Research on the causes of the food waste phenomenon in the European Union

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Abstract

Nijloveanu, D., Tița, V., Bold, N., Chiurciu, I. A. & Smedescu, C. (2023). Research on the causes of the food waste phenomenon in the European Union. *Bulg. J. Agric. Sci., 29* (Supplement 1), 132–139

The food waste is one of the consumer economic behaviors that have a development with a great difficulty in explanation. As an economic phenomenon, it has several effects with a huge impact related to resources and optimization within the economic systems. In this paper, we propose to develop a research study which aims to identify a series of causes to food waste and to determine the quantitative impact of these causes on the phenomenon. The study is made based on the statistical data observed in a certain period and the previous research studies presented in the literature. The final part of the research is based on the determination of the influence of the identified causes on this specific consumer behavior using specific statistical methods, such as correlation.

Keywords: food waste; Food behavior; household; Food policy

Introduction

Food waste is a major problem in Europe, where significant amounts of food are thrown away every year. This is due to factors, such as consumer behavior, trade policy, strict food appearance standards and expiry dates. Food waste has social, economic and environmental consequences, affecting both consumers, who face food difficulties, and industry, which loses money from unsold products. In Europe, there are concerted efforts to reduce food waste through education, distributing excess food to those in need, and improving regulations to minimize this problem, thus contributing to the region's sustainability goals. [1]

This paper shows a bibliographical study and a statistical analysis regarding the food waste phenomenon in Europe, in order to determine the amount of influence of several factors on the food waste amount. In this matter, specific materials and methods such as direct observations, correlation determinations and statistical analyses were used in order to obtain several key conclusions related to the dynamic of food waste phenomenon in Europe. [3]

Materials and Methods

In order to determine the aspects that influence the food waste in the European Union region, we have established a series of factors that can be taken into consideration related to food loss and waste. In this matter, the process of this determination consists in several steps:

1. the determination of the main causes of the food loss and waste phenomenon, based on literature research analysis and a bibliographic study;
2. the statistical observation and description of the main statistical indicators related to the obtained factors;

3. the determination of the influence of the statistical indicators (independent variables) on the food waste statistical indicators (dependent variable) using the statistical correlation;
4. the analysis of the influence and the establishment of the statistical, economic and social significance of the obtained relations. [4]

Thus, the main instruments used within this process will be related to the needs of every phase. In this matter, the bibliographic study will use a research database (Dimensions. ai) and a term mapping software (VOSViewer), which will process the database search results. [2] The statistical analysis will be made using the data extraction and extrapolation from the existent datasets (e.g., Eurostat, FAO datasets). The determination of the influence of the found indicators on food waste quantity will be made using a simple Pearson correlation coefficient determination between each indicator as independent variable and the food waste indicator as dependent variable. A multiple correlation was not made between the multitude of statistical indicators and food waste quantity due to small amounts of data within the series. Finally, the analysis of the influences and their statistical, economic and social significance will be made using the interpretation of the statistical parameters of the obtained correlations, depending mainly on t-tests and their results applied to these correlations. [6]

Results and Discussions

1.1. The bibliographic study

Research on food waste in Europe is a growing field. In recent years, numerous studies have been published that have analyzed the causes, consequences and ways to reduce food waste.

One of the most important studies on food waste in Europe was carried out by Eurostat in 2020. The study estimated that 88 million tons of food were wasted in the EU in 2020, representing 127 kilograms per capita. This represents a 1.5% increase over 2019. [8] [10]

The bibliographical study shows that the research of the food loss and waste in Europe is concentrated on the biological and economic aspects of food production and properties. In this matter, the term used for search in the research database was established to be "Europe food loss and waste". Based on this search term, a number of 637,162 publications were found, which contained several key terms related to food loss and waste. The processing step of the search results took into consideration two major indicators given by the software, i.e., the number of occurrences of the term in the search results and the relevance score, which delimited the

most used terms that were more specific to the search term and not used in common subjects. The threshold for the number of occurrences for a term was firstly set to 10 occurrences and then to 100 occurrences. Table 1 presents a list of the terms that were found based on the number of occurrences of the term in the search results for the threshold of 100. [5] [7]

