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Water, Energy, Food, Waste Nexus: Between Synergy and Trade-Offs in Romania Based on Entrepreneurship and Economic Performance

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Abstract: Boosting the externalities across the water, energy, food, and waste (WEFW) sectors is challenging, especially considering tightening constraints such as population growth, climate change, resource-intensive lifestyles, increased waste production, sanitary crises and many others. The nexus approach supports the transition to a more sustainable future because intersectoral trade-offs can be reduced and externalities exploited, making imperative for decision makers, entrepreneurs, and civil society to simultaneously engage, with respect to all the components of the nexus. This research addressed intersectoral synergies and trade-offs in the case of the WEFW nexus in Romania, judging from the perspectives of entrepreneurial activity and economic results. The objective of this research was to explore the nexus in-depth by statistically analyzing the financial and economic indicators reported by active enterprises at county-level, based on the Romanian Ministry of Public Finance data. Research results describe the effects of the policies implemented in the fields of WEFW sectors. At the same time, attention was paid to the quality of the entrepreneurial activity, analyzed from the perspective of economic performance. This paper fills a research gap regarding the WEFW nexus by resorting to an economic and entrepreneurial performance assessment in order to find sectoral pathways toward policy cohesion in Romania. Findings suggested the existence of major trade-offs among sectors, owing to the fact that each county has a different development degree.

Keywords: interconnectedness; transdisciplinarity; policy coherence; entrepreneurial activity assessment; circular economy

1. Introduction

The water–energy–food nexus was officially approached at the Bonn 2011 Nexus Conference, when the German Federal Government organized the international conference "The Water Energy and Food Security Nexus—Solutions for the Green Economy", aiming to contribute to the efforts specific to designing a more sustainable future (Rio + 20). In 2011, Hoff explained the emergence and international urge to respond to global challenges such as climate change, population growth, globalization, economic growth, and urbanization—challenges that call for a multisectoral approach, which was the case of the water, energy, food and waste (WEFW) sectors [1]. In 2021, Hoff's analysis still represents a major point of reference for recent research studies [2–8] and has gained new meanings in the context of the European Green Deal [9–13].

The nexus can be defined by the relationships that exist within it. To begin, there is the water-energy connection, which demonstrates how water is critical for energy creation in a variety of ways, including hydroelectric plants, cooling thermal (fossil-fuel or nuclear)

power plants, and growing plants for biofuel production. Additionally, as far as the relationship between the water and food sectors is concerned, water is a necessary component of the agro-food supply chain. By gaining a greater understanding of the relationships that occur within the nexus, it may be possible to explain how food and energy are connected. Energy is a critical input at every stage of the agro-food supply chain, from water pumping to food processing, transportation, and refrigeration. The waste component completes the nexus in terms of sustainable development plans. Healthy ecosystems are a necessary condition for sustainability; hence, the waste component fully complements the nexus for constructing a new economic system.

Given that resource extraction and processing contribute to more than half of all greenhouse gas emissions and more than 90% of biodiversity loss and water stress, the European Green Deal developed a coordinated approach to attaining a climate-friendly, resource-efficient, and competitive economy. The expansion of the circular economy from pioneers to critical economic actors will contribute significantly to achieving climate neutrality by 2050 and decoupling economic growth from resource consumption, while also ensuring the EU's long-term competitiveness and ensuring that no one is left behind [14].

In order to reach this ambitious aim of competitiveness and sustainable growth, the EU intends to speed up the transition to a model of regenerative development, such that it returns to the earth more than it receives, heading toward a situation in which it uses less resources, thus establishing the common goal for the entire European Community bloc. The European Commission adopted, in 2020, the framework for the new Circular Economy Action Plan, for a cleaner and more competitive Europe [15].

The circular economy is an economic principle that aims to maintain resources in the economy for as long as possible, by following a round path. This can be accomplished through reducing the use of raw materials, the production of waste, the emission of pollutants, and the consumption of energy. Waste and recycling industries currently account for the majority of the circular economy, with approximately 600 million tons of waste that is either recyclable or reusable in Europe [16].

A circular economy system can alleviate future resource scarcity, address climate change, and reduce economic inefficiency. Resource inefficiency of the traditional "make-use-dispose" economy model generates environmental pressure on the natural capital and contributes to the generation of large volumes of greenhouse gas emissions specific to high carbon energy. Consequently, the traditional model contributes to the intensification of the negative effects of climate change [17]. Instead, the circular economy model is grounded on reusing resources for as long as possible in loop systems, aiming for low carbon energy, clean technology, and minimal resource usage [18]. Circular economy strategies and solutions should strive to innovatively reduce greenhouse gas emissions through actions with significant impact on mitigating climate change [19–21]. The new system promotes innovation at its core by closing the circle from waste to resources, extending the life of products and giving "new life", meaning, and purpose to what the linear economy system views as waste [22,23]. This system is offered as a complement to the linear system on the grounds that the linear economy of "take-dispose" cannot be sustained in the long run due to resource price volatility and supply disruptions as well as economic losses and environmental degradation. When viewed through the lens of the circular economy, the nexus of WEFW emphasizes future transformations.

The objective of this research paper was to economically approach the different and complex layers of the WEFW nexus in the case of Romania and analyze the performance of the entrepreneurial activity in these sectors at county-level. The analysis was conducted by resorting to official financial and economic indicators reported by the active enterprises, based on data available from the Romanian Ministry of Public Finance. Whether the results indicate synergies, trade-off issues or dysfunctionalities between sectors, the economic performance results were discussed in the spotlight of two different perspectives: (a) these results represent the effect of the policies designed by decision makers in the fields of

WEFW sectors; (b) conversely, the same results can be interpreted as the quality of the entrepreneurial activity in each of the counties analyzed.

The concept of a nexus encapsulating the WEFW elements has been gaining attention in the scientific literature. Corroborated with the increasing interest of decision makers in determining the perfect policy mix and resource allocation to achieve and maintain water, energy, and food security in the long-term, these two factors justify the importance of the WEFW nexus in the current global context. Regarding the novelty factor of this paper, the research conducted places the WEFW nexus in the spotlight of the economic and entrepreneurial factors as well as provides the assessment methodology to study the performance of the nexus in regard to the previously mentioned factors. Although the case of Romania is explained in this paper though the lens of the WEFW nexus, additional attention was paid to the importance of trans-discipline and on finding pathways for the improvement of policy coherence by analyzing sectoral synergies and trade-offs.

This research paper is structured as follows: after the brief introduction in Section 1, Section 2 engages more with the scientific literature on the WEFW nexus, with special focus on the economic implications of this nexus. The same section covers the perspectives for the organic waste and entrepreneurial sectors with respect to the nexus. The last Section 2.3 includes a short literature review and discussion on the imperative of a multi-intersectoral approach of the water, energy, food, and organic waste sectors in Romania in the context of the European Green Deal. Section 3 is dedicated to the research methodology, and it covers the full description of the materials and methods used to conduct the research. Section 4 represents the core of this paper and the authors' unique contribution to the scientific literature—in this section, the Romanian WEFW sectors were analyzed at county-level through the lens of economic indicators, while considering the quality of the entrepreneurial activities at local level. This was accomplished by resorting to the economic results of the companies assigned to the European Nomenclature of Economic Activities (NACE) specific to the previously mentioned sectors. Finally, the last section, Section 5, concludes the main research findings and highlights the relevance of this paper. Moreover, this section is aimed at supporting decision makers to better understand the WEFW nexus in Romania from an economic and environmental point of view, with a special focus on synergies and trade-offs. Lastly, the limitations of this research and future directions were explained in Section 5.

2. Literature Review

Water, energy, and food resources are subject to substantial pressure. The United States National Intelligence Council estimated that demands for water (40%), energy (50%), and food (35%) will increase by 2030 [24]. Irrigation is one of the main water consumption sources: 70% of water abstracted from freshwater systems is destined for agriculture, due to the high demand of water for crop irrigation [25] necessary for sustaining 40% of the global food production [26]. To add the energy component into the equation, many multidisciplinary assessment studies have been conducted to evaluate the dynamic between socio-economic factors, climate change, and bioenergy, in relation to land-use [27–32]. In this context of successfully meeting water, energy, and food security globally in a sustainable manner, the nexus has received increased attention in the literature, especially since 2015 after the 2030 agenda for sustainable development was published by the United Nations [33].

There is a growing trend in the scientific literature for exploring the modern version of the traditional water–energy–food nexus [34–36], which includes the waste component [37–39]. Since the elements comprising the traditional water–energy–food nexus are interlinked in numerous ways, a multisectoral approach is needed in order to harmonize the actions of decision makers from all sides, since: (a) agricultural policy has implications on water demand and can influence the active agents in the water market. Water policy has implications in the field of agriculture, since the latter is dependent on water resources [40]; (b) agricultural policy influences energy demand. Energy policy can influence agri-food production and market prices [41]; (c) water policy can influence energy demand. Energy

policy can influence water demand [42]. Proactively creating solutions to resource management challenges, achieving the Sustainable Development Goals (SDGs) in time, and responding to the on-going COVID-19-related issues are three factors that amplify the scientific interest for the WEFW nexus [43]. Moreover, the food loss–waste–food security dynamic has also become an ardent topic in the societal and scientific attention, as it contributes to holistically understanding the issues occurred as a result of unsustainable consumption and production patterns [44–46].

