ASSESSING ECO-PRODUCTIVITY CHANGE IN CHILEAN MUNICIPAL SOLID WASTE SERVICES

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OUTLINE

1. MOTIVATION
2. MAIN OBJECTIVE
3. METHODOLOGY
4. EMPIRICAL APPLICATION
5. RESULTS
6. CONCLUSIONS

1. MOTIVATION

Sustainable Development Goals 2030

Target 11.6

By 2030, reduce the negative environmental impact per capita of cities, including paying particular attention to air quality and municipal waste management.

Target 12.5

By 2030, significantly reduce the generation of waste through prevention, reduction, recycling, and reuse activities.

1. MOTIVATION

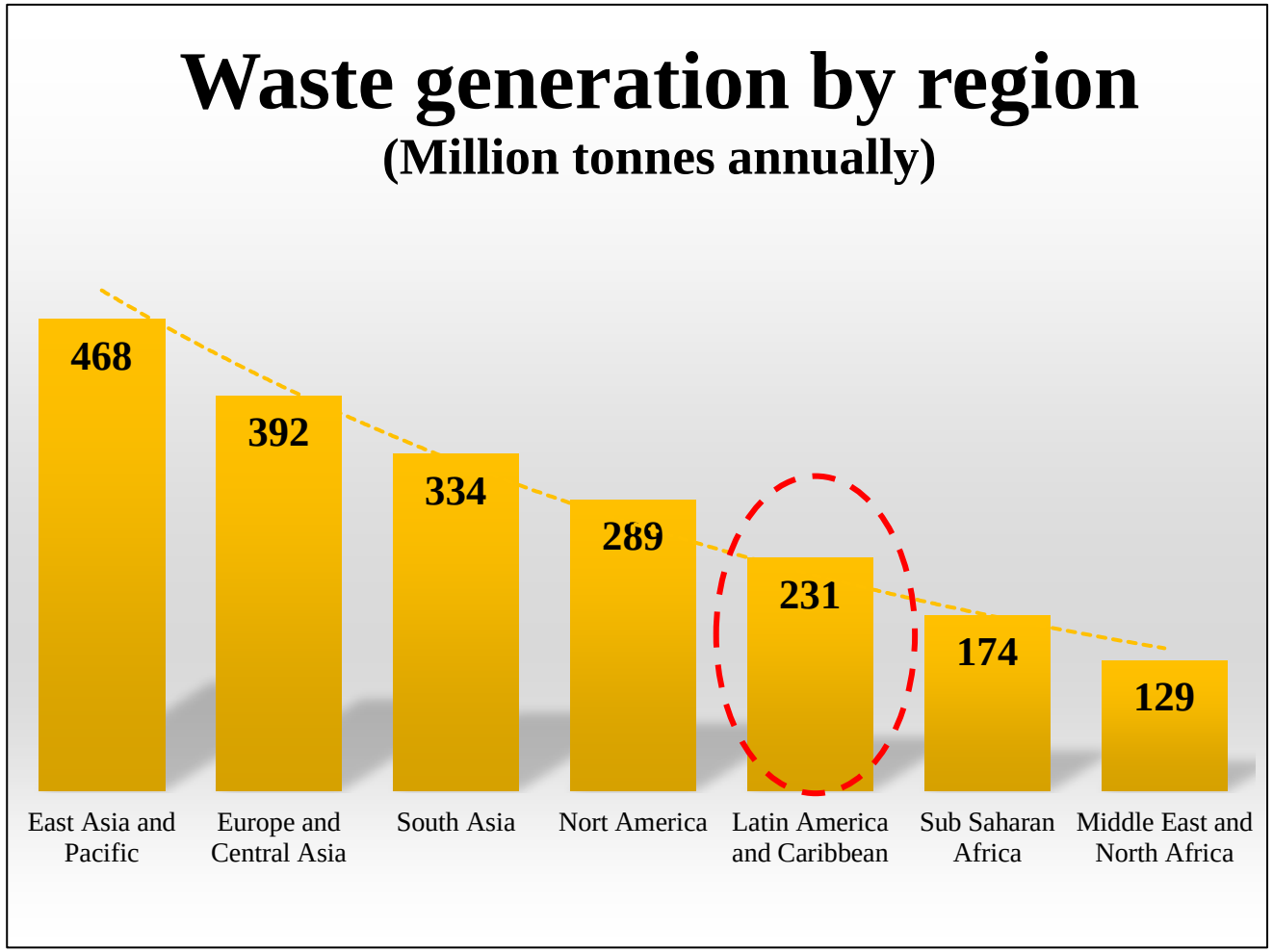


Figure 1: Waste generation by region (Million tonnes annually). Source: Own elaboration from World Bank Infographics (2018) What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050

