Spatial autocorrelation analysis of food waste in the EU

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Keywords: food waste, spatial analysis, autocorrelation, GIS
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Food loss and waste has been little investigated in quantitative and special terms, due to the lack of homogeneous, standardized, and comparable measurement systems. Therefore, further efforts are needed to address research questions related to this global phenomenon, as it affects both developed and developing economies, at every stage of food production and consumption. Given the significant environmental and economic impacts, the prevention of food waste and the need to adopt a more sustainable production and consumption model is a priority area in the EU's Circular Economy Action Plan. Spatial analysis allows for solving complex problems that have a spatial reference. It helps to explore and understand data from a geographical perspective, identify relationships, identify and quantify patterns, assess trends, and, ultimately, make predictions and support decision-making. Spatial analysis goes beyond mapping and allows the study of the characteristics of space and the relationships that develop within it. With spatial analysis, information from many sources can be combined and new information can be extracted by applying a set of spatial operators. The tools of spatial analysis help address complex spatial questions that could not be answered by simple statistical analysis, which cannot take into account the spatial context (location, proximity, distance, etc.). The aim of this study is: i) to map parameters related to food waste in the EU; and, ii) to apply spatial analysis tools to investigate potential spatial relations and patterns of food waste generation (by country and by stage of the supply chain). At the same time, possible correlations with other socio-economic patterns, at the country level, that may be related to food waste generation were also investigated. The results could be combined with a qualitative study of the phenomenon, to gain better understanding of the food waste problem and potential prevention and valorisation pathways. In this way, they could be a source of additional information for the adoption of mitigation measures for the environmental, economic and social impacts of food wastage. Food waste is a pressing global issue that has far-reaching social, economic, and environmental consequences. According to the FAO, approximately one-third of the food produced for human consumption is lost or wasted each year, equivalent to approximately 1.3 billion tons. This waste not only results in significant economic losses but also contributes to greenhouse gas emissions and other environmental impacts, such as water pollution and land degradation (Evans *et al.*, 2012).

In this study, we conducted a food waste spatial analysis of European countries. Specifically, we collected data on food waste from Eurostat database[1] and used GIS software to create maps that illustrate the spatial distribution of waste. We then performed spatial analysis to identify hotspots of waste and investigate the drivers of waste in different regions. The findings from this analysis can inform policies and interventions to reduce food waste in Europe, thereby contributing to the goal of achieving more sustainable and equitable food systems. This work presents the European waste data via several maps. Through mapping data and different indices, it is easy to explore relations through space that otherwise would not have been identified. ArcGIS Pro has been used to create the maps. Moran's I index has been used to explore the spatial autocorrelation of food waste data and the selected indices within European countries. The first step of the methodology is data collection to create a database. Then, a geo-database is created by linking the previous database to spatial data of European countries. Mapping data and contacting Moran's I autocorrelation analysis follow to generate the Results to interpret. The general flowchart of the methodology is presented in Figure 1.

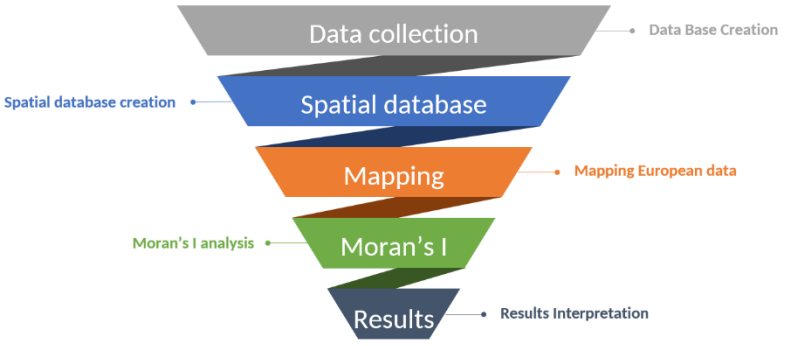

Figure 1. The flow chart of the methodology.

