water

MDPI

Article

A New Model for Quantifying the Impact of the Social Economy on the Sustainability of Water Resources

Lucian Puiu Georgescu [1], Romeo-Victor Ionescu [2], Valentin-Marian Antohi [3,*], Monica Laura Zlati [3] and Catalina Iticescu [1]

[1] REXDAN Research Infrastructure, Department of Chemistry, Physics and Environment, Dunarea de Jos University of Galati, 800008 Galati, Romania; lucian.georgescu@ugal.ro (L.P.G.); catalina.iticescu@ugal.ro (C.I.)
[2] Department of Administrative Sciences and Regional Studies, Dunarea de Jos University of Galati, 800008 Galati, Romania; ionescu_v_romeo@yahoo.com
[3] Department of Business Administration, Dunarea de Jos University of Galati, 800008 Galati, Romania; sorici_monica@yahoo.com
* Correspondence: valentin_antohi@yahoo.com

Abstract: The importance of sustainable use of water sources in the context of social economy development is a topic of interest in the context of current regional and global challenges. The main objective of this study is to analyze the disparity of correlations between sector-specific social economy indicators and their impact on water sources at the EU27 level. The methods used are meta-analysis, followed by the substantiation of working hypotheses based on this, as well as database design for modeling and the use of correlational and econometric statistical methods. The novelty of this approach is the definition and validation of a new model, on the basis of which we formulate viable public policy proposals to support the evolution of the green social economy. The present study is characterized by its complexity (a very large number of statistical variables analyzed) and dynamic approach. The main conclusion of our research is that even with sustained efforts on environmental protection, the European social economy's fluctuating results tend to overshadow environmental objectives, even at the risk of exceeding budget allocations in the field.

Keywords: social economy; water pollution; social responsibility; public policy; econometric model

check for updates

Academic Editor: Christos S. Akratos

Received: 23 December 2024
Revised: 9 February 2025
Accepted: 13 February 2025
Published: 14 February 2025

Citation: Georgescu, L.P.; Ionescu, R.-V.; Antohi, V.-M.; Zlati, M.L.; Iticescu, C. A New Model for Quantifying the Impact of the Social Economy on the Sustainability of Water Resources. *Water* **2025**, *17*, 561. https://doi.org/10.3390/w17040561

1. Introduction

The European Union is a performance-driven regional organization at the forefront of areas such as sustainable economic development, striving for equal opportunities for citizens and creating a favorable climate for future generations. In doing so, it uses strategic challenges of equitable economic development, reducing pollution, combating climate change, etc. A strategic objective is the social economy, which brings together social and environmental protection goals through economic sectors encouraged to invest in new innovative technologies. There are currently more than 2.8 million social and economic entities in the EU27, offering 13.6 million jobs. The main aim of the social economy is "creating the right environment for the social economy to thrive" [1].

Since 2023, based on the recommendations of the European Council, social economy framework conditions have been developed. As a result, The Action Plan was defined in order to improve good practice and public accountability to promote the objectives of the social economy beyond the EU. With this approach, the EU wants to increase the visibility of the social economy and its recognition as a socio-economic system by having the European Commission support it through communications discussing the impact of this type of economic development on sustainability. It is believed that the social economy can support the transition to a green economy by improving the dialog between public administration and citizens. In this context, our approach is based on specific objectives to correlatively determine the capacity of the social economy to produce sustainable effects in terms of pollution reduction and transition to a green economy. Thus, the following research objectives were defined:

O1. Determining the main trends in the recognition of the social economy's capacity to support the green development objective at the EU level in the literature.
O2. Identifying relevant indicators to highlight the links between the two areas.
O3. Developing a new econometric model of social economy performance with environmental impact.
O4. The testing, validation, and implementation of the proposed new model.
O5. Formulating public policy proposals to strengthen the ecological capacity of the social economy.

The first objective of this research involves studying the literature, following which we noted the following topics of interest: social economy and environment, social economy and working conditions, evolution of the concept of social economy, social economy impact investing, social economy and public health, social economy and water resource quality, economic, social and environmental sustainability, social economy and sustainable governance.

The literature review on the topic "social economy" AND "environment" OR "social economy" AND "water pollution" OR "employment" AND "sustainability" generated 4268 articles written between 1991 and 2023. After refining the research according to the last 5 years of reference, it resulted that between 2019 and 2023, 2161 articles were published on the aforementioned topic with a Hirsch index of 48 points, i.e., 13,279 citations excluding self-citations, with a citation rate per item of 6.74. The most interesting articles with more than 100 citations per item were in the following research areas: the circular economy in the context of waste recovery and environmental efficiency; the connection between the social economy and urban water sources; sustainable development through the lens of environmental trends; and the relationship between the social economy and sustainable development (see Figure 1).

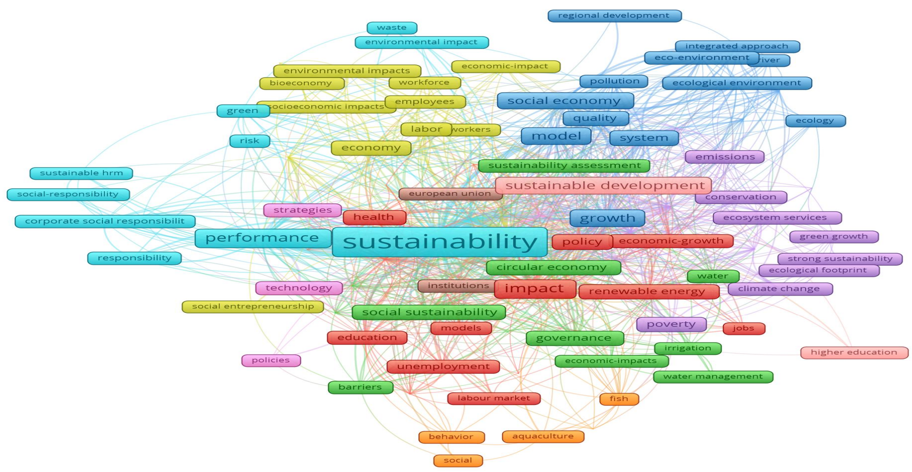

Figure 1. Mapping of the main areas of interest in the literature on the impact of social economy development on water resources. Source: author contribution using the Web of Science platform.

We used the information extracted from the Web of Science through the RIS reference software version 2.71.0, which we then processed using the WosWiewer program. The analysis revealed through the mapping of bibliographic sources using the item co-occurrence method 10 research clusters, of which the first obtained (16 items) concerns the interest in sustainable economic development based on labor market stabilization under the impact of innovation and sustainable social policies. The second cluster (15 items) is about integrated aquatic waste management in the context of sustainable economy and social sustainability. The third cluster (14 items) concerns eco-environment, water pollution, regional development, and social economy. The fourth cluster (14 items) examines the bioeconomy in relation to environmental impact and social development. Cluster 5 (14 items) addresses climate change and biodiversity protection in the context of the transition to a green economy and sustainable economic growth. The sixth cluster (12 items) covers social responsibility in relation to environmental impact and corporate social responsibility. Cluster 7 (6 items) examines aquaculture, social systems, and socially responsible behavior. Cluster 8 (4 items) examines sustainable development at the EU level through the growth of higher education and institutional accountability. Cluster 9 (4 items) examines environmental strategies and policies through the lens of new technologies. Cluster 10 (2 items) examines sustainable development and higher education in comparison. The meta-analysis we carried out supports the importance and necessity of our scientific approach and creates niches in the approach to the topic that we will try to cover through research.

2. Theoretical Background

The social economy plays a vital role in promoting economic growth while addressing environmental and social challenges. This section explores its interaction with sustainability by examining its impact on labor markets, environmental protection, investment trends, and governance structures. The analysis highlights the need for coordinated policies to balance economic expansion with sustainability goals. The discussion begins with the degree of coupling coordination, which measures the alignment between economic growth and environmental sustainability, particularly in resource-based cities. Additionally, the social cost of carbon is introduced as a key metric for assessing the long-term economic impact of emissions, reinforcing the necessity of carbon pricing mechanisms. These concepts illustrate the trade-offs between economic progress and environmental degradation. The analysis shifts to the social economy's role in labor markets, highlighting its contribution to employment stability and inclusion. However, disparities in implementation across countries emphasize the need for regulatory frameworks to maximize its benefits. The discussion also addresses the expansion of the social economy as a research field, including its relevance in impact investing, circular economy models, and digital transformation. Another key focus is the social economy's impact on public health and water resource sustainability, emphasizing how governance, urbanization, and industrial activities shape environmental outcomes. Sectoral analyses, particularly in construction and transport, reveal the need for policies that mitigate pollution while fostering sustainable development. Also, this section underscores the social economy's potential to achieve SDGs, advocating for integrated policies that ensure economic prosperity aligns with environmental conservation and social equity. The first objective of the research involves the study of the literature, following which we noted the following topics of interest: social economy and environment, social economy and working conditions, evolution of the concept of social economy, social economy impact investing, social economy and public health, social economy and water resource quality, economic, social and environmental sustainability, social economy and sustainable governance.

2.1. Social Economy and the Environment

There is a contradiction between the social economy and the environment, as analyzed by Li et al. [2]. The authors argue that sustainable urban development requires a balance between economic growth and environmental protection, applying this approach to 19 resource-based cities in Northeast China. To assess this relationship, the study employs a degree of coupling coordination model, a methodological framework that measures the extent to which two or more systems interact harmoniously over time. In this context, the model quantifies the synergy between social economy expansion and environmental sustainability, revealing how well urban development integrates ecological considerations. A low degree of coupling coordination indicates that the growth of the social economy outpaces environmental improvements, leading to sustainability risks. Conversely, a high level of coordination suggests that economic expansion is accompanied by effective environmental policies, ensuring long-term ecological balance. The findings highlight that many urban areas struggle with asymmetric development, where socio-economic progress is achieved at the cost of environmental degradation. Understanding the degree of coordination between these two domains is important for designing public policies that foster integrated and sustainable urban planning, ensuring that economic gains do not come at the expense of natural resources.

An interesting analysis by Zhang et al. [3] examines the relationship between the social economy and emissions of carbon dioxide and other greenhouse gases, introducing the concept of the social cost of carbon (SCC) as a fundamental tool for evaluating the long-term economic damages associated with carbon emissions. The SCC represents the monetized value of the environmental, health, and economic impacts resulting from an additional ton of carbon dioxide emitted into the atmosphere. It is an essential metric in climate policy, as it helps determine the economic benefits of carbon reduction strategies. Zhang et al. conduct a meta-analysis of various carbon pricing methodologies and propose a comprehensive framework for quantifying SCC based on factors such as equity weighting, uncertainty, risk aversion, and discount rates. Their findings emphasize that an accurate calculation of SCC is essential for policymakers to design effective carbon pricing mechanisms, emission taxes, and market-based incentives that align with sustainable economic growth.

The broader implications of these concepts extend to the implementation of the United Nations Sustainable Development Goals (SDGs) for 2030 [4], which face practical challenges that can be addressed through the social economy. Promoting social economy entities can contribute to job creation, reduce socio-economic disparities, increase local investment, and enhance sustainability. In this regard, researchers have explored the role of small-scale social fishing enterprises in achieving SDG 14 on the conservation and sustainable use of oceans, seas, and marine resources [5,6]. This approach ensures that small-scale artisanal fishers maintain equitable access to marine resources and markets while integrating environmentally responsible practices into their economic activities.

Authors such as Wan et al. [7] further argue that harmonizing the social economy with environmental objectives is a fundamental pillar of sustainable development. They define a coordination index to assess the degree of alignment between economic growth and environmental sustainability. Their regression analysis, which incorporates indicators such as foreign direct investment, GDP growth, net exports, air quality levels, and public green space per capita, reveals a strong correlation between a region's socio-economic progress and its environmental policies. The results suggest that sustainable urban development requires a systemic approach, where environmental sustainability and social economy initiatives reinforce each other rather than operate in isolation.

From an economic sustainability perspective, Fan et al. [8] classify cities into distinct categories based on their level of coordination between social and environmental factors, including joint-high class, social economy-high class, joint-low class, and ecological-high class. The goal of this classification is to identify policy interventions that promote balanced economic growth while minimizing environmental trade-offs. The coupling coordination approach, as explored by Fan et al., offers a scientific basis for integrating social economy principles into urban sustainability frameworks, reinforcing the need for multidimensional policies that support economic inclusion while safeguarding natural ecosystems.

These studies collectively underscore the necessity of a coordinated policy framework that integrates socio-economic growth with environmental sustainability. The degree of coupling coordination and the social cost of carbon provides essential analytical tools for assessing the impact of economic expansion on ecological systems, helping policymakers design regulatory mechanisms that align economic incentives with long-term environmental goals. By incorporating these approaches, governments can move toward a sustainable social economy model, where economic prosperity and ecological preservation are not mutually exclusive but mutually reinforcing.

2.2. Social Economy and Working Conditions

The social economy is often presented as a human-centered alternative to conventional economic models, with the potential to improve working conditions, promote gender equality, and support sustainable employment. However, despite its strengths, it also faces structural challenges that limit its ability to provide stable, long-term employment solutions, particularly for vulnerable groups such as youth and women. This section critically examines both the opportunities and limitations of the social economy in shaping labor markets, ensuring a more nuanced interpretation of existing research findings.

A key dimension of the social economy's impact on labor markets is its role in gender equality and improving working conditions for women. The study conducted by Núñez et al. [9] applied quasi-experimental counterfactual techniques to assess labor conditions in social economy enterprises versus traditional profit-seeking firms in Spain from 2008 to 2017. Their findings indicate that social economy entities contribute to higher female workforce participation, job stability, and reduced gender-based career limitations (glass ceiling effect), aligning with Goals 5, 8, and 10 of the UN 2030 Agenda. The underlying reasons behind these findings stem from the governance structures and operational principles of social economy entities, which emphasize inclusive decision-making, cooperative work models, and flexible employment conditions. However, while these characteristics foster greater gender inclusivity, they may also contribute to gender job segmentation, with women often concentrated in lower-wage, care-oriented, or temporary roles. Additionally, social enterprises often lack financial stability, meaning that jobs created within these structures may offer fewer long-term benefits and weaker social protection mechanisms compared to traditional employment. This suggests that while the social economy promotes greater female participation, it does not always eliminate gender-based labor inequalities, particularly in wage disparities and career progression opportunities.

Beyond gender-specific challenges, the capacity of the social economy to address youth unemployment has also been questioned. At the EU level, policymakers generally support the expansion of social enterprises based on the assumption that they contribute to sustainable employment and economic resilience. However, research by Avagianou et al. [10], which examines social economy models in Spain, Italy, Greece, and Cyprus, highlights significant disparities in their implementation and effectiveness. The study's findings reveal that, in some cases, the social economy fails to reduce youth unemployment and, in fact, may contribute to precarious work conditions. This contradiction can be explained by variations in national policies, economic structures, and levels of institutional support for social enterprises. In countries with strong cooperative traditions and stable regulatory frameworks (e.g., Spain and Italy), social enterprises are more effective at offering stable employment. However, in countries where the social economy remains underdeveloped or inadequately regulated (e.g., Greece and Cyprus), these entities often struggle with financial sustainability, leading to a higher prevalence of temporary contracts, informal work, and low wages.

These findings suggest that the social economy is not a universal solution to labor market inequalities but rather a mechanism that requires strong institutional support, favorable policies, and sector-specific strategies to be effective. While social economy enterprises promote inclusive employment, their ability to provide long-term job security, particularly for young workers, depends on the broader socio-economic context. Policymakers must therefore strengthen regulatory frameworks, improve funding mechanisms, and introduce measures to ensure that social enterprises offer competitive wages and career development opportunities.

In conclusion, while the social economy plays a vital role in shaping fairer labor markets, it cannot fully eliminate precarious work conditions without institutional support and targeted policies. The contradictions observed in existing studies reflect the complexity of social economy models, which can either enhance or weaken labor market stability depending on their economic, social, and regulatory environments. To maximize its benefits, the social economy must be integrated into broader labor market strategies, ensuring that it complements traditional employment models rather than functioning as a temporary or secondary workforce alternative.

