

GREEN TRANSFORMATION: TRENDS AND PROSPECTS OF GREEN JOBS IN ROMANIA

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ABSTRACT. Green Transformation: Trends and Prospects of Green Jobs in Romania. This study investigates the trends and potential of green jobs in Romania, particularly focusing on sectors crucial to the green economy, such as agriculture, energy, and waste management. The emergence of green jobs signifies a shift towards ecological sustainability and economic resilience, highlighted by the growth in sectors A (Agriculture, Forestry, and Fishing), D (Electricity, Gas, Steam, and Air Conditioning Supply), and E (Water Supply; Sewerage, Waste Management, and Remediation Activities) from NACE rev.2 codes. The analysis reveals an evolving labor market, with an increase in sustainable agricultural practices and a shift towards more sustainable energy production methods. Furthermore, significant increases in average annual net wages across these sectors from 2018 to 2023 suggest an appreciation of labor value in green jobs, potentially reflecting heightened demand, technological advancements, and a shift towards more specialized skill sets. This study contributes to the academic discourse on green jobs, offering valuable insights for policymakers, industry stakeholders, and the labor market in fostering a sustainable and resilient economy. Future research should address methodological limitations, explore the impact of policy interventions, and examine the role of technological advancements in developing green jobs in Romania.

Keywords: green jobs; sustainable development; GIS; agriculture; energy; waste management; labor market dynamics; Romania.

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1. Introduction

In an era where human impact on the environment is becoming increasingly significant, the discussion surrounding green jobs as a crucial component of ecological sustainability is gaining prominence within environmental policy (Ilovan et al., 2018) and economic strategic planning. This conversation, underpinned by the works of Söderholm (2020), Jacobs (2012) or Adams (2008), not only accentuates the imperative shift towards a more sustainable, less fossil fuel-reliant economy but also brings to light the innovative strategies for biodiversity conservation and the sustainable management of natural resources, as evidenced by previous research (Egoh et al., 2021; Hahn et al., 2022; Maxwell et al., 2020).

Amidst the pressing challenges of climate change (Nistor et al., 2018; 2019) and the global push for sustainable development, green jobs are increasingly recognized as both a viable and necessary solution. Defined by the United Nations Environment Programme (UNEP) and the International Labour Organization (ILO), green jobs are those that contribute to the conservation or restoration of the environment, help reduce greenhouse gas emissions, decrease energy and raw material consumption, and support the preservation of biodiversity and ecosystems (UNEP, 2008; ILO, 2013). This nexus between economic growth and environmental stewardship underscores the essential role of green jobs in fostering a fair and sustainable transition towards more resilient economies (Schor, 2010).

The concept of green jobs has growing attention over the past two decades, spotlighting earlier initiatives such as The Green Job Initiative – a collaborative effort by UNEP, the International Trade Union Confederation (ITUC), the International Organization of Employers (IOE), and ILO. This initiative aims to unlock developmental potential, promote equality, and ensure a transition to sustainable economic models (UNEP, 2008). Green jobs are broadly defined as positions that are either dependent on the environment or are created, substituted, or redefined in the process of shifting towards a greener economy (Pociovălișteanu et al., 2015). According to Dell’Anna (2021), these include dignified roles that facilitate environmental conservation or rehabilitation, spanning traditional sectors like manufacturing and construction to emerging areas such as renewable energy and energy efficiency.

The green job sector offers a framework for examining the relationship between sustainability transition and labor market dynamics (Mathieu, 2024), suggesting that anyone from solar engineers to architects and even waste pickers can find a niche within this segment (World Bank podcast, 2024). The European Commission further delineates green jobs as those directly involved with using information, technologies, or materials to enhance environmental

quality, necessitating advanced skills, comprehensive knowledge, and specialized training (Flash Eurobarometer 456, 2024). Despite varied economist perspectives on what constitutes a green job, Colijn (2024) presents a nuanced view, suggesting that green jobs support the transition towards a socio-ecological framework by promoting renewable energy use and reducing non-renewable energy consumption.