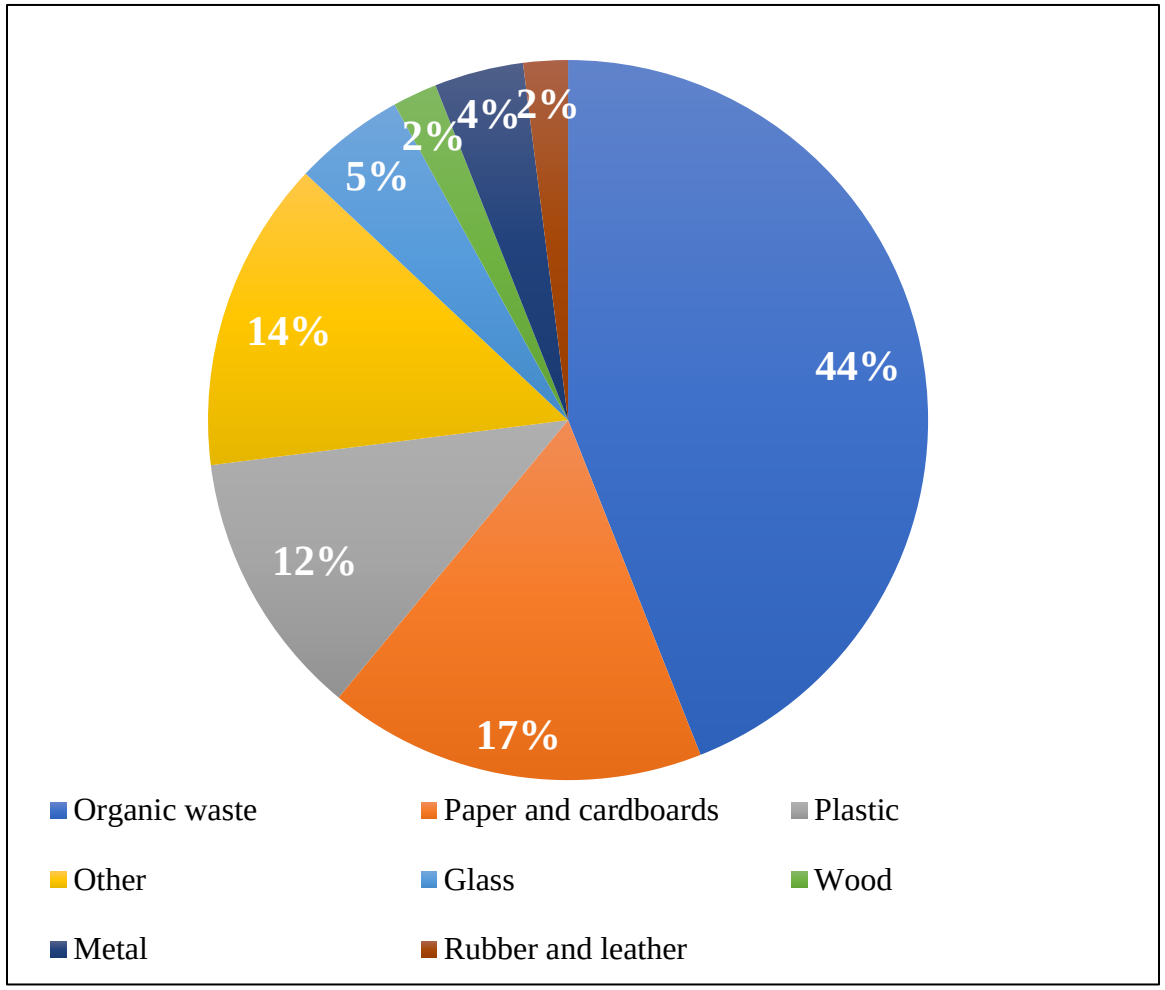


Figure 2. Global Waste Composition percent. Source: Own elaboration from What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050

1. MOTIVATION

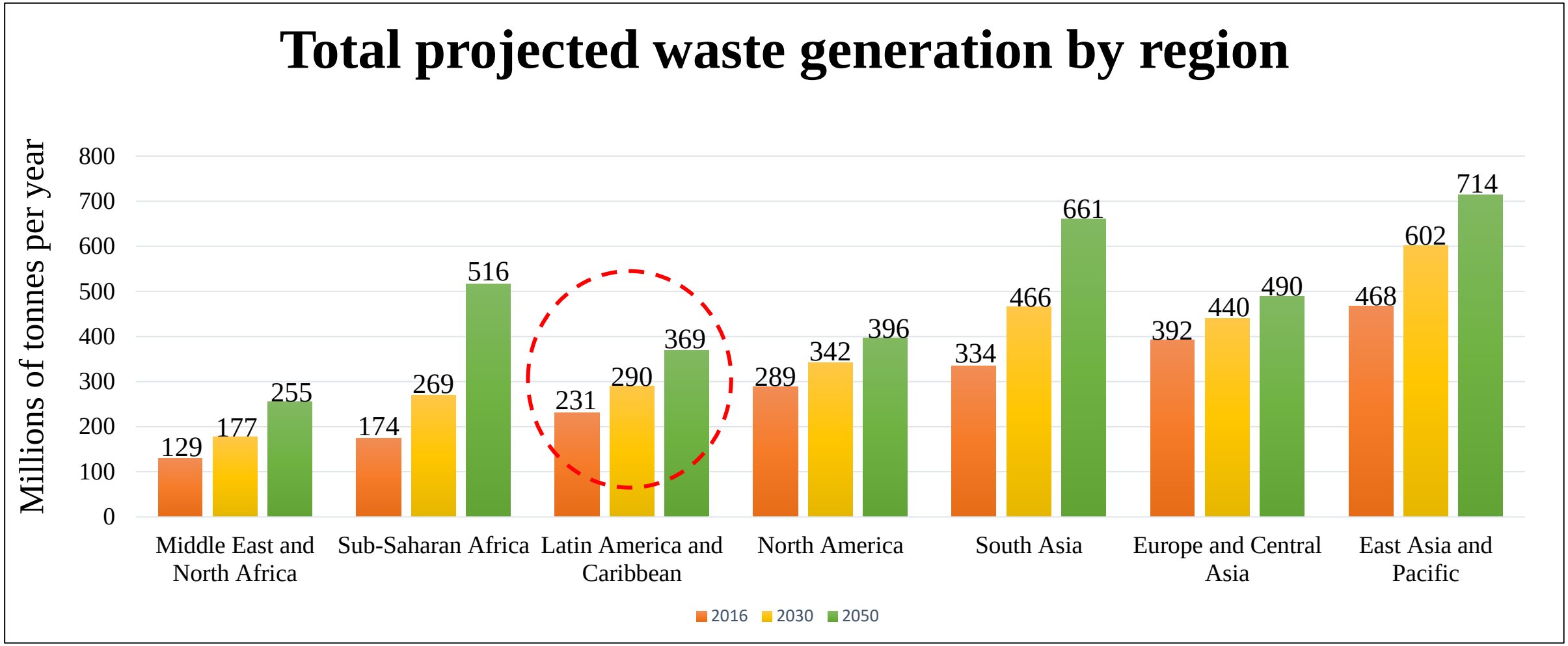


Figure 3. Total projected waste generation by Region (Millions of tonnes per year). Source: Own elaboration from What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050.

1. MOTIVATION

Figure 4. Municipal waste management annual costs per capita for the Municipalities of the Metropolitan Region, Chile. Source: Own elaboration from Census (2017) and SINIM (2017) data.

1. MOTIVATION

Difference between the concept of Productivity and Eco-Productivity

Productivity Change

Simões *et al*. (2012)

- Performance over time considering the outputs obtained and the inputs used.
- Dynamic evaluation.

Eco-Productivity Change

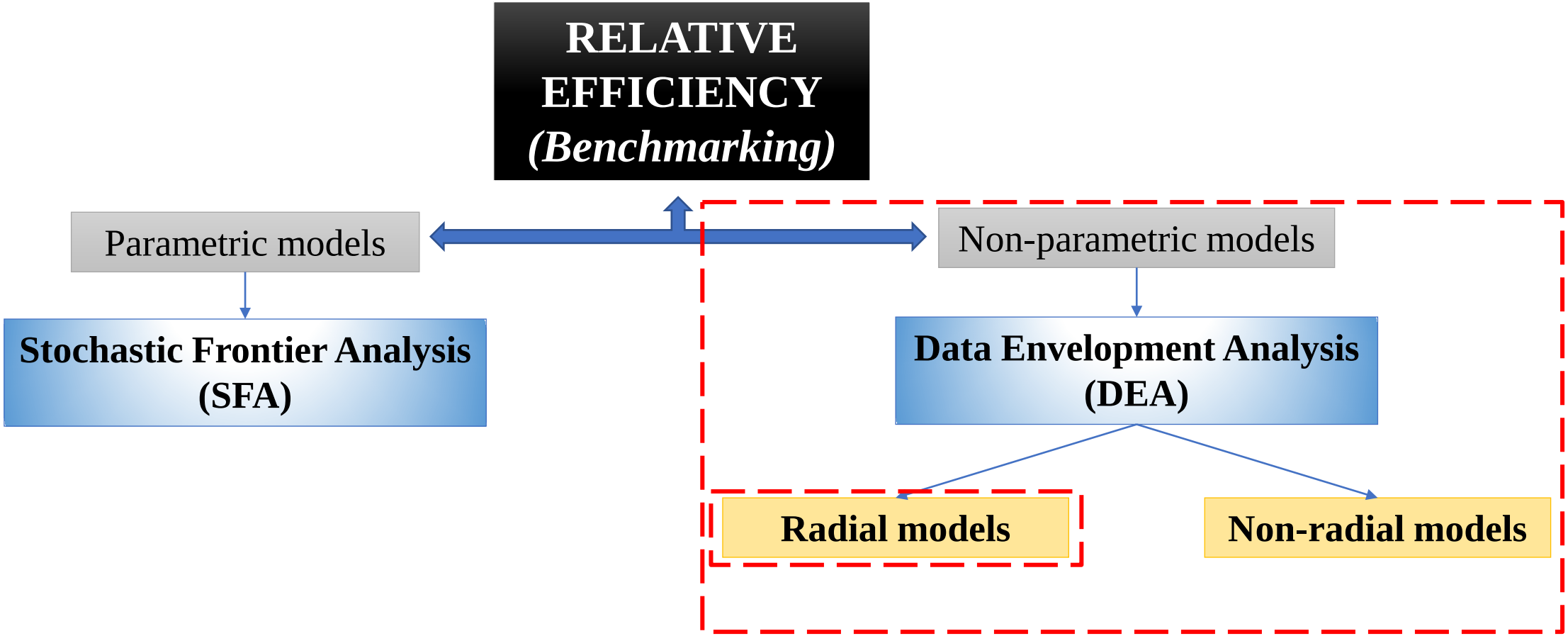
Maziotis *et al*. (2017)

