing the amount of mixed organic waste whose contribution in quantity and quality to be recycled and/or valorized could be much more higher.

6. REFERENCES

Hoehn, D.; Laso, J.; Cristóbal, J.; Ruiz-Salmón, I.; Butnar, I.; Borrión, A.; Bala, A.; Fullana-i-Palmer, P.; Vázquez-Rowe, I.; Aldaco, R.; et al. Regionalized strategies for food loss and waste management in Spain under a life cycle thinking approach. *Foods* **2020**, *9*, Aldaco, R.; Butnar, I.; Margallo, M.; Laso, J.; Rumayor, M.; Domínguez-Ramos, A.; Irabien, A.; Dodds, P.E. Bringing value to the chemical industry from capture, storage and use of CO₂: A dynamic LCA of formic acid production. *Sci. Total Environ.* **2019**, *663*, 738–753.

7. ACKNOWLEDGEMENTS

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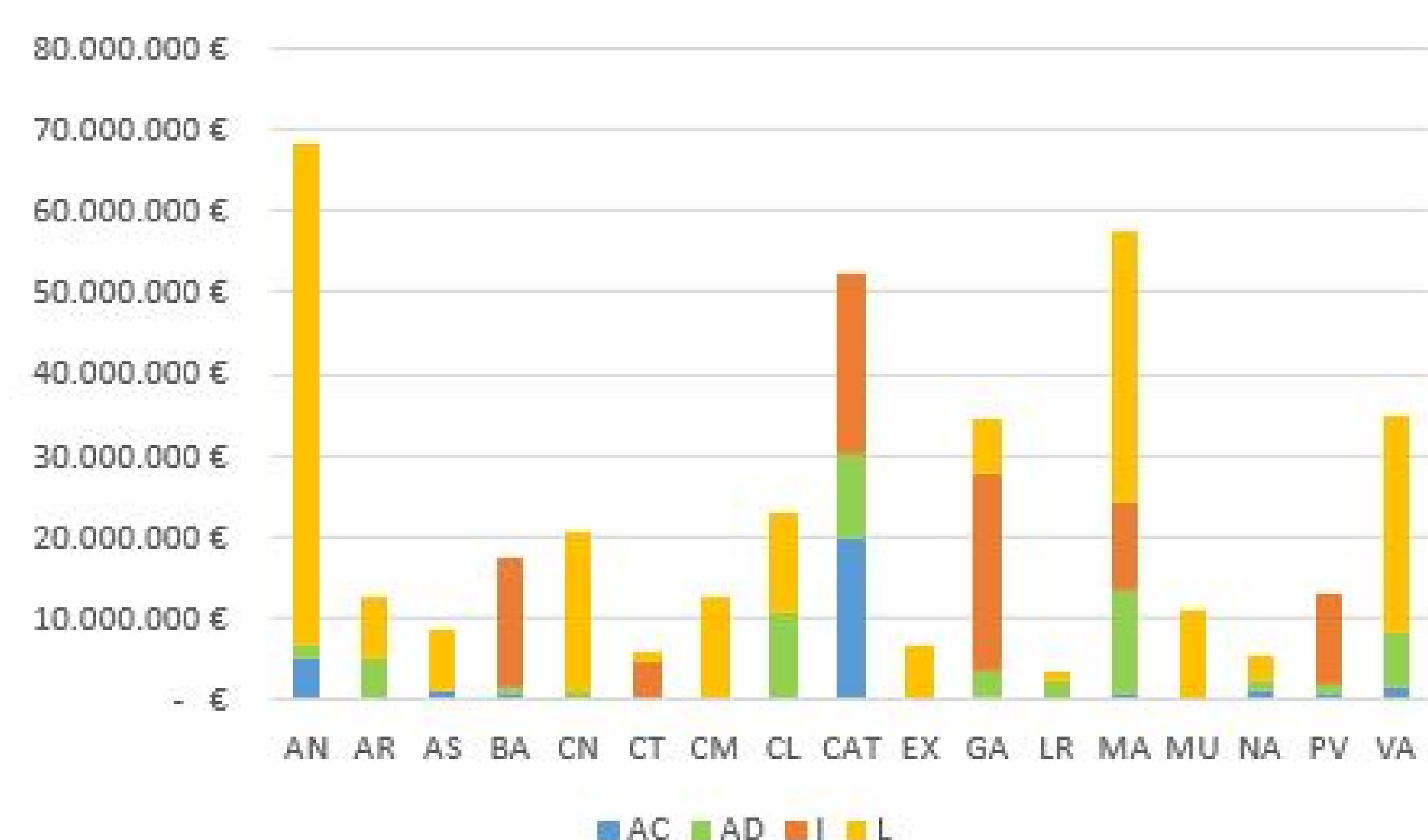
2. OBJETIVE

This study aims to include an LCC approach to a previous work that evaluated the carbon footprint for the 17 Spanish regions from 2015 until 2040 in a framework of (i) compliance and (ii) non-compliance with the Paris Agreement targets, with a Water-Climate-Food Nexus thinking approach.

4. PRELIMINARY RESULTS

The figure above represents the preliminary results concerning the currently situation of economic costs of each considered FLW management option, along the 17 Spanish regions. Currently, the highest costs have been detected on landfill management, followed by incineration. Nevertheless, until now, no significant investment has been done in Spain in terms of anaerobic digestion and aerobic composting FLW management plants. Therefore, for analyzing the LCC of the different options there is a need of assessing different potentially scenarios. Consequently, as represented in the table, five different simulated scenarios will be assessed (S2-S6) as a comparison with the currently situation in the Spanish regions (S1).

ESTIMATED COSTS OF THE DIFFERENT FLW MANAGEMENT OPTIONS AT EACH SPANISH REGION



SCENARIOS OF FLW MANAGEMENT: CURRENTLY AND SIMULATED SITUATIONS

| Scenarios | Landfill | Incineration | Anaerobic digestion (AD) | Aerobic composting (AC) |
|-----------|--------------------------|--------------|--------------------------|-------------------------|
| S1 | Dependent on each region | | | |
| S2 | 2.5% | 2.5% | 20% | 75% |
| S3 | 2.5% | 2.5% | 75% | 20% |
| S4 | 3.3% | 90% | 3.3% | 3.3% |
| S5 | - | 33.3% | 33.3% | 33.3% |
| S6 | - | - | 50% | 50% |



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