The academic discourse reveals no singularly accepted definition of green jobs, with the concept continually evolving (Bowen et al., 2018; Rodríguez, 2019). Research methods in this field range from qualitative to quantitative, with the latter often focusing on econometric models that measure the prevalence of ecological jobs within national economies (Sulich et al. 2018). Green jobs are closely linked with sustainable development, ecological and circular economies, and the welfare economy, signaling a broad connection with sustainable growth and employability (Battaglia et al., 2018; Darmandieu et al., 2022; García-García et al., 2022). Our research delves into the emerging landscape (Maroși et al., 2019) and potential of green jobs within the Romanian economy, aiming to categorize NACE codes directly related to green occupations and to analyze, from a Geographic Information System (GIS) perspective, wage earnings and employee engagement in sectors A (Agriculture, Forestry, and Fishing), D (Electricity, Gas, Steam, and Air Conditioning Supply), and E (Water Supply; Sewerage, Waste Management, and Remediation Activities) as per the CAEN rev. 2 classification. This in-depth approach offers comprehensive insights into the economic and distributional effects of green jobs across key sectors, outlining both overarching and sector-specific research objectives pertinent to advancing Romania's green employment and sustainable development agendas.

A transdisciplinary approach is deemed essential in addressing the complexity and interconnectedness of environmental, economic, and social issues. It entails collaboration across various academic fields and practices, from natural sciences to social sciences, economics, and engineering, to develop innovative and comprehensive solutions to global challenges (Nicolescu, 1999; Brandt et al., 2013). Such an approach enhances the proposed solutions' effectiveness and ensures the integration of multiple perspectives and stakeholder interests in formulating and implementing sustainable development policies (Klein et al., 2001). However, the narrative of the transdisciplinary approach to green jobs for sustainable development and economic growth encapsulates a broad array of scholarly insights, illustrating the critical need for a holistic and transdisciplinary methodology in understanding the nexus between sustainable development, green job creation, and spatial dynamics. Through the lens of GIS technology application (Adorean et al., 2020; Avădănei et al., 2018; Nicula et al., 2018; Nistor et al., 2019; 2020; Nistor and Nicula, 2021), we gain invaluable

perspectives on the power of spatial analysis in environmental and socio-economic planning, underscoring its pivotal role in crafting strategies for green employment. Complementing this spatial emphasis, the research shifts the focus towards environmental energy challenges, presenting innovative methodologies for leveraging emissions in energy production (Cociș et al., 2012; Soporan et al., 2012; Soporan et al., 2013 a, b). This body of work emphasizes the adaptability required to harness environmental changes for sustainable growth, highlighting a critical area for green job expansion. The study aims to generate innovative and applicable solutions for promoting green jobs within the Romanian context through cross-sectoral and interdisciplinary collaboration.

2. Materials and Methods

The study adopts a transdisciplinary approach, integrating knowledge from various fields - economics, ecology, information technology, and social sciences - to address the complexity of green jobs and their impact on sustainable development. This methodology allows for a holistic understanding of market dynamics and the ecological and social impacts of green jobs, reflecting the interconnectedness between economic, social, and natural systems (Lawrence, 2004).

Research methodologies on green jobs vary, employing both qualitative and quantitative approaches (Nicula et al., 2017; Bîrsănuț et al., 2020) to explore the role and impact of these positions within the economy and society (Sulich et al., 2018). The discourse connects green jobs with sustainable development, circular economy, and other key themes in sustainability (Battaglia et al., 2018; Darmandieu et al., 2022; García-García et al., 2022).