2.1. The Water, Energy, Food, Waste (WEFW) Nexus: Economic Implications

The WEFW nexus calls for the need to properly manage linked resources, avoid waste, and strive to achieve sustainability [47]. It captures the interconnections, synergies, dependencies, trade-offs, and various linkages between production and, conversely, the nature of energy, food, and water resource consumption patterns [48]. While allowing a holistic, multidisciplinary understanding of the (un)intended consequences of policies, the WEFW nexus represents a multi-dimensional scientific tool that seeks to answer the complexity of human-environment interactions [49]. It is a scientific duty to identify solutions to maximize benefits across the water, energy, and food sectors through encapsulating the impact of waste and unsustainable behaviors on all the components of the nexus in a cost-efficient and sustainable managerial solution to societal issues [50].

Efficient adaptation to shocks, the emergence of change, and embracing it with proper managerial techniques and resilience, which all require coordinated and concentrated efforts to maximize intersectoral synergies and minimize trade-offs [51] as well as proper management of the use of water, energy, land and other crucial resources, does not only encompass an environmental perspective, but an economic perspective as well [52]. This is a major challenge, especially for developing countries, which are still facing issues in achieving food, water, and energy security, which is directly correlated to climate change issues [53,54]. However, food loss and waste represent opposite global issues with significant economic implications yet are specific to developed countries. For these issues, diverse solutions have been found [55–57], but have not been placed into practice rapidly [58]. Furthermore, large quantities of organic waste are generated throughout the water, energy, and food nexus. In this context, waste may not be treated appropriately, especially in times of crisis [59], because the true cost of waste can be hard to quantify economically. Once again, this proves the complexity of the WEFW nexus.

The concept of the WEFW nexus aims to encompass all socioeconomic and environmental interconnections between the production, consumption, logistics, and recycling or reuse of food, water, and energy [60]. Interactions among resource availability and economics, resulted food waste, environmental issues, and social justice can serve as an instrument that expresses intersectoral inefficiencies and externalities connected to different components of the nexus [61].

As far as resource recovery from waste streams is concerned, it represents an actual solution and promise of improving both ecologic and economic performances of nexus system flows [62,63]. Resource recovery is a complex process relevant for the WEFW nexus because it involves the creation of additional revenue streams through the recovery of valuable resources that will have otherwise been treated as waste [64]. In accordance with the principles of circular economy [65], identifying resource recovery opportunities calls for treatment endeavors forecasted with economic profit with the help of economists and ecologists collaborating together.

2.2. The Role of Entrepreneurship in Water, Energy, Food and Waste (WEFW) Nexus

In the face of the numerous environmental issues, societies seek performant and innovative solutions to achieve sustainable development simultaneously with economic growth and, in this regard, entrepreneurship is of great apprehension in the literature [66–68]. After the 2030 agenda for sustainable development was published, scientific attention has been increasingly paid to the role of environmentally oriented entrepreneurship in relation

with various economic sectors, including the WEFW sectors. In this context, an emergent question is: how can environmental degradation and climate change be mitigated through sustainable entrepreneurship [69–71]?

Advocating for sustainable business models in the WEFW sectors involves more than adopting green technologies that promote the protection of the natural capital [72]. Sustainable business models call for multidisciplinary research and intersectoral approaches developed by entrepreneurs, managers, as well as consumers [73,74]. Understanding the synergies trade-off issues or dysfunctionalities between sectors makes entrepreneurs more responsible about their role in society and their impact on the natural capital and places the economic aspect into a greater perspective [75].

2.3. WEFW Nexus: The Imperative of a Multi-Intersectoral Approach in Romania in the European Context

As part of the European Union, Romania is expected to efficiently move forward with coherent policies in pursuit of the goal of carbon neutrality by 2050, with effects on numerous economic sectors, including the WEFW sectors [76]. However, Central and Eastern European countries, Romania included, face multidimensional challenges of economic catching-up with older member states [77–79], to which Romania must respond in a sustainable manner [80] while considering the synergies and trade-offs specific to the WEFW nexus [81,82]. Sustainable management of resources and paying respect to the WEFW nexus have gained momentum, as it is imperative for delivering the United Nations' 2030 agenda for sustainable development in time [83] and for successfully implementing the European Green Deal [84,85]. In this regard, the nexus and multi- and intersectoral approaches are essential for Romania in the race for meeting the SDGs, the Paris Agreement, and the EU's climate neutrality goal [86]. Although there are still factors that need to be resolved, referring to the operational application of the nexus approach in decision-making, it is responsible and appropriate to consider it as means to ensure success in multiple sectors simultaneously through promoting policy coherence via optimal policy mixes and governance harmonization across the WEFW sectors [87]. By respecting the nexus, decisions can avoid the unintended consequences of uncoordinated policies and actions between multiple sectors.

This research paper complements the existing literature by approaching the Romanian WEFW sectors at county-level through the lens of economic indicators, considering those as the results of the entrepreneurial quality at the local level. From this perspective, the synergies and trade-offs between sectors were analyzed based on the entrepreneurial convergence toward the same economic actions locally, environmentally friendly or not, as instilled in Romania's WEFW policies.

3. Materials and Methods

The raw data used for conducting this research were taken from two sources:

(a) Data related to the active enterprises in Romania and their financial and economic results corresponding to the year 2020 were taken over from TopFirme (https://www.topfirme.com/; accessed on 15 May 2021). TopFirme is an online aggregator platform based on Romanian Ministry of Public Finance public data. At the moment of conducting this research, financial and economic data corresponding to the year 2020 were the most recent reported by the analyzed active companies;

(b) The Romanian National Institute of Statistics (via the online platform, TEMPO; http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table; accessed on 15 May 2021), which was used to extract data regarding the consumption of thermal energy (Energy purchased and distributed by thermo-electric power stations and thermal stations, as well as the thermal energy distributed by thermal microstations of blocks of flats or residential districts, belonging to local administration units) at county level in Romania (indicator code GOS109A) and data regarding the legally resident population: the number of persons with Romanian citizenship and legal residence on the territory of Romania (indicator code POP107A).

Table 1 contains relevant information regarding the nature of the analyzed types of business and their connection with the WEFW nexus. However, as far as the energy sector is concerned, instead of approaching active enterprises and their economic performance, this study was centered around the nature of energy consumption. In this regard, the nominal consumption of thermal energy at the level of each Romanian county was analyzed. The transition to a more sustainable energy consumption model was studied by comparing the nominal thermal energy consumption in 2019 to the consumption reported in 2009 (decreases of nominal Gcal consumed was considered improvement).

**Table 1.** Overview of the types of analyzed business activities.

CAEN [2] Code	Name of CAEN [2] Code	Full Description of the Business Activity
3600	Water production, treatment, and supply	Water abstraction from rivers, lakes, and wells; treatment and distribution of water for industrial and domestic purposes; collection of rainwater; water distribution. It does not include operations for irrigation systems (agricultural purposes), wastewater treatment and transport via pipelines
3700	Sewage collection and treatment	Collection and transport of wastewater from industrial or communal activities; rainwater through sewers and sewage tanks; cleaning and maintenance of sewage systems, closed stormwater channels
3821	Treatment and disposal of non-hazardous waste	Treatment and disposal of solid or non-solid non-hazardous waste, including food waste; operation of landfills for non-hazardous waste; treatment and disposal of organic waste
3811	Collection of non-hazardous waste	Collection of non-hazardous solid waste (including household and food waste); collection of mixed but non-hazardous solid waste generated by households and enterprises

[2] CAEN: classification of activities in the national economy.

With respect to the analyzed business activities, multiple economic performance indicators (see Table 2) were calculated at county-level and results are visually represented in Figures 1–4.