2.3. The Evolution of the Social Economy Concept

Research on the evolution of the concept of social economy is conducted by Macías Ruano et al. [11] using a bibliometric analysis with WoS and Scopus as sources. The authors note a positive development in research on the social economy since 2004, with the vast majority of scientific products being found in Spain, the US, China, the UK, and Canada. In addition, scientific production is predominantly carried out in universities and research institutions and is directly related to terms such as sustainable development, climate change, urbanization, and management in economics and social sciences. The United Nations 2030 Agenda describes the Sustainable Development Goals, which, according to Chaves-Avila and Gallego-Bono [12], can also be supported by the social economy. EU Member States are implementing new social policies to maximize the positive effects of this approach. The authors analyze new social economy policies in the EU and Spain based on especially collected quantitative data. The analysis shows that the new policy model for supporting the social economy overlaps with the public-community partnership governance model and the mainstream approach. The main vulnerabilities of this approach relate to the difficulty of implementation in practice and financial constraints.

2.4. Impact Investments on Social Economy

Social enterprises are highly sensitive to impacting investment. According to Islam and Habib [13], the pandemic crisis has been a major challenge for investors in the context of supporting vulnerable people and social enterprises during the pandemic. The analysis highlights that impact investors support the development and consolidation of a supportive social impact ecosystem. This social impact ecosystem is able to protect the portfolio of social enterprises and their beneficiaries. The development of a model called "Social, Economic, Environmental and Technical" in the context of large infrastructure projects is the objective of the research conducted by Singh et al. [14] using multi-criteria decision-making techniques. The authors quantify the social, economic, and environmental impacts of such decisions using fuzzy analysis for hydropower construction. The main conclusion of the analysis is that the state can achieve economic benefits and sustainability by implementing this model.

2.5. Social Economy and Public Health

The effects of social, economic, and environmental indicators on public health and global health inequality are analyzed by Yang and Geng [15] in relation to human development and social justice. Statistical modeling was carried out using spatial econometric models and geographically weighted models applied to indicators such as urbanization rate, level of social education, and social governance capacity, ultimately finding that these social indicators support public health and the elimination of global health inequalities. However, there are large health disparities between countries, with major health vulnerabilities highlighted. The pandemic crisis has had a major impact on socio-economic development and public health management. Research in this regard by [16] refers to clinical characteristics and paraclinical findings in patients with SARS-CoV-2 (Severe Acute Respiratory Syndrome-Corona Virus-2) and is based on a statistical survey covering 106 patients administered the Lawton Instrumental Activities of Daily Living (IADL) Scale. The authors conclude that the current social economy needs to provide more time for longer rehabilitation programs for COVID-19 patients to improve their quality of life. A similar theme is addressed by Vasile et al. [17] based on an interesting meta-analysis. The authors consider how COVID-19 affects quality of life, and that this virus has a psychological impact on mental health worldwide. In this context, financial and material support for the study of these phenomena should become a new priority for the social economy.

2.6. Circular Social Economy

The circular social economy represents a convergence of circular economy principles with social economy objectives, aiming to reduce waste, optimize resource use, and promote sustainable social enterprises. While theoretical discussions emphasize the mutual reinforcement between these models, practical applications reveal both opportunities and structural challenges in integrating circular practices into social enterprises.

Lobato-Calleros et al. [18] analyze the potential of social enterprises in circular economy models using the Circular and Social Economy Index, a framework designed to measure both current public acceptance (satisfaction) and long-term viability (loyalty) of circular economy initiatives. Their case study highlights a waste recovery enterprise that collects used cooking oil and transforms it into biodiesel, demonstrating how circular business models can be both economically and environmentally viable. However, while such initiatives present scalable solutions, they often face barriers in financing, regulatory constraints, and technological adoption, which can hinder their widespread implementation. The OECD and the European Commission [19] have also explored the integration of social and circular economy principles, particularly in quantifying social benefits derived from environmental conservation. A key factor in sustaining circular social enterprises is their ability to reinvest a portion of profits into social or environmental objectives rather than solely focusing on financial returns. This model ensures that businesses remain mission-driven, but it also poses financial sustainability challenges, as social enterprises must balance profitability with impact-driven reinvestment.

An important scaling-up strategy for social enterprises in the circular economy is collaboration with local governments and private stakeholders. Public–private partnerships can facilitate access to green financing, encourage regulatory incentives, and support knowledge-sharing initiatives that help businesses transition to circular models. For example, in France and The Netherlands, social enterprises in the fashion and textile industry have partnered with municipalities to develop large-scale textile recycling initiatives, reducing fabric waste while creating jobs in material recovery and resale markets. These initiatives demonstrate how government-backed incentives can drive circular social entrepreneurship. Incorporating the circular economy into corporate social responsibility (CSR) strategies has also been a focus of recent studies. Bîrgovan et al. [20] conducted a survey on corporate environmental responsibility in the social economy, assessing firms' readiness to transition to circular models. Their findings suggest that while firms recognize the benefits of circular practices, many struggle with implementation due to a lack of standardized frameworks, insufficient investment in sustainable technologies, and market competition from conventional enterprises. These challenges highlight the need for policy interventions that provide tax incentives, infrastructure support, and market-access initiatives to help social enterprises scale their circular economy contributions.

The authors argue that strengthening the circular social economy requires concrete policy measures, including introducing mandatory recycling targets for businesses, incentivizing circular business models through tax credits, and creating training programs for workers transitioning into circular industries. By embedding circular economy principles into social enterprise operations, these businesses can contribute to job creation, environmental protection, and long-term economic resilience.

2.7. Social Economy and the Introduction of Technical Progress

The evolution of the social economy is closely linked to the emergence of new global economic and technological trends, which are shaping its structure, sustainability, and role in contemporary societies. Stukalo and Simakhova [21] explore this dynamic transformation, emphasizing how research and development (R&D), Industry 5.0, smart enterprises, and smart cities influence the evolution of social economy models. Their study provides a comparative analysis of the pre- and post-pandemic periods, highlighting both accelerated digitalization and emerging vulnerabilities that redefine the future of the social economy.

One of the most significant developments in the post-pandemic social economy is the integration of smart technologies in cooperative and non-profit organizations. Industry 5.0, which focuses on human–machine collaboration, artificial intelligence, and automation, has led to greater efficiency in social enterprises, enabling them to scale their impact while reducing operational costs.

Digital platforms that facilitate crowdfunding for social enterprises, blockchain-driven transparent financial transactions, and AI-powered resource allocation systems are becoming integral to the sector. However, this transformation also presents challenges related to digital inequality, as not all social economy actors have the resources or skills required to adopt and integrate emerging technologies.

Another major trend shaping the evolution of the social economy is the transition toward smart cities, where urban planning integrates sustainability, participatory governance, and digital solutions to improve social services, waste management, and public resource allocation. Smart city initiatives in Finland and Canada, for example, have incorporated social economy enterprises into municipal planning, engaging cooperatives and social enterprises in local energy production, circular economy initiatives, and urban food networks. While these efforts create opportunities for social enterprises, they also require strong policy frameworks to ensure fair access to funding, technology, and infrastructure.

The pandemic has further redefined vulnerabilities within the social economy, as many cooperatives and non-profit organizations struggled with financial sustainability due to reduced public funding and shifting economic priorities. Stukalo and Simakhova [21] argue that the crisis accelerated the need for hybrid business models, where social enterprises combine profit-generating activities with social impact initiatives to maintain resilience. This shift has led to the rise in impact investment funds and green bonds, supporting the financial sustainability of social economy organizations. However, the post-pandemic era has also introduced new risks, including inflationary pressures, labor shortages, and geopolitical instability, all of which directly impact the operational models of social enterprises.

In response, governments and international organizations have begun developing policy frameworks that facilitate financial stability, encourage digital adaptation, and promote inclusive economic strategies. The European Union, for example, has introduced funding programs to support social innovation in the digital economy, ensuring that social enterprises can remain competitive while maintaining their social mission.

To ensure the sustainable evolution of the social economy in this rapidly changing landscape, policy interventions are needed to bridge the digital divide, provide training programs for social enterprise workers, and facilitate access to impact financing mechanisms.

The integration of R&D-driven business models, data-driven social services, and participatory governance systems can help the social economy adapt to emerging trends while maintaining its core principles of social inclusion and sustainability.

2.8. Social Economy and Water Quality

An interesting approach is that of Liu et al. [22], which connects the social economy to the quality of water resources. The authors aim to investigate the spatio-temporal distribution and dynamics of source water quality subsystems in the Nansi Lake watershed in China. Mathematical modeling argues that there is a direct correlation between the development of the social economy and the quality of water sources. In addition, coordinating the coupling of the social economy with water resources achieves a relatively difficult balance. The authors propose a model for addressing the link between the environment and the social economy and offer policy proposals for policymakers. Other authors, such as Pintilie et al. [23], start with the analysis of the impact of the economy on water sources using gross alpha and gross beta activities targeting boreholes, spring water, and surface water (from the Danube River). The authors make a comparative analysis of the maximum allowable limits for gross alpha activity and gross beta activity at the national level (Romania) and compare them with those in other regions of the world. The main conclusion of the analysis is that the highest values for both gross alpha and gross beta activity were measured in water from drilled wells. For many EU27 Member States, the river Danube is an important source of water. As a result, a study by Calmuc et al. [24] on water quality in this river is based on the Water Quality Index (WQI), the Water Pollution Index (WPI), and the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI) and looks at the seasonal and spatial variation in water quality in the lower Danube. The water samples covered the period 2018–2019 and allowed water quality to be classified in quality classes II and III. A complex 10-year analysis of water quality parameters by Popa et al. [25] focuses on the same Danube River. The authors process the raw statistical data obtained using the Kolmogorov–Smirnov test, principal component analysis (PCA), factor analysis (FA), and ANOVA to quantify the seasonal variability of water quality status parameters. A positive conclusion of this analysis is that the Danube River has some self-filtration capacity. The coordinating relationship of coupling between the social economy and the urban-scale water environment is the subject of research by Cui et al. [26], covering the period 2016–2025 in China. The authors use the alternative scenarios method, which quantifies the impact of socio-economic development patterns on water resource quality. Through a comparative analysis of the effects of the five proposed models, the authors consider that the optimal solution is to implement a medium-speed socio-economic development model with high-intensity water protection. In the context of the social economy, water resources can also be protected by reducing water consumption for production and households and improving wastewater collection and reuse rates. Interesting research by Luo and Zuo [27] looks at the coordination of social economy, water, and ecology. The authors consider that current methods of regulation do not sufficiently take into account the mechanisms of interaction between socio-economic, water, and ecological factors. As a result, they propose the SEWE model, which succeeds in highlighting the connections between a rainfall–runoff model with river water quality and ecological models. The social economy is approached through the lens of the use of water resources in the context of sustainable development by Wang et al. [28]. The analysis aims to highlight the characteristics of the spatial and temporal distribution of the level of carrying capacity of the water resources system, the level of development of the social economy system, and the level of protection of the ecological system.

2.9. Economic, Social and Environmental Sustainability

In their approach, Rincon-Roldan and Lopez-Cabrales [29] claim that the social economy contributes to achieving economic, social, and environmental sustainability. The authors use a sample of 124 social economy cooperative entities and the statistical data obtained are modeled using the Partial Least Squares method (PLS-SEM). In the case of Italy, Terzo [30] investigated the correlation between social capital and economic resilience at the regional level under the impact of the economic crisis. The analysis focuses on social economy organizations and is based on specific indicators which, modeled using econometric techniques, show that social capital can shape local responses to crises. There is also a negative relationship between local resilience and the density of social cooperatives. Resilience at the level of a nationally known rural cooperative in Indonesia was studied by Wulandhari et al. [31] in relation to social capital. The authors found that while building social capital economically leads to organizational transparency and collaborative working, social capital built socially supports the emergence of resilience capabilities at the individual level.

2.10. Social Economy, Organizations, and Sustainable Governance

The social economy is characterized by sustainable governance, according to Lacan [32]. The authors refer to the French economy and argue their hypotheses based on a dedicated meta-analysis. They are aware that this approach is a first step in the methodological algorithm that can lead to sustainable governance in the social economy. This idea is also addressed by Zhao et al. [33], who start from the quality management system at the firm level and investigate whether this system is able to support the achievement of sustainable development goals as defined by the UN. The authors benchmark six quality management practices, covering specific operations from product and process innovation to environmental, social, and economic innovation. These indicators come from processing data from a questionnaire completed by medium and large service and manufacturing firms. Environmental innovation is found to have an insignificant impact on social sustainability.

Geradts and Alt [34] demonstrate a gap in the literature through the poor research on social entrepreneurship in the social economy. The authors studied how entrepreneurs in social enterprises approach innovation, resource allocation, and uncertainty. The theme of social entrepreneurship and social enterprises was taken up by Ho and Yoon [35] in the context of social innovation. The authors considered that social enterprises need to be supported by third parties in developing and growing social business ecosystems. Thus, technology accelerators or incubators emerge to support social entrepreneurial systems. Moreover, sustainable social innovation systems can be built.

The social economy can be a viable solution for developing countries to eradicate some of the challenges related to food security and rural sustainability. Ku and Kan [36] conducted an investigation on this topic in the case of China and focused on the role of the social economy in sustainable food production and consumption through local initiatives. The main conclusion of the analysis was that the social economy is the solution for sustainable economic development. The social economy orchestrates a wide variety of private organizations (associations, foundations, cooperatives, and social enterprises), which, in his view, Bassi and Fabbri [37] are sensitive to institutional configuration. These organizations interface with the European Commission in the context of its implementation of social policy. The analysis covers ten Member States and concludes by outlining the current conjuncture of the social economy in Europe. The same organizations were analyzed by Kim et al. [38] according to the ratio of their financial performance to their social purpose. The authors point out that a condition for the optimal functioning of social economy-related organizations is the existence of effective leadership to ensure business competitiveness. Social economy organizations implement innovative business models. According to Weerawardena et al. [39], these models allow organizations to increase their social and economic contribution. The authors conducted a meta-analysis on innovative business models used by organizations in the context of the social economy that can become examples of best practices. There is extensive debate in the literature about the evolution of social economy organizations. Bretos et al. [40] carried out a meta-analysis in this regard in order to highlight the organizational development processes related to these organizations.

There are concerns related to the regeneration of social economy enterprises, such as those of Lapoutte [41], which consider living systems, i.e., permaculture. The authors explained how permaculture relates to appropriate management models for alternative organizations such as social economy enterprises. The performance of social profit institutions in the context of the social economy was examined by Alam et al. [42] through case studies highlighting the innovative features of each development model. The authors emphasized the need to develop a classification system that encompasses all new forms of social enterprises and hybrids "in a way that reflects their uniqueness and individual design".