Our research utilizes a comprehensive methodological approach, analyzing structural data on the number of employees and the average annual net wage by activities of the national economy according to NACE Rev.2. This data, derived from the National Institute of Statistics of Romania's Tempo database, underwent both graphical representation and relational analysis. The spatial distribution of employees was scrutinized using Geographic Information System (GIS) technology, focusing on NACE codes A (Agriculture, Forestry and Fishing), D (Electricity, Gas, Steam and Air Conditioning Supply), and E (Water Supply; Sewerage, Waste Management and Remediation Activities). However, this study encounters several methodological limitations. Firstly, the Tempo database (Romanian National Institute of Statistics, 2024) does not account for NACE code T (Activities of private households as employers of domestic personnel; activities of private households producing goods and services for own use),

which pertains to household activities as employers of domestic personnel and for own use. Including this category could potentially broaden the understanding and categorization of green jobs, thereby highlighting an area for future data enhancement and research. Secondly, the research is constrained by outdated data regarding the Employed Population in the Environmental Goods and Services Sector, with the latest available data being from 2018. This poses a significant challenge for our analysis, which aims to cover developments in the green job sector between 2018 and 2022. The absence of up-to-date data limits the ability to fully capture and analyze the most recent trends and transformations within Romania's green employment realm.

The methodological approach targets the literature gap regarding the direct involvement of specific NACE codes in green jobs, a segment not explicitly defined by Eurostat, the ILO, or the UNEP. Moreover, our approach includes a computational bibliometric analysis utilizing VOSviewer to identify citation clusters and the prevalence of green job-related concepts within the Web of Science database.

Within the complex network presented by the VOSviewer bibliometric analysis, the central concept of "green jobs" anchors a rich tapestry of research topics, illustrating the field's expansive reach from macroeconomic effects to detailed analyses of educational and sector-specific skill requirements. The myriad connections depicted through linkages in the map articulate the multifaceted and interdisciplinary dialogue within green jobs research, underscoring the interplay between policy formulation, industry practices, and labor market dynamics in the context of sustainable economies. Each strand in this network denotes a strand of scholarship, evolving and expanding over the six-year span (2016-2022), highlighting key thematic concentrations and the progressive integration of emerging issues such as "algorithm" and "energy consumption". This visual representation not only underscores the foundational themes underpinning the sector but also traces the trajectory of academic inquiry, marking a clear direction towards new research frontiers and evolving priorities within the sustainable development paradigm. The figure intricately maps the scholarly terrain surrounding "green jobs", revealing a constellation of related terms—such as "economy", "climate change", "energy", and "education" which collectively narrate an ongoing discourse that intertwines environmental sustainability with economic growth, workforce development, and the transition to renewable energies.

The specialized literature was computationally analyzed using VOSviewer software, with 171 processed scientific documents on the concept of "green job*" on the Web of Science Clarivate. The main reason for resorting to computer-assisted literature review lies in the multiple advantages it encompasses:

(i) storing, manipulating, managing, and analyzing a substantial volume of bibliometric data and information; (ii) objective analysis of citation and co-citation clusters on related topics (for example: citation clusters sustainable development – education – health – renewable energy – waste management (Fig. 1); (iii) centralization and diachronic analysis of bibliographic references; (iv) graphical visualization of citation/co-citation clusters.