Table 1. The list of the terms resulted from the bibliographic study sorted by the number of occurrences

No.	Term	Number of occurrences	Relevance score
1.	waste	882	0,4027
2.	product	760	0,3944
3.	production	760	0,3320
4.	impact	637	0,4221
5.	food	626	0,3218
6.	process	555	0,7527
7.	source	552	0,2702
8.	environment	541	0,3645
9.	application	496	0,9968
10.	level	434	0,3742

We can observe that the most frequent terms in research related to food loss and waste in Europe are related to economic aspects. Thus, the terms are linked to the agrifood chain (production, process, source, environment, level), showing that the research is mainly focused on the economic causes and impact of the food loss and waste. Table 2 presents the results of the same search instance, but the criteria used for sorting was the relevance score. According to the software documentation, this score is used to exclude generic terms and to increase specificity of the mapping process. [8] [9]

The sort results by the relevance score shows that more specific terms related to the research of food loss and waste

Table 2. The list of the terms resulted from the bibliographic study sorted by the relevance score

No.	Term	Number of occurrences	Relevance score
1.	pandemic	155	8,5040
2.	covid	173	7,8471
3.	anaerobic digestion	110	2,9231
4.	valorization	149	2,9016
5.	micro plastic	119	2,5224
6.	person	168	2,4692
7.	food security	121	2,3985
8.	climate change	197	1,4678
9.	recovery	212	1,4652
10.	human	157	1,4619

in Europe are related to the socio-economic aspects, as well as the biological ones. Extensive research was made on the impact of the pandemic of COVID-19 on food waste and interest is shown also in other factual topics, such as climate change and food security. Moreover, several aspects are related to biological implications of food waste (e.g., anaerobic digestion or micro plastic).

The determination of the terms mapping was made based on the two values for the occurrence threshold (10 and 100). For each value, a map was generated based on the number of the occurrences. The obtained maps are shown in Figure 1.

The map obtained for a threshold of 10 occurrences shows a grouping of five clusters related to food loss and waste. The five clusters are grouped based on their common category. Thus, the five clusters are comprised of the next term categories:

- chemical industry, represented by terms, such as "plastic" and "biodegradation", showing that the most important research directions are related to plastic management and packaging issues;
- bio economy, represented by terms, such as "life cycle assessment", "temperature" or "fuel", which shows that the most important aspects are related to biological product characteristics and the production process;
- biology, represented by terms such as "content", "fermentation", "fruit" and "bioactive compound", which shows the interest in research related to natural decay processes in food;
- environment, represented by terms, such as "ecosystem", "pollutant", "microplastic" and "toxicity", which shows interests in plastic waste and environmental pollution;
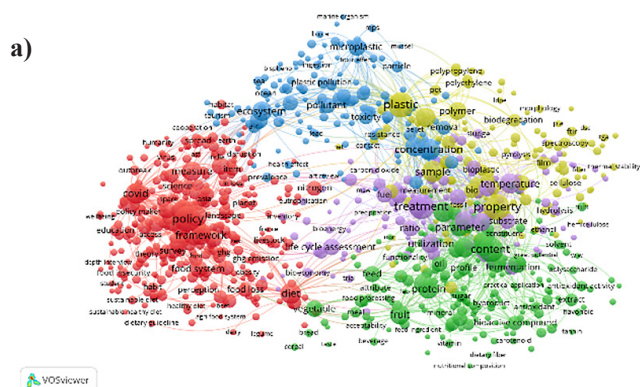
- socio-economic policies, represented by terms such as "policy", "framework", "measure" and "covid", which leads to an approach based on the determination of causes, challenges and impact of food loss and solutions to these using socio-economic policies.

This configuration leads to the conclusion that the research in the European space is mainly related to the socio-economic aspects of the food loss and waste.