In the view of Chetty et al. [43], social capital is a potential determinant of socio-economic development. To analyze this, the authors turned to social networks and considered 21 billion Facebook friends. Three elements of the analysis are identified, namely connectivity between different types of people, social cohesion, and civic engagement. Based on economic mobility at the regional level, the analysis correlates variations in economic connectivity with upward income mobility and racial segregation, poverty rates, and inequality. The Facebook network was used by Chetty et al. [44] to quantify social interaction across social classes. The authors concluded that socio-economic integration can increase economic connectivity. The connection between social capital and women's board presence was discussed by Afzali et al. [45] based on specific indicators such as voter turnout, census participation, and social network density. The analysis is based on the hypothesis that a high degree of social capital supports the presence of women directors on the boards of local firms. Fifty-three thousand six hundred and seventy-one situations in public companies in the United States over the period 2000–2018 are studied, and the research hypothesis is found to be validated by the actual situation. People's behavior in the context of the pandemic crisis was analyzed by Alfano [46] in relation to the restrictions imposed during 2020 in various countries. The authors found that countries with higher social capital have lower incidences of COVID-19. The effects are accentuated in a positive direction if the equity is bonding. Researchers such as Nguyen et al. [47] studied the connection between older internet users, social engagement, and social capital. The statistics come from a national survey conducted in Switzerland among adults aged 60 and over. The analysis found that adults who access social networks more often have higher social capital connectedness. Social capital is associated with the financial performance of nonprofit organizations by Dell et al. [48]. The authors found that where there is a high level of social capital, there are better networking opportunities for community participants. In this context, Fraser and Naquin [49] found that the transformative effect of the social capital of residents in a region influences the level of vulnerability of communities. The analysis was conducted at the Japanese level using difference–indifference models and matching experiments. The authors come to the same conclusion about the social capital–community vulnerability correlation as in the previous study presented above. A separate approach was taken by Beausaert et al. [50], who saw social capital as a tool to combat mental health decline. The analysis covers the pre-university education system in Australia and Ireland and is based on a questionnaire analysis of almost 3000 school principals. The analysis found that schools where higher levels of internal or external social relationships were reported also had higher levels of well-being. There is an interesting connection between human and social capital, a connection studied by Andersen et al. [51] in relation to directorships of listed companies in New Zealand between 2000 and 2015. The authors define a unique index to measure human capital and analyze social networks. The process of social capital formation in social economy organizations, especially among social enterprises, is studied by Oudeniotis and Tsobanoglou [52], with special reference to the connection of these social enterprises with other social enterprises and third-sector organizations. The authors conclude that this connection is based on shared values such as trust and reciprocity.

The structure of the banking system in relation to regional unemployment in the context of the social economy is the subject of research by Schneiberg and Parmentier [53] covering the period 2007–2016. The researchers found that increasing the number of community banks and local credit unions can lead to lower levels of regional unemployment and faster post-crisis economic recovery with lower social costs. Basically, there is a connection between the social structures of the banking system and regional economic performance in the context of the social economy.

Based on the literature review, we have stated the following working hypotheses:

H1. *The development level of the social economy shows a strong significant correlation between Sewage sludge production and disposal from urban wastewater (Urban wastewater treatment plants—total). The definition of this hypothesis is also based on the results of research carried out by Cui et al.; Liu et al.; Luo and Zuo; and Wang et al. [22,26–28].*

H2. *Of all the sectors of the social economy, the construction sector shows the strongest correlation, followed by wholesale and retail trade, transport, accommodation, and food service activities. The hypothesis is supported by the findings of studies carried out by Lacan; Rincon-Roldan and Lopez-Cabrales; and Zhao et al. [29,32,33].*

H3. *Under the impact of multiple economic crises, the level of correlation of the two indicators (Sewage sludge production and disposal from urban wastewater and Gross value added and income) tends to decrease in intensity. Authors such as Cui et al., Liu et al., Luo and Zuo, and Wang et al. [22,26–28] support their research through this hypothesis.*

H4. *The development level of the social economy expressed by the indicators of Gross value added in terms of compensation of employees shows a strong significant correlation with the protection of the aquatic environment (sewage sludge production and disposal from urban wastewater). Research such as that carried out by Afzali et al., Andersen et al., Chetty et al., Fraser and Naquin, and Nguyen et al. support this hypothesis [43,45,47,49,51].*

H5. *The strongest correlations are for the construction sector and arts, entertainment and recreation, other service activities, and activities of household and extra-territorial organizations and bodies. The* *definition of this hypothesis is also based on the results of research carried out by Alfano; Beausaert et al.; Chetty et al.; Dell et al.; and Oudeniotis and Tsobanoglou [44,46,48,50,52].*

H6. *In dynamics, Pearson correlations under the impact of economic crises between social economy indicators (GVA) in terms of compensation of employees tend to decrease in intensity. The hypothesis is supported by the findings of studies carried out by Geradts and Alt; Ho and Yoon; and Schneiberg and Parmentier [34,35,53].*

H7. *The correlations between the level of wages offered by the social economy and the intensity of the phenomenon of protection of water sources are directly proportional, following the general trend of evolution presented in hypotheses H3 and H6.*

H8. *The evolution of water source protection indicators shows a strong and regressive correlation between the impact of economic crises with the dependent variable (Sewage sludge production and disposal from urban wastewater). This hypothesis is supported by research such as that carried out by Alam et al. and Lapoutte [41,42].*

3. Methodology

The methodological approach of approach is based on the creation of a structured database to be consolidated in relation to the selected analysis period (2010–2022). To this end, 937 annual indicators reported by Eurostat have been identified, grouped into 74 categories of items, which capture the evolution of the social economy and environmental protection, in particular the aquatic environment.

Thirteen annual dynamic correlation models of water source pollution in terms of social economy development will be defined, which will be subjected to statistical validation tests, homogeneity tests, and different levels of statistical significance will be highlighted in order to finally obtain the correlation table of pollution in relation to the social economy development index.

3.1. Conceptual Model Development

The conceptual model is based on establishing the intensity of linkages between phenomena impacting environmental protection based on the working hypotheses formulated in Section 2. The conceptual model of the study is shown in Figure 2.

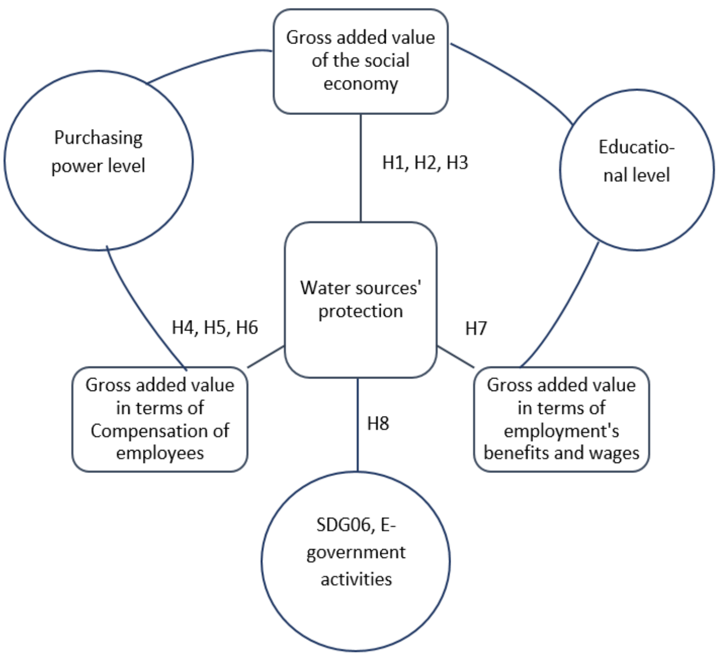

Figure 2. Logical scheme of the conceptual model. Source: authors' contribution.

Figure 2 makes the connection between the research hypotheses, research objectives, and analysis indicators.

3.2. Data Collection

Statistical analysis and database consolidation methods were used to collect the database information based on public information reported by Eurostat over the period 2010–2022, as shown in Table 1.

Table 1. Indicators of analysis.

	Symbol	Explanation	MU	Database
Life expectancy	MLEXPEC	Life expectancy by age and sex (less than 1 year)	% of EU average	[54]
Educational attainment	15-24EDATI	Population by educational attainment level, sex, and age (15–24 years) Less than primary, primary, and lower secondary education	% of total population 15–24 years	[55]
	25-54EDATI	Population by educational attainment level, sex, and age (25–54 years) Less than primary, primary, and lower secondary education	% of total population 25–54 years	[55]
	55-64EDATI	Population by educational attainment level, sex, and age (55–64 years) Less than primary, primary, and lower secondary education	% of total population 55–64 years	[55]
	15-24EDATII	Population by educational attainment level, sex, and age (15–24 years) Upper secondary, post-secondary non-tertiary, and tertiary education	% of total population 15–24 years	[55]
	25-54EDATII	Population by educational attainment level, sex, and age (25–54 years) Upper secondary, post-secondary non-tertiary, and tertiary education	% of total population 25–54 years	[55]
	55-64EDATII	Population by educational attainment level, sex, and age (55–64 years) Upper secondary, post-secondary non-tertiary, and tertiary education	% of total population 55–64 years	[55]
	15-24EDATIII	Population by educational attainment level, sex, and age (15–24 years) Tertiary education	% of total population 15–24 years	[55]
	25-54EDATIII	Population by educational attainment level, sex, and age (25–54 years) Tertiary education	% of total population 25–54 years	[55]
	55-64EDATIII	Population by educational attainment level, sex, and age (55–64 years) Tertiary education	% of total population 55–64 years	[55]
E-government activities	ISOCAUTH	E-government activities of individuals via websites Internet use: interaction with public authorities (last 12 months)	% of individuals	[56]
	ISOCWEB	E-government activities of individuals via websites Internet use: obtaining information from public authority websites (last 12 months)	% of individuals	[56]
	ISOCPUBWEB	E-government activities of individuals via websites Internet use: obtaining information from public authority websites (last 12 months)	% of individuals who used the internet within the last year	[56]
	ISOCFORMS	E-government activities of individuals via websites Internet use: downloading official forms (last 12 months)	% of individuals	[56]

Table 1. *Cont.*

	Symbol	Explanation	MU	Database
	ISOCPUBFORMS	E-government activities of individuals via websites Internet use: downloading official forms (last 12 months)	% of individuals who used the internet within the last year	[56]
	ISOCINTACT	E-government activities of individuals via websites Internet use: interaction with public authorities (last 12 months)	% of individuals	[56]
Employment	15-24EMPL	Employment and activity by sex and age—annual data (15–24 years) Total employment (resident population concept—LFS)	% of total population	[57]
	25-54EMPL	Employment and activity by sex and age—annual data (25–54 years) Total employment (resident population concept—LFS)	% of total population	[57]
	55-64EMPL	Employment and activity by sex and age—annual data (55–64 years) Total employment (resident population concept—LFS)	% of total population	[57]
Gross value added of the social economy	GVANACE	Gross value added and income by A*10 industry breakdowns Total—all NACE activities	% of EU27	[58]
	GVAAGR	Gross value added and income by A*10 industry breakdowns Agriculture, forestry, and fishing	% of EU27	[58]
	GVAIND	Gross value added and income by A*10 industry breakdowns Industry (except construction)	% of EU27	[58]
	GVAMAN	Gross value added and income by A*10 industry breakdowns Manufacturing	% of EU27	[58]
	GVACONST	Gross value added and income by A*10 industry breakdowns Construction	% of EU27	[58]
	GVAWHS	Gross value added and income by A*10 industry breakdowns Wholesale and retail trade, transport, accommodation, and food service activities	% of EU27	[58]
	GVAINF	Gross value added and income by A*10 industry breakdowns Information and communication	% of EU27	[58]
	GVAFIN	Gross value added and income by A*10 industry breakdowns Financial and insurance activities	% of EU27	[58]
	GVAREST	Gross value added and income by A*10 industry breakdowns Real estate activities	% of EU27	[58]
	GVASCI	Gross value added and income by A*10 industry breakdowns Professional, scientific, and technical activities; administrative and support service activities	% of EU27	[58]
	GVAPADM	Gross value added and income by A*10 industry breakdowns Public administration, defense, education, human health, and social work activities	% of EU27	[58]
	GVAART	Gross value added and income by A*10 industry breakdowns Arts, entertainment, and recreation, other service activities, activities of household and extra-territorial organizations and bodies	% of EU27	[58]

Table 1. *Cont.*

	Symbol	Explanation	MU	Database
Gross value added to the social economy (Compensation of employees)	GVAEMPCNACE	Gross value added and income by A*10 industry breakdowns Compensation of employees Total—all NACE activities	% of EU27	[58]
	GVAEMPCAGR	Gross value added and income by A*10 industry breakdowns Compensation of employees Agriculture, forestry, and fishing	% of EU27	[58]
	GVAEMPCIND	Gross value added and income by A*10 industry breakdowns Compensation of employees Industry (except construction)	% of EU27	[58]
	GVAEMPCMAN	Gross value added and income by A*10 industry breakdowns Compensation of employees Manufacturing	% of EU27	[58]
	GVAEMPCCONST	Gross value added and income by A*10 industry breakdowns Compensation of employees Construction	% of EU27	[58]
	GVAEMPCWHS	Gross value added and income by A*10 industry breakdowns Compensation of employees Wholesale and retail trade, transport, accommodation, and food service activities	% of EU27	[58]
	GVAEMPCINF	Gross value added and income by A*10 industry breakdowns Compensation of employees Information and communication	% of EU27	[58]
	GVAEMPCFIN	Gross value added and income by A*10 industry breakdowns Compensation of employees Financial and insurance activities	% of EU27	[58]
	GVAEMPCREST	Gross value added and income by A*10 industry breakdowns Compensation of employees Real estate activities	% of EU27	[58]
	GVAEMPCSCI	Gross value added and income by A*10 industry breakdowns Compensation of employees Professional, scientific, and technical activities; administrative and support service activities	% of EU27	[58]
	GVAEMPCPADM	Gross value added and income by A*10 industry breakdowns Compensation of employees Public administration, defense, education, human health, and social work activities	% of EU27	[58]
	GVAEMPCART	Gross value added and income by A*10 industry breakdowns Compensation of employees Arts, entertainment, and recreation, other service activities, activities of household, and extra-territorial organizations and bodies	% of EU27	[58]

Table 1. *Cont.*

	Symbol	Explanation	MU	Database
Gross value added of the social economy (benefits)	GVAWGSNACE	Gross value added and income by A*10 industry breakdowns Wages and salaries Total—all NACE activities	% of EU27	[58]
	GVAWGSAGR	Gross value added and income by A*10 industry breakdowns Wages and salaries Agriculture, forestry, and fishing	% of EU27	[58]
	GVAWGSIND	Gross value added and income by A*10 industry breakdowns Wages and salaries Industry (except construction)	% of EU27	[58]
	GVAWGSMAN	Gross value added and income by A*10 industry breakdowns Wages and salaries Manufacturing	% of EU27	[58]
	GVAWGSCONST	Gross value added and income by A*10 industry breakdowns Wages and salaries Construction	% of EU27	[58]
	GVAWGSWHS	Gross value added and income by A*10 industry breakdowns Wages and salaries Wholesale and retail trade, transport, accommodation, and food service activities	% of EU27	[58]
	GVAWGSINF	Gross value added and income by A*10 industry breakdowns Wages and salaries Information and communication	% of EU27	[58]
	GVAWGSFIN	Gross value added and income by A*10 industry breakdowns Wages and salaries Financial and insurance activities	% of EU27	[58]
	GVAWGSREST	Gross value added and income by A*10 industry breakdowns Wages and salaries Real estate activities	% of EU27	[58]
	GVAWGSSCI	Gross value added and income by A*10 industry breakdowns Wages and salaries Professional, scientific, and technical activities; administrative and support service activities	% of EU27	[58]
	GVAWGSPADM	Gross value added and income by A*10 industry breakdowns Wages and salaries Public administration, defense, education, human health, and social work activities	% of EU27	[58]
	GVAWGSART	Gross value added and income by A*10 industry breakdowns Wages and salaries Arts, entertainment, and recreation; other service activities; activities of household and extra-territorial organizations and bodies	% of EU27	[58]

Table 1. *Cont.*

	Symbol	Explanation	MU	Database
Gross value added of the social economy (Employers' social contribution)	GVAESCNACE	Gross value added and income by A*10 industry breakdowns Employers' social contributions Total—all NACE activities	% of EU27	[58]
	GVAESCAGR	Gross value added and income by A*10 industry breakdowns Employers' social contributions Agriculture, forestry, and fishing	% of EU27	[58]
	GVAESCIND	Gross value added and income by A*10 industry breakdowns Employers' social contributions Industry (except construction)	% of EU27	[58]
	GVAESCMAN	Gross value added and income by A*10 industry breakdowns Employers' social contributions Manufacturing	% of EU27	[58]
	GVAESCCONST	Gross value added and income by A*10 industry breakdowns Employers' social contributions Construction	% of EU27	[58]
	GVAESCWHS	Gross value added and income by A*10 industry breakdowns Employers' social contributions Wholesale and retail trade, transport, accommodation, and food service activities	% of EU27	[58]
	GVAESCINF	Gross value added and income by A*10 industry breakdowns Employers' social contributions Information and communication	% of EU27	[58]
	GVAESCFIN	Gross value added and income by A*10 industry breakdowns Employers' social contributions Financial and insurance activities	% of EU27	[58]
	GVAESCREST	Gross value added and income by A*10 industry breakdowns Employers' social contributions Real estate activities	% of EU27	[58]
	GVAESCSCI	Gross value added and income by A*10 industry breakdowns Employers' social contributions Professional, scientific, and technical activities; administrative and support service activities	% of EU27	[58]
	GVAESCPADM	Gross value added and income by A*10 industry breakdowns Employers' social contributions Public administration, defense, education, human health and social work activities	% of EU27	[58]
	GVAESCART	Gross value added and income by A*10 industry breakdowns Employers' social contributions Arts, entertainment, and recreation; other service activities; activities of household and extra-territorial organizations and bodies	% of EU27	[58]
Purchasing power parities	PPP	Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates Actual individual consumption	Nominal expenditure as a percentage of GDP (GDP = 100)	[59]

Table 1. *Cont.*

	Symbol	Explanation	MU	Database
SDG06	SDG0620	Population connected to at least secondary waste water treatment Urban, independent and other wastewater treatment—at least secondary treatment	Percentage	[60]
	TEN00020	Population connected to urban wastewater collecting and treatment systems, by treatment level Urban wastewater collecting system	Percentage	[61]
	TEN00020TT	Population connected to urban wastewater collecting and treatment systems, by treatment level Independent wastewater treatment—total	Percentage	[61]
	TEN00030	Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)) Sludge production—total Urban wastewater treatment plants—total	% of EU27	[62]
	TEN00030SS	Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)) Sludge disposal—total Urban wastewater treatment plants—total	% of EU27	[62]
	TEN00030SPP	Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)) Sludge disposal—agricultural use Urban wastewater treatment plants—total	% of EU27	[62]

The database thus constructed contains a number of 26,236 items, which will be used to build correlation models.