Table 2. Overview of analyzed indicators.

| Indicator	Explanation
County-level contribution to the national turnover generated by economic activities registered under "X" CAEN code	Represents the turnover registered by all the active enterprises in a Romanian county with "X" CAEN code reported to the total turnover registered at national level under the "X" CAEN code
Impact of "X" CAEN code economic activities on the local economy	Represents the turnover registered by all the active enterprises in a Romanian county with "X" CAEN reported to the total turnover registered at county level under the "X" CAEN code
Profit generated by all companies registered with "X" CAEN code	Represents the total profit generated by the active enterprises registered with "X" CAEN code, reported in only in a specific Romanian county
Profitability of the companies registered with "X" CAEN code	Represents the total profit generated by the active enterprises registered with "X" CAEN code reported to the total turnover registered by the same enterprises, calculated at county level
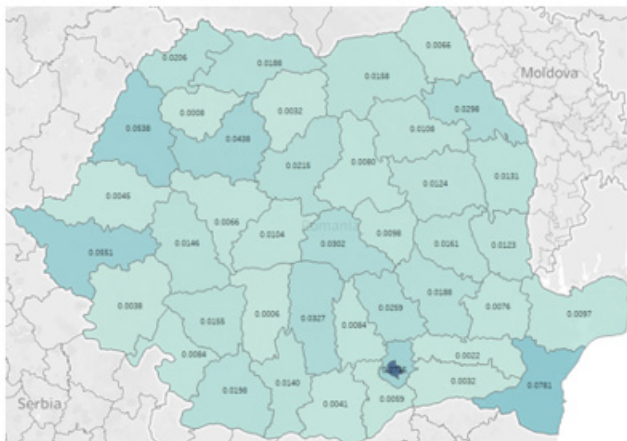
County-level contribution to the national turnover generated by the economic activities registered under the 3811 CAEN code
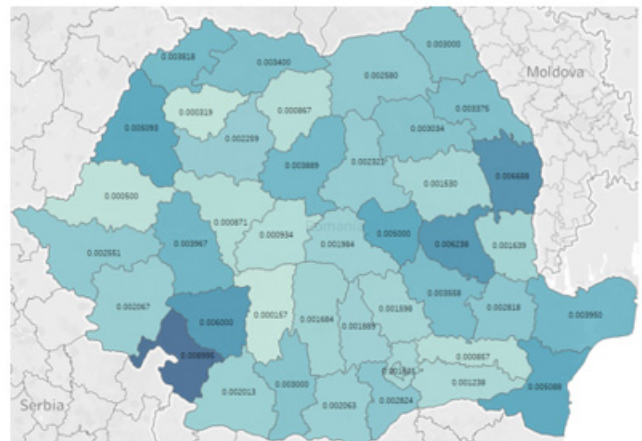
Impact of the 3811 CAEN code economic activities on the local economy (turnover)
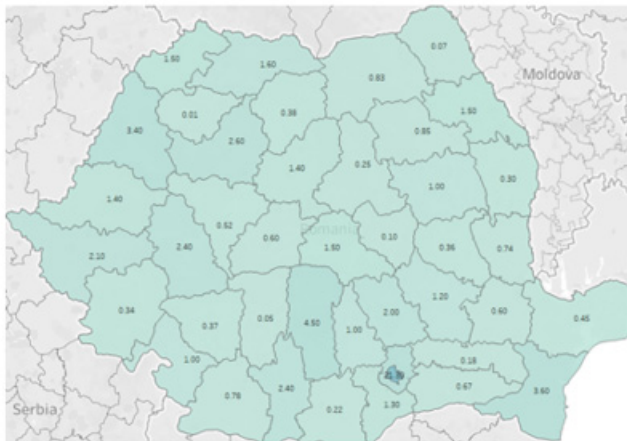
Profit generated by all companies registered under the 3811 CAEN code
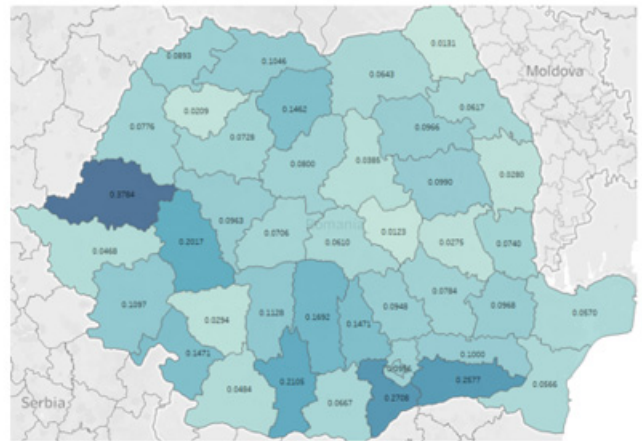
Profitability of the companies registered under the 3811 CAEN code

Figure 1. Overview on 3811 CAEN code.

County-level contribution to the national turnover generated by the economic activities registered under the 3821 CAEN code

Impact of the 3821 CAEN code economic activities on the local economy (turnover)
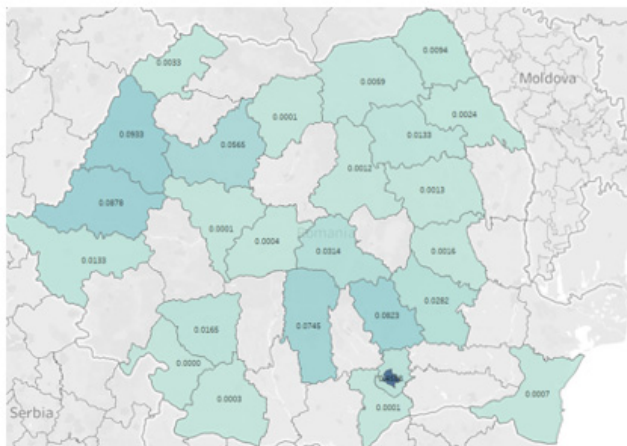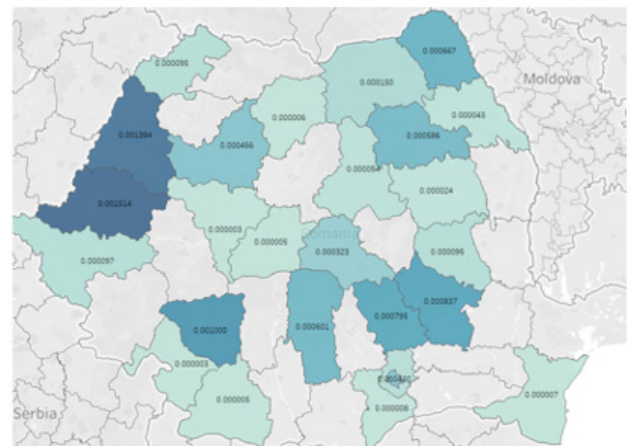
Figure 2. *Cont.*

Profit generated by all companies registered under the 3821 CAEN code

Profitability of the companies registered under the 3821 CAEN code

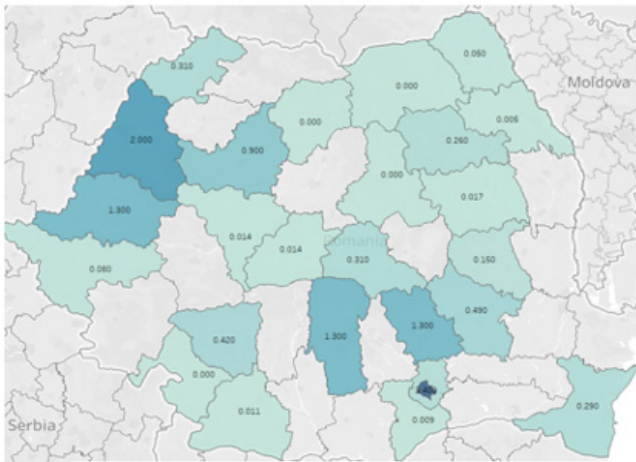**Figure 2.** Overview on 3821 CAEN code.

County-level contribution to the national turnover generated by the economic activities registered under the 3600 CAEN code
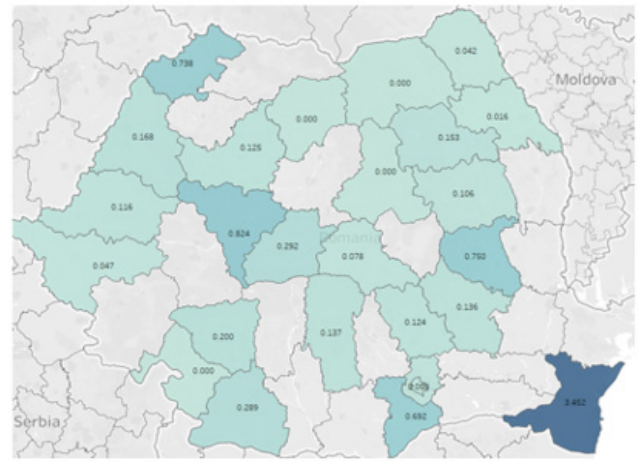
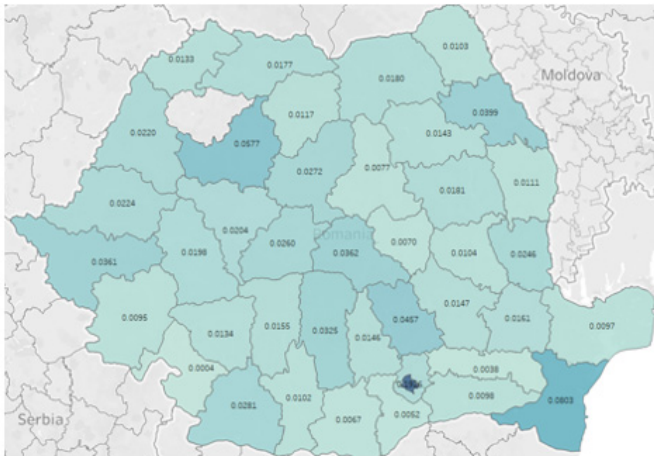Impact of the 3600 CAEN code economic activities on the local economy (turnover)