The map obtained for a threshold of 100 occurrences shows a grouping of three clusters related to food loss and waste. The terms configuration gains specificity and the terms are more related to food and waste. The configuration shown in Figure 1 (b) has three clusters of terms, each one of them related to food processing and economic aspects (production, product, waste, industry), social aspects (person, country, population, climate change, health, pandemic) and environmental issues (ecosystem (micro-)plastic, environment, water, source). This configuration shows a narrower, more niched and finer set of results related to food loss and waste, due to the higher threshold related to the frequency and relevance of the found terms.

Due to the high frequency of environmental aspects of the waste concept, the land-related issues are also studied, with a high number of occurrences and a relatively high relevance score. The indicators for the land-related issues research are shown in Table 3.

The issues found in the literature regarding the waste impact on land were mainly related to land use in the food production and industry, the usage of agricultural land and the landscape issues. As for the geographical interest in food loss and waste, the distribution of the number of documents found in each country in Europe is shown in Figure 2. According to the chart, the most interested countries
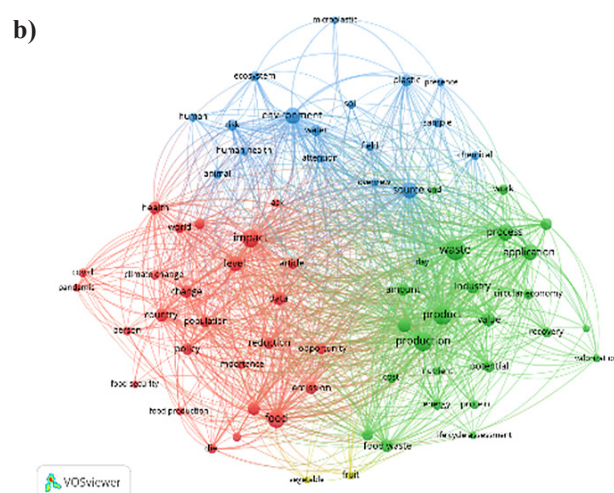
a)

b)

Fig. 1. The search term maps obtained for a threshold of frequency of (a) 10 occurrences; (b) 100 occurrences

Table 3. The land-related term configuration within the bibliographic study

No.	Term	Number of occurrences	Relevance score
497	land use	48	0.7608
499	landscape	35	0.6555
498	land use change	18	1.3644
24	agricultural land	17	0.7392
211	cropland	15	1.3022
934	wetland	11	0.8889
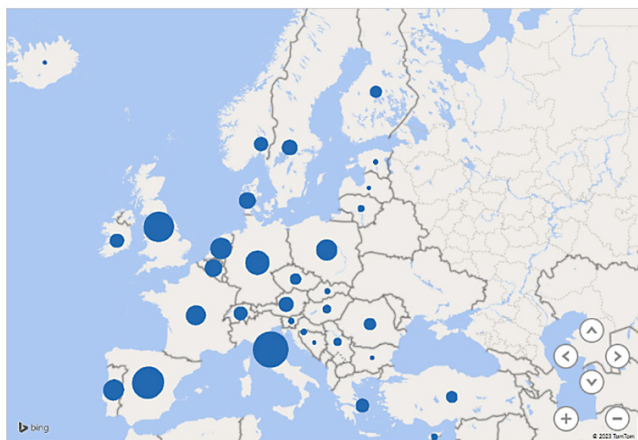
Fig. 2. The distribution of the number of documents of research for the European countries

in the research of FLW are Italy (346 documents), Spain (275), United Kingdom (259) and Germany (164), while Romania has 42 documents listed for the subject in the database. [8] [10]

In conclusion, some of the most important aspects of food loss and waste research in Europe are related to the environmental, social, economic and biological aspects of the phenomenon, related to the causes. As a result, there are a number of reasons why food waste occurs in the EU. In the EU, there are strict quality standards for food, which can lead to the rejection of food that is still edible. Also, the "best before" and "use by" expiration labels are not always well understood by consumers, which can lead to food that is still edible being thrown away. Consumers often throw away non-perishable food for reasons such as lack of time, boredom or lack of culinary inspiration.