3.3. Model Description

This study develops a Social Economy–Environmental Impact Econometric Model (SEEIM) designed to assess the relationship between social economy performance indicators and environmental impact, particularly in terms of water resource sustainability. The SEEIM is formulated to quantify the correlation between key social economy variables—such as gross value added (GVA) in various economic sectors, employment distribution, and digital governance adoption—and water pollution indicators, specifically Sewage Sludge Production and Disposal from Urban Wastewater (TEN00030SS). This approach allows us to examine how different dimensions of the social economy contribute to environmental sustainability or pressure. The model follows a multiple linear regression framework, where the dependent variable is TEN00030SS, and the independent variables include economic indicators (e.g., Gross Value Added by NACE sectors, employment levels); environmental impact variables (e.g., wastewater treatment coverage, sludge disposal methods); social and digital governance factors (e.g., e-government adoption rates), according to Table 1 data's. Correlation tests and regression analysis were applied to the 26,236 items using the least squares method, resulting in the multiple linear regression models shown below:

$$TEN00030SS_t = \beta_0 + \sum_{i=1}^{n} \beta_i \cdot X_{it} + \epsilon_t \quad (1)$$

where $TEN00030SS_t$ represents the sewage sludge production and disposal at time t; X_{it} denotes the independent variables influencing wastewater pollution, including social economy performance indicators; β_0 is the intercept; β_i represents the coefficients estimating the effect of each independent variable; and ϵ_t is the error term capturing unobserved effects.

The calculation of the correlation coefficients of the SEEIM dynamic model is presented in Table 2 below:

Table 2. Regression coefficients of SEEIM dynamic model and their significance level.

Coefficients	TEN00030SS												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
MLEXPEC	−0.41	0.34 ***	0.02 ***	0.11 ***	0.03 ***	−0.43 ***	0.35 ***	0.32 ***	0.25 ***	0.09 ***	0.31 ***	0.24 **	0.33 **
15-24EDATI	−0.14	0	0.07	0	0.31	0	0	0	−0.18	−0.1	0	0	−0.81
25-54EDATI	0	0	0	0	0	0.18	0	0	0	0	−0.03	0	0
55-64EDATI	0.24	0.07	0	−0.02	0	0.13	0	−0.15	0	−0.01	0	−0.07	0
15-24EDATII	0	−0.19	0	0.14	0	0.32	−0.09	0.12	0	0	−0.19	0.17	0
25-54EDATII	0.04	0.02	0.06	−0.31	−0.37	0	0.17	−0.43	−0.62	−0.22	0	0.07	−1.45
55-64EDATII	0	0	−0.2	0	0.05	0	−0.06	0	0.27	0	−0.15	0	0.78
15-24EDATIII	−0.01	−0.03	0.05	−0.56	0.06	−0.24	0.13	0.15	0.14	0.32	0.62	−0.08	−0.13
25-54EDATIII	−0.15	−0.11	−0.08	0.27	0.27	0.42	−0.18	0.07	0.18	0.02	−0.13	−0.09	0.19
55-64EDATIII	0.34	0.24	0.26	0.31	−0.18	0.04	0.17	0.29	0.06	0.28	0.71	−0.14	0.15
ISOCAUTH	0	−0.19	−0.5	−0.66	−1.17	−0.6	0.5	−0.69	−0.39	−0.31	−0.38	0.11	−0.48
ISOCWEB	0.45	−0.22	0	1.04	0	0	0	0	−0.12	0	0	0.1	−1.68
ISOCPUBWEB	−0.08	0.35	0.35	−0.39	0.71	0.29	0.09	0.36	0.58	0.38	0.43	−0.23	2
ISOCFORMS	0.64	0.43	0.16	−1.05	0.12	0.16	0.83	−0.37	0.72	0.44	0.25	−0.1	0
ISOCPUBFORMS	−0.35	−0.32	−0.06	0.91	−0.01	−0.35	−0.7	0.29	−0.77	−0.55	−0.5	0.11	−0.16
ISOCINTACT	−0.51	−0.08	0.09	0	0.46	0.41	−0.72	0.34	0	0	0	0	0.3
15-24EMPL	−0.14	−0.05	−0.11	−0.11	−0.21	−0.06	−0.05	−0.13	−0.17	−0.16	−0.13	−0.01	−0.25
25-54EMPL	−0.01	−0.01	−0.06	0.09	−0.56	0	−0.03	−0.2	−0.2	−0.24	−0.35	0.03	−0.24
55-64EMPL	−0.08	0.05	−0.03	−0.19	0.06	−0.06	0.13	−0.03	−0.03	0	−0.09	0.24	0.26
GVAAGR	0 ***	−0.86 ***	0 ***	−2.3 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***
GVAINF	0 ***	0 ***	−1.18 ***	0 ***	−3.23 ***	−1.41 ***	−0.78 ***	−1.86 ***	−0.92 ***	−1.46 ***	−2.37 ***	0 ***	−2.15 ***
GVAFIN	−0.9 ***	−1 ***	−0.34 ***	0.4 ***	0.44 ***	−1.34 ***	0.05 ***	−0.85 ***	−0.77 ***	−0.73 ***	0.07 ***	1.93 ***	0.29 ***
GVAREST	0 ***	0 ***	0.6 ***	2.2 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***
GVAART	0 ***	0 ***	0 ***	0 ***	0 ***	1.76 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***
GVAWGSAGR	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	1.41 ***	0 ***	0 ***	0 ***	0 ***	0 ***
GVAEMPCWHS	0 ***	1.6 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***
GVAWGSMAN	−0.51 ***	−1.12 ***	−0.42 ***	−2.24 ***	0.31 ***	−0.4 ***	−1.36 ***	−0.3 ***	−0.76 ***	−0.74 ***	−0.69 ***	−2.52 ***	−1.56 ***
GVAWGSREST	−0.61 ***	0 ***	0.32 ***	0 ***	0.72 ***	0 ***	1.4 ***	0 ***	0.02 ***	0.6 ***	0.89 ***	0 ***	0.78 ***
GVAESCAGR	−0.11 ***	0.28 ***	−0.13 ***	0.2 ***	0.06 ***	0.61 ***	−0.61 ***	−0.65 ***	0.08 ***	0.17 ***	0.85 ***	−0.63 ***	−1.07 ***
GVAESCFIN	0.54 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***
GVAESCREST	0.69 ***	0 ***	0.42 ***	0.81 ***	0.89 ***	0.59 ***	−1.28 ***	1.36 ***	0.74 ***	0.57 ***	1.56 ***	0.03 ***	0.32 ***
GVAESCSCI	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	−2.37 ***	0 ***
GVAESCPADM	0 ***	0 ***	0 ***	−1.45 ***	0 ***	−0.59 ***	0 ***	0 ***	0 ***	−0.23 ***	−2.19 ***	0 ***	1.25 ***
GVAESCART	0 ***	0 ***	0 ***	0 ***	0 ***	0 ***	2.15 ***	0 ***	0 ***	0 ***	0 ***	3.55 ***	0 ***
PPP	−0.15	−0.08	−0.18	−0.05	−0.38	−0.25	−0.15	−0.44	−0.37	−0.4	−0.43	0.04	−0.68
SDG0620	0.07	−0.04	0.02	0.08	0.14	0.11	−0.04	0.05	0.05	0.02	−0.09	0.03	0.21
TEN00020TT	0.06	0.06	0.1	0.08	0.19	0.15	0.01	0.13	0.12	0.14	0.16	0.03	0.19
TEN00030SPP	1.91 ***	2.17 ***	1.74 ***	3.42 ***	1.82 ***	1.71 ***	1.49 ***	1.96 ***	2.67 ***	2.84 ***	2.94 ***	1.05 ***	3.21 ***
ϵ	49.12	−18.51	22.26	10.26	66.76	25.67	−26.73	41.43	50.92	56.64	56.13	−51.88	95.98

Notes: *** p-value < 0.005; ** p-value < 0.01; * p-value < 0.05.

The best correlation coefficient of the regressors with the dependent variable in 2010 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2010), which shows that the main contribution to pollution reduction is made by the SDG06 targets. Another indicator with a significant correlation is ISOCWEB2010 (E-government activities of individuals via websites). At the opposite pole, low correlation coefficients are 25-54EMPL2010 (employment and activity by sex and age—annual data (25–54 years)) and 25-54EDATII2010 (population by educational attainment level, sex, and age (55–64 years)—upper secondary, post-secondary non-tertiary, and tertiary education). This shows that the green character of the social economy is mainly influenced by the outputs of the social system and the strategic directions for the development of the green economy promoted by the EU. The target of actively involving the population in achieving environmental and climate objectives was not reached in 2010.

The best correlation coefficient of the regressors with the dependent variable in 2011 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2010), increasing compared to the previous year, which shows that the main contribution to pollution reduction is the SDG06 targets. Another indicator with a significant correlation is ISOCFORMS2011 (E-government activities of individuals via websites—Internet use: downloading official forms (last 12 months)). At the opposite pole, low correlation coefficients are 25-54EMPL2011 (employment and activity by sex and age—annual data (25–54 years)) and 25-54EDATII2011 (population by educational attainment level, sex, and age (55–64 years)—upper secondary, post-secondary non-tertiary, and tertiary education). This confirms the observations presented in the 2010 model, with no significant changes in terms of social economy and water pollution.

The best correlation coefficient of the regressors with the dependent variable in 2012 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)- TEN00030SPP2012), decreasing compared to the previous year, which shows that the main contribution to pollution reduction is made by SDG06 targets. Another indicator with a significant correlation is ISOCPUBWEB2012 (E-government activities of individuals via websites—Internet use: obtaining information from public authorities' websites (last 12 months)). At the opposite pole, low correlation coefficients show 55-64EMPL2012 (employment and activity by sex and age—annual data (55–64 years)) and 55-64EDATII2011 (population by educational attainment level, sex, and age (55–64 years)—upper secondary, post-secondary non-tertiary, and tertiary education). For the year 2012, there is a trend towards an erosion of SDG06 correlations in relation to pollution of water sources and a trend towards an increase in the impact of the social economy in terms of strengthening social responsibility based on the indicator gross value added and income by A*10 industry breakdowns—employers' social contributions.

The best correlation coefficient of the regressors with the dependent variable in 2013 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2012), increasing the correlation coefficient by more than 100% compared to the previous year, which shows that the main contribution to pollution reduction is made by SDG06 targets. Other significant indicators are GVA of social economy and ISOCWEB2013 (E-government activities of individuals via websites—Internet use: obtaining information from public authorities' websites (last 12 months)). At the opposite pole, low correlation coefficients show 55-64EDATI2013 (population by educational attainment level, sex, and age (55–64 years)—Less than primary, primary, and lower secondary education) and PPP2013 (purchasing power parities (PPPs), price level indices, and real expenditures for ESA 2010 aggregates). An increase in the intensity of the model correlations and a more significant approximation of the social economy to the environmental protection objectives in terms of SG06 is observed for 2013.

The best correlation coefficient of the regressors with the dependent variable in 2014 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2014), decreasing correlation from the previous year, which shows that the main contribution to pollution reduction is SDG06 targets. Other significant indicators increasing in correlative weight are GVA of social economy and ISOCAUTH2014 (E-government activities of individuals via websites—Internet use: interaction with public authorities (last 12 months). At the opposite pole, low correlation coefficients are shown by MLEXPEC2014 (life expectancy by age and sex) and 55-64EDATII2014 (population by educational attainment level, sex, and age (55–64 years)—upper secondary, post-secondary non-tertiary, and tertiary education). Significant variations in direct and inverse proportional correlations of social economy GVA with the level of pollution of water sources in terms of SDG06 and a low contribution of social responsibility on environmental objectives are observed for 2014.

The best correlation coefficient of the regressors with the dependent variable in 2015 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2015), slightly decreasing compared to the previous year, which shows that the main contribution to pollution reduction is made by SDG06 targets. Other significant indicators increasing in correlation weight are GVA of social economy and ISOCINTACT2015 (E-government activities of individuals via websites—Internet use: interaction with public authorities (last 12 months)). At the opposite pole, low correlation coefficients show 55-64EDATIII2015 (population by educational attainment level, sex, and age (55–64 years)—tertiary education). It can be observed that for 2015 the output values of the social economy show a regression correlated with the environmental objectives, while the efforts of public administration and e-government produce effects on the objectives of pollution reduction.

The best correlation coefficient of the regressors with the dependent variable in 2016 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2016), slightly decreasing compared to the previous year, which shows that the main contribution to pollution reduction is made by SDG06 targets. Other significant indicators with increasing correlation weights are gross value added and income—wages and salaries and ISOCFORMS2016 (E-government activities of individuals via websites—Internet use: downloading official forms (last 12 months)). At the opposite pole, low correlation coefficients show 25-54EMPL2016 (employment and activity by sex and age—annual data (55–64 years)). Total employment (resident population concept—LFS) and 55-64EDATII2016 (population by educational attainment level, sex, and age (55–64 years) and upper secondary, post-secondary non-tertiary, and tertiary education. It can be observed that for 2016 the values of social economy outputs show a regression correlated with the environmental objectives.

The best correlation coefficient of the regressors with the dependent variable in 2017 was recorded for the values of pollution indicators in the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2017), increasing from the previous year, which shows that the main contribution to pollution reduction is SDG06 targets. Other significant indicators increasing in correlative weight are gross value added and income—wages and salaries, agriculture, forestry and fishing, and ISOCAUTH2017 (E-government activities of individuals via websites; Internet use: interaction with public authorities). At the opposite pole, low correlation coefficients show 55-64EMPL2017 (employment and activity by sex and age—annual data

(55–64 years) Total employment (resident population concept—LFS)) and 55-64EDATI2017 (population by educational attainment level, sex, and age (55–64 years). Less than primary, primary, and lower secondary education). It can be observed that for 2017 the values of the social economy outputs show progress correlated with the environmental objectives.

