

## Consumption-Based Carbon Emissions in Spain: Regional Footprints and Socioeconomic Drivers

Topic: Input-Output Analysis: Sustainable Production and Consumption policies (5)

Author: María Victoria Román

Co-Authors: Arkaitz Usubiaga, Manuel Tomás, Ignacio Cazcarro, Neus Escobar, Xaquín García-Muros, Eva Alonso-Epelde, Iñaki Arto

Achieving climate neutrality by 2050 requires profound transformations not only in production systems but also in consumption patterns. While climate policies and official monitoring frameworks primarily focus on territorial greenhouse gas (GHG) emissions, an increasing body of research highlights the importance of incorporating consumption-based indicators to better understand the environmental impacts associated with household demand. In Spain, however, consumption-based perspectives remain largely absent from climate policy debates, and up-to-date and regionally detailed estimates of household carbon footprints are limited.

This paper addresses this gap by providing estimates of the carbon footprint of household consumption for Spain and its autonomous communities (NUTS2 regions) over the period 2010–2023. The analysis combines the FIGARO multi-regional input–output (MRIO) database produced by Eurostat with microdata from the Spanish Household Budget Survey, enabling the allocation of national carbon footprints across regions and socioeconomic groups. This approach ensures methodological consistency with official statistics, a key requirement of indicators for potential policy use.

The results provide a detailed picture of the evolution, composition, and regional distribution of carbon footprints over more than a decade. To better understand the determinants of regional differences, the paper combines two analytical approaches: an index decomposition analysis of per capita carbon footprints and regression models using household-level data from the Household Budget Survey. These analyses assess how variations in expenditure levels, consumption structures, and socioeconomic characteristics influence household carbon footprints across Spanish regions.

The results show that the per capita carbon footprint of Spanish households declined from 6.69 t CO<sub>2</sub>e in 2010 to 5.36 t CO<sub>2</sub>e in 2023, representing a reduction of approximately 20%. This decrease occurred across all regions, although with varying magnitudes. Despite this improvement, absolute emission levels remain well above those considered compatible with global climate stabilization targets. The analysis also reveals substantial regional disparities. In 2023, the highest per capita footprints were observed in Comunidad de Madrid, Comunidad Foral de Navarra, Illes Balears, and País Vasco, while Canarias, Extremadura, and Ceuta and Melilla exhibited the lowest values. These differences are strongly correlated with household expenditure levels and reflect variations in consumption patterns and socioeconomic characteristics across regions.

Across all regions, three consumption categories dominate the carbon footprint: private transport, food consumption, and residential energy use. Together, these categories account for the majority of emissions associated with household demand. The decomposition analysis indicates that differences in total per capita expenditure constitute the primary driver of regional footprint disparities. Higher-income regions tend to exhibit larger carbon footprints primarily due to higher consumption levels, although their consumption structures often shift toward relatively less carbon-intensive goods and services as expenditure increases.

Conversely, regions with lower expenditure levels tend to allocate a larger share of consumption to carbon-intensive necessities such as food and private transport.

Regression results further highlight the importance of socioeconomic factors. Household income

emerges as the strongest determinant of carbon footprints, with an elasticity of approximately 0.44 at the national level. Household size exhibits a negative relationship with per capita emissions, reflecting economies of scale in energy use and consumption. Dwelling size is positively associated with emissions, likely due to higher heating and cooling requirements. Other variables, including population density, education level, and household age structure, also contribute to explaining variations in carbon footprints, although their effects differ across regions.

Overall, the findings underscore the value of adopting a consumption-based perspective alongside traditional production-based emission accounting. Carbon footprint indicators can provide complementary information for climate policymaking by highlighting demand-side drivers of emissions and identifying regional consumption patterns that contribute disproportionately to climate impacts. In the Spanish context, integrating consumption-based indicators into national and regional policy frameworks could help design more comprehensive mitigation strategies that address both production systems and household lifestyles. Moreover, the methodological approach presented here demonstrates that reliable and policy-relevant carbon footprint estimates can be generated using official statistical data, making them suitable for monitoring progress toward climate objectives at bo