- Performance over time considering the desirable and undesirable outputs obtained and the inputs used.
- Dynamic evaluation.

2. MAIN OBJECTIVE

Evaluate the performance over time, i.e., eco-productivity change, of a representative sample of 313 Chilean municipalities (91%) which provide MSW services.

3. METHODOLOGY



Scheme 1. Methodologies to evaluate efficiency. Source: Own elaboration based on Schiltz, (2018).

3. METHODOLOGY

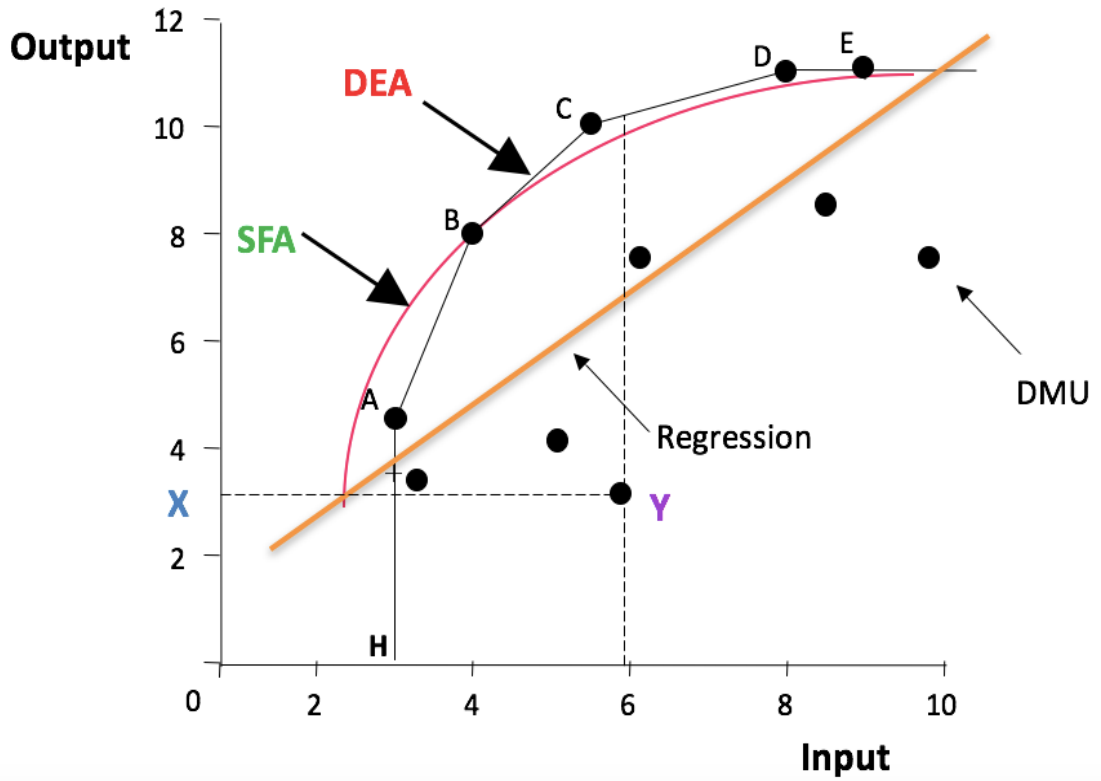
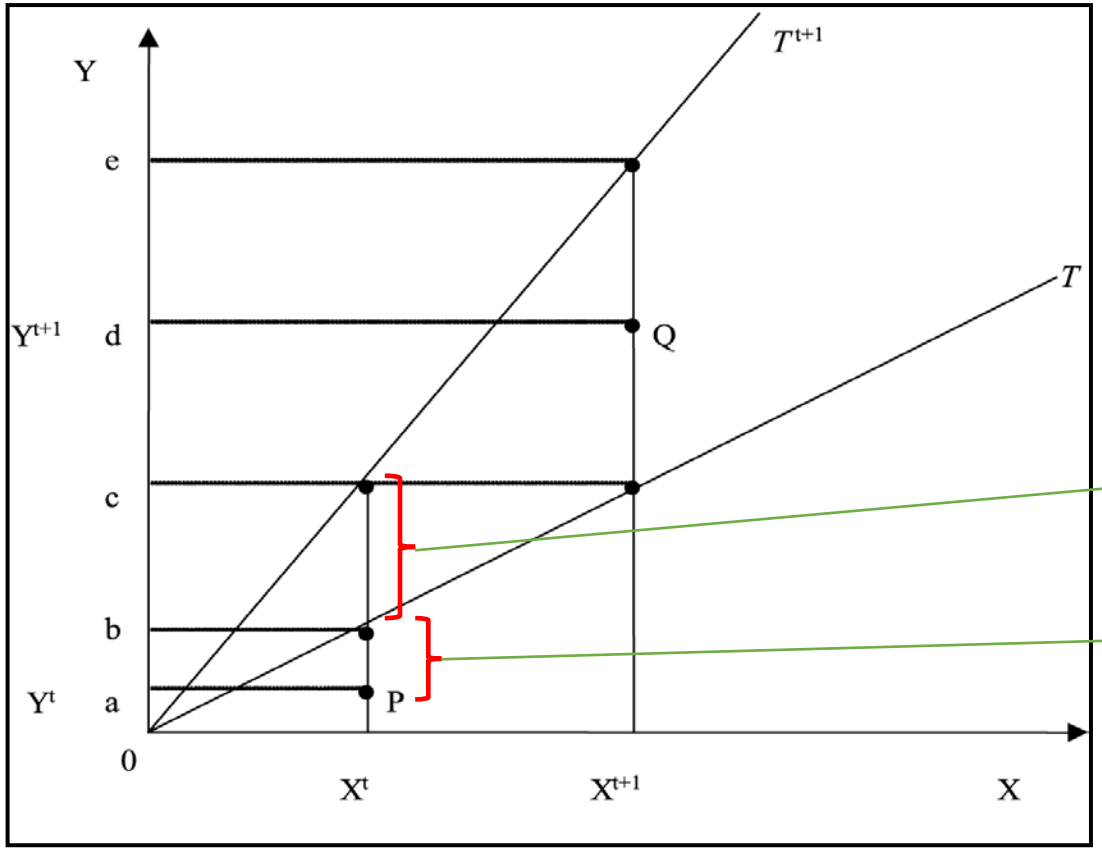


Figure 5. Comparison of DEA and SFA approach.
Source: own elaboration based on Seiford, L. M., & Zhu, J. (2011)
*DMU: Decision making units

Methods	Advantages	Disadvantages
SFA (Parametric method)	➢ Can test hypotheses. ➢ Specifies noise (separates noise from efficiency scores).	➢ Functional form needs to be specified.
DEA (Non-parametric method)	➢ Can accommodate multiple inputs and outputs. ➢ Functional form is not specified.	➢ Does not support data noise (noise is part of the efficiency score).