The best correlation coefficient of the regressors with the dependent variable in 2019 was recorded for the values of pollution indicators from the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2019), increasing from the previous year. Other significant indicators increasing in correlative weight are gross value added and income (wages and salaries) and ISOCFORMS2019 (E-government activities of individuals via websites. Internet use: downloading official forms (last 12 months)). At the opposite pole, low correlation coefficients show 15-24EDATI2019 (population by educational attainment level, sex, and age (15–24 years). Less than primary, primary, and lower secondary education) and 25-54EDATI2019 (population by educational attainment level, sex, and age (25–54 years)). Tertiary education). It can be seen that for 2019 the values of the social economy outputs remain in correlation with the environmental objectives.

The best correlation coefficient of the regressors with the dependent variable in the year 2020 was recorded for the values of pollution indicators from the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2020), increasing from the previous year. Other significant indicators increasing in correlative weight are gross value added and income (wages and salaries) and GVAINF2020 (gross value added and income—Information and communication) as a result of the pandemic and the intensification of the digital economy. At the opposite pole, low correlation coefficients show 25-54EDATI2020 (population by educational attainment level, sex, and age (25–54 years). Less than primary, primary, and lower secondary education) and 25-54EDATIII2020 (population by educational attainment level, sex, and age (25–54 years). Tertiary education). As a result of the pandemic crisis, an improvement in the correlation is observed for the year 2020 against the background of the intensification of the digital economy as a result of the implementation of measures to combat the spread of the disease.

The best correlation coefficient of the regressors with the dependent variable in the year 2021 was recorded for the values of pollution indicators from the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2021), strongly decreasing from the previous year. Other significant indicators increasing in correlative weight are GVAESCSCI2021 (gross value added and income. Employers' social contributions—professional, scientific, and technical activities; administrative and support service activities) and GVAFIN2021 (gross value added and income—financial and insurance activities). At the opposite pole, low correlation coefficients show 15-24EMPL2021 (employment and activity by sex and age—annual data (15–24 years)). Total employment (resident population concept—LFS)) and ISOCFORMS2021 (E-government activities of individuals via websites. Internet use: downloading official forms (last 12 months)). A decrease in the correlation intensity of the model is observed for 2021.

The best correlation coefficient of the regressors with the dependent variable in the year 2022 was recorded for the pollution indicator values of the agriculture branch (Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)—TEN00030SPP2022), which recovered from the regression of the previous year, reaching a strong correlative position with the dependent variable. Other significant indicators increasing in correlative weight are ISOCPUBWEB2022 (E-government activities of individuals via websites. Internet use: obtaining information from public authority's websites (last 12 months), gross value added and income—wages and salaries, and GVAINF2022 (gross value added and income—Information and communication), as a result of the development of the side through efforts to overcome the economic crisis. At the opposite pole, low correlation coefficients show 25-54EDATIII2022 (population by educational attainment level, sex, and age (25–54 years). Tertiary education) and 15-24EDATIII2022 (Population by educational attainment level, sex and age (15–24 years). Tertiary education). For the year 2022, it can be seen that the correlation between the phenomena studied reaches a peak, which leads us to state that, given the sustained efforts to protect the environment, the even fluctuating results of the European social economy tend to cover the environmental objectives even at the risk of exceeding the budgetary allocations in this field. This aspect demonstrates working hypothesis H1.

In order to achieve the objectives of the study, in accordance with the conceptual model, the authors applied the statistical method of multiple linear regression, disseminating the results of the significance of the model in Table 3 below.

The analysis presented in Table 3 shows that the model is well represented over the whole range analyzed, with sinusoidal variations according to the Durbin–Watson test results, with the best distributions in 2017 and 2022. The analysis highlights the evolving relationship between socio-economic factors and the sustainability of water resources. The consistently high Adjusted R-Square values, ranging between 0.899 and 0.910, confirm the strong explanatory power of the models, demonstrating that the selected socio-economic indicators effectively capture the variations in water resource sustainability. Despite occasional fluctuations, the robustness of the models remains evident, with minor variations reflecting the impact of economic, policy, and environmental shifts. The Significance of F-Change (Sig. F Change) generally remains below the 0.05 threshold, indicating that the included predictors significantly contribute to explaining the dependent variable. However, the models for 2013 and 2016 present marginal significance levels, with *p*-values of 0.08 and 0.066, respectively, suggesting a weaker statistical association between socio-economic factors and water sustainability in those years.

Table 3. Models' summary.

Model	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
			R Square Change	F Change	df1	df2	Sig. F Change	
2010	0.905	1.3751	0.950	220.110	25	2	0.005	2.487
2011	0.910	0.3416	0.956	3415.111	26	1	0.014	1.446
2012	0.909	0.5676	0.954	1226.255	26	1	0.023	2.397
2013	0.900	2.0229	0.945	97.423	26	1	0.080	1.876
2014	0.908	0.9512	0.953	460.228	25	2	0.002	2.296
2015	0.908	0.7716	0.953	671.498	26	1	0.030	2.232
2016	0.904	1.6714	0.949	143.070	26	1	0.066	2.270
2017	0.899	2.1769	0.944	88.642	25	2	0.011	2.078
2018	0.909	0.5619	0.954	1336.699	25	2	0.001	1.594
2019	0.905	1.5413	0.950	177.752	25	2	0.006	1.751
2020	0.909	0.6804	0.954	922.239	25	2	0.001	2.249
2021	0.910	0.4447	0.956	2160.567	25	2	0.000	1.906
2022	0.909	0.4707	0.954	1864.684	26	1	0.018	2.134

Notes: Predictors: (constant), TEN00030SPPyear, 15-24EDATIIIyear, SDG0620year, 25-54EMPLyear, ISOCPUBWEByear, TEN00020TTyear, PPPyear, 55-64EMPLyear, ISOCPUBFORMSyear, 25-54EDATIIyear, 15-24EMPLyear, 25-54EDATIIIyear, MLEXPECyear, 15-24EDATIyear, 55-64EDATIIIyear, ISOCAUTHyear, GVAESCRESTyear, 55-64EDATIIyear, GVAESCAGRyear, GVAWGSMANyear, ISOCWEByear, GVAINFyear, GVAFINyear, GVAESCPADMyear, GVAWGSRESTyear, and ISOCINTACTyear. Dependent variable: TEN00030SSyear.

The marginal significance level in 2013, reflected by a p-value of 0.08, suggests that while the model still explains water sustainability trends, its explanatory power is slightly weaker compared to other years. This result can be attributed to the broader economic and environmental context of that period, particularly the lingering effects of the Eurozone financial crisis (2012–2013), which placed significant financial constraints on environmental programs across Europe. During this period, many governments shifted their priorities toward economic stabilization, reducing immediate investments in infrastructure projects related to wastewater treatment and pollution mitigation. This may have led to inconsistencies in policy implementation, temporarily weakening the measurable impact of socio-economic determinants on water resource sustainability. Furthermore, legislative transitions in European environmental directives during this time may have created a period of regulatory uncertainty, delaying the full enforcement of sustainability measures. The observed marginal significance in 2013 does not indicate a fundamental breakdown in the relationship between social economy factors and water sustainability but rather reflects a temporary phase where external macroeconomic stressors reduced the immediate effectiveness of environmental policies. A similar observation can be made for 2016, where the model presents a marginal significance level with a p-value of 0.066. This period coincides with shifts in European Union funding allocations for environmental and infrastructure projects, particularly in the aftermath of policy adjustments following the 2015 financial instability in several European economies. The transition to new funding frameworks under the European Structural and Investment Funds (ESIF) may have temporarily disrupted the consistency of investments in water management initiatives, leading to a weaker statistical relationship between socio-economic indicators and water resource sustainability. Additionally, 2016 marks a phase where digital governance tools, such as e-government services for regulatory enforcement, were still developing, which may explain why their role in environmental compliance was not yet fully reflected in statistical models.

Despite these fluctuations, the overall trend demonstrates that socio-economic influences on water sustainability become increasingly robust in later years, particularly in 2018, 2020, and 2021, where the models exhibit strong significance levels ($p < 0.01$). These years align with heightened global awareness of climate change policies, stricter environmental regulations, and a surge in digital governance mechanisms, which strengthened the enforcement of sustainability programs. The increasing role of e-government platforms and digital compliance tools facilitated better monitoring and enforcement of environmental standards, leading to greater consistency in model significance.

The ANOVA test constructed to validate the alternative hypotheses of the 13 annual models shows that from the point of view of the one-criteria probability test, the Sig. coefficients values of the annual models are lower than the chosen error significance level (0.05), which allows rejecting the null hypothesis and maintaining the alternative hypothesis for all the models presented, and the distribution of the regression squares on each annual case is clearly higher than the residual value, which confirms the homogeneity of the models (see Table 4).

From the ANOVA table, it can be seen that the degrees of freedom of regression vary between 25 and 26 out of 27 possible. For the year 2022, there was an improvement in the model parameters, this being much better represented among those after the onset of the pandemic.

The analysis of econometric models spanning the period from 2010 to 2022 reveals several key socio-economic factors that significantly influence water resource quality (Table 5).

Table 4. ANOVA test.

Model		Sum of Squares	df	Mean Square	F	Sig.
2010	Regression	10,404.628	25	416.185	220.110	0.005 [b]
	Residual	3.782	2	1.891		
	Total	10,408.410	27			
2011	Regression	10,362.128	26	398.543	3415.111	0.014 [b]
	Residual	0.117	1	0.117		
	Total	10,362.244	27			
2012	Regression	10,271.127	26	395.043	1226.255	0.023 [b]
	Residual	0.322	1	0.322		
	Total	10,271.450	27			
2013	Regression	10,365.557	26	398.675	97.423	0.080 [b]
	Residual	4.092	1	4.092		
	Total	10,369.650	27			
2014	Regression	10,409.061	25	416.362	460.228	0.002 [b]
	Residual	1.809	2	0.905		
	Total	10,410.870	27			
2015	Regression	10,395.346	26	399.821	671.498	0.030 [b]
	Residual	0.595	1	0.595		
	Total	10,395.941	27			
2016	Regression	10,391.277	26	399.664	143.070	0.066 [b]
	Residual	2.793	1	2.793		
	Total	10,394.070	27			
2017	Regression	10,501.104	25	420.044	88.642	0.011 [b]
	Residual	9.477	2	4.739		
	Total	10,510.581	27			
2018	Regression	10,549.678	25	421.987	1336.699	0.001 [b]
	Residual	0.631	2	0.316		
	Total	10,550.310	27			
2019	Regression	10,557.210	25	422.288	177.752	0.006 [b]
	Residual	4.751	2	2.376		
	Total	10,561.961	27			
2020	Regression	10,674.938	25	426.998	922.239	0.001 [b]
	Residual	0.926	2	0.463		
	Total	10,675.864	27			
2021	Regression	10,679.677	25	427.187	2160.567	0.000 [b]
	Residual	0.395	2	0.198		
	Total	10,680.073	27			
2022	Regression	10,743.417	26	413.208	1864.684	0.018 [b]
	Residual	0.222	1	0.222		
	Total	10,743.639	27			

Notes: Dependent variable: TEN00030Ssyear. Predictors: (constant), TEN00030SPPyear, 15-24EDATIIIyear, SDG0620year, 25-54EMPLyear, ISOCPUBWEByear, TEN00020TTyear, PPPyear, 55-64EMPLyear, ISOCPUBFORMSyear, 25-54EDATIIyear, 15-24EMPLyear, 25-54EDATIIIyear, MLEXPECyear, 15-24EDATIyear, 55-64EDATIIIyear, ISOCAUTHyear, GVAESCRESTyear, 55-64EDATIIyear, GVAESCAGRyear, GVAWGSMANyear, ISOCWEByear, GVAINFyear, GVAFINyear, GVAESCPADMyear, GVAWGSRESTyear, and ISOCINTACTyear. [b]: The significance values (Sig.) correspond to the probability of observing the test results under the null hypothesis. A value below 0.05 typically indicates statistical significance, meaning the independent variables collectively explain a significant proportion of the variance in the dependent variable. The interpretation of these values is subject to the sample size and degrees of freedom.

Table 5. Major socio-economic influences on environmental sustainability.

Socio-Economic Factor	Impact Direction	Evolution Over Time
GVA in Agriculture (GVAAGR)	Negative (↑Pollution)	Consistently high negative impact, requiring stricter regulations
GVA in Manufacturing (GVAMAN)	Negative (↑Pollution)	Strong negative impact, though decreasing with improved policies
Employment (25-54EMPL)	Positive (↓Pollution)	Steady positive influence, reinforcing the role of economic stability
Higher Education Attainment (25-54EDATIII)	Positive (↓Pollution)	Increasing importance, highlighting the role of education in sustainability
E-Government Adoption (ISOCAUTH, ISOCWEB)	Positive (↓Pollution)	Growing impact, with stronger policy enforcement through digital tools
Purchasing Power Parity (PPPyear)	Positive (↓Pollution)	Fluctuating impact, weakening during economic crises
Sustainable Development Goals (SDG 06—Clean Water & Sanitation)	Positive (↓Pollution)	Strong influence, but effectiveness depends on financial and policy support

Note: The arrows (↑and ↓) indicate the direction of the relationship between the socio-economic factor and environmental sustainability.

Among the most impactful variables, gross value added (GVA) by sector plays a central role, with the agriculture and manufacturing sectors exhibiting a strong correlation with sewage sludge production and disposal. This relationship underscores the considerable environmental footprint of these industries, where intensive resource use and pollutant discharge contribute to the degradation of water quality. Conversely, the financial sector has demonstrated an indirect but notable effect, as increased capital investment in environmental policies and sustainable initiatives has contributed to pollution mitigation efforts.

Employment and educational attainment have also emerged as critical determinants, shaping the dynamics of water sustainability. Higher employment levels, particularly within the 25–54 age group, correlate negatively with water pollution, suggesting that regions with robust labor markets tend to exhibit better regulatory enforcement and environmental compliance. Similarly, increased educational attainment, especially at tertiary levels, has been positively associated with improved water sustainability, reflecting the role of informed policymaking and heightened public awareness in environmental conservation.

The growing influence of digital governance is another defining trend observed throughout the study period. Indicators reflecting e-government adoption, such as the use of online platforms for public administration and environmental reporting, have progressively gained importance. These digital tools facilitate compliance with wastewater management regulations, ensuring more efficient monitoring and enforcement of sustainability policies. The correlation between digital governance and water resource quality strengthens over time, indicating that increased reliance on digital platforms enhances policy effectiveness in environmental management.

Economic capacity, as captured by purchasing power parity, has shown a moderate yet consistent impact on water resource sustainability. Regions with higher purchasing power demonstrate stronger investments in water protection infrastructure and environmental initiatives. However, this correlation weakens during periods of economic downturn, such as those observed in 2012, 2015, and 2020, highlighting the vulnerability of sustainability efforts to broader financial constraints. The findings further emphasize that economic stability plays an important role in maintaining and advancing environmental protection measures, as financial insecurity tends to delay necessary investments in wastewater treatment and pollution control mechanisms.

The impact of water policies, particularly those aligned with the Sustainable Development Goals (SDG 06—Clean Water and Sanitation), has remained significant throughout the study period. Indicators associated with wastewater treatment infrastructure consistently show strong positive correlations with improvements in water quality. Nonetheless, during years marked by economic crises, these relationships weaken, revealing the dependence of sustainability programs on financial and institutional support.

A common pattern emerging from the study is that the agriculture and industrial sectors remain the primary contributors to water pollution, necessitating stricter environmental regulations and enforcement measures. Meanwhile, education and digital governance have gained increasing importance in mitigating pollution, demonstrating that knowledge dissemination and technological advancements enhance policy implementation. Economic stability has also been confirmed as a key determinant of water sustainability, with financial fluctuations impacting the effectiveness of long-term environmental strategies. Lastly, the progressive integration of e-government solutions has proven to be an essential tool for regulatory compliance, ensuring that environmental policies are more efficiently executed and monitored.

4. Results and Discussions

For the demonstration of the other seven working hypotheses, we constructed the Pearson correlation table, according to which there are different intensities of correlation of the social economy indicators concerning the model variable, i.e., TEN00030SS: Sewage sludge production and disposal from urban wastewater (in dry substance (d.s)), Sludge disposal—total. Urban wastewater treatment plants—total), (see Table 6).

