

Evaluation of UN SDGs Achievements Considering the Eco-Innovations Metrics. Case: European Union Countries

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Abstract— The current research paper explores the relationship between eco-innovation metrics and progress towards UN SDGs, contributing to the discussion on sustainable development. To achieve the research goals, the authors use easily interpretable and statistically significant methods to test the hypotheses, like Pearson correlation coefficients, multiple regression analysis. The methods are considered relevant to demonstrate statistical relationships between UN SDGs and the eco-innovation index, to discuss country performance typologies, and to formulate policy implications for future sustainable development. The results demonstrate that EU countries with higher UN SDG performance tend to have higher eco-innovation scores, moreover, eco-innovation capacities of EU nations are more aligned with the performance on environmental sustainability than on any other aspect of sustainable development. The authors conclude that eco-innovation dimensions operate at diverse levels of influence on the performance of UN SDG 12, while resource efficiency outcomes stand out, being the best predictor, so it should be strongly considered in policy recommendations and strategies.

Keywords— *UN SDGs, eco-innovation index, circular economy, planetary boundaries.*

I. INTRODUCTION

Connections between sustainable development and environmental innovation have become a gradually important field of research within modern sustainable

development studies. Moreover, the framework of the United Nations Sustainable Development Goals (UN SDGs) is often used as a pattern for sustainable development on the global level, meaningfully interconnects with the eco-innovation metrics and thus develops an interesting area for empirical studies and theoretical advancement in the fields of sustainability.

The relationship between eco-innovation metrics (based on the EU eco-innovation index) and progress towards UN SDGs forms both a complex and multi-dimensional field for research. The authors of the current paper are willing to demonstrate that when the EU eco-innovation index (alongside its composition elements) is viewed alongside UN SDG achievements, they establish a strong analytical framework for understanding how innovative technological solutions serve to achieve sustainable development results and thus this relation should be considered for further analysis.

The current research paper investigates the quantitative relationship of eco-innovation indices with the performance of the UN SDGs. The specific objectives of the research are finding correlation patterns of eco-innovation metrics with specific UN SDG targets and identifying the most important components of eco-innovation indices with strong association with sustainable development outcomes. As a result, this research contributes to the discussion on the field of sustainability and theoretical and practical policy progress

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as nations across the globe struggle to commit to their UN SDGs while simultaneously innovating new technologies to address environmental challenges.

II. MATERIALS AND METHODS

Eco-innovation is an indispensable tool for promoting economic growth and protecting the environment. It combines innovation and sustainable development and is essential for achieving sustainable development goals, addressing environmental challenges and promoting economic growth. Eco-innovation has been a key focus of the European Union (EU) policy agenda over the past decades. Eco-innovation is a proactive approach and delivers positive environmental outcomes. The performance of eco-innovation is a factor determining its effectiveness in achieving sustainable development goals. The study [1] examined the average value of eco-innovation performance in EU Member States using data from the Eco-innovation Scoreboard and provided a comparative analysis of eco-innovation performance in EU Member States in two different periods, 2013–2017 and 2018–2022. The study used indicators such as eco-innovation investments, eco-innovation activities, eco-innovation outcomes, resource efficiency outcomes and socio-economic outcomes. The results of the analysis indicate dynamic changes in eco-innovation performance in EU countries.

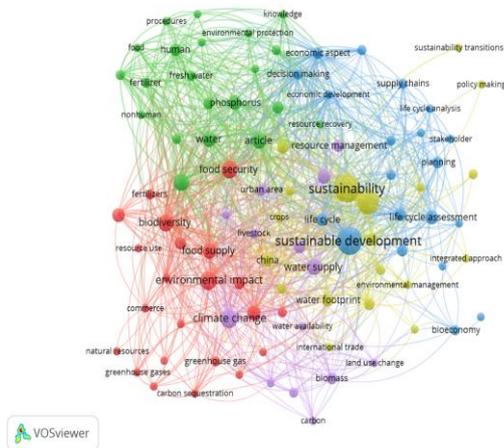


Fig. 1. VOSviewer tool

It is important to assess the differences between countries in terms of the degree to which they have achieved the SDGs related to the levels of innovation they have implemented. The study on innovation drivers and sustainable development [2] used two types of analysis. First, cluster analysis was used to examine changes in regional groups with similar innovation characteristics over the period 2015–2020. Data for 122 countries were collected from the World Bank, the SDG Index and the Global Innovation Index. Second, multiple linear regression analysis was used to assess the ability of the model variables to explain the level of sustainable development. The results reveal four clusters (low, medium, high and very high innovation drivers and

sustainable development) as well as movements between these clusters over the period 2015–2020.