Table 1. Comparative between DEA and SFA methods.
Source: Own elaboration based on Schiltz, (2018).

3. METHODOLOGY



Technical Change

Efficiency Change

Figure 6. Analysis of Change in Productivity. Own elaboration based on Molinos *et al.*, (2018).

3. METHODOLOGY

ECO-PRODUCTIVITY CHANGE

- Malmquist-Luenberger Productivity Index (MLPI)

Notation

$x \in \mathfrak{N}_{+}^{N}$: Vector of inputs
$y \in \mathfrak{N}_{+}^{M}$: Vector of desirable outputs
$b \in \mathfrak{N}_{+}^{M}$: Vector of undesirable outputs
t : Time. First year of study
$t+1$: Time. Last year of study

$$MLPI = Efficiency\ change\ (MLECH) * Technical\ change\ (MLTCH)$$

MLPI > 1 Productivity has increased;
MLPI < 1 Productivity has decreased;
MLPI = 1 Productivity has not changed

$$MLPI_{t}^{t+1} = \left[\frac{\left(1+\bar{D}_{0}^{t}(x^{t},y^{t},b^{t};g^{t})\right)}{\left(1+\bar{D}_{0}^{t}(x^{t+1},y^{t+1},b^{t+1};g^{t+1})\right)} * \frac{\left(1+\bar{D}_{0}^{t+1}(x^{t},y^{t},b^{t};g^{t})\right)}{\left(1+\bar{D}_{0}^{t+1}(x^{t+1},y^{t+1},b^{t+1};g^{t+1})\right)}\right]^{1/2} = \text{MELCH} * \text{MLTH}$$

Molinos-Senante *et al.*, (2014)

4. EMPIRICAL APPLICATION

Sample

313 Chilean Municipalities

	Eco-Productivity Assessment
INPUT	i) Total costs of MSW collection and disposal (CLP/year)
DESIRABLE OUTPUTS	i) Quantity of paper and paperboard collected and recycled (ton/year); ii) Quantity of glass collected and recycled (ton/year); iii) Quantity of plastics collected and recycled (ton/year). iv) Quantity of organic waste collected and recycled (ton/year). v) Quantity of other waste collected and recycled (ton/year).
UNDESIRABLE OUTPUT	i) Unsorted waste (ton/year).

5. RESULTS

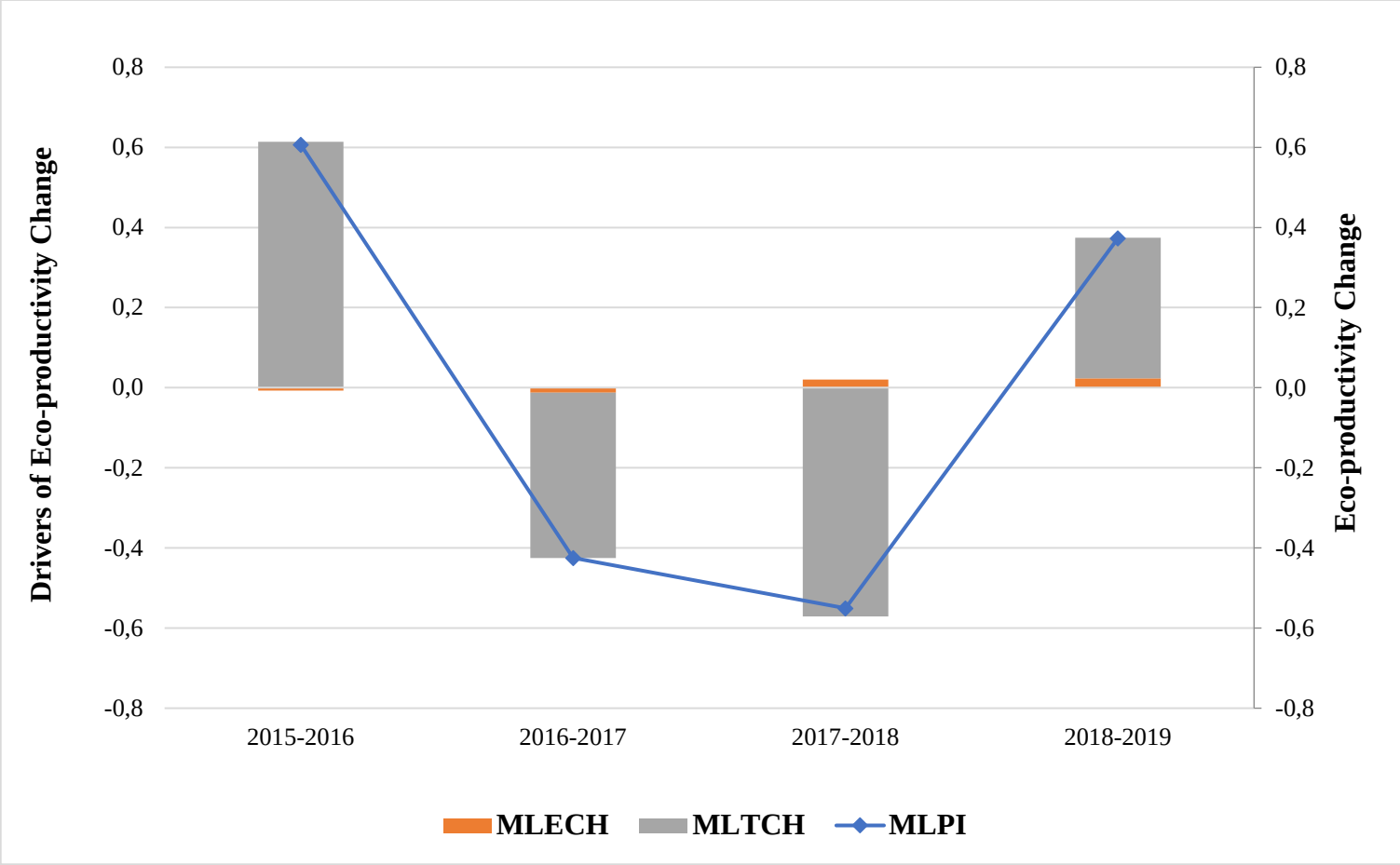


Figure 7. Drivers of eco-productivity change of Municipal Solid Waste Services (MSW).