As can be seen from the table, increasing life expectancy has a potential impact on water pollution in terms of increasing urban water consumption (see Figure 3).

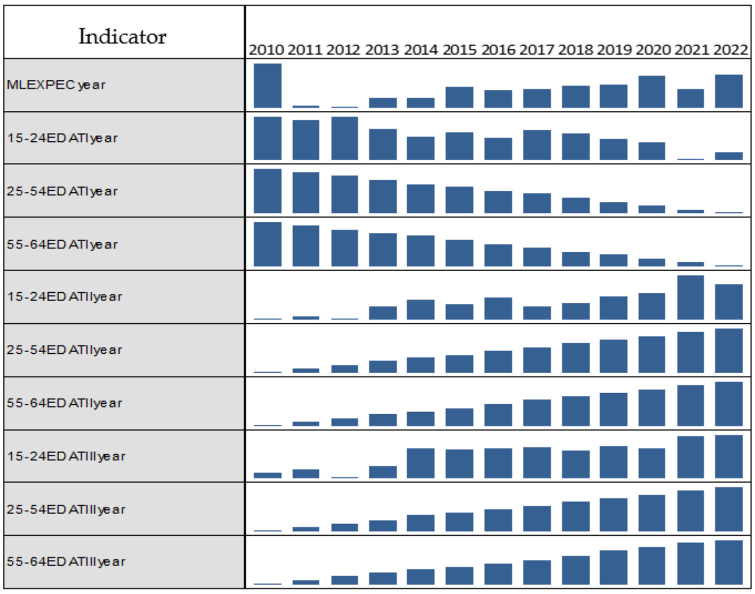

Figure 3. Dynamics of correlations with the dependent variable of demographic and educational regressors. Source: authors' contribution.

The level of inverse correlation between environmental protection actions and increased life expectancy has an average intensity of 46% to 56%, i.e., a one-year increase in life expectancy accelerates the level of pollution by 0.05%.

Table 6. Pearson correlations.

Pearson	TEN00030SS												
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
MLEXPECyear	0.230	−0.564	−0.558	−0.547	−0.533	−0.562	−0.552	−0.558	−0.558	−0.555	−0.568	−0.463	−0.524
15-24EDATIyear	0.107	0.108	0.079	0.075	0.140	0.129	0.110	0.085	0.072	0.058	0.021	0.088	0.045
25-54EDATIyear	0.130	0.132	0.142	0.145	0.152	0.154	0.168	0.190	0.204	0.215	0.233	0.271	0.274
55-64EDATIyear	0.104	0.102	0.110	0.110	0.107	0.109	0.113	0.120	0.131	0.132	0.149	0.160	0.151
15-24EDATIIyear	−0.107	−0.108	−0.079	−0.075	−0.140	−0.129	−0.110	−0.085	−0.072	−0.058	−0.021	−0.088	−0.045
25-54EDATIIyear	−0.130	−0.132	−0.142	−0.145	−0.152	−0.154	−0.168	−0.190	−0.204	−0.215	−0.233	−0.271	−0.274
55-64EDATIIyear	−0.104	−0.102	−0.110	−0.110	−0.107	−0.109	−0.113	−0.120	−0.131	−0.132	−0.149	−0.160	−0.151
15-24EDATIIIyear	0.036	0.038	0.102	0.070	0.002	0.009	0.027	0.039	0.059	0.065	0.105	0.073	0.064
25-54EDATIIIyear	−0.016	−0.028	−0.024	−0.023	−0.055	−0.056	−0.058	−0.057	−0.061	−0.058	−0.053	−0.073	−0.074
55-64EDATIIIyear	−0.056	−0.056	−0.051	−0.050	−0.058	−0.043	−0.050	−0.040	−0.046	−0.047	−0.034	−0.047	−0.037
ISOCAUTHyear	0.027	0.017	0.009	0.037	−0.029	−0.034	−0.055	−0.064	−0.040	−0.052	−0.050	−0.076	−0.080
ISOCWEByear	0.024	0.018	0.006	0.008	−0.040	−0.045	−0.057	−0.069	−0.049	−0.052	−0.041	−0.108	−0.113
ISOCPUBWEByear	0.043	0.027	0.013	0.038	−0.038	−0.045	−0.062	−0.080	−0.062	−0.066	−0.055	−0.122	−0.122
ISOCFORMSyear	−0.021	−0.023	−0.021	−0.021	−0.024	−0.033	−0.011	−0.017	0.006	−0.032	0.009	−0.040	0.048
ISOCPUBFORMSyear	0.005	−0.001	−0.001	0.005	−0.011	−0.027	−0.001	−0.013	0.008	−0.040	0.003	−0.045	0.046
ISOCINTACTyear	−0.005	−0.011	−0.013	0.004	−0.035	−0.037	−0.050	−0.054	−0.031	−0.037	−0.034	−0.064	−0.057
15-24EMPLyear	−0.039	−0.042	−0.018	−0.031	−0.055	−0.075	−0.076	−0.089	−0.096	−0.085	−0.082	−0.075	−0.101
25-54EMPLyear	−0.091	−0.094	−0.096	−0.119	−0.144	−0.156	−0.145	−0.188	−0.203	−0.217	−0.235	−0.227	−0.233
55-64EMPLyear	0.065	0.058	0.039	0.039	0.047	0.049	0.047	0.023	−0.003	−0.010	−0.024	−0.040	−0.032
GVANACEyear	0.968	0.970	0.973	0.967	0.965	0.961	0.959	0.946	0.941	0.940	0.929	0.928	0.920
GVAAGRyear	0.973	0.975	0.977	0.976	0.975	0.975	0.976	0.969	0.967	0.963	0.960	0.955	0.944
GVAINDyear	0.960	0.961	0.965	0.958	0.955	0.951	0.948	0.932	0.927	0.926	0.917	0.916	0.909
GVAMANyear	0.957	0.958	0.961	0.954	0.950	0.946	0.944	0.928	0.922	0.922	0.912	0.911	0.902
GVACONSTyear	0.980	0.977	0.978	0.969	0.969	0.965	0.964	0.951	0.947	0.946	0.933	0.928	0.912
GVAWHSyear	0.972	0.975	0.978	0.973	0.972	0.969	0.968	0.957	0.953	0.951	0.937	0.938	0.932
GVAINFyear	0.964	0.965	0.969	0.962	0.960	0.955	0.953	0.939	0.933	0.931	0.921	0.918	0.910
GVAFINyear	0.961	0.962	0.967	0.958	0.958	0.954	0.954	0.943	0.941	0.939	0.932	0.931	0.929
GVARESTyear	0.965	0.969	0.974	0.968	0.967	0.961	0.959	0.946	0.942	0.940	0.932	0.929	0.921
GVASCIyear	0.956	0.959	0.963	0.956	0.956	0.952	0.949	0.934	0.930	0.929	0.919	0.916	0.908
GVAPADMyear	0.966	0.968	0.971	0.965	0.964	0.959	0.957	0.943	0.939	0.937	0.928	0.924	0.916
GVAARTyear	0.972	0.974	0.977	0.972	0.970	0.967	0.966	0.954	0.949	0.947	0.933	0.931	0.927
GVAEMPCNACEyear	0.967	0.968	0.971	0.963	0.962	0.957	0.955	0.940	0.935	0.934	0.924	0.922	0.913
GVAEMPCAGRyear	0.969	0.972	0.972	0.967	0.967	0.965	0.964	0.955	0.952	0.950	0.942	0.942	0.937
GVAEMPCINDyear	0.955	0.956	0.959	0.950	0.945	0.939	0.938	0.921	0.914	0.913	0.904	0.902	0.893
GVAEMPCMANyear	0.953	0.954	0.957	0.947	0.943	0.937	0.935	0.918	0.911	0.910	0.900	0.899	0.891
GVAEMPCCONSTyear	0.977	0.974	0.973	0.963	0.962	0.958	0.956	0.942	0.939	0.940	0.931	0.929	0.919
GVAEMPCWHSyear	0.972	0.973	0.976	0.969	0.968	0.964	0.962	0.949	0.945	0.944	0.933	0.931	0.925
GVAEMPCINFyear	0.963	0.965	0.967	0.960	0.958	0.954	0.951	0.935	0.930	0.927	0.918	0.916	0.904
GVAEMPCFINyear	0.964	0.966	0.969	0.962	0.959	0.954	0.952	0.937	0.932	0.931	0.921	0.918	0.909
GVAEMPCRESTyear	0.950	0.953	0.956	0.946	0.948	0.944	0.942	0.928	0.925	0.927	0.914	0.907	0.898
GVAEMPCSCIyear	0.955	0.957	0.960	0.952	0.953	0.948	0.945	0.929	0.924	0.923	0.915	0.913	0.901
GVAEMPCPADMyear	0.967	0.969	0.972	0.965	0.964	0.960	0.958	0.943	0.938	0.937	0.928	0.926	0.918
GVAEMPCARTyear	0.975	0.976	0.979	0.972	0.971	0.967	0.965	0.952	0.947	0.945	0.934	0.934	0.924
GVAWGSNACEyear	0.967	0.968	0.971	0.963	0.961	0.956	0.954	0.939	0.934	0.932	0.922	0.920	0.911
GVAWGSAGRyear	0.972	0.974	0.975	0.970	0.970	0.968	0.967	0.959	0.956	0.953	0.945	0.946	0.940
GVAWGSINDyear	0.953	0.954	0.956	0.946	0.941	0.936	0.934	0.917	0.910	0.909	0.900	0.898	0.890
GVAWGSMANyear	0.951	0.952	0.953	0.944	0.939	0.933	0.931	0.914	0.906	0.906	0.897	0.896	0.887
GVAWGSCONSTyear	0.976	0.973	0.972	0.961	0.960	0.956	0.954	0.940	0.937	0.938	0.928	0.926	0.917
GVAWGSWHSyear	0.971	0.973	0.975	0.968	0.967	0.963	0.961	0.948	0.943	0.942	0.930	0.928	0.922
GVAWGSINFyear	0.962	0.965	0.967	0.960	0.958	0.953	0.950	0.934	0.928	0.926	0.916	0.915	0.903
GVAWGSFINyear	0.963	0.965	0.968	0.961	0.958	0.952	0.950	0.935	0.930	0.929	0.918	0.916	0.906
GVAWGSRESTyear	0.950	0.953	0.957	0.947	0.949	0.945	0.943	0.929	0.925	0.927	0.914	0.907	0.899
GVAWGSSCIyear	0.955	0.957	0.960	0.952	0.953	0.948	0.945	0.928	0.923	0.922	0.913	0.912	0.900
GVAWGSPADMyear	0.969	0.971	0.973	0.966	0.965	0.961	0.958	0.944	0.939	0.937	0.928	0.924	0.916
GVAWGSARTyear	0.974	0.976	0.978	0.972	0.971	0.966	0.964	0.951	0.946	0.943	0.933	0.932	0.923
GVAESCNACEyear	0.964	0.966	0.968	0.961	0.961	0.956	0.954	0.941	0.937	0.937	0.929	0.927	0.919
GVAESCAGRyear	0.950	0.954	0.953	0.945	0.947	0.944	0.942	0.932	0.927	0.929	0.923	0.917	0.913
GVAESCINDyear	0.959	0.960	0.965	0.957	0.955	0.949	0.947	0.932	0.927	0.924	0.915	0.911	0.903
GVAESCMANyear	0.957	0.959	0.964	0.956	0.953	0.947	0.945	0.930	0.925	0.922	0.913	0.909	0.902
GVAESCCONSTyear	0.978	0.974	0.974	0.966	0.965	0.962	0.960	0.948	0.947	0.950	0.944	0.937	0.924
GVAESCINFyear	0.960	0.962	0.965	0.959	0.957	0.951	0.949	0.935	0.929	0.930	0.922	0.916	0.903
GVAESCFINyear	0.964	0.965	0.968	0.962	0.961	0.957	0.953	0.939	0.935	0.936	0.927	0.920	0.915
GVAESCRESTyear	0.948	0.949	0.952	0.941	0.944	0.939	0.937	0.922	0.920	0.926	0.914	0.902	0.896
GVAESCSCIyear	0.953	0.954	0.957	0.949	0.951	0.946	0.943	0.928	0.925	0.928	0.922	0.915	0.904
GVAESCPADMyear	0.959	0.962	0.965	0.957	0.958	0.953	0.951	0.937	0.933	0.932	0.924	0.928	0.921
GVAESCARTyear	0.974	0.976	0.979	0.971	0.971	0.966	0.965	0.952	0.949	0.948	0.939	0.938	0.929
PPPyear	0.081	0.086	0.071	0.080	0.096	0.101	0.097	0.100	0.101	0.091	0.080	0.088	0.094
SDG0620year	0.151	0.142	0.129	0.124	0.108	0.103	0.102	0.090	0.086	0.083	0.077	0.061	0.053
TEN00020TTyear	−0.077	−0.073	−0.068	−0.070	−0.067	−0.067	−0.067	−0.065	−0.067	−0.067	−0.070	−0.066	−0.065
TEN00030year	0.982	0.983	0.986	0.979	0.978	0.976	0.976	0.966	0.963	0.959	0.953	0.950	0.945
TEN00030SPPyear	0.983	0.984	0.987	0.981	0.979	0.977	0.976	0.968	0.964	0.961	0.955	0.953	0.948

The level of education at the three educational stages (primary, secondary, and tertiary) shows low correlations with citizens' proactive environmental behavior, which means that the objectives of information and awareness of human impact on the environment do not produce the desired effects among the population to ensure sustainable development, including from the perspective of protecting water sources (Figure 3).

The analysis of the empowerment of sustainable social behavior through e-governance highlights that the level of correlation of these phenomena is variably low, without reaching the potential desired by the European authorities (see Figure 4). In dynamics, it is observed that the authorities' efforts increase in intensity with the exception of post-pandemic outputs on Internet use: obtaining information from public authorities' websites. However, government digitization efforts are dissipating as a result of a lack of public interest or preparedness in the field.

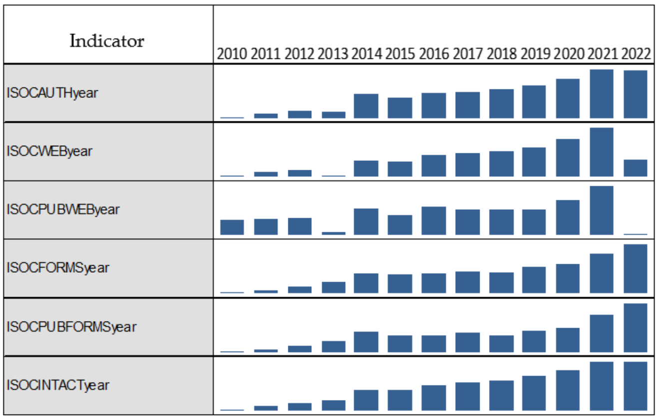

Figure 4. Dynamics of correlations with the dependent variable of e-governance regressors. Source: authors' contribution.

The analysis of employment levels by age group in relation to sustainable social behavior is another area that constitutes a risk factor for environmental protection in the absence of environmental education. We believe that public policies are needed to stimulate sustainable social behavior, which contributes to balancing the risk factors of environmental pollution through the judicious use of resources and the reduction in waste (see Figure 5).

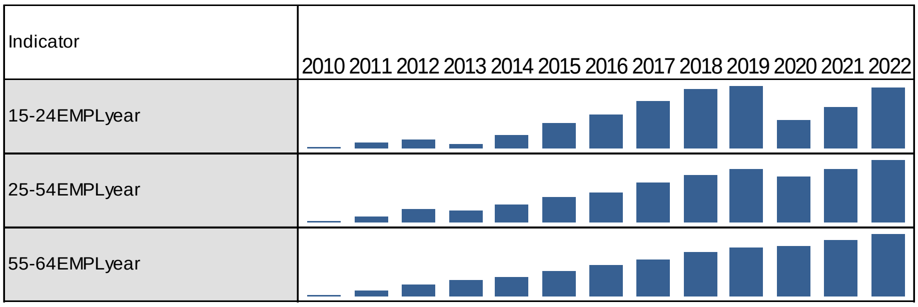

Figure 5. Dynamics of correlations with the dependent variable of employment regressors. Source: authors' contribution.