The authors performed a literature analysis applying the VOSviewer tool to contribute to understanding the theoretical research topic. The analysis results are shown in the Fig. 1 below and discussed further on. Key-words: “regional development”, “Sustainable development goals”, “circular economy”, “indexes”, “resources scarcity”, “planetary boundaries” In the analyzed papers (developed by the authors via VosViewer based on 118 documents found - period 2014-2024 in Europe).

Based on the bibliometric analysis, one can determine several interrelated thematic domains within sustainability studies in European literature for the last ten years (from 2014 to 2024). The central node, positioned as “sustainability”, is one of the most important and serves as a conceptual bridge between various research areas, marking its fundamental in modern environmental discussions.

The climate change node shows strong links with environmental impact assessments and greenhouse gas emissions. This cluster stresses anthropogenic drivers responsible for climate change (including carbon sequestration and use of natural resources). The density of connections in this cluster signifies strong attention in research toward climate mitigation and strategies for adaptation. Such a strategy is the development of smart cities [3].

The resource management and water & food security cluster exhibits a strong interconnection with water management and agricultural systems. These two nodes' appearance and connection to sustainability transitions reflect an evolving research focus towards food systems and resource use. Further on, food security appears to be a crucial node in sustainable development discourses.

The life cycle assessment cluster stands for the methodological approaches to sustainability measurement. The connections of this cluster indicate the increasing importance of systematic evaluation methods in sustainability science. The position of the cluster relative to nodes with policy-making implications indicates that this cluster has a major role in informing evidence-based decisions. The policy making implications are in particular important as soon as they are based on empirical findings such as covering waste-to-energy approaches [4] or construction and demolition waste practices [5].

The economic development and sustainable development policy cluster deals with stakeholder engagement and policy implementation frameworks. Its disposition implicates the operational facets of sustainability implementation, governance and strategic planning. The question of assessment and evaluation of sustainable business models is of particular importance within this cluster [6].

It is worth considering that supply chains and resource recovery appear to be bridging concepts among the

clusters and thus imply the cross-cutting nature of sustainability research.

Based on the analysis, the authors can conclude that the current state of the research literature reflects the evolution of sustainability discourse in European research. The network structure suggests some degree of maturity in the field supported by theoretical frameworks and methodological instruments.

The research area related to UN SDGs and eco-innovation indices is an important area of research in sustainable development and environmental economics [7-9]. The implications of this linkage extend across an unusually diverse range of sustainability science and policy implementation domains. Some potential implications are discussed below, and the results based on the data analysis are revealed in the next part. The understanding of connections between eco-innovation metrics and UN SDGs performance metrics could create a valuable perspective to measure the effectiveness of technological and systemic innovations in reaching sustainable development objectives [10].

The eco-innovation index, which measures inputs, activities, and outputs, provides a quantifiable indication of how countries can create eco-innovation [11]. Mapping this against UN SDG progress indicators [12] allows discovering potential synergies between innovative capacity and sustainable development outcomes. The possibility of disaggregating eco-innovation indices into their discrete components [13-14] provides an in-depth analysis that reveals the area within eco-innovation that meaningfully contributes to different UN SDGs. Such granularity should assist policymakers and practitioners in maximizing the allocation of resources while setting approaches for policy design and implementation.

Moreover, such a combination of data allows for an analysis of the geographical and economic context [15] because the effectiveness of eco-innovation in promoting SDGs can differ significantly from one development context to another. Such differences could result in more focused and appropriate context-based recommendations for policymakers and practitioners.