1.2. The statistical analysis

According to the previous step, the main factors that will be taken into consideration will be:

- economic factors: GDP per capita, prices index (HICP), crop production;
- social factors: students enrolled in education, students enrolled in tertiary education, consumption expenditure per household;
- environmental factors: land use, plastic packaging waste per capita.

The presentation of the factors is shown in the next part of the paper. Figure 3 presents the evolution of GDP per capita in the period 2000-2022.
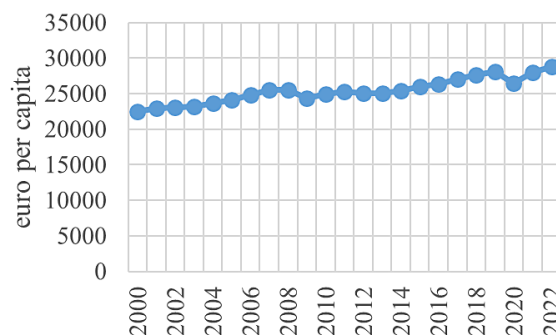

Fig. 2. The distribution of the number of documents of research for the European countries

The main indication of the GDP evolution shows that a slight increase is stated between 2000 and 2022, at an average value of 27 thousand euro per capita. Next, Figure 4 presents the evolution of the Harmonised Index of Consumer Prices (HICP) in the period 2000–2022 in Europe.
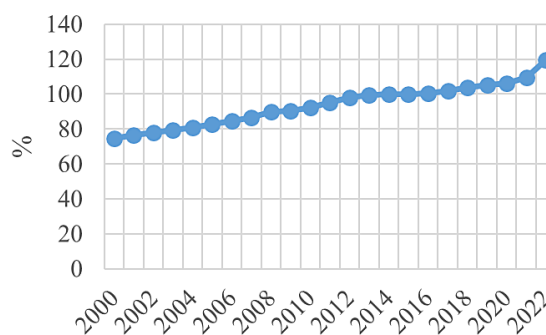

Fig. 3. GDP per capita evolution in Europe

The main indication of the HICP evolution shows that a slight increase is stated between 2000 and 2022. Next, Figure 5 presents the evolution of crop production in the period 2000–2022 in Europe.

The crop production in the mentioned period, measured in EU standard humidity per 1000 tons, shows fluctuations, due
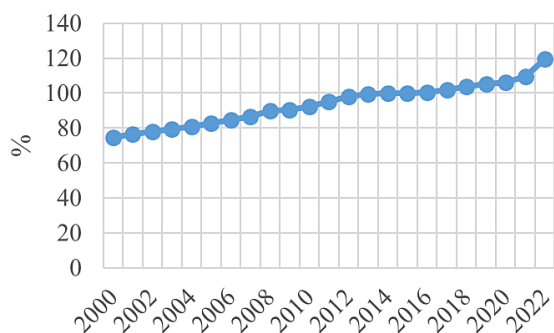
Fig. 4. The Harmonised Index of Consumer Prices (HICP) evolution during 2000–2022
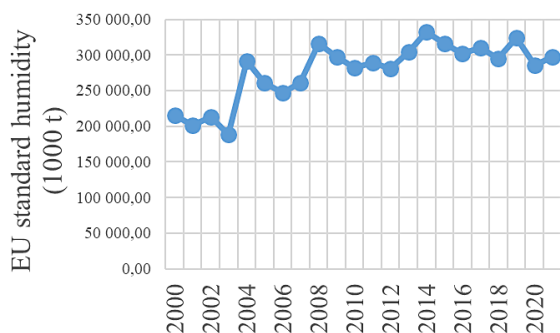

Fig. 5. Crop production between 2000 and 2020

to the instability of the climatic factors and the socio-economic ones. Next, Figure 6 presents the evolution of the number of students enrolled in all levels of education (primary, secondary, tertiary) in the period 2015–2021 in Europe.

The dynamic of student enrollment is an increasing one, with minor fluctuations. Next, Figure 7 presents the evolution of the number of students enrolled at the tertiary level of education in the period 2013–2021 in Europe.