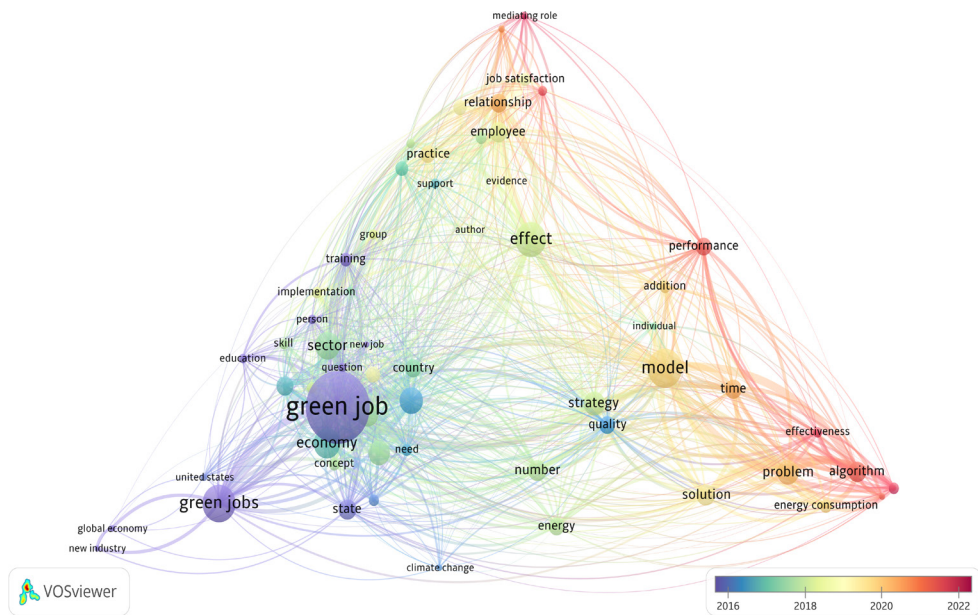


Fig. 1. Bibliometric Network Analysis of Green Jobs Research (2016-2024)
Data: Web of Science; Software: VOSviewer

3. Results

In the context of the study, the previously presented analysis can be reinterpreted through the lens of ecological transformation and the emergence of green jobs in Romania. By extrapolating and adapting the data to this context, we investigate how different regions (Fig. 2a) adapt and contribute to the green economy, highlighting the disparities and opportunities in creating sustainable jobs.

The centrality of Bucharest in the green transition is notable, having the highest absolute values indicated in the original data for categories E and D, with percentages of 21.40% and 10.96%, respectively. This suggests a significant concentration of sustainability initiatives and investments in the capital, potentially due to superior access to resources, infrastructure, and knowledge. Bucharest emerges as an epicenter of green innovation, potentially shaping national trends. The strategic importance of Constanța and Gorj is underscored by their percentages in categories E and D (Constanța: 5.92%, Gorj: 4.82% for E and Constanța: 6.71%, Gorj: 6.65% for D). These regions reflect key sectors in the green transition, including developing renewable energy and conservation initiatives. Their presence indicates the geographical diversification of commitment to sustainability and the need to leverage local resources efficiently. Highlighting Timiș, Ialomița, and Călărași in category A, with percentages of 4.70%, 4.17%, and 3.75%, respectively, signals emerging regions in the green economy. These could represent areas with innovative initiatives in organic agriculture, water resource management, and reforestation projects, contributing to the diversification and resilience of the green job ecosystem in Romania.

Evaluating the data on employees in national economic activities, we notice a nuanced trend across categories A, D, and E. From 2018 to 2022, category A shows an overall growth of approximately 2.64%, indicating a steady rise in employment within the primary sector. This could suggest bolstering the country's agriculture or related primary industries, possibly due to increased investment, policy support, or technological advancements in these fields. In contrast, Category D reveals a decline in the workforce of about 3.17% over the five-year period. The downtrend might reflect a shift in energy production methods, increased efficiency, or a transition to more sustainable energy sources requiring less human labor. Category E remains relatively stable, with a marginal increase of around 1.05% (Fig. 2a). The steadiness in this sector could be due to consistent demand for water and waste management services, which are essential and less susceptible to economic fluctuations. These trends are indicative of a broader economic transition. The slight but steady growth in Category A employment might emphasize developing sustainable agricultural practices or enhancing self-sufficiency in primary commodities. The reduction in Category D could signal a restructuring of the energy sector, aligning with global trends towards sustainable energy production. The stability in Category E suggests an ongoing need for employees to manage critical infrastructure services, which are crucial for environmental health and other economic sectors' functioning (Fig. 2).