[1] Eurostat, 2022, Food waste and food waste prevention by NACE Rev. 2 activity - tonnes of fresh mass, https://ec.europa.eu/eurostat/databrowser/view/env_wasfw/default/table?lang=en

Moran's I index is a very valuable indicator in spatial analysis for investigating autocorrelation (Clif and Ord, 1981; Fotheringham *et al*, 2002; Chalkias *et al*, 2013). This index is given by the following formula.

$$I = \frac{n \sum\sum w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{w \sum (x_i - \bar{x})^2}$$

Where x_i is the value of x at the point i, $\bar{x}$ is the mean value of x and W is the sum of w_{ij} (weights). Moran's I values fluctuate from +1 to -1. Low values of Moran's I value suggests a strong negative spatial autocorrelation of high values close to low values and vice versa. High Moran's I value suggests a strong positive spatial autocorrelation of similar values. Values of Moran's I close to 0 indicates a random distribution (Schuurman et al, 2009). Moran's I index is a statistical tool used to measure spatial autocorrelation or the degree to which neighbouring observations are similar to each other. In the context of food waste, Moran's I index can be used to determine whether the amount of food waste in one area is related to the amount of food waste in neighbouring areas. By analysing the spatial distribution of food waste using Moran's I, policymakers and researchers can identify waste hotspots and design targeted interventions to reduce waste in these areas. The next figure presents the map of the Total Food Waste and the corresponding Moran's I (clustered) for twenty-four selected European countries.

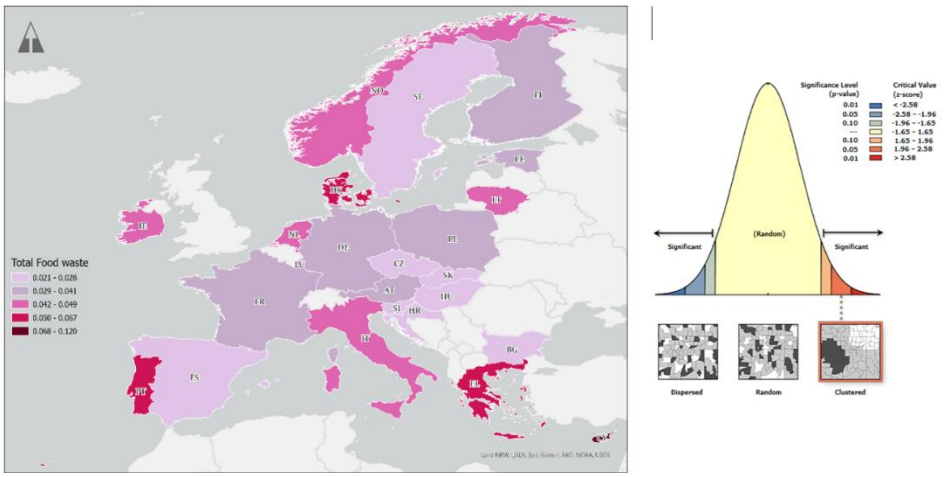

Figure 2. Total food waste map and Moran's I.

The autocorrelation analysis of food waste data has provided valuable insights into the patterns and trends of food waste over time. The analysis has revealed a significant positive autocorrelation, indicating that food waste levels in the specific index of primary production are strongly correlated with food waste levels. This suggests that there are persistent underlying factors that contribute to food waste, such as food production, consumption patterns, and food provisioning and preparation practices. These findings are consistent with previous research on food waste, which has identified systemic factors that contribute to food waste, such as supply chain inefficiencies, consumer behaviour, and waste disposal practices (Neff *et al.*, 2015). Additionally, the positive autocorrelation observed in this analysis suggests that interventions to reduce food waste should target these underlying factors and address the root causes of waste, rather than focusing solely on short-term solutions such as food recovery programs (Gustavsson *et al.*, 2011).

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Acknowledgment: This poster is partly co-funded by the European Commission through the LIFE programme "Circular Economy Implementation in Greece" - LIFE-IP CEI-Greece (LIFE18 IPE/GR/000013) and the Green Fund.