Profit generated by all companies registered under the 3600 CAEN code

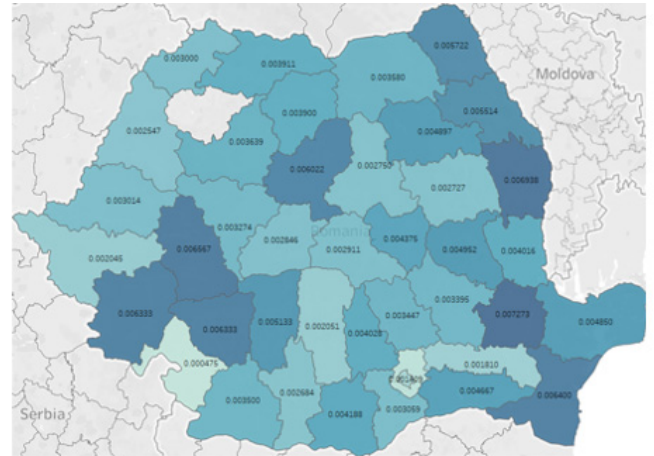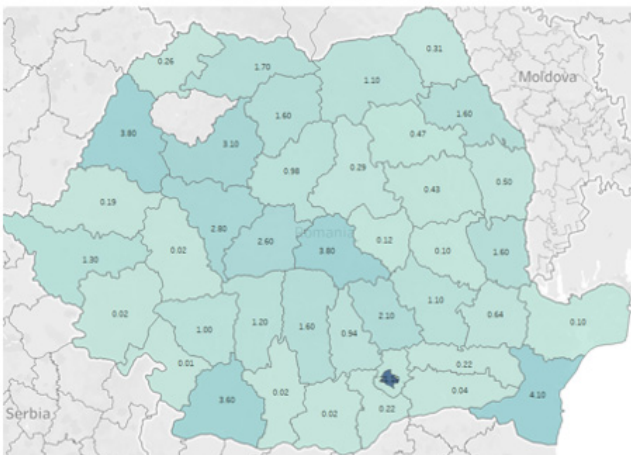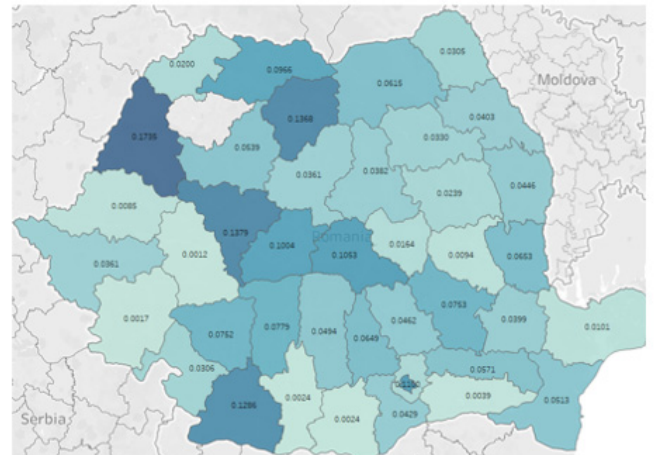Profitability of the companies registered under the 3600 CAEN code

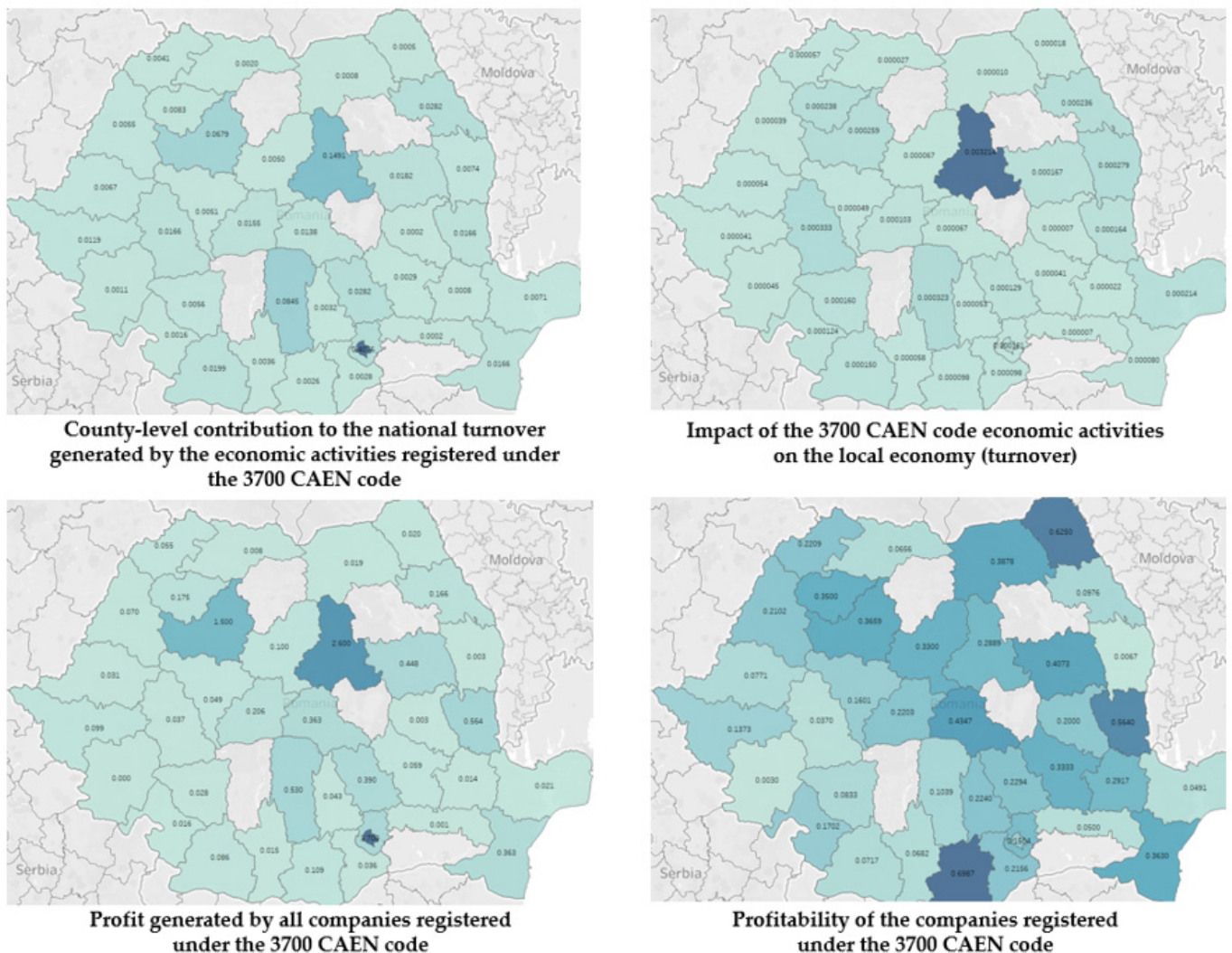**Figure 3.** Overview on 3600 CAEN code.

Figure 4. Overview on 3700 CAEN code.

The complex layers of the WEFW nexus were statistically analyzed based on the performance of the entrepreneurial activity in these sectors at county-level in Romania, according to the sample explained in Table 1 and using the indicator set from Table 2. Whether the results hint at synergies, trade-off issues, or dysfunctionalities between sectors, the results were discussed in the spotlight of two different perspectives: up to a certain degree, the economic analysis reflects the results of the policies designed by decision makers in the fields of WEFW sectors, and the same results partially reflect the quality of the entrepreneurial activity in each of the county analyzed.

4. Research Results

It is the primary focus of this research to investigate the economics of the WEFW nexus. It is vital to obtain a better grasp of the economic condition of each Romanian county. It is necessary to examine the WEFW sectors in order to gain a better understanding of the strategic perspectives of local actors such as local institutions and how they implement the European Union's recommendations on natural resource conservation, which fall under the purview of the water sector, as well as a closer examination of the food, energy, and waste sectors, in order to find the best managerial strategies to implement the EU's recommendations.

When it comes to sole proprietorships, Romanian law categorizes them according to the type of activity they engage in; this type of law allows business owners to choose a

CAEN code, an acronym for classification of activities in the national economy, a code that respects the regulations provided by the European Nomenclature of Economic Activities (NACE). The economic overview of the 3811 activity code is described in Figure 1. The CAEN code 3811 is assigned to the collection of non-hazardous waste. In the context of garbage collection, the term "business-activity codes" refers to the collection of non-hazardous waste, which includes organic waste.

According to the available data, an analysis of the non-hazardous waste collection industry was conducted based on economic efficiency standards by counting the number of enterprises specializing in non-hazardous waste collection in each county.

Furthermore, in order to gain a better understanding of the economic aspects of businesses that are oriented toward waste management and that have as their primary object of activity the 3811 CAEN code, clusters were created at county-level. As a result, economic aspects were approached and discussed, according to the specifics of each county, and key recommendations to help diversify the local economies were made.

When discussing the contribution of the county's businesses that have the main object of activity the collection of non-hazardous waste, for the total fiscal value generated by each business on a national level, three clusters were identified:

(a) Bucureşti (27%), Constanţa (7.81%), Timiş (5.51%), Bihor (5.38%), Ilfov (4.90%), and Cluj (4.38).