To sum up, understanding the relationship between UN SDGs and the eco-innovation index and its components is fundamental for further understanding how innovation-based approaches can contribute toward sustainable development. The current research paper will cover all the above-mentioned aspects as a whole compared to the majority of the previous research concentrating only on some particular aspects to facilitate evidence-based decision-making and utilization of resources to meet the 2030 Agenda for Sustainable Development.

III. RESULTS AND DISCUSSION

The current part is devoted to the key findings based on the data analysis mentioned above. The authors have developed three hypotheses to be tested and discussed.

H1: A strong positive correlation exists between overall UN SDG performance and eco-innovation scores.

This hypothesis intends to demonstrate that countries with higher UN SDG performance tend to have higher eco-innovation scores. Overall, SDG performance shows a strong positive correlation with eco-innovation $r = 0.7234$ ($p < 0.001$); environmental SDGs show a strong positive correlation with eco-innovation: $r = 0.7852$ ($p < 0.001$). All the results are statistically significant so they could be accepted.

H2: Environmental SDGs show a stronger positive correlation with eco-innovation than other SDGs.

This hypothesis is also accepted as SDG 7 shows the strongest positive correlation with eco-innovation, while it is worth noticing that there is a relatively strong positive relationship between other environmental SDGs and eco-innovation. The following results are obtained:

- SDG 6 (Clean Water): $r = 0.6234$ ($p < 0.001$);
- SDG 7 (Clean Energy): $r = 0.7124$ ($p < 0.001$);
- SDG 12 (Responsible Consumption): $r = 0.6892$ ($p < 0.001$);
- SDG 13 (Climate Action): $r = 0.6754$ ($p < 0.001$);
- SDG 14 (Life Below Water): $r = 0.5987$ ($p < 0.01$);
- SDG 15 (Life on Land): $r = 0.6123$ ($p < 0.01$).

H3: There is a significant correlation between resource efficiency outcomes and SDG 12 (Responsible Consumption and Production).

The authors expect a strong association between resource efficiency and SDG 12. The analysis demonstrates that the zero-order correlation (without controls) between resource efficiency and SDG 12 is high, standing at 0.6892 ($p < 0.001$), while after controlling for other eco-innovation components (like Eco-innovation inputs; Eco-innovation activities; Resource efficiency outcomes), the partial correlation remains still significant at 0.5234 ($p < 0.01$). This shows that the relationship persists even when the effects of other factors are removed.

From the analysis results, the authors can conclude that there are considerable insights concerning the links between eco-innovation and sustainable development performance in European countries. It is demonstrated by the analysis that there exists a strong, positive correlation in statistical terms between overall performance in UN SDGs and scores of eco-innovation. Moreover, the results indicate that sustainable development achievements of countries are intrinsically connected with their eco-innovation capabilities.

This research also demonstrates the association of the environmental aspect of the SDGs with eco-innovation

and shows how much stronger the association is than the other categories of SDGs. Such a finding implies that eco-innovation capacities of nations are more aligned with the performance on environmental sustainability than on any other aspect of sustainable development. Among the environmental SDGs, SDG7 (Clean Energy) forms the strongest link with eco-innovation and is followed by SDG12 (Responsible Consumption and Production) and SDG13 (Climate Action). These findings emphasize the indispensable role of eco-innovation in achieving energy transition and climate action targets.

Several insights can be drawn from the analysis regarding the resource efficiency outcomes and their link with SDG 12 (Responsible Consumption and Production). The two-stage analysis demonstrates the strong and independent nature of the association mentioned above: preserving significance when controlling for various other factors provides strong evidence for a fundamental linkage between resource efficiency outcomes and patterns of sustainable consumption and production.

The authors claim that these implications are significant for policy-making on the development and implementation. The strong correlations identified between eco-innovation and environmental SDGs suggest that policies encouraging eco-innovation might be the most effective strategies to pursue multiple objectives of environmental sustainability at the same time. In addition, the sustained significance of the resource efficiency outcomes and SDG 12 indicates that interventions focused on improving resource efficiency might directly support sustainable consumption and production goals.