The analysis of social economy outputs in relation to environmental policy shows a strong correlation between the impact of sustainability-enhancing measures taken by European policymakers, thus demonstrating that among all social economy sectors, the strongest correlation is shown by the construction sector, followed by wholesale and retail trade, transport, accommodation, and food service activities (which validates the working hypothesis H2).

At the same time, it can be seen from Figure 6 that under the impact of multiple economic crises, the correlation level of the two indicators (Sewage sludge production and disposal from urban wastewater and gross value added and income) tends to decrease in intensity (validation of hypothesis H3).

Table 4 and Figure 6 show that the level of development of the social economy expressed by gross value added indicators in terms of compensation of employees shows a strong significant correlation with the protection of the aquatic environment (Sewage sludge production and disposal from urban wastewater), (hypothesis H4).

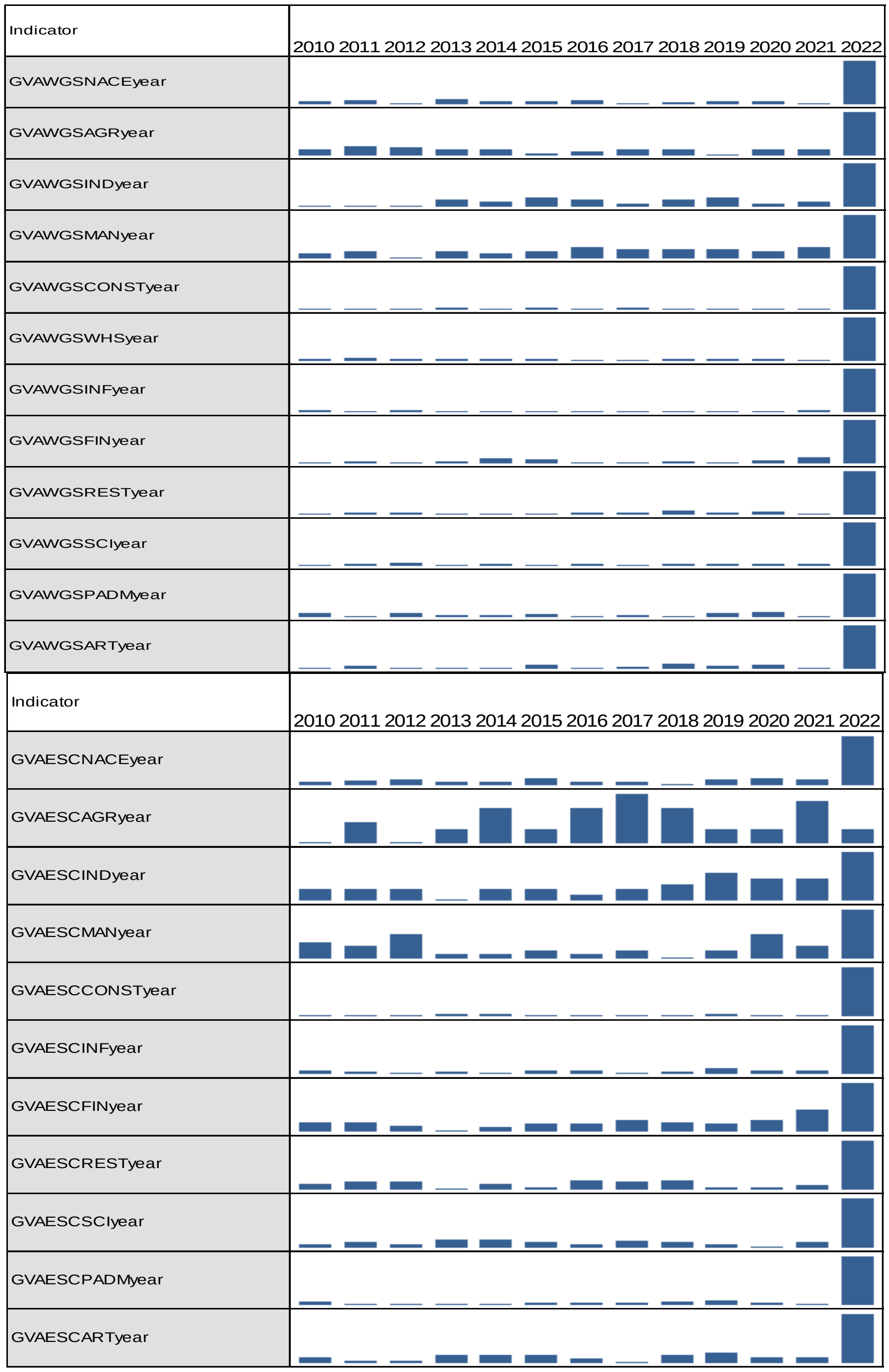

Figure 6. Dynamics of correlations with the dependent variable of social economy regressors. Source: authors' contribution.

The strongest correlations are for construction and arts, entertainment and recreation, other service activities; activities of household and extra-territorial organizations and bodies (validation of hypothesis H5).

The analysis reveals that in dynamics, Pearson correlations under the impact of economic crises between social economy indicators (GVA) in terms of compensation of employees tend to reduce in intensity (validation of hypothesis H6). At the same time, the correlations between the level of compensation offered by the social economy and the intensity of the phenomenon of protection of water sources are directly proportional, a development that validates hypothesis H7.

A surprising aspect of the analysis is the weak results of the correlation of SDG06 indicators with the outputs of water pollution control activities observed through the evolution of the dependent variable at the level of 27 Member States. It is observed that, as in the case of e-governance, the evolution of the sustainability indicator increases in intensity, but the linear correlation with the dependent variable remains weak (see Figure 7).

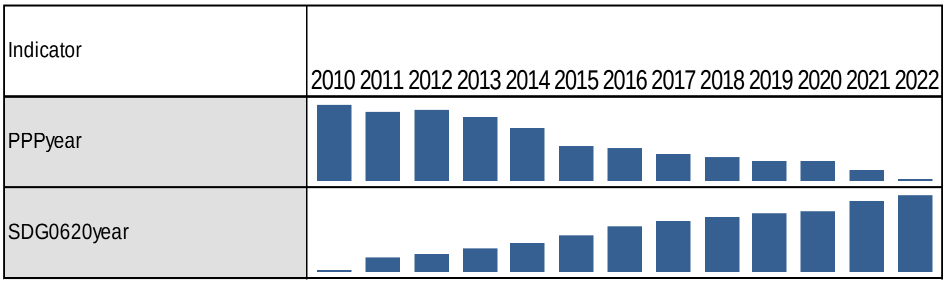

Figure 7. Dynamics of correlations with the dependent variable of SDG06 regressors. Source: authors' contribution.

The evolution of water source protection indicators shows a strong and regressive correlation between the impact of economic crises with the dependent variable (Sewage sludge production and disposal from urban wastewater), which validates hypothesis H8 (see Figure 8).

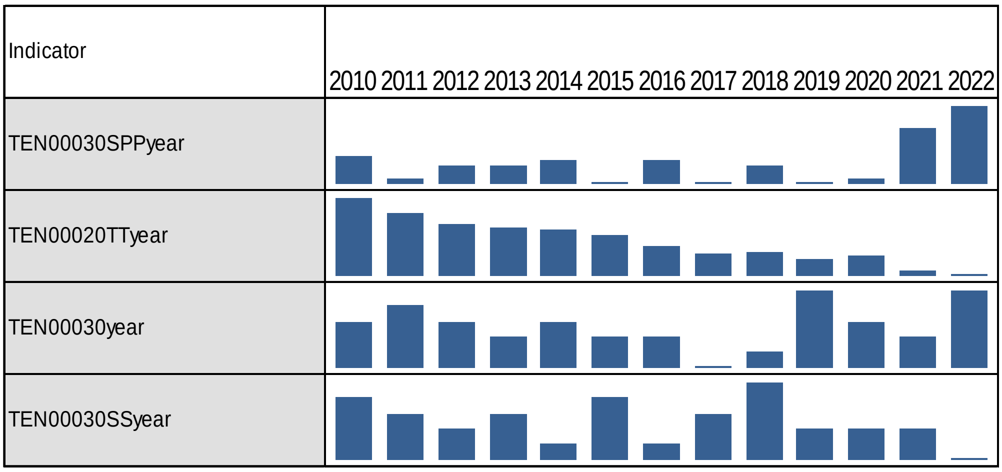

Figure 8. Dynamics of correlations with the dependent variable of water source pollution regressors. Source: authors' contribution.

The dynamic analysis of socio-economic indicators reveals that the social economy significantly influences water resource quality, with this influence varying according to economic sectors, broader macroeconomic conditions, and implemented policies at regional and national levels. The results confirm the existence of strong correlations between social economy development and water pollution levels, emphasizing the need for effective resource management measures to mitigate negative environmental impacts. One of the most significant findings of the statistical analysis is the strong correlation between the development of the social economy and water pollution levels, measured through the production and disposal of sludge from urban wastewater. This relationship indicates that as the social economy grows and diversifies, pressure on water resources increases both through water consumption in economic processes and through the generation of waste and pollutants. Although the social economy promotes sustainability and social responsibility principles, without proper regulations and resource optimization strategies, it can indirectly contribute to the degradation of water quality.

The impact of the social economy on water quality varies significantly depending on the economic sector. One of the sectors with the highest negative impact is the construction industry, where a strong correlation has been observed between sectoral activities and water pollution levels. This result can be explained by the intensive use of water in construction processes, the generation of solid and liquid waste, and the alterations made to aquatic ecosystems through infrastructure projects. Without strict regulations on waste treatment and disposal in construction, this sector can become a major source of water pollution.

Other sectors significantly affecting water resources include wholesale and retail trade, transport, accommodation, and food services. The expansion of these economic activities leads to increased water consumption and wastewater generation, especially in urban and tourist areas. Hospitality businesses, restaurants, and commercial centers are major water consumers, and without an efficient wastewater management system, these activities can contribute to water pollution. Furthermore, transport sector development entails risks related to fuel spills and toxic substances infiltrating the soil and groundwater, impacting drinking water quality and aquatic ecosystems.

On the other hand, some sectors of the social economy have a positive impact on water quality. The arts, entertainment, and recreation sectors have been found to correlate with water resource protection, likely due to corporate social responsibility initiatives promoted in this field. Many cultural and recreational projects include awareness campaigns on environmental protection, responsible resource use, and the implementation of eco-friendly practices in event organizations and leisure activities. Therefore, this sector can contribute to shifting collective behavior toward more sustainable water use.

The evolution of socio-economic impact on water quality is also influenced by economic cycles. During economic crises, correlations between social economy development and water pollution tend to weaken, suggesting a reduction in economic activities that negatively impact the environment. This phenomenon can be explained by decreased investments in resource-intensive industries and reduced production and construction activities. Conversely, during periods of economic growth, pressure on water resources intensifies, necessitating the implementation of stricter policies to protect the environment. Thus, it is important that economic expansion is accompanied by regulatory and monitoring measures to ensure sustainable water management.

A positive aspect identified in the analysis is the increasing influence of digitalization and e-governance policies on sustainability. Indicators measuring the use of online platforms for accessing public information and downloading administrative forms have demonstrated a positive impact on water resource management. This finding suggests that digital technologies can optimize water management processes, enhance transparency in environmental regulation enforcement, and reduce unnecessary resource consumption. The digitalization of public administration and the implementation of electronic reporting systems for water consumption and pollutant emissions can support more effective decision-making for environmental protection.

Additionally, the analysis revealed that an increase in employer social contributions is associated with a higher level of environmental protection. This result indicates that social economy initiatives promoting corporate responsibility and sustainability investments can contribute to reducing water pollution. By developing taxation and subsidy mechanisms that encourage sustainable business practices, policymakers can stimulate the social economy to adopt more environmentally friendly production and consumption models.

The study results demonstrate that the social economy plays a significant role in shaping water resource quality, with its impact influenced by specific economic sectors, macroeconomic conditions, and implemented policies. The most affected sectors include construction, trade, transport, and hospitality, which exert considerable pressure on water resources. However, certain sectors, such as arts and entertainment, can play a positive role in promoting sustainability and environmental protection.

On the basis of the analysis carried out, the following public policy proposals with an impact on increasing the protection of the aquatic environment are formulated:

- Introduction of optional subjects on social responsibility towards the aquatic environment in the educational curriculum;
- Introducing in the educational curriculum optional subjects of personal development in a friendly natural environment;
- Implementation of public policies to involve labor in protecting the environment and reducing waste of water sources by offering incentives to entities with real results in this field;
- Government support for the development of corporate responsibility for the environment, including water sources;
- Adopting strategies to transform the social economy into a green economy;
- A differentiated approach to environmental protection policies according to the level of pollution of economic sectors of activity;
- Accelerating the implementation of organic farming policies.
- Implementing stricter water resource protection regulations in sectors with the highest pollution risks, such as construction, wholesale and retail trade, transport, and hospitality.
- Expanding the use of digital platforms to monitor water consumption and pollutant emissions in real time.

Promoting green technologies in industries with a high impact on water, increasing transparency in water resource management through digitalization, and encouraging corporate social responsibility initiatives in the private sector contribute to improving water sustainability and reducing the negative environmental impact of economic activities. By adopting these measures, the social economy can become a driver of sustainable development, ensuring a balance between economic growth and the protection of essential natural resources, such as water.

5. Conclusions

This study provides a comprehensive analysis of the relationship between the social economy and water resource sustainability, emphasizing how socio-economic indicators correlate with water pollution levels across different sectors. The findings reveal that while the social economy fosters sustainability and social responsibility, its expansion can also exert pressure on water resources, necessitating well-structured policies and regulatory frameworks to mitigate negative environmental impacts.

The present research has achieved its objectives in terms of analyzing the correlations between the social economy and environmental protection, i.e., water resources, in their dynamics and the impact of new challenges at the regional level.

The developed model has been successfully tested and validated and demonstrates that despite the concentrated efforts of European decision-makers, there are significant risks and vulnerabilities at the regional level in terms of social economy output in a sustainable context. This model is a new one and not an update of an existing one. The model is impactful through the many statistical variables analyzed and the solutions offered to potential national and supranational decision-makers. The econometric models confirm that socio-economic factors significantly influence water resource sustainability, with a high degree of explanatory power across the analyzed years (2010–2022). However, in specific years such as 2013 and 2016, macroeconomic instability, policy transitions, and evolving governance mechanisms appear to have temporarily weakened the statistical association between the selected predictors and the dependent variable. These fluctuations should not be interpreted as a failure of the model but rather as evidence of how economic and policy environments influence the stability of sustainability trends. The results reinforce the importance of stable funding mechanisms, strong policy enforcement, and the integration of digital governance tools in ensuring the long-term effectiveness of socio-economic determinants in water resource management.

The research validated the eight working hypotheses, showing explicitly that, with sustained efforts toward environmental protection, fluctuating results of the European social economy tend to overshadow the environmental objectives, even at the risk of exceeding the budgetary allocations in the field.

The findings of this study underscore the dual nature of the social economy's impact on water sustainability. While it offers opportunities for sustainable growth, its expansion must be accompanied by targeted policy interventions to ensure environmental protection. Based on the results of the analysis, proposals for public policies have been formulated in the field with a significant impact on the sustainable development of the social economy. By integrating digital governance, sector-specific environmental regulations, and economic incentives for sustainability, policymakers can enhance the positive contributions of the social economy while mitigating its ecological footprint.

The limitations of this scientific approach lie in the relatively short time period considered, and the authors propose extending the analysis in future research.

Author Contributions: Conceptualization, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Methodology, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Software, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Validation, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Formal Analysis, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Investigation, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Resources, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Data Curation, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Writing—Original Draft Preparation, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Writing—Review and Editing, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I.; Visualization, L.P.G., R.-V.I., V.-M.A., M.L.Z. and C.I. All authors have read and agreed to the published version of the manuscript.