(b) Argeş (3.27%), Braşov (3.02%), Iaşi (2.98%), Prahova (2.59%), Mureş (2.15%), Satu Mare (2.06%), Dolj (1.98%), Buzău (1.88%), Maramureş (1.88%), Vrancea (1.61%), Suceava (1.58%), Gorj (1.55%), Hunedoara (1.46%), Olt (1.40%), Vaslui (1.31%), Bacău (1.24%), Galaţi (1.23%), Neamţ (1.08%), and Sibiu (1.04%);

(c) Covasna (0.98%), Tulcea (0.97%), Dâmboviţa (0.84%), Mehedinţi (0.84%), Harghita (0.80%), Brăila (0.76%), Alba (0.66%), Botoşani (0.66%), Giurgiu (0.59%), Arad (0.45%), Teleorman (0.41%), Caraş-Severin (0.38%), Bistriţa Năsăud (0.32%), Călăraşi (0.32%), Ialomiţa (0.22%), Sălaj (0.08%), and Vâlcea (0.06%).

Three clusters were identified: counties that contribute more than 4% to the national fiscal value of non-hazardous waste collection, counties that contribute between 1% and 3%, and counties that contribute less than 1% to the national fiscal value of the activity, represented by the 3811 activity-code. As a result of this cluster view study, we can identify Bucharest as the highlight of this sector since it is the capital of Romania; Bucharest alone contributes 27% to the national fiscal value of non-hazardous waste collection. The significant contribution made by Bucharest to the entire fiscal value of the activity is attributed to a variety of socioeconomic factors, including population density and the capital's high level of development. As a result of civil society's involvement in the waste management problem, there has been an increase in public awareness of the need for a more ecological and circular approach to waste management.

The primary contributors in brackets (a) and (b) consist of more developed countries than those in bracket (c). In this way, obtaining an understanding of the cluster perspective indicates that all 42 counties in Romania have achieved a high level of development while simultaneously diversifying their own local economies.

As the EU strongly advises the members to improve their waste management policies, Romania and its private capital market applies the recommendations.

Obtaining a deeper understanding of the local economy, the cluster analysis was applied regarding the contribution of the business activity of collecting non-hazardous waste, to each county's economy:

(a) Mehedinţi (0.90%), Vaslui (0.67%), Vrancea (0.62%), Gorj (0.60%), Bihor (0.51%), Constanţa (0.51%), and Covasna (0.50%);

(b) Hunedoara (0.40%), Tulcea (0.40%), Mureş (0.39%), Satu Mare (0.38%), Buzău (0.36%), Maramureş (0.34%), Iaşi (0.34%), Neamţ (0.30%), Botoşani (0.30%), Olt (0.30%), Giurgiu (0.28%), Brăila (0.28%), Suceava (0.26%), Timiş (0.26%), Harghita (0.23%), Cluj (0.23%), Caraş-Severin (0.21%), Teleorman (0.21%), Dolj (0.20%), and Braşov (0.20%);

(c) Dâmboviţa (0.19%), Argeş (0.17%), Galaţi (0.16%), Bucureşti (0.16%), Prahova (0.16%), Bacău (0.15%), Ilfov (0.15%), Călăraşi (0.12%), Sibiu (0.09%), Alba (0.09%), Bistriţa Năsăud (0.09%), Ialomiţa (0.09%), Arad (0.05%), Sălaj (0.03%), and Vâlcea (0.02%).

At first glance, the contribution of businesses whose primary objective is the collection of non-hazardous waste to the local economy may appear insignificant, especially when compared to other sectors such as services or retail; however, it is important to remember that Romania is a developing country in which the entrepreneurial spirit has not yet been deeply embedded in the general public's mind. The collection of non-hazardous waste may appear to provide a small contribution to the local economy, but in the case of counties, every percent counts toward the successful implementation of a more effective development strategy.

As a result of Bihor County being one of the wealthiest and most powerful counties in the country in terms of economic power, economic activity 3811 contributes significantly more to the local economy than other counties; this is primarily due to widespread awareness of the importance of separate waste collection; Bihor County ranks first in the country in this category. The county's accomplishments stem from a successful public consultation on the subject, with Bihor becoming the first county to develop a waste management plan that incorporates the efforts of civil society and private partners such as companies whose primary objective is the collection of non-hazardous waste.

In-depth examination of the economic features of our proposed analysis reveals that business profitability is a critical signal for a better understanding of the sector of waste collection dimensions.

(a) Arad (37.84%), Giurgiu (27.08%), Călăraşi (25.77%), Olt (21.05%), Hunedoara (20.17%), Argeş (16.92%), Dâmboviţa (14.71%), Mehedinţi (14.71%), Bistriţa Năsăud (14.62%), Vâlcea (11.28%), Caraş-Severin (10.97%), and Maramureş (10.46%);

(b) Ialomiţa (10.00%), Bacău (9.90%), Brăila (9.68%), Neamţ (9.66%), Alba (9.63%), Bucureşti (9.56%), Prahova (9.48%), Satu Mare (8.93%), Ilfov (8.27%), Mureş (8.00%), Buzău (7.84%), Bihor (7.76%), Galaţi (7.40%), Cluj (7.28%), Sibiu (7.06%), Teleorman (6.67%), Suceava (6.43%), Iaşi (6.17%), Braşov (6.10%), Tulcea (5.70%), and Constanţa (5.66%);

(c) Dolj (4.84%), Timiş (4.68%), Harghita (3.85%), Gorj (2.94%), Vaslui (2.80%), Vrancea (2.75%), Sălaj (2.09%), Botoşani (1.31%), and Covasna (1.23%).

Using profit margins to analyze the sector's economic performance, each county has a normal commercial activity in the field of non-hazardous waste collection. This quality has been reached as a result of effectively implemented public awareness programs emphasizing the need of separate waste collection.

It is worthwhile to study the waste sector in detail while examining the energy-waste-water nexus. As a result, the Romanian waste sector was examined via the economic prism of business activity code 3821, which stands for treatment and disposal of non-hazardous waste. As illustrated in Figure 2, 26 counties have seen an increase in the number of businesses dedicated to the treatment and disposal of non-hazardous waste.

The same approach will be utilized to further compress the study into clusters in order to gain a deeper understanding of each county's unique characteristics. To begin, the impact of the 3821 CAEN code economic activities on the local economy (turnover) was analyzed based on the following identified clusters:

(a) Bucureşti (45.88%), Bihor (9.33%), Arad (8.78%), Prahova (8.23%), Argeş (7.45%), and Cluj (5.65%);

(b) Braşov (3.14%), Buzău (2.82%), Ilfov (1.73%), Gorj (1.65%), Neamţ (1.33%), and Timiş (1.33%);

(c) Botoşani (0.94%), Suceava (0.59%), Satu Mare (0.33%), Iaşi (0.24%), Vrancea (0.16%), Bacău (0.13%), Harghita (0.12%), Constanţa (0.07%), Sibiu (0.04%), Dolj (0.03%), Alba (0.01%), Bistriţa Năsăud (0.01%), Giurgiu (0.01%), and Mehedinţi (0.01%).

As a starting point, it is important to mention that, regarding the sector of treatment and disposal of non-hazardous waste, out of the 42 counties in Romania, only 26 of them have some form of activity in this field, according to the first observation. This may be

because of the variety of waste types, yet waste production is largely associated with our consumption and manufacturing processes. Another issue is the sheer volume of products that are being introduced into the market. Thus, establishing centers for the treatment and disposal of non-hazardous waste in accordance with EU standards is a complex task.

Taking a more economic approach to non-hazardous waste treatment, the contribution of the entire sector to the local economy was assessed in order to gain a better picture of each county's degree of development:

(a) Arad (0.15%), Bihor (0.14%), and Gorj (0.10%);

(b) Buzău (0.08%), Prahova (0.08%), Botoşani (0.07%), Argeş (0.06%), Neamţ (0.06%), and Cluj (0.05%);

(c) Bucureşti (0.04%), Braşov (0.03%), Suceava (0.02%), Timiş (0.01%), Satu Mare (0.01%), Vrancea (0.01%), Ilfov (0.01%), and Harghita (0.01%).

The fact that the activity code 3821 contributes to the local economy in developed counties does not indicate that the county's economy is fragile, but rather that it is powerful. As a result, the local economy is growing more diverse, and the labor market is becoming more stable and competitive. For example, in Arad County, during the first programming period from 2007 to 2013, following Romania's entry into the EU, one of the first projects undertaken with EU funds was a project for the construction of an integrated waste management system, which was one of the first projects undertaken with EU funds.

The project was staged, beginning with the construction of new systems, and ending with the closure and restoration of obsolete systems. The initial stages of establishment comprised the acquisition of collection equipment for domestic, commercial, industrial, and institutional garbage (including containers and transport vehicles) and the construction of four transfer stations, a sorting line, and two composting plants. Simultaneously, extensive work has been undertaken on the closure and rehabilitation of landfills, including eight urban and 67 rural sites, the total closure of two urban sites, and the closure and clean-up of 46 rural sites. Additionally, the project featured public awareness programs aimed at reducing trash and promoting recycling at the source.