5. RESULTS

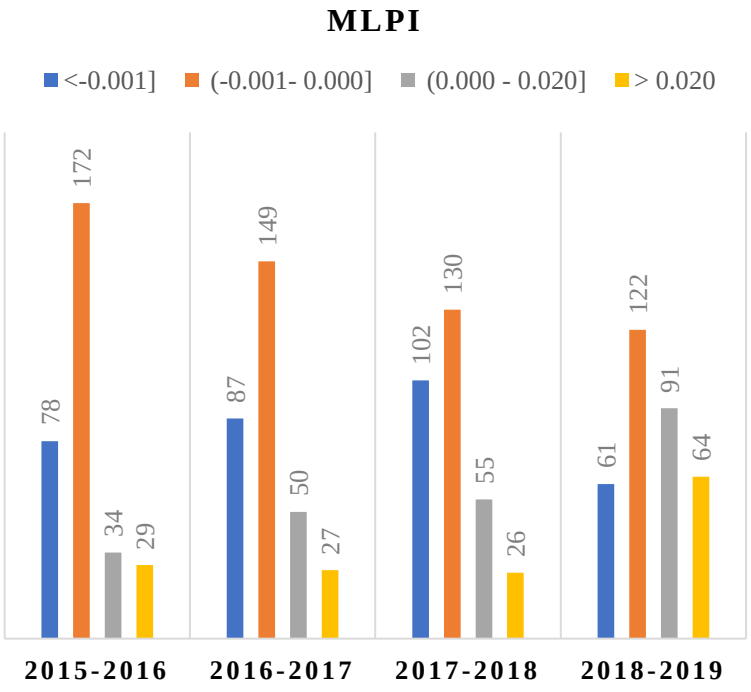


Figure 8. Histogram with MSW groups according to MLPI values, considering unwanted outputs.

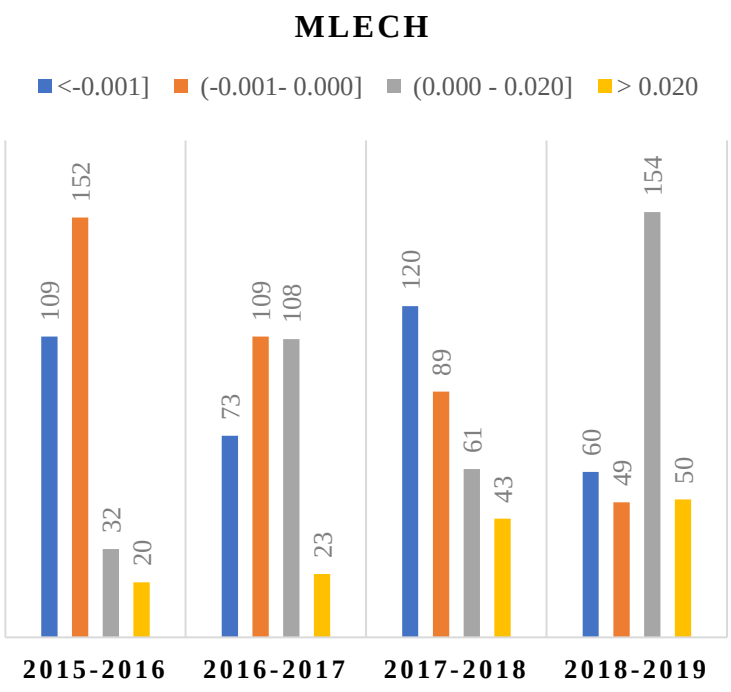


Figure 9. Histogram with MSW groups according to MLECH values, considering unwanted outputs.

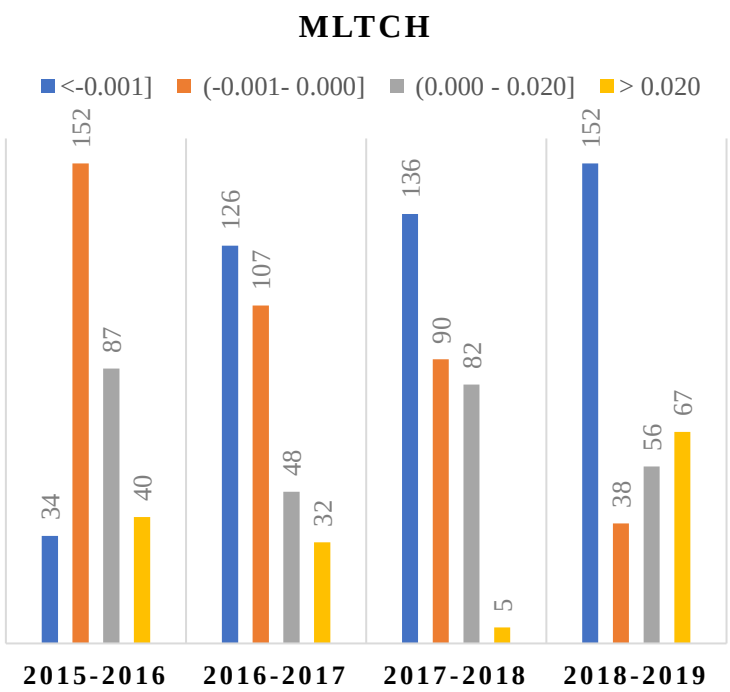
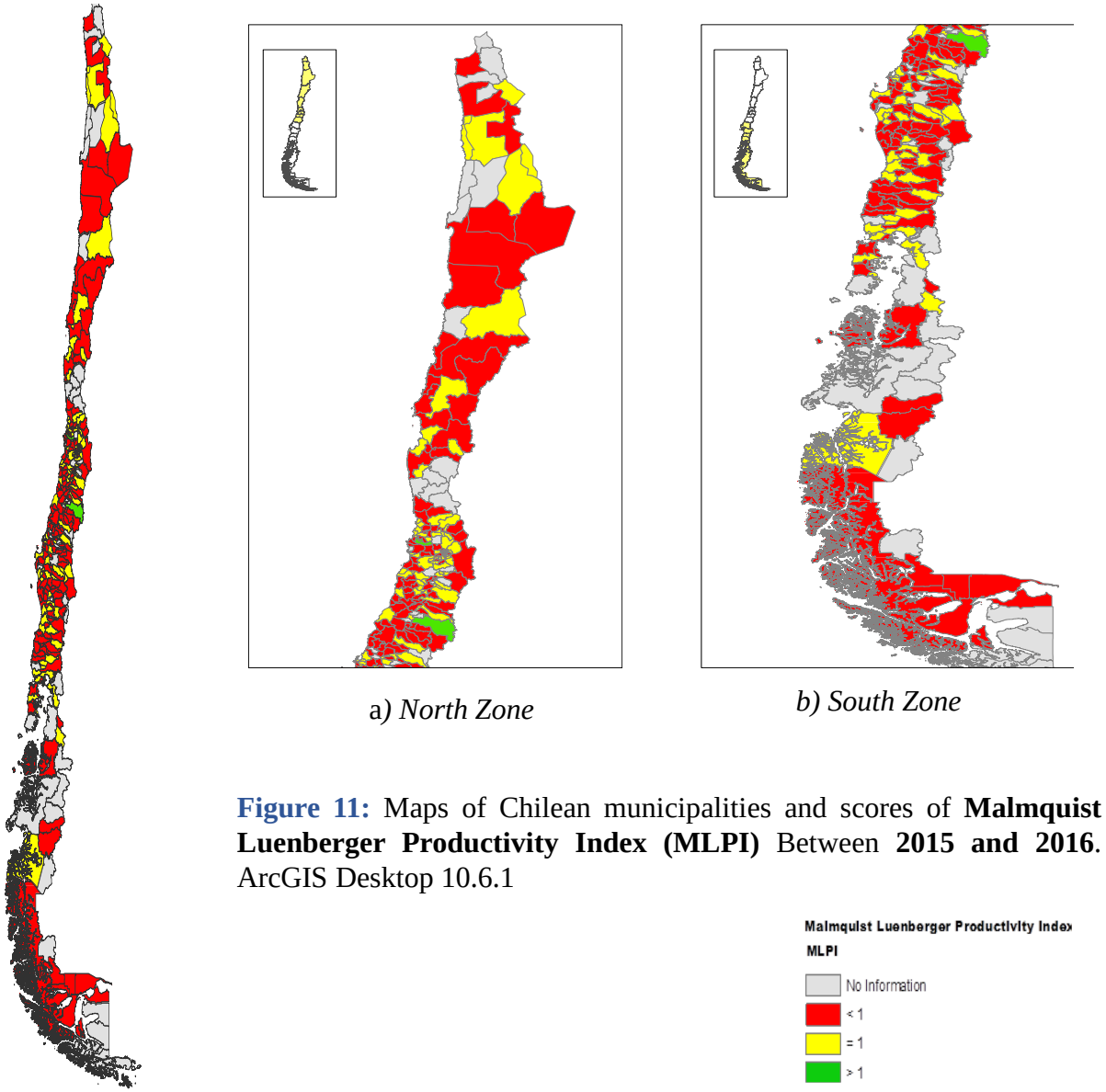