The proportion of students enrolled in tertiary education
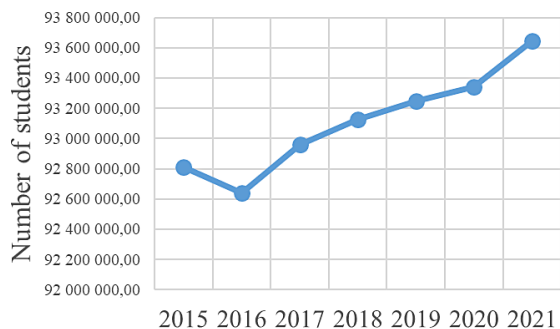
Fig. 6. Students enrolled in all levels of education between 2015 and 2021
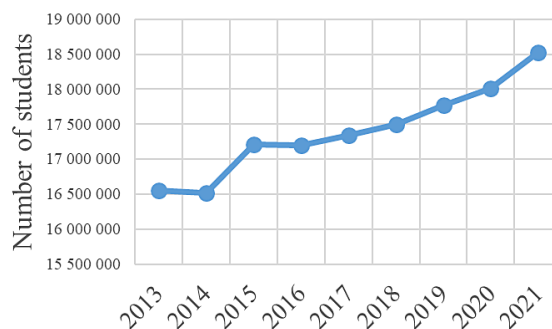

Fig. 7. Students enrolled in tertiary education between 2013 and 2021

is almost at 20% from the total number of enrolled students. Next, Figure 8 presents the evolution of household consumption in the years 1994, 1999, 2005, 2010, 2015 and 2020 in Europe.
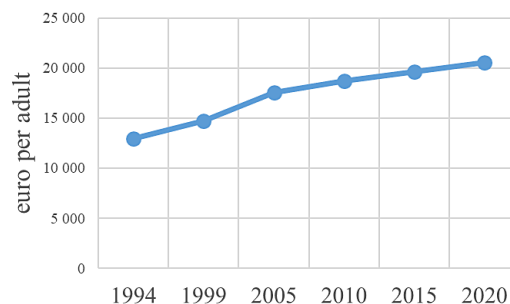

Fig. 8. Household consumption between 1994 and 2020

The value of the annual average consumption level is situated in 2020, at approximately 20 thousand euro per adults within the household. Next, Figure 9 presents the evolution of the surface of land use for agriculture in the years 2009, 2012, 2015 and 2018 in Europe.
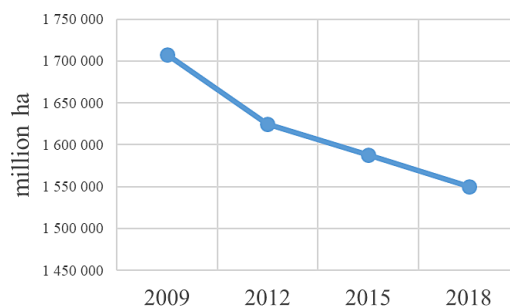

Fig. 9. Land use for agriculture between 2009 and 2018

The land use for agriculture shows a decrease in the mentioned years. Next, Figure 10 presents the evolution of quantity of plastic waste sourcing from packaging per capita in the period 2005–2020 in Europe.
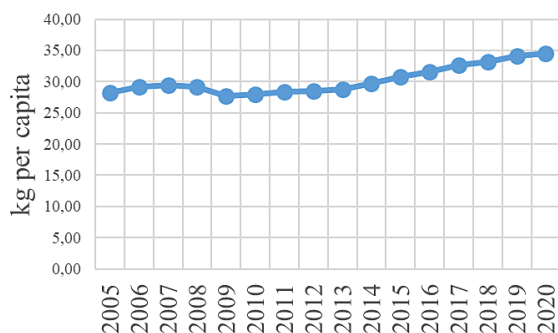