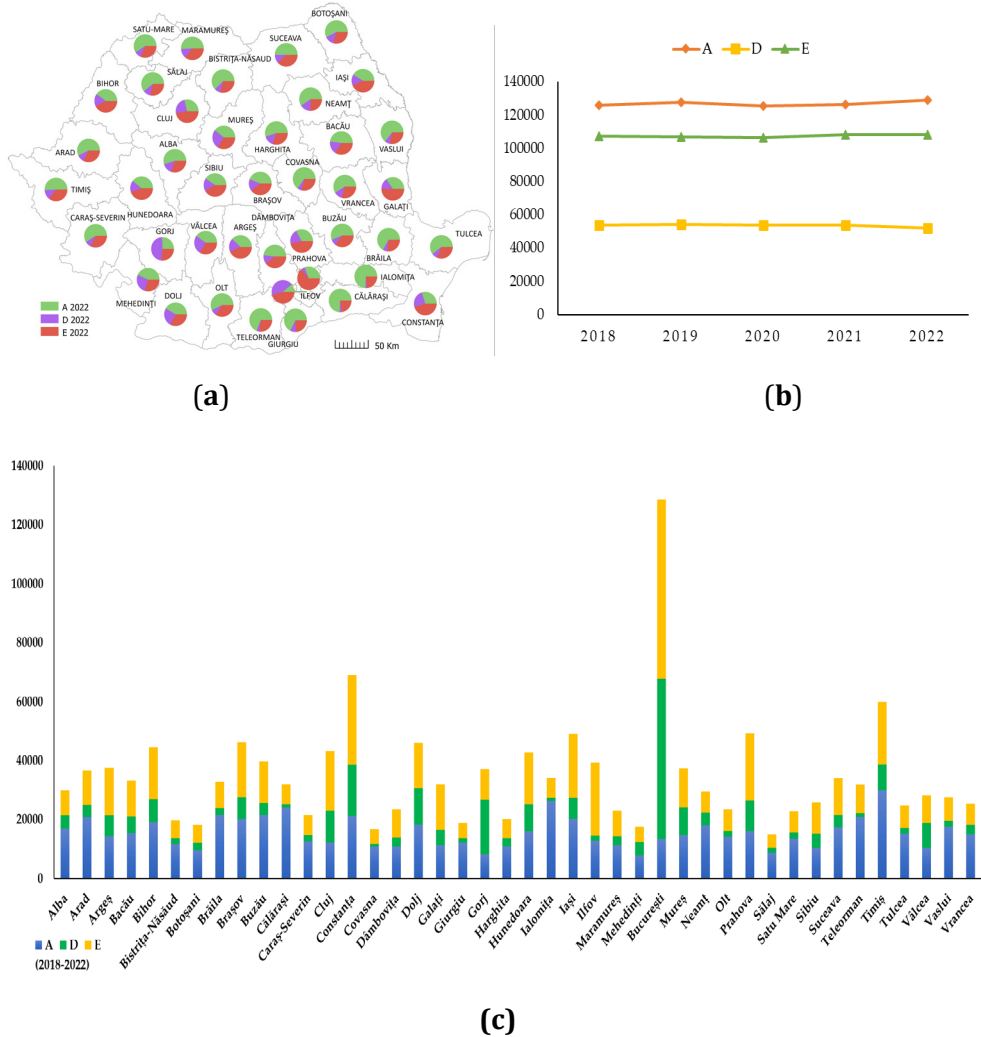


Fig. 2. The geographical distribution of green job employment by county at the end of the year 2022 **(a)**; The trend in employee numbers within national economic activities from 2018 to 2022 **(b)**; The number of employees at the end of the year 2022, by activities of the national economy (sections and divisions) NACE Rev.2, by counties **(c)**. Legend: A = Agriculture, Forestry, and Fishing; D = Production and Supply of Electricity and Thermal Energy, Gas, Hot Water, and Air Conditioning; E = Water Distribution, Sanitation, Waste Management, And Remediation Activities.