Moreover, a greater contribution from Prahova County's treatment and disposal sector can be observed. Regarding organic waste, it is possible to highlight Prahova County efforts to maintain a presence in the WEFW nexus. The cluster analysis identified a considerable contribution to the local economy in the field of non-hazardous waste treatment and disposal, which may be attributed in part to the formation of a strategic partnership between Genesis Biopartner and Cris-Tim, a well-known Romanian producer of cold meats. Both parties profit from the strategic alliance: Genesis Biopartner earns revenue from the sale of thermal energy generated by the cogeneration plant, while Cris-Tim benefits from lower thermal energy production costs and more efficient waste management in the meat processing business. Cris-Tim contributes waste from the cold meat manufacturing industry in exchange for a significant decrease in the costs of thermal energy production. This is because Genesis Biopartner's system requires agricultural residues and organic waste to generate electricity and heat, with the option of storing biogas. As an example of best practices that are aligned with the EU's goals and policies for transitioning to a more circular economy, this collaboration is being used to promote circular economy awareness. The local economy and communities will be the principal beneficiaries of the expansion of waste management partnerships and public involvement in waste management.

However, having examples of good practices is insufficient; data suggest that there are nine counties where the sector of non-hazardous waste treatment and disposal does not contribute to the local economy. This may be exemplified by the domain's lack of entrepreneurial spirit:

(a) Alba (82.35%), Vrancea (75.00%), Satu Mare (73.81%), and Giurgiu (69.23%);

(b) Constanţa (34.52%), Sibiu (29.17%), Dolj (28.95%), Gorj (20.00%), Bihor (16.81%), Neamţ (15.29%), Argeş (13.68%), Buzău (13.61%), Cluj (12.50%), Prahova (12.38%), Arad (11.61%), Bacău (10.63%), and Ilfov (10.45%);

(c) Braşov (7.75%), Bucureşti (5.81%), Timiş (4.71%), Botoşani (4.17%), and Iaşi (1.61%).

The research of this cluster resulted in exchanges of counties' economic performance. One can notice that certain counties have seen no economic benefit from this activity; this lack of economic benefit in the treatment and disposal of non-hazardous waste sector is attributable to a lack of application of waste-management strategies. Continuing the examination, the water sector contributes significantly to the nexus of water, energy, food, and waste. The sector of collection, treatment, and water distribution's contribution to the national fiscal value as defined by the 3600 business-activity code was analyzed and a visual representation was designed as shown in Figure 3:

(a) Bucureşti (19.26%), Constanţa (8.03%), Cluj (5.77%), Prahova (4.57%), Iaşi (3.99%), Braşov (3.62%), Timiş (3.61%), Argeş (3.25%), Dolj (2.81%), Mureş (2.72%), Sibiu (2.60%), Galaţi (2.46%), Arad (2.24%), Bihor (2.20%), and Alba (2.04%);

(b) Hunedoara (1.98%), Ilfov (1.93%), Bacău (1.81%), Suceava (1.80%), Maramureş (1.77%), Brăila (1.61%), Vâlcea (1.55%), Buzău (1.47%), Dâmboviţa (1.46%), Neamţ (1.43%), Gorj (1.34%), Satu Mare (1.33%), Bistriţa Năsăud (1.17%), Vaslui (1.11%), Vrancea (1.04%), Botoşani (1.03%), and Olt (1.02%);

(c) Călăraşi (0.98%), Tulcea (0.97%), Caraş-Severin (0.95%), Harghita (0.77%), Covasna (0.70%), Teleorman (0.67%), Giurgiu (0.52%), Ialomiţa (0.38%), and Mehedinţi (0.04%).

As illustrated in cluster (a), Bucharest (19.6%) contributes the most to the national fiscal value of the CAEN code 3600, indicating that the capital's network of water collection, treatment, and distribution is more developed than in the situation of the other counties such as those illustrated in the (c) section of the cluster. This feature includes socioeconomic factors such as the city's population density, which underscores the importance of such a developed network for water collection, treatment, and distribution.

Concentrating on the facts, Romania is fundamentally different from the rest of the EU; as a developing country, the link between energy, water, and waste is conspicuous and quantifiable; and the three sectors have a greater economic impact on Romania than the others. With the recent adoption of the new Green Deal, the EU Commission emphasized the critical role of the nexus in preserving natural resources; only when the nexus's component sectors operate in perfect harmony can one discuss how to leverage the nexus's component sectors' relationships to develop and implement strategic conservation actions.

The nexus is also critical for the EU's 2050 carbon neutrality targets. The European Union lays the groundwork for a green transition to a low-carbon economy, which indicates that wastewater volumes must be lowered in order to meet the circular economy's ambitions. To acquire a deeper understanding of the local economy's structure, the analysis will be expanded to include specific clusters illustrating the contribution of 3600 business-activity codes to each county's economy:

(a) Brăila (0.73%), Vaslui (0.69%), Hunedoara (0.66%), Constanţa (0.64%), Gorj (0.63%), Caraş-Severin (0.63%), Mureş (0.60%), Botoşani (0.57%), Iaşi (0.55%), Vâlcea (0.51%), and Vrancea (0.50%);

(b) Neamţ (0.49%), Tulcea (0.49%), Călăraşi (0.47%), Covasna (0.44%), Teleorman (0.42%), Dâmboviţa (0.40%), Galaţi (0.40%), Maramureş (0.39%), Bistriţa Năsăud (0.39%), Cluj (0.36%), Suceava (0.36%), Dolj (0.35%), Prahova (0.34%), Buzău (0.34%), Alba (0.33%), Giurgiu (0.31%), Arad (0.30%), and Satu Mare (0.30%);

(c) Braşov (0.29%), Sibiu (0.28%), Harghita (0.28%), Bacău (0.27%), Olt (0.27%), Bihor (0.25%), Argeş (0.21%), Timiş (0.20%), Ialomiţa (0.18%), Bucureşti (0.14%), Ilfov (0.07%), and Mehedinţi (0.05%).

When discussing the contributions of the collection, treatment, and distribution of water sectors, the cluster analysis separated the 42 counties into three groups, each divided by the value of the sector's contribution to local economic diversification. The water sector was underdeveloped, particularly in rural areas, given Romania's status as a developing country. The sector's current contributions can be attributed to investments made at the start of the first programming period; in 2007, following Romania's accession to the EU, the major projects funded by EU funds were first acceded for this special issue of providing clean water to a large number of people. For example, the project "Extension

and rehabilitation of water and wastewater infrastructure in Hunedoara County (Jiu Valley area)" had a total eligible budget of EUR 40,000,000, with the contribution from the Cohesion Fund amounting to EUR 34,000,000. Concerning the implementation of the project, the following outcomes were achieved: 99% of the local population now has access to safe drinking water, and the same percentage of the population has been linked to the sewerage system as before the project. Indeed, this project brought an additional 2990 individuals from impoverished rural communities next to the primary zone of interest, Valea Jiului, to the drinking water delivery system. Similar projects have been implemented throughout Romania's counties; however, there is still a long way to go before the water collecting, treatment, and distribution network is standardized. The challenges exist in rural areas, where considerable portions of the population still lack access to sewerage facilities, according to a report by the National Institute of Statistics; the population connected to sewerage systems represented 55.8% of Romania's resident population in 2020, and the population connected to sewerage systems equipped with treatment plants represented 54.5% of Romania's resident population [88]. These statistics lay the groundwork for establishing a more effective development strategy.

Profitability in the water collection, treatment, and distribution sector is quantified at the business level as a result of public infrastructure investment and collaboration with private players to maximize the standard of living in each county. Three groups of counties with varying levels of profit acquisition in the sector were defined. This analysis provides an overview of the counties' development stage and quantifies the entrepreneurial factor, which is critical for the process of diversifying local economies, particularly in rural areas.

(a) Bihor (17.35%), Alba (13.79%), Bistriţa Năsăud (13.68%), Dolj (12.86%), Bucureşti (11.00%), Braşov (10.53%), and Sibiu (10.04%);

(b) Maramureş (9.66%), Vâlcea (7.79%), Buzău (7.53%), Gorj (7.52%), Galaţi (6.53%), Dâmboviţa (6.49%), Suceava (6.15%), Ialomiţa (5.71%), Cluj (5.39%), Constanţa (5.13%), Argeş (4.94%), Prahova (4.62%), Vaslui (4.46%), Giurgiu (4.29%), Iaşi (4.03%), Brăila (3.99%), Harghita (3.82%), Mureş (3.61%), Timiş (3.61%), Neamţ (3.30%), Mehedinţi (3.06%), Botoşani (3.05%), Bacău (2.39%), Ilfov (2.11%), and Satu Mare (2.00%);

(c) Covasna (1.64%), Tulcea (1.01%), Vrancea (0.94%), Arad (0.85%), Călăraşi (0.39%), Teleorman (0.24%), Olt (0.24%), Caraş-Severin (0.17%), and Hunedoara (0.12%).

In order to realize the accuracy of the water component of the nexus, the analysis into clusters was applied to obtain a better understanding of the specific of the counties; this cluster division helps us understand where there are similarities in the counties strategies and gives us a better perspective on how the nexus works and in which ways to improve its efficiency. Returning to the industry's profitability, the water sector is critical for human progress; as a result of its importance, the sector has gained an economic dimension, and both private and public firms have aligned their strategies in order to provide cleaner waters.