Fig. 10. Plastic packaging waste between 2005 and 2020

The mentioned quantity shows an increase during the period, reaching 35 kilograms per capita in 2020. Next, Figure 11 presents the evolution of the total quantity of the food waste in households in the period 2010-2020 in Europe.
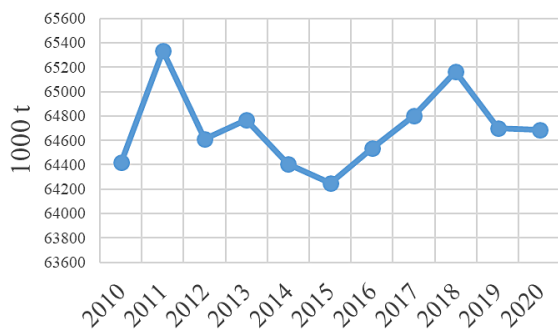

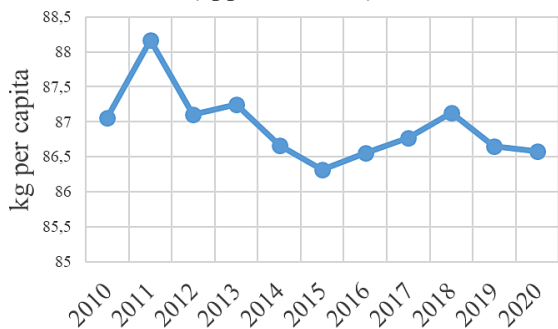**Fig. 11. Total food waste between 2010–2020 (approximation)**

Fig. 12. Food waste per capita between 2010 and 2020 (approximation)

The quantity was determined as a fraction (10%, as shown in the Eurostat report in 2020) from the total quantity of food produced for consuming. The data for consumption was aggregated as the sum of the quantities of food categories produced for consuming. Next, Figure 12 presents the evolution of the quantity of the food waste per capita in the period 2010–2020 in Europe.

The value of the annual average consumption level is situated in 2020 at approximately 20 thousand euro per adults within the household.

These values were obtained using the same methodology as for the quantity of total waste and shows minor fluctuations, remaining at an average level of 87 kg per capita. In order to show the extension of the food waste during the entire agrifood chain, data for food waste quantity per level of agrifood chain is shown in Figure 13 for 2020.
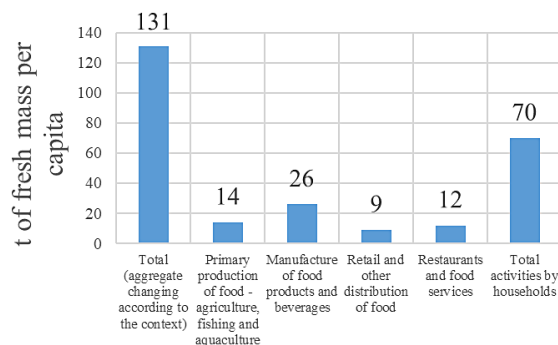

Fig. 13. Distribution of food waste per level of agrifood chain in 2020

Each indicator was then established as an independent variable in the determination of a correlation between two variables. For each indicator, the dependent variable was established to be the amount of food waste per capita, shown in Figure 12. Then, a determination of a Pearson correlation

Table 4. The values obtained for the statistical analysis

No.	Indicator	PCC	p-value	Obs.
1.	GDP	-0,36	9,66463E-27	11
2.	HICP	-0,51	5,33094E-10	11
3.	Crop production	-0,48	5,93223E-24	11
4.	Students enrolled	0,36	5,84229E-26	6
5.	Students enrolled tertiary	-0,29	3,26481E-21	8
6.	Household consumption	-0,57	1,19413E-23	11
7.	Land use	0,54	2,23991E-22	9
8.	Plastic waste	-0,53	2,78623E-26	11

coefficient (PCC) was made between each pair of the independent variables and the dependent one and the statistical significance was verified using a t-Test (two-sample assuming equal variances). The number of observation (Obs.) for each pair of variables was established as the number of common years presented in the statistical series of data. For the discrete variables (i.e., the ones which presented values for several years), the approximation of a continuity throughout

the years was made using an interpolation method. The values for the explained methodology are presented in Table 4.