Funding: The present research was carried out within the project An Integrated System for the Complex Environmental Research and Monitoring in the Danube River Area, REXDAN, SMIS code 127065, project co-funded by the European Regional Development Fund through the Competitiveness Operational Programme 2014–2020, contract no. 309/10.07.2020 and contract no. 5206/2022—The impact of heavy metals and microplastics from aquatic organisms on human health, project funded by Fondo Proserpina S.R.L. This work was supported by a grant from the Ministry of Research, Innovation and Digitization, CNCS/CCCDI—UEFISCDI, project number PN-IV-P8-8.1-PRE-HE-ORG-2024-0212, within PNCDI IV.

Data Availability Statement: The data that support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. European Commission. Employment, Social Affairs & Inclusion. 2021. Available online: https://ec.europa.eu/social/main.jsp?langId=en&catId=89&newsId=10117&furtherNews=yes#navItem-1 (accessed on 15 November 2024).
2. Li, W.; Yi, P.; Zhang, D.; Zhou, Y. Assessment of coordinated development between social economy and ecological environment: Case study of resource-based cities in Northeastern China. *Sustain. Cities Soc.* **2020**, *59*, 102208. [CrossRef]
3. Zhang, H.; Jin, G.; Zhang, Z. Coupling system of carbon emission and social economy: A review. *Technol. Forecast. Soc. Change* **2021**, *167*, 120730. [CrossRef]
4. United Nations. Sustainable Development Goals. 2015. Available online: https://sdgs.un.org/goals (accessed on 15 November 2024).
5. García-Lorenzo, I.; Varela-Lafuente, M.; Garza-Gil, M.D.; Sumaila, U.R. Social and solidarity economy in small-scale fisheries: An international analysis. *Ocean Coast. Manag.* **2024**, *253*, 107166. [CrossRef]

6. López-Ercilla, I.; Rocha-Tejeda, L.; Fulton, S.; Espinosa-Romero, M.J.; Torre, J.; Fernández Rivera-Melo, F.J. Who pays for sustainability in the small-scale fisheries in the global south? *Ecol. Econ.* **2024**, *226*, 108350. [CrossRef]
7. Wan, J.; Li, Y.; Ma, C.; Jiang, T.; Su, Y.; Zhang, L.; Song, X.; Sun, H.; Wang, Z.; Zhao, Y.; et al. Measurement of Coupling Coordination Degree and Spatio-Temporal Characteristics of the Social Economy and Ecological Environment in the Chengdu–Chongqing Urban Agglomeration under High-Quality Development. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1629. [CrossRef] [PubMed]
8. Fan, Y.; Fang, C.; Zhang, Q. Coupling coordinated development between social economy and ecological environment in Chinese provincial capital cities-assessment and policy implications. *J. Clean. Prod.* **2019**, *229*, 289–298. [CrossRef]
9. Núñez, R.B.; Bandeira, P.; Santero-Sánchez, R. Social Economy, Gender Equality at Work and the 2030 Agenda: Theory and Evidence from Spain. *Sustainability* **2020**, *12*, 5129. [CrossRef]
10. Avagianou, A.; Gourzis, K.; Pissourios, I.; Iosifides, T.; Gialis, S. Quite promising yet marginal? A comparative study of social economy in the EU South. *Comp. Eur. Polit.* **2022**, *20*, 484–509. [CrossRef]
11. Macías Ruano, A.J.; Milán-García, J.; Marruecos Rumí, M.E.; De Pablo Valenciano, J. Scientific Production on the Social Economy: A Review of Worldwide Research. *Volunt. Int. J. Volunt. Nonprofit Organ.* **2021**, *32*, 925–943. [CrossRef]
12. Chaves-Avila, R.; Gallego-Bono, J.R. Transformative Policies for the Social and Solidarity Economy: The New Generation of Public Policies Fostering the Social Economy in Order to Achieve Sustainable Development Goals. The European and Spanish Cases. *Sustainability* **2020**, *12*, 4059. [CrossRef]
13. Islam, S.M.; Habib, A. How impact investing firms are responding to sustain and grow social economy enterprises in light of the COVID-19 pandemic. *J. Bus. Ventur. Insights* **2022**, *18*, e00347. [CrossRef]
14. Singh, S.; Upadhyay, S.P.; Powar, S. Developing an integrated social, economic, environmental, and technical analysis model for sustainable development using hybrid multi-criteria decision making methods. *Appl. Energy* **2022**, *308*, 118235. [CrossRef]
15. Yang, X.; Geng, L. An Integrated Analysis of Social, Economic, and Environmental Indicators' Effects on Public Health and Health Inequality Globally: From the Perspective of Vulnerability. *Soc. Indic. Res.* **2022**, *162*, 1261–1279. [CrossRef]
16. Postolache, P.A.; Nechifor, A.; Buculei, I.; Soare, I.; Mocanu, H.; Petrariu, F.D. Clinical Features and Paraclinical Findings in Patients with SARS CoV-2 Pneumonia and the Impact of Pulmonary Rehabilitation on the Instrumental Activities of Daily Living in POST-COVID-19 Patients. *J. Pers. Med.* **2023**, *13*, 182. [CrossRef]
17. Vasile, C.I.; Vasile, M.C.; Zlati, M.L.; Herbei, E.E.; Lepădatu, L.; Munteanu, C.; Nechifor, A.; Tatu, A.L. Post COVID-19 Infection Psychosis: Could SARS-CoV-2 Virus Infection Be a Neuropsychiatric Condition That Triggers Psychotic Disorders?—A Case-Based Short Review. *Infect. Drug Resist.* **2022**, *15*, 4697–4705. [CrossRef]
18. Lobato-Calleros, O.; Fabila-Rodríguez, K.; Roberts, B. Methodology to Improve the Acceptance and Adoption of Circular and Social Economy: A Longitudinal Case Study of a Biodiesel Cooperative. *Sustainability* **2022**, *14*, 12394. [CrossRef]
19. OECD; European Commission. *Policy Brief on Making the Most of the Social Economy's Contribution to the Circular Economy*; OECD Publishing: Paris, France, 2022. [CrossRef]
20. Bîrgovan, A.L.; Vatca, S.D.; Bacali, L.; Szilagyi, A.; Lakatos, E.S.; Cioca, L.I.; Ciobanu, G. Enabling the Circular Economy Transition in Organizations: A Moderated Mediation Model. *Int. J. Environ. Res. Public Health* **2022**, *19*, 677. [CrossRef]
21. Stukalo, N.; Simakhova, A. Global Trends in the Social Economy Development. *Int. Econ. Policy* **2021**, *34*, 7–22. [CrossRef]
22. Liu, Y.; Yang, L.; Jiang, W. Coupling coordination and spatiotemporal dynamic evolution between social economy and water environmental quality—A case study from Nansi Lake catchment, China. *Ecol. Indic.* **2020**, *119*, 106870. [CrossRef]
23. Pintilie, V.; Ene, A.; Georgescu, L.P.; Moraru, L.; Iticescu, C. Measurements of gross alpha and beta activity in drinking water from Galati region, Romania. *Rom. Reports Phys.* **2016**, *68*, 1208–1220.
24. Calmuc, M.; Calmuc, V.; Arseni, M.; Topa, C.; Timofti, M.; Georgescu, L.P.; Iticescu, C. A Comparative Approach to a Series of Physico-Chemical Quality Indices Used in Assessing Water Quality in the Lower Danube. *Water* **2020**, *12*, 3239. [CrossRef]
25. Popa, P.; Murariu, G.; Timofti, M.; Georgescu, L.P. Multivariate statistical analyses of Danube river water quality at Galati, Romania. *Environ. Eng. Manag. J.* **2018**, *17*, 1249–1266. [CrossRef]
26. Cui, D.; Chen, X.; Xue, Y.; Li, R.; Zeng, W. An integrated approach to investigate the relationship of coupling coordination between social economy and water environment on urban scale—A case study of Kunming. *J. Environ. Manag.* **2019**, *234*, 189–199. [CrossRef] [PubMed]
27. Luo, Z.; Zuo, Q. Evaluating the coordinated development of social economy, water, and ecology in a heavily disturbed basin based on the distributed hydrology model and the harmony theory. *J. Hydrol.* **2019**, *574*, 226–241. [CrossRef]
28. Wang, X.; Dong, Z.; Xu, W.; Luo, Y.; Zhou, T.; Wang, W. Study on Spatial and Temporal Distribution Characteristics of Coordinated Development Degree among Regional Water Resources, Social Economy, and Ecological Environment Systems. *Int. J. Environ. Res. Public Health* **2019**, *16*, 4213. [CrossRef]
29. Rincon-Roldan, F.; Lopez-Cabrales, A. Ethical values in social economy for sustainable development. *Ann. Public Coop. Econ.* **2021**, *92*, 705–729. [CrossRef]
30. Terzo, G. Social capital, social economy and economic resilience of Italian provinces. *Pap. Reg. Sci.* **2021**, *100*, 1113–1135. [CrossRef]

31. Wulandhari, N.B.I.; Gölgeci, I.; Mishra, N.; Sivarajah, U.; Gupta, S. Exploring the role of social capital mechanisms in cooperative resilience. *J. Bus. Res.* **2022**, *143*, 375–386. [CrossRef]
32. Lacan, A. Value-Based Governance as a Performance Element in Social and Solidarity Economy Organizations: A French Sustainable Post-Modern Proposal. *Sustainability* **2022**, *14*, 2153. [CrossRef]
33. Zhao, L.; Gu, J.; Abbas, J.; Kirikkaleli, D.; Yue, X.G. Does quality management system help organizations in achieving environmental innovation and sustainability goals? A structural analysis. *Econ. Res. Istraz.* **2022**, *36*, 2484–2507. [CrossRef]
34. Geradts, T.H.J.; Alt, E. Social entrepreneurial action in established organizations: Developing the concept of social intrapreneurship. *J. Bus. Res.* **2022**, *151*, 197–206. [CrossRef]
35. Ho, J.Y.; Yoon, S. Ambiguous roles of intermediaries in social entrepreneurship: The case of social innovation system in South Korea. *Technol. Forecast. Soc. Change* **2022**, *175*, 121324. [CrossRef]
36. Ku, H.B.; Kan, K. Social work and sustainable rural development: The practice of social economy in China. *Int. J. Soc. Welf.* **2020**, *29*, 346–355. [CrossRef]
37. Bassi, A.; Fabbri, A. Under pressure: Evolution of the social economy institutional recognition in the EU. *Ann. Public Coop. Econ.* **2020**, *91*, 411–433. [CrossRef]
38. Kim, D.; Cho, W.; Allen, B. Sustainability of social economy organizations (SEOs): An analysis of the conditions for surviving and thriving. *Soc. Sci. J.* **2020**, *61*, 93–109. [CrossRef]
39. Weerawardena, J.; Salunke, S.; Haigh, N.; Sullivan Mort, G. Business model innovation in social purpose organizations: Conceptualizing dual social-economic value creation. *J. Bus. Res.* **2021**, *125*, 762–771. [CrossRef]
40. Bretos, I.; Bouchard, M.J.; Zevi, A. Institutional and organizational trajectories in social economy enterprises: Resilience, transformation and regeneration. *Ann. Public Coop. Econ.* **2020**, *91*, 351–358. [CrossRef]
41. Lapoutte, A. The problem is the solution: Can permaculture management regenerate social economy enterprises? *Ann. Public Coop. Econ.* **2020**, *91*, 479–492. [CrossRef]
42. Alam, J.; Boamah, M.I.; Moir, R. An examination of the social economy: Some new theoretical insights. *Int. J. Soc. Econ.* **2018**, *45*, 940–956. [CrossRef]
43. Chetty, R.; Jackson, M.O.; Kuchler, T.; Stroebel, J.; Hendren, N.; Fluegge, R.B.; Gong, S.; Gonzalez, F.; Grondin, A.; Jacob, M.; et al. Social capital I: Measurement and associations with economic mobility. *Nature* **2022**, *608*, 108–121. [CrossRef]
44. Chetty, R.; Jackson, M.O.; Kuchler, T.; Stroebel, J.; Hendren, N.; Fluegge, R.B.; Gong, S.; Gonzalez, F.; Grondin, A.; Jacob, M.; et al. Social capital II: Determinants of economic connectedness. *Nature* **2022**, *608*, 122–134. [CrossRef] [PubMed]
45. Afzali, M.; Silvola, H.; Terjesen, S. Social capital and board gender diversity. *Corp. Gov. An Int. Rev.* **2022**, *30*, 461–481. [CrossRef]
46. Alfano, V. Does social capital enforce social distancing? The role of bridging and bonding social capital in the evolution of the pandemic. *Econ. Polit.* **2022**, *39*, 839–859. [CrossRef]
47. Nguyen, M.H.; Hunsaker, A.; Hargittai, E. Older adults' online social engagement and social capital: The moderating role of Internet skills. *Inf. Commun. Soc.* **2022**, *25*, 942–958. [CrossRef]
48. Dell, S.; Subedi, M.; Hsu, M.K.; Farazmand, A. Social Capital and Financial Performance in Nonprofits. *Public Organ. Rev.* **2022**, *22*, 193–210. [CrossRef]
49. Fraser, T.; Naquin, N. Better together? The role of social capital in urban social vulnerability. *Habitat Int.* **2022**, *124*, 102561. [CrossRef]
50. Beausaert, S.; Froehlich, D.E.; Riley, P.; Gallant, A. What about school principals' well-being? The role of social capital. *Educ. Manag. Adm. Leadersh.* **2021**, *51*, 405–421. [CrossRef]
51. Andersen, A.; Garel, A.; Gilbert, A.; Tourani-Rad, A. Social capital, human capital, and board appointments. *Glob. Financ. J.* **2022**, *54*, 100758. [CrossRef]
52. Oudeniotis, N.; Tsobanoglou, G.O. Interorganizational Cooperation and Social Capital Formation among Social Enterprises and Social Economy Organizations: A Case Study from the Region of Attica, Greece. *Soc. Sci.* **2022**, *11*, 104. [CrossRef]
53. Schneiberg, M.; Parmentier, E. Banking structure, economic resilience and unemployment trajectories in US counties during the great recession. *Socio-Econ. Rev.* **2022**, *20*, 85–139. [CrossRef]
54. Eurostat. Life Expectancy by Age and Sex. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/view/DEMO_MLEXPEC__custom_5211687/default/table (accessed on 16 November 2024).
55. Eurostat. Population by Educational Attainment Level, Sex and Age (%). 2023. Available online: https://ec.europa.eu/eurostat/databrowser/view/edat_lfs_9903/default/bar (accessed on 16 November 2024).
56. Eurostat. E-Government Activities of Individuals via Websites. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/view/ISOC_CIEGI_AC__custom_5212088/default/table (accessed on 16 November 2024).
57. Eurostat. Employment and Activity by Sex and Age—Annual Data. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/view/LFSI_EMP_A__custom_5211439/default/table (accessed on 16 November 2024).
58. Eurostat. Gross Value Added and Income by A*10 Industry Breakdowns. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/view/NAMA_10_A10__custom_5211246/default/table (accessed on 16 November 2024).

59. Eurostat. Purchasing Power Parities (PPPs), Price Level Indices and Real Expenditures for ESA 2010 Aggregates. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/product/page/PRC_PPP_IND$DEFAULTVIEW (accessed on 16 November 2024).
60. Eurostat. Population Connected to at Least Secondary Waste Water Treatment. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/view/sdg_06_20/default/table?lang=en (accessed on 16 November 2024).
61. Eurostat. Population Connected to Urban Wastewater Collecting and Treatment Systems, by Treatment Level. 2023. Available online: https://ec.europa.eu/eurostat/databrowser/product/page/ten00020 (accessed on 16 November 2024).
62. Eurostat. Sewage Sludge Production and Disposal from Urban Wastewater (in Dry Substance (d.s)). 2023. Available online: https://data.europa.eu/data/datasets/hzwkcfkt5mxeafijeoa?locale=en (accessed on 16 November 2024).