When conducting an analysis of wastewater collection and treatment, it is critical to understand that the wastewater sources frequently include micro-industries, such as laundries, hotels, and hospitals, as well as the larger macro-industry, which is a large consumer of water and a primary actor in the process of industrial wastewater pollution. Wastewater is collected and treated at a centralized sewage treatment plant (STP) via sewage systems, which are usually composed of underground sewage pipelines. In that case, a more detailed examination of the wastewater collection and treatment sector's economic situation was conducted in order to gain a better knowledge of the economic situation of local operators and their economic contribution to the sector's total fiscal value:

(a) Bucureşti (40.76%), Harghita (14.91%), Argeş (8.45%), and Cluj (6.79%);

(b) Ilfov (2.82%), Prahova (2.82%), Iaşi (2.82%), Dolj (1.99%), Bacău (1.82%), Galaţi (1.66%), Constanţa (1.66%), Hunedoara (1.66%), Sibiu (1.55%), Braşov (1.38%), and Timiş (1.19%);

(c) Sălaj (0.83%), Vaslui (0.74%), Tulcea (0.71%), Arad (0.67%), Gorj (0.56%), Bihor (0.55%), Alba (0.51%), Mureş (0.50%), Satu Mare (0.41%), Olt (0.36%), Dâmboviţa (0.32%), Buzău (0.29%), Giurgiu (0.28%), Teleorman (0.26%), Maramureş (0.20%), Mehedinţi (0.16%),

Caraş-Severin (0.11%), Suceava (0.08%), Brăila (0.08%), Botoşani (0.05%), Vrancea (0.02%), and Ialomiţa (0.02%).

Reviewing the wastewater collection and treatment sector as described by the 3700 business-activity codes, the research revealed that out of 42 counties in Romania, 88 percent (37 counties) had a market for enterprises that uses the 3700 business-activity codes as their primary activity code. By examining the data that represents each county's contribution to the national fiscal value of the overall activity described by the wastewater collection and treatment sector, Bucharest is the largest contributor. Along with socioeconomic factors such as density and population dynamics, which point to the need for improved wastewater management that does not contribute to pollution, the city of Bucharest and the Ilfov county have been taking steps toward greening the public system for wastewater collection and treatment.

Bucharest, Romania's capital, and largest city, has a population of approximately two million people inside its metropolitan agglomeration. It is bounded on three sides by Ilfov County, which, together, form the Bucharest-Ilfov development region. Ilfov County has a population of close to 400,000 people. Due to this socioeconomic issue in the development zone of Bucuresti-Ilfov, local state actors developed a scheme aimed at more sustainable protection of the region's population. The total cost of implementing the project "Completion of the Glina treatment plant, rehabilitation of the main sewer collectors, and the Dâmboviţa sewer (CASETA)—Phase II" is EUR 390,404,609, with the EU contributing EUR 196,459,342 through the Cohesion Fund for the 2014–2020 programming period.

To gain a deeper understanding of the economic operators' contribution to the counties' local economies, the national analysis of the business companies active with the primary economic activity described by the 3700 CAEN was performed, which is graphically illustrated in Figure 4.

As far as the impact of the 3811 CAEN code economic activities on the local economy (turnover) is concerned, the following county-level clusters were identified:

(a) Harghita (0.32%), Hunedoara (0.03%), Argeş (0.03%), Vaslui (0.03%), and Cluj (0.03%);

(b) Sălaj (0.02%), Iaşi (0.02%), Tulcea (0.02%), Bucureşti (0.02%), Bacău (0.02%), Galaţi (0.02%), Gorj (0.02%), and Dolj (0.02%);

(c) Prahova (0.01%), Mehedinţi (0.01%), Sibiu (0.01%), Giurgiu (0.01%), Teleorman (0.01%), Constanţa (0.01%), Braşov (0.01%), Mureş (0.01%), Ilfov (0.01%), Olt (0.01%), Satu Mare (0.01%), Arad (0.01%), and Dâmboviţa (0.01%).

Water is necessary for human health, economic prosperity, and social development; it is also a critical resource for sustainable development. By facilitating the water cycle, aiding water sanitation and reuse, assisting with energy production, and enabling the recovery of various goods from waste, wastewater utilities can function as catalysts for the circular economy. Thus, the water sector has the potential to make a sizable contribution to both the 2015 Paris Agreement's aim and each country's nationally determined contributions. As a result, this business sector contributes to the local economy in 26 of the 42 counties, paving the way for a more diverse local economic system. However, given that Romania is a developing country, the entrepreneurial spirit has potential to grow in the sector of wastewater collection and treatment, given that there are counties that contribute no economic value to the county. Three clusters based on the profitability factor were identified:

(a) Teleorman (69.87%), Botoşani (62.50%), Galaţi (56.40%), Braşov (43.47%), Bacău (40.73%), Suceava (38.78%), Cluj (36.59%), Constanţa (36.30%), Sălaj (35.00%), Buzău (33.33%), and Mureş (33.00%);

(b) Brăila (29.17%), Harghita (28.89%), Ilfov (26.94%), Prahova (22.94%), Dâmboviţa (22.40%), Satu Mare (22.09%), Sibiu (22.03%), Giurgiu (21.56%), Bihor (21.02%), Vrancea (20.00%), Mehedinţi (17.02%), Alba (16.01%), Bucureşti (15.04%), Timiş (13.73%), and Argeş (10.39%);

(c) Iaşi (9.76%), Gorj (8.33%), Arad (7.71%), Dolj (7.17%), Olt (6.82%), Maramureş (6.56%), Ialomiţa (5.00%), Tulcea (4.91%), Hunedoara (3.70%), Vaslui (0.67%), and Caraş-Severin (0.30%).

When examining the profitability of the wastewater collection and treatment sector, it is necessary to examine the total fiscal value generated by the 3700 business-activity codes in each county. For example, in cluster (a), where the profitability of businesses with wastewater collection and treatment as a primary objective exceeds 30%, the fiscal value of the entire activity defined by the 3700-business activity code is extremely low, indicating that the wastewater collection activity is not as developed as it appears. Although projects to finance water supply and sewage systems were implemented in every county throughout the first (2007–2013) and second (2014–2020) programming periods, the entrepreneurial activity in the area has not reached its full potential.

Moving the discussion to the energy sector, a critical element when analyzing the WEFW nexus, it provides valuable inputs into a country's development strategy, especially considering the EU's policy agenda regarding the sector, by examining the European Commission's 2000 study, *The Green Paper Towards a European Energy Security Strategy*, which sheds light on the energy market's requirements. Later, this report was adopted as the European Union's official energy policy through 2030. Following a review of this strategy, the following conclusions were drawn about the EU's energy future: (1) The EU utilizes 41% oil, 22% natural gas, 16% coal, 15% nuclear energy, and 6% renewable energy; the EU is 50% reliant on foreign energy sources. (2) Natural resource deposits are concentrated in a small amount of countries; about half of the European Union's natural gas consumption is sourced from only three countries (Russia, Norway, and Algeria), while the Middle East accounts for nearly half of oil imports. (3) The EU's energy supply is insufficient to fulfill domestic demand; the EU's energy-intensive economy places constraints on available resources. (4) Global energy consumption is expanding; by 2030, global energy demand is predicted to climb by around 60%. (5) Petroleum and natural gas prices have nearly doubled in recent years, increasing the cost of energy and heat and placing customers in a tough position.

All of this demonstrates the true economic value of the entire energy industry, as well as the sector's political importance. While energy is critical for the strategic development of every country, it also contributes significantly to environmental degradation. Thermal energy comprises a sizable portion of the energy sector. Thermal energy, which includes public utilities responsible for centralized heat distribution, accounts for more than half of Romania's energy usage.

Due to its crucial role in Romania's sustainable development, energy is a critical component of the nexus examined in this research. According to nominal thermal energy consumption improvement analyses, a large number of Romanian countries have registered progress with regards to transition to a more sustainable energy consumption model, by decreasing the amount of thermal energy consumed. In this regard, Figure 5 represents the nominal thermal energy consumption improvement (decrease of nominal thermal energy consumed, 2019 reported to 2009, Gcal per capita).

(a) București (3.73), Sibiu (1.00), Caraș-Severin (0.87), Arad (0.82), Dolj (0.59), Hunedoara (0.55), Cluj (0.43), Harghita (0.41), Satu Mare (0.41), Brăila (0.40), Ilfov (0.39), Sălaj (0.38), Tulcea (0.32), Brașov (0.30), Argeș (0.26), Dâmbovița (0.25), Gorj (0.17), Bacău (0.17), Neamț (0.13), Galați (0.12), Teleorman (0.07), Buzău (0.07), Suceava (0.06), Bistrița-Năsăud (0.05), Maramureș (0.03), Iași (0.03), Giurgiu (0.03), Timiș (0.02), and Prahova (0.01);

(b) Alba (−0.02), Ialomița (−0.02), Bihor (−0.07), and Constanța (−0.20).