Figure 10. Histogram with MSW groups according to MLTCH values, considering unwanted outputs.

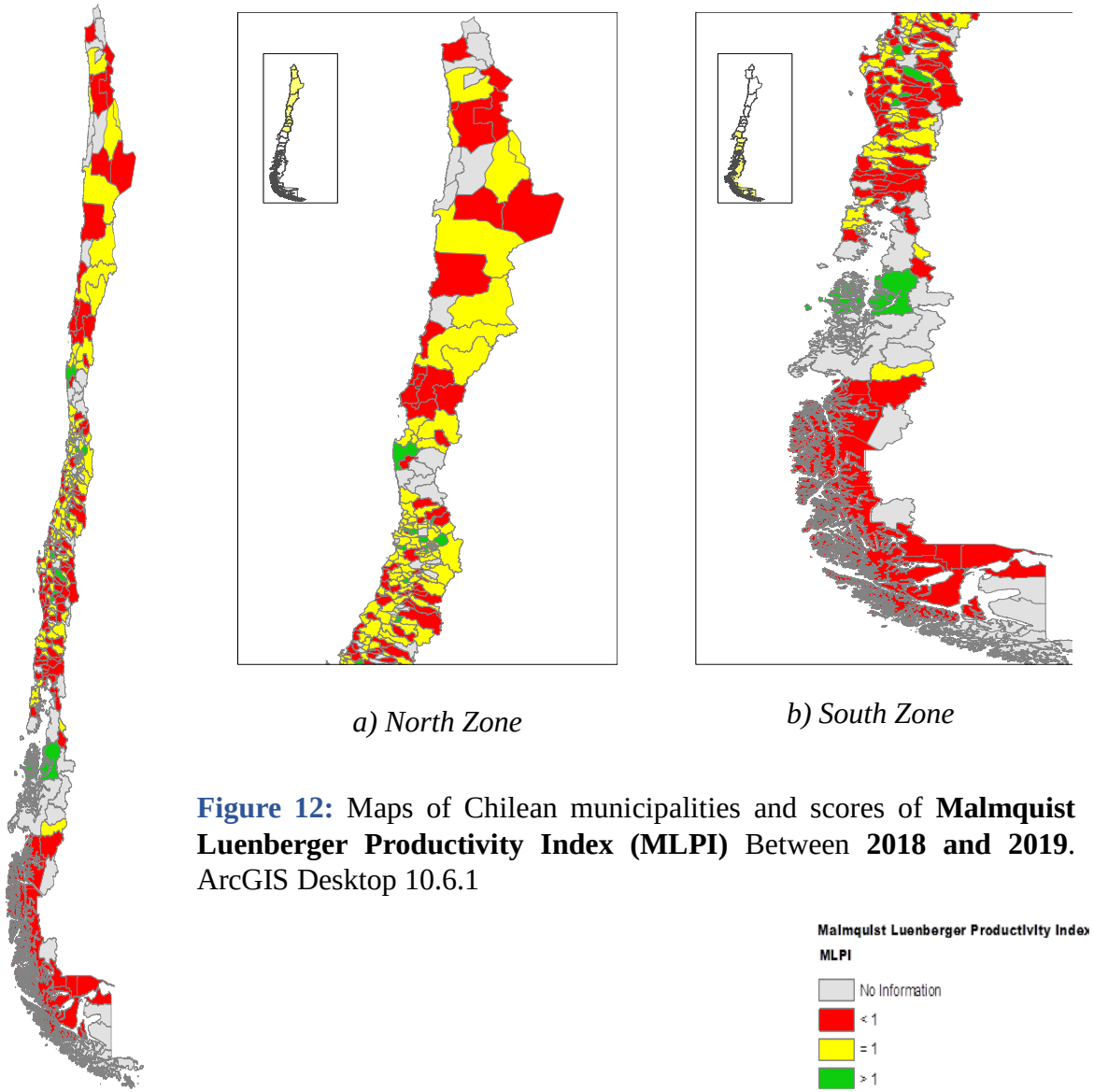
5. RESULTS



a) *North Zone*

b) South Zone

Figure 11: Maps of Chilean municipalities and scores of **Malmquist Luenberger Productivity Index (MLPI)** Between **2015 and 2016**. ArcGIS Desktop 10.6.1