As we can observe, all the correlation determinations were statistically significant (p-value being lower than 0.05), with inverse correlation determined for GDP, HICP, crop production, the number of enrolled students at tertiary level, household consumption and plastic packaging waste amount and direct correlation for the number of enrolled students and the land use for agriculture. The graphical representation of all the correlation determinations is shown in Figure 14.

The values of the PCC (Pearson Correlation Coefficient) show a medium or low intensity of correlation between the independent variables and the dependent one, as the cloud shape of the data points emphasize in the graphical representation of the correlation determinations. From the independent variables, the ones with the most influence found on food waste are the HICP index (inverse), the crop production (inverse), the household consumption (inverse), land use (direct) and the amount of plastic packaging waste (inverse).

Conclusions

Food waste in Europe has complex origins and involves multiple aspects, including consumer behavior, business practices, supply chain management and quality standards. This can be caused by overfeeding, misunderstanding of food labeling data, retail stock management policy, and strict requirements on food aesthetics, and losses during transport and storage, as well as expiry dates. Tackling this issue requires educating consumers, improving industry practices and updating expired food management policies to reduce food waste in Europe and promote sustainability in the food sector.

Future work will be establish for the refinement of the data using more specific datasets and the usage of the results in further analysis of the effects, impacts and solutions for the food waste phenomenon.

Fig. 14. The graphical representation of the correlation determinations

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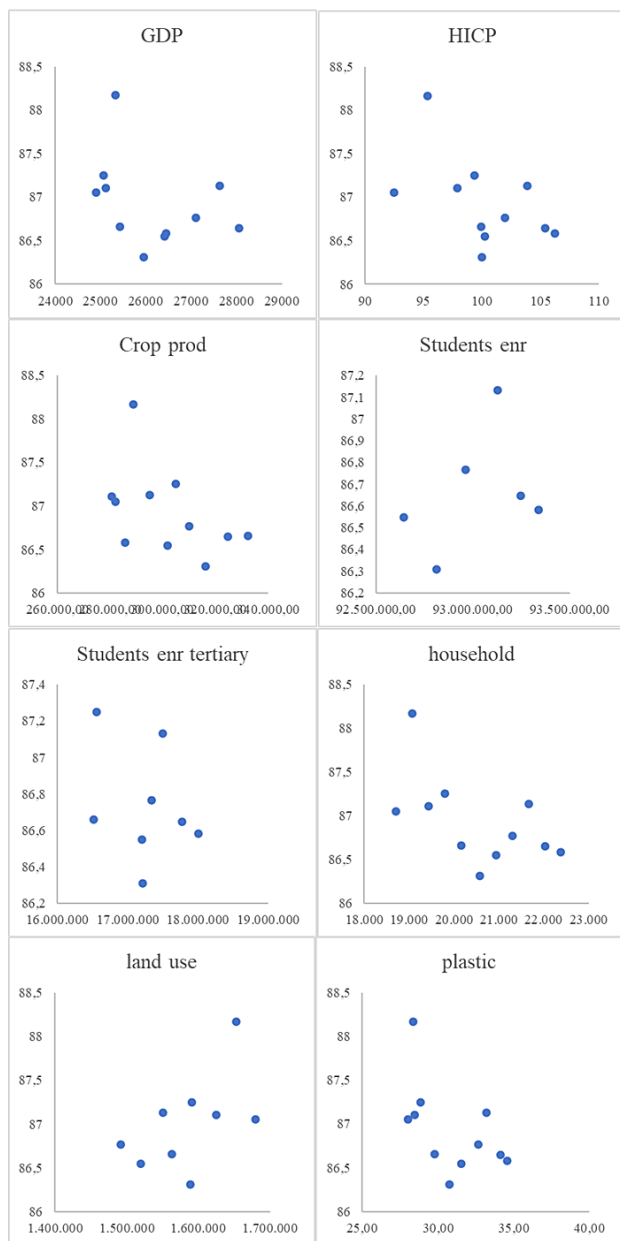
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