The primary source of greenhouse gases in Romania is the combustion of fossil fuels, primarily in the energy sector. Agriculture, waste, various industrial activities, reclaimed land use, and land use change all contribute considerably to the emissions cost [89]. The primary energy sources for power and heat production are still fossil fuels, most notably coal and natural gas. Renewable energy sources have increased their proportion of the national energy mix, reaching 24% in 2018 [90]. Although trends in fossil-fuel energy output are declining, Romania remains significantly reliant on imports of oil, gas, and coal products [79].
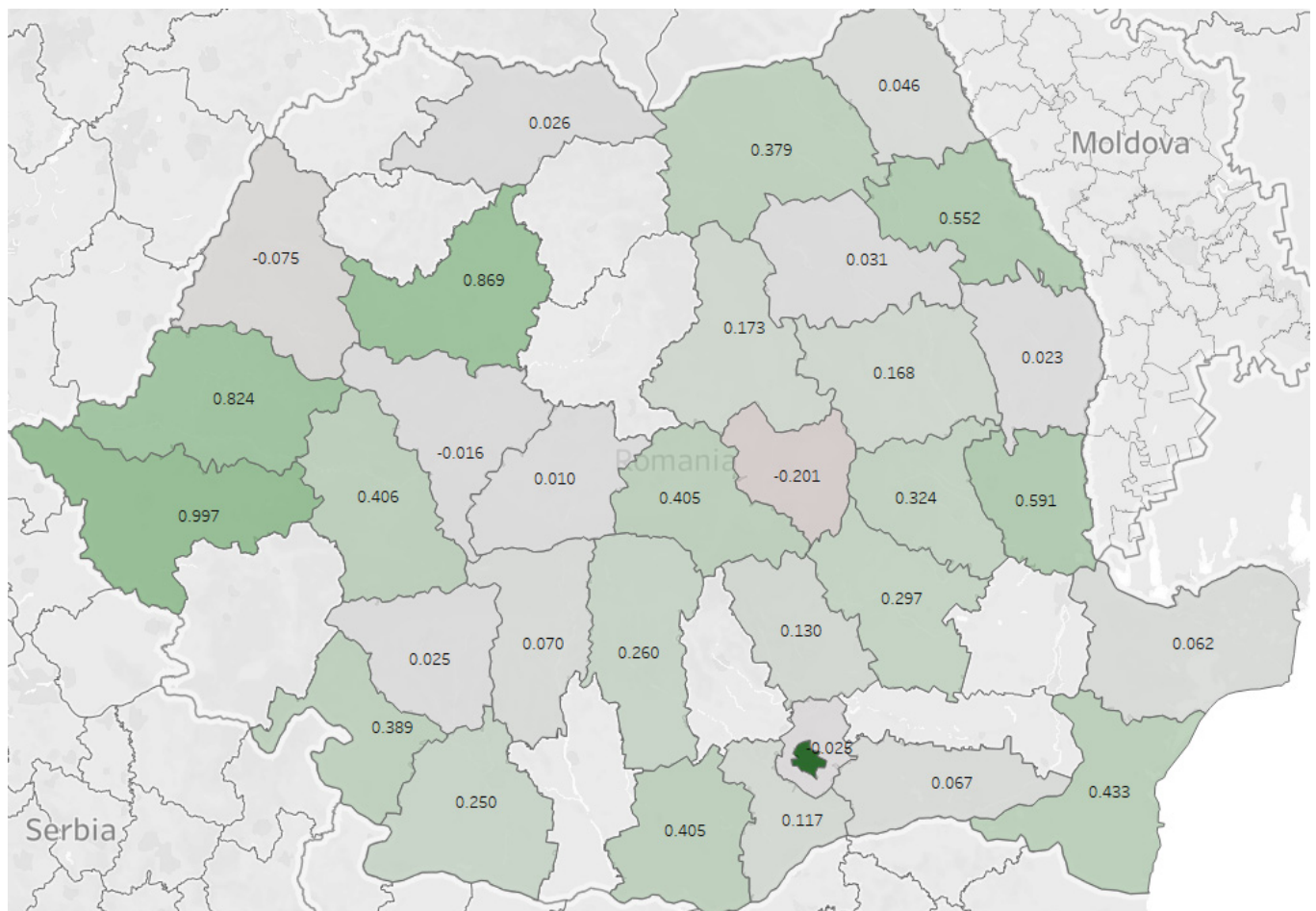
Figure 5. The heatmap of the nominal thermal energy consumption improvement (2019 vs. 2009, unit of measurement: Gcal per capita).

In cluster (a), a depiction of counties that have reduced their nominal Gcal consumption can be observed, which has resulted in a movement toward more sustainable methods of heating the county's population, such as heating with electricity generated by renewable energy sources. Counties in cluster (b) have experienced a rise in the process of distributing Gcal to their own population. The EU Climate Action Plan confronts the issue of energy consumption trade-offs by establishing the objective of ending the EU's reliance on fossil fuels [15].

A great perspective was given last year when, in 2020, limits imposed in reaction to the pandemic lowered energy demand across the continent, but the most drastic reduction occurred in the case of energy produced from fossil fuels, which is more expensive. This has supported renewables in taking the majority of electricity generation in the European Union, a share that will continue to grow as the Community bloc strives to meet its environmental goals. Renewable energy sources generated 38% of EU electricity in 2020, up from 34% in 2019. This gain was sufficient to surpass, for the first time, fossil-fuel-generated electricity, which fell to 37% in 2018 [91].

5. Conclusions

Global challenges such as climate change, population growth, globalization and rapid urbanization must be addressed using a multidimensional coherent strategy. The WEFW nexus is a modern mechanism that can improve global impact assessments on natural resources, the cooperation between the four sectors can be beneficial in achieving the SDGs and the aim of the European Green Deal.

When combined with the critical issue of climate change, developing countries face significant challenges in meeting expanding demands for WEFW sectors. This nexus arises at the junction of these four critical sectors for the development of any country.

The objective of this research was obtained and the complex layers of the WEFW nexus were analyzed with respect to the entrepreneurial and economic performance of activities specific to the WEFW sectors at county-level in Romania. This was made possible by resorting to a systematic statistical analysis. In relation to the research objective, the findings of this research show: (a) the lack of cohesion in designing efficient policies in the fields of WEFW in Romania, for various reasons: decision makers do not completely understand the interconnectedness and transdisciplinarity factors and this can cause designing poor policies in the WEFW sectors; (b) entrepreneurs cannot fully capitalize on market opportunities due to the lack of a coherent legislative framework in Romania; (c) the development degree in certain Romanian counties does not stimulate entrepreneurs to start new businesses in the WEFW sectors.

Upon investigating the interactions between the four sectors in greater detail, the findings of this research indicate that in Romania, the components of the nexus are not harmonized by coherent policies, and they do not successfully complement one another. Additionally, there are considerable trade-offs between sectors, such as water and waste. The economic performance analysis shows that the water business in Romania is not as developed as the waste sector, yet this leaves market opportunities for entrepreneurs.

Due to each distinct region having unique characteristics in terms of critical interconnections, the nexus framework is context-specific. Bucharest is the leader in terms of revenue in the field of collection of non-hazardous waste, but Arad is the leader in terms of profitability, which can be attributed to the demographic differences between the two counties and the number of operators in the field, as well as related activities such as waste recycling and raw material acquisition for other economic sectors.

The scenario is repeated in the sector of activity defined by 3821 business-activity codes for the treatment and disposal of non-hazardous waste; Bucharest contributes the most to this sector on a national level, but Arad leads on a local level, which can be attributed to the diversity of economic activities and active economic operators. The intensity of the economic activities conducted in the Romanian water sector is low in comparison to the economic intensity observed in the waste sector, owing to Romania's lack of sewers systems and wastewater treatment facilities.

Energy is vital for any country's strategic growth; it also significantly contributes to environmental damage. Thermal energy, which includes public utilities responsible for centralized heat distribution, accounted for more over half of Romania's energy use, according to the findings. Although significant improvements in the use of thermal energy have been observed, the scale of the issue of Romania's reliance on fossil fuels extends beyond the scope of this research and may serve as the basis for future research publications.

The research limitations of the study include data shortage in certain counties, which prevented the construction of a comprehensive picture of all economic activity associated with the nexus under consideration. Numerous socioeconomic factors contribute to the data scarcity; these factors include each county's level of development and degree of economic diversification. Future directions of study regarding the water, energy, food, and waste nexus will be guided by the findings of this study. As far as research applicability is concerned, this research method can be applied in the case of other countries when reviewing the nexus of interest.

Decision makers frequently prioritize short-term and sectoral challenges and advantages, heedless to the system's long-term effects [92]. The results of this research raise serious concerns about the policies designed by decision makers in the sectors of WEFW. Based on our findings, this study comes in the support of decision makers by providing them with an entrepreneurial and economic overview on the analyzed nexus, hoping to give a better understanding of the intersectoral synergies and trade-offs. This study can be at the core of future initiatives of decision makers when creating solutions designed

to harmonize policies across the WEFW sectors, especially in the context of the European Green Deal.

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