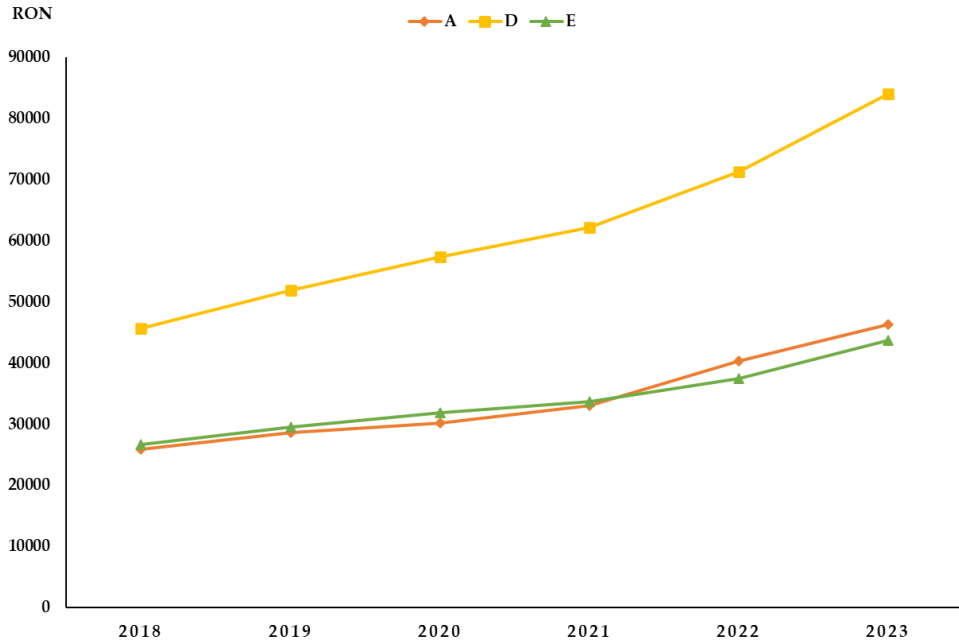


Fig. 3. The average annual net wage (RON) by activities (A, D, and E) of the national economy NACE Rev.2.

The average annual net wage trends analysis reveals significant increases from 2018 to 2023. Sector A observed a 78.37% increment in average annual net wages, ascending from 25,949 RON to 46,286 RON. This notable surge potentially reflects enhanced valuation of agricultural work, perhaps due to increased agricultural outputs or improved market conditions for agricultural products. In Sector D, wages experienced an 83.80% escalation, indicating the sector's dynamic wage growth from 45,716 RON to 84,027 RON. This substantial growth could be attributed to heightened energy demands, technological evolution within the sector, and a possible elevation in skill requisites and specialization for energy sector employees. Lastly, Sector E witnessed a 63.75% rise in wages, climbing from 26,687 RON to 43,699 RON (Fig. 3). Though less steep than the other sectors, this increase still represents significant growth, suggesting expanding requirements for environmental management services and possibly an augmentation in the sector's investment in human capital.

These sector-specific wage inflations underscore the economic vitality and appreciation of labor value within these fundamental sectors. They may indicate broader economic inflationary trends and sectoral shifts in the labour market, reflecting Romania's evolving economic landscape.

4. Discussion

The emergence of green jobs in Romania represents a pivotal shift towards ecological sustainability and economic resilience. This study's findings illustrate a significant trend toward the greening of the Romanian economy, particularly in sectors A (Agriculture, Forestry, and Fishing), D (Electricity, Gas, Steam, and Air Conditioning Supply), and E (Water Supply; Sewerage, Waste Management, and Remediation Activities), which align with global movements towards environmental conservation and reduced carbon footprints. The strategic importance of Bucharest, Constanța, and Gorj in leading these transitions highlights regional strengths and potential for future development.