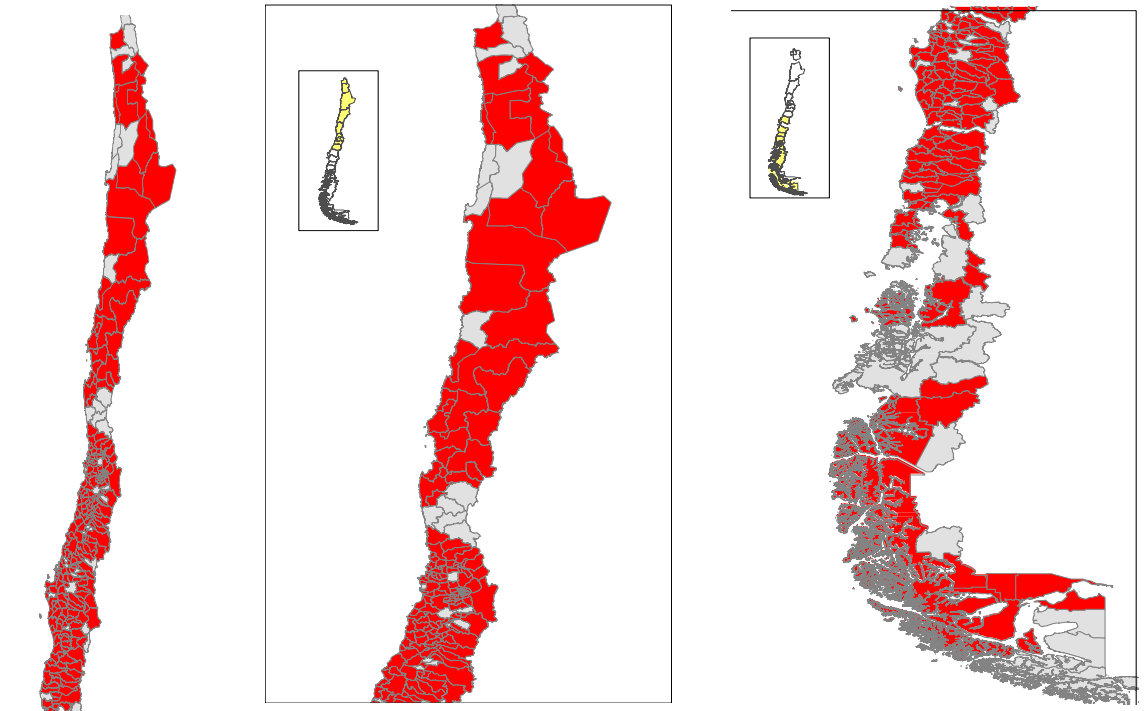


a) North Zone

b) South Zone

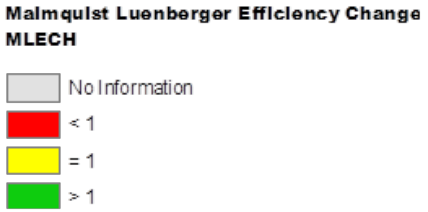
Figure 12: Maps of Chilean municipalities and scores of **Malmquist Luenberger Productivity Index (MLPI)** Between **2018 and 2019**. ArcGIS Desktop 10.6.1

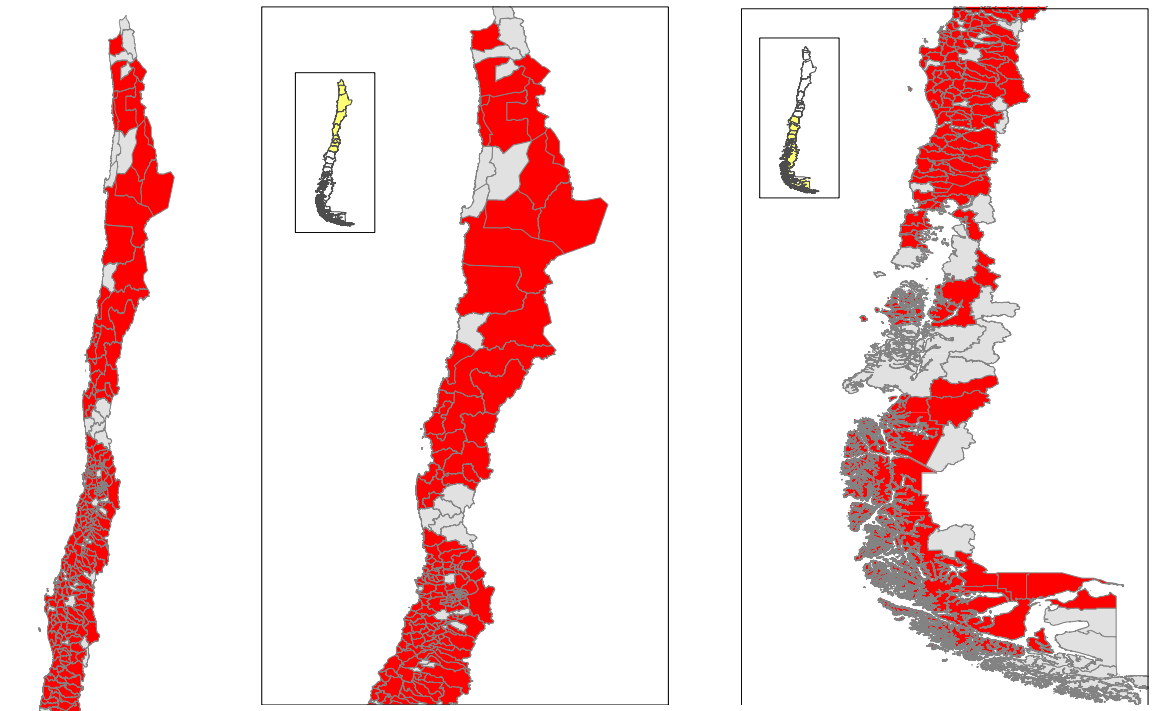
5. RESULTS



a) *North Zone* *b) South Zone*

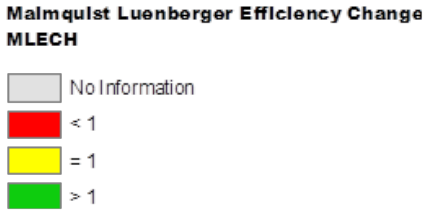
Figure 13: Maps of Chilean municipalities and scores of **Malmquist Luenberger Efficiency Change (MLECH)** Between **2015 and 2016**. ArcGIS Desktop 10.6.1