The data analyzed from 2018 to 2022 reveals an evolving labor market, with the primary sector showing growth, indicating an increase in sustainable agricultural practices or technological advancements. Conversely, the decline in sector D's workforce could suggest a shift towards more sustainable energy production methods, aligning with global sustainability goals. The stability in sector E emphasizes the ongoing need for essential water and waste management services, underscoring their critical role in ecological conservation.

The substantial increases in average annual net wages across sectors A, D, and E from 2018 to 2023 suggest an appreciation of labor value in these green jobs, potentially reflecting heightened demand, technological advancements, and a shift towards more specialized skill sets within these sectors. These trends demonstrate the economic vitality of green jobs and highlight broader economic and labor market shifts toward sustainability in Romania.

The discourse on green jobs represents a complex interplay between sustainability's ethical, environmental, and economic dimensions. On one hand, green jobs are lauded for their contribution to environmental conservation, promotion of energy efficiency, and the creation of equitable economic opportunities, underlining a societal shift towards sustainability and respect for natural resources. These roles are crucial in driving innovation, improving job quality, and fostering economic growth within sustainable development. On the other hand, the transition faces criticism concerning the economic viability, technological feasibility, and potential socio-economic disruptions, including job displacement, skill mismatches, and the environmental footprint of green technologies themselves.

Critiques extend to the uneven geographic distribution of green jobs, which might exacerbate regional inequalities and the risk of new power dynamics that could sideline disadvantaged communities. Concerns are also raised about the high initial investments required, the adequacy of current technologies to meet energy demands sustainably, and the comprehensive policy and training

strategies needed for a truly equitable transition. These challenges highlight the delicate balance between advancing green jobs and mitigating adverse effects on traditional sectors and vulnerable populations.

Navigating this transition demands a nuanced, holistic approach that integrates the positive aspirations of green job proponents with realistic assessments of potential hurdles. Effective policy-making and strategic planning must thus prioritize economic stability, technological advancement, and social fairness, ensuring that the move towards a green economy not only fosters environmental stewardship but also addresses the practical concerns of sustainability, equity, and inclusivity. This balanced perspective is essential for achieving a genuinely sustainable, equitable, and efficient green job market, paving the way for a future that harmonizes human economic activities with the planet's ecological limits.

Future research directions in the context of green jobs, especially within Romania or similar economies transitioning towards sustainability, can explore several key areas to build upon the current study's findings. These directions not only aim to address gaps identified but also to expand the understanding and impact of green jobs in fostering economic resilience and environmental sustainability:

- ❖ **Longitudinal Studies:** Future research could focus on longitudinal studies to track the evolution of green jobs over time, assessing the long-term impacts of economic policies, technological advancements, and global sustainability trends on the labor market;
- ❖ **Sector-specific Analysis:** There is a need for deeper sector-specific analyses that explore the dynamics of green jobs within particular industries, such as renewable energy, sustainable agriculture, or waste management. This can help identify specific challenges and opportunities within each sector and guide targeted interventions;
- ❖ **Skill Gaps and Education:** Investigating the skill requirements for green jobs and identifying potential skill gaps in the current workforce could be crucial. Research could also explore how educational programs and training initiatives are adapting to meet the demands of a greener economy;
- ❖ **Comparative International Studies:** Comparing the development of green jobs in Romania with other countries at similar stages of economic development or with leading countries in green employment can provide valuable insights into best practices and policy frameworks that support sustainable labor markets;
- ❖ **Impact of Policy Interventions:** Analyzing the effectiveness of existing policies and interventions promoting green jobs can help identify what works and what doesn't. This includes incentives for green businesses, subsidies for renewable energy projects, and regulations that drive demand for sustainable products and services;