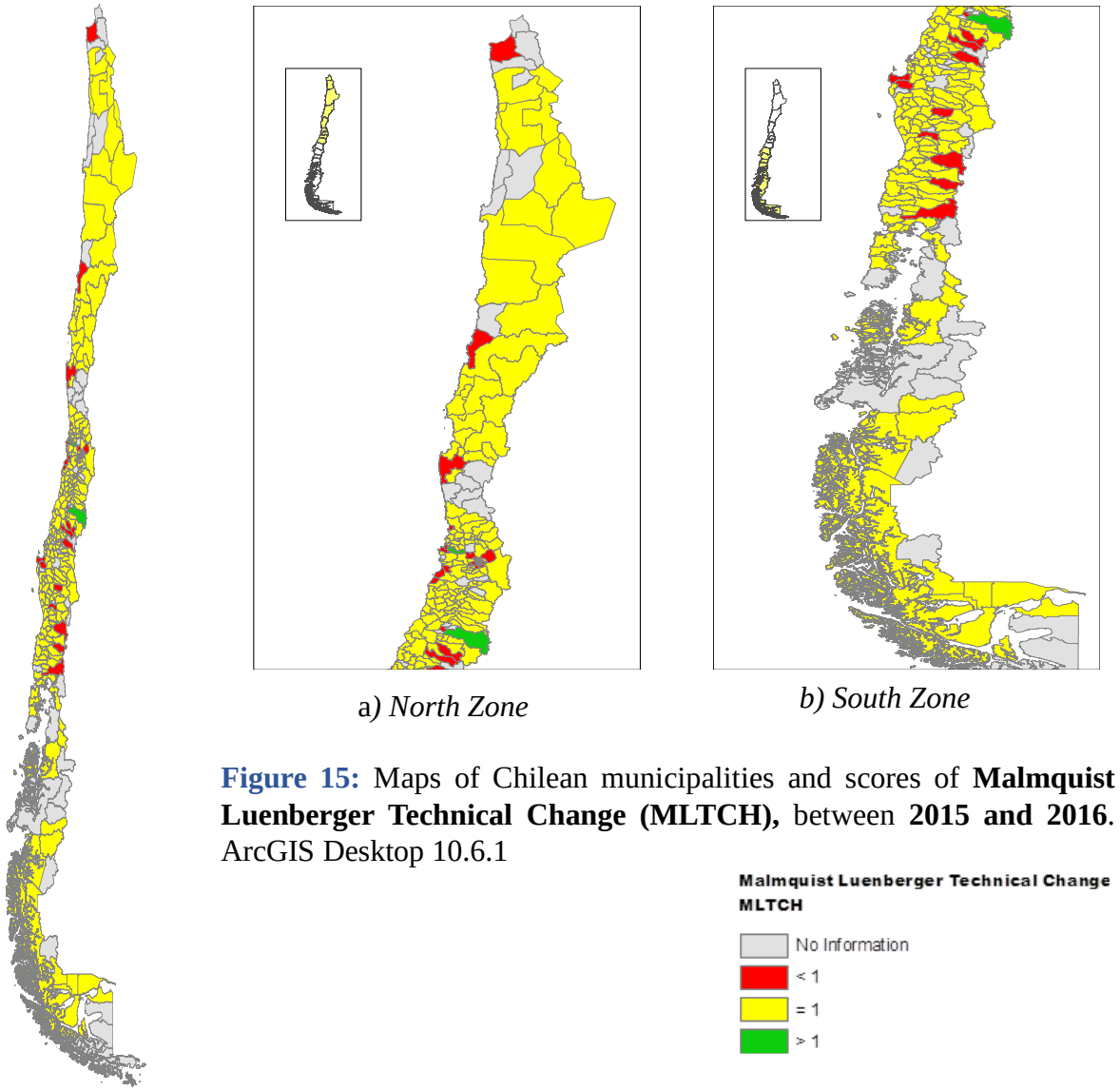


a) North Zone *b) South Zone*

Figure 14: Maps of Chilean municipalities and scores of **Malmquist Luenberger Efficiency Change (MLECH)** Between **2018 and 2019**. ArcGIS Desktop 10.6.1



5. RESULTS



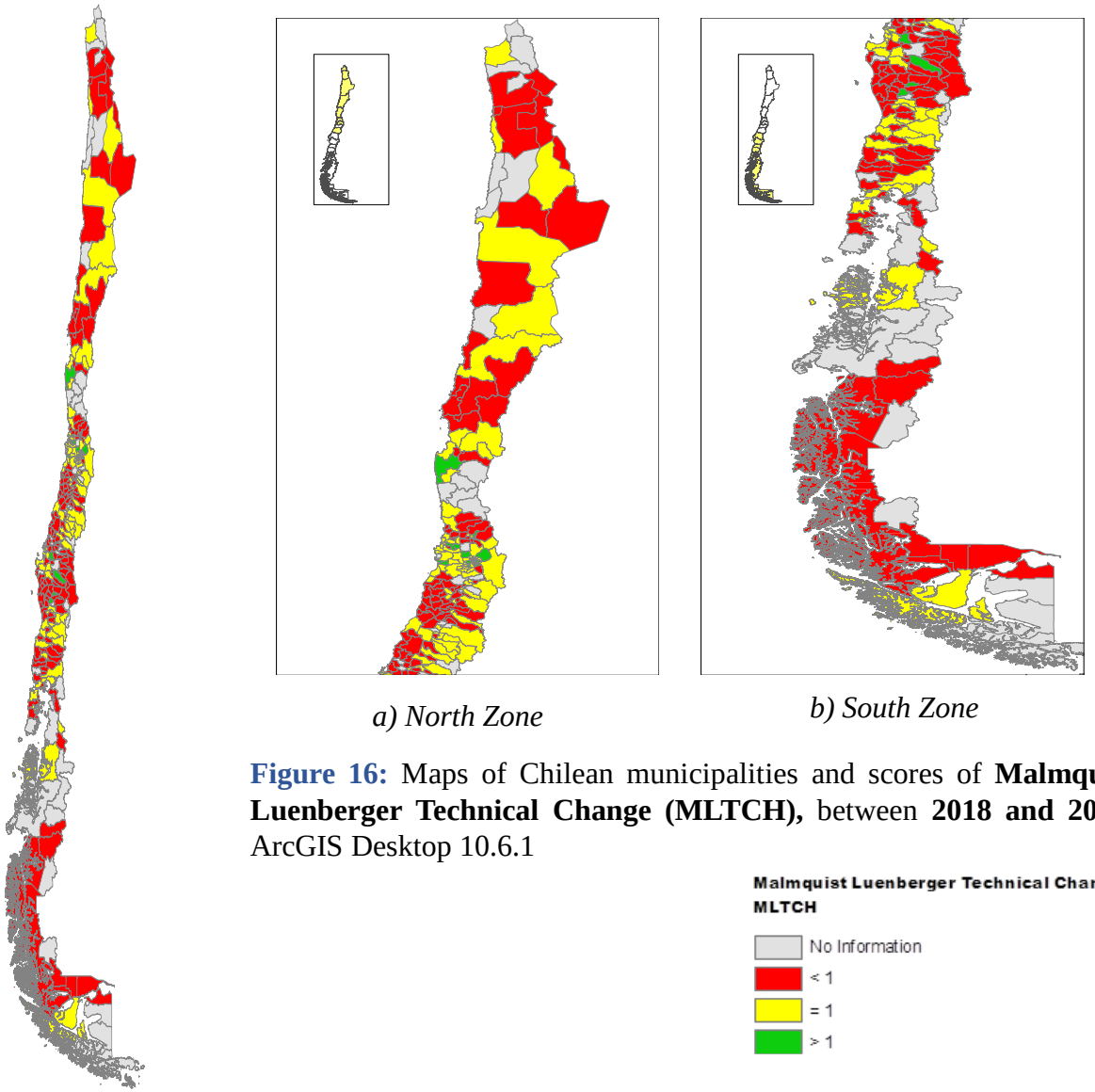
a) *North Zone*

b) *South Zone*

Figure 15: Maps of Chilean municipalities and scores of **Malmquist Luenberger Technical Change (MLTCH),** between **2015 and 2016**. ArcGIS Desktop 10.6.1

Malmquist Luenberger Technical Change MLTCH

- No Information
- < 1
- = 1
- > 1



a) North Zone

b) South Zone

Figure 16: Maps of Chilean municipalities and scores of **Malmquist Luenberger Technical Change (MLTCH),** between **2018 and 2019**. ArcGIS Desktop 10.6.1

Malmquist Luenberger Technical Change MLTCH

- No Information
- < 1
- = 1
- > 1

6. CONCLUSIONS

- Between 2016 and 2018, the Technological Change (MLTCH) had a decrease reaching scores close to -0.6. On the contrary, the Change in Efficiency (MLECH) tended to be constant over time.
- Between the years 2018 and 2019, only 64 municipalities obtained a Malmquist Luenberger Eco-productivity Index > to 0.020, which means that there was an improvement concerning the management of waste from its origin considering both the change in efficiency and the change technological, this be due to the implementation of improvements in the municipal waste management service, but still very insufficient.
- Regarding the MLTCH, it remained without significant changes between 2018 and 2019 (seen on maps).
- The MLECH between 2015 and 2019 has tended to decrease, which is a significant opportunity to improve the applicable policies for Chile.
- This methodology is diagnostic for evaluating the eco-productivity of waste collection services in municipalities, which can be replicated in other study areas and countries for improving policymaker public concerning waste services.

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Thanks all for your attention!