- ❖ **Technology Adoption and Innovation:** Exploring the role of technological innovation in creating new green jobs and transforming existing ones could provide insights into future trends. This includes the impact of digitalization, artificial intelligence, and other emerging technologies (Nicula et al., 2022) on the green economy;
- ❖ **Social and Economic Impacts:** Further research is needed on the social and economic impacts of the transition to a green economy, including effects on employment levels, income inequality, and regional development. This can help ensure that the shift towards green jobs promotes social equity and inclusiveness;
- ❖ **Barriers to Green Job Creation:** Identifying and analyzing the barriers to creating green jobs, such as financial constraints, lack of infrastructure, or regulatory hurdles, can inform strategies to overcome these obstacles and accelerate the transition to a sustainable economy;
- ❖ **Environmental Impact Assessments:** Assessing the direct and indirect environmental impacts of green jobs, including reductions in carbon emissions and improvements in biodiversity, can provide a more comprehensive understanding of the benefits of transitioning to a green economy.

By addressing these future research directions, scholars and policymakers can further contribute to developing a robust, sustainable, and inclusive green job sector that supports economic growth and environmental preservation.

5. Conclusions

This study underscores the significant potential and evolving nature of green jobs in Romania, aligning with global sustainability and environmental conservation trends. The increased focus on sectors integral to the green economy, such as agriculture, energy, and waste management, reflects a crucial transition towards sustainable development and economic resilience. The findings suggest a dynamic shift in labor market dynamics, with increased investment in green jobs fostering economic growth, technological advancement, and labor market transformation.

Furthermore, the rise in average annual net wages across key green sectors highlights the growing recognition of the value of green jobs in the Romanian economy, suggesting a positive trajectory towards environmental sustainability and economic growth. This study contributes to the academic discourse on green jobs and provides valuable insights for policymakers, industry stakeholders, and the labor market in fostering a sustainable and resilient economy.

Future research should address the methodological limitations encountered in this study, particularly the need for updated and comprehensive data on the green job sector. Additionally, exploring the direct involvement of other NACE codes and sectors in the green economy and the impact of policy interventions and technological advancements on the growth and development of green jobs in Romania will be crucial in advancing the understanding and support for sustainable economic transformation.

These sections aim to encapsulate the study's findings within the broader context of sustainable development and economic transformation in Romania, offering a comprehensive overview of the current state and future prospects of green jobs in the region.

Reflecting on the comprehensive analysis presented in this paper, several key conclusions can be drawn that encapsulate the essence of the study and its implications for the future of the green economy in Romania.

- ❖ **Significant Potential for Green Jobs:** The study highlights the considerable potential and evolving nature of green jobs in Romania, which aligns with global sustainability and environmental conservation trends. It emphasizes the crucial transition towards sustainable development and economic resilience, with increased focus on sectors integral to the green economy, such as agriculture, energy, and waste management;
- ❖ **Dynamic Shift in Labor Market Dynamics:** There is a dynamic shift observed in labor market dynamics with increased investment in green jobs, fostering economic growth, technological advancement, and labor market transformation. This shift indicates a move towards more sustainable agricultural practices, energy production methods, and essential services in water and waste management;
- ❖ **Appreciation of Labor Value in Green Jobs:** The rise in average annual net wages across key green sectors (Agriculture, Forestry and Fishing; Electricity, Gas, Steam and Air Conditioning Supply; and Water Supply; Sewerage, Waste Management, and Remediation Activities) from 2018 to 2023 suggests a growing recognition of the value of green jobs in the Romanian economy. This trend reflects potentially heightened demand, technological advancements, and a shift towards more specialized skill sets within these sectors;
- ❖ **Strategic Importance of Specific Regions:** The study identifies the strategic importance of regions such as Bucharest, Constanța, and Gorj in leading the green transitions. These areas show a significant concentration of sustainability initiatives and investments, indicating regional strengths and potential for future development in the green job sector;

- ❖ **Need for Future Research and Policy Intervention:** The conclusions call for future research to address methodological limitations encountered in the study, particularly the need for updated and comprehensive data on the green job sector. Additionally, exploring the direct involvement of other sectors in the green economy and the impact of policy interventions and technological advancements on the growth and development of green jobs in Romania is deemed crucial for supporting sustainable economic transformation.

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