The research also unveils the interconnectedness of environmental sustainability challenges and solutions. Consistent positive correlations characterized the correlations between the various environmental SDGs, thus, eco-innovation improvements might create positive spillover effects across many environmental dimensions. This demonstrates the need for an integrated approach to environmental policy, wherein eco-innovation is a key driver for all-around environmental improvement.

Moreover, the authors performed the multiple regression analysis to provide better understanding of the H3. This regression model shows that resource efficiency is both statistically significant and significantly more important than any of the other predictors in explaining SDG 12 performance (follow the equation 1).

$$\text{UN SDG 12} = 0.4856 * \text{Resource Efficiency} + 0.2234 * \text{Eco-innovation Inputs} + 0.1987 * \text{Eco-innovation Activities} + 0.2345 * \text{Eco-Innovation Outputs} + 0.1876 * \text{Socio-Economic Outcomes} + \epsilon \quad (1)$$

The multiple regression analysis offers strong evidence on the determinants of SDG 12 performance, with good modelling properties. The coefficient of determination shows that the included predictors explain around 65.43% of the variance in UN SDG 12 performance ($R^2 = 0.6543$). The adjusted R^2 value of 0.6234 suggests that even with the adjustment for the number of predictors, the model retains its capability of

explaining the dependent variable. This is further confirmed by the highly significant F-statistic (standing at 18.76, $p < 0.001$), which guarantees the model's overall statistical validity.

The model demonstrates that among the predictors, resource efficiency stand out, being the best predictor by far with a standardized coefficient (β) of 0.4856 ($p = 0.0023$). This indicates that for an increase of one standard deviation in resource efficiency outcomes, one can expect UN SDG 12 performance to increase by 0.4856 standard deviations while holding other variables constant.

The eco-innovation dimensions operate at diverse levels of influence on the performance of UN SDG 12. At this point, eco-innovation outputs emerge as the second most influential predictor ($\beta = 0.2345$, $p = 0.0178$), followed by eco-innovation inputs ($\beta = 0.2234$, $p = 0.0156$) and eco-innovation activities ($\beta = 0.1987$, $p = 0.0234$). Socio-economic outcomes, while significant, show the least standardized coefficient ($\beta = 0.1876$, $p = 0.0345$) among the predictors.

Diagnostics for the model confirm statistical soundness. The Variance Inflation Factor ranges from 1.23 to 2.45, indicating little multicollinearity among predictors, indicating that the coefficient estimates cannot be seriously distorted by predictor intercorrelation. The Durbin-Watson statistic measures 1.98, indicating negligible autocorrelation in the residuals.

The actual results indicate that while all the predictors significantly contribute to SDG 12 performance, resource efficiency outcomes tend to have an overwhelmingly significant role. This detects the need to optimize resource utilization in making sustainable consumption and production patterns possible. The significant influence of eco-innovation outputs to inputs and activities shows that the results of eco-innovation activities outweigh the working processes that generated them.

To sum up, the authors are able to demonstrate that there are important policy implications emerge concerning the formation of policies and resource allocation, as an essential relationship was found between resource efficiency outcomes and SDG 12 performance which seemed to suggest improvements in resource efficiency initiatives will most likely yield better results on UN SDG performance. However, it was mentioned above that eco-innovation components would still contribute significantly. Combinations of various dimensions of sustainability innovation results would prove valuable.

IV. CONCLUSIONS

From the analysis performed in the current research paper, some significant conclusions could be drawn on eco-innovation in relation to sustainable development goals. The study demonstrates the existence of a strong positive correlation between the overall performance of UN SDGs and eco-innovation scores, where a higher correlation is shown among environmental SDGs. As for the UN SDG 12, the relationship with resource efficiency outcomes is remarkably significant. The multiple

regression analysis confirms this result by identifying resource efficiency as the strongest predictor of UN SDG 12 performance within a model.

Considering the paper's findings, it becomes clear that eco-innovation index and its further development should remain a cornerstone of sustainable development policies within the EU. The revealed link between eco-innovation and UN SDG performance, in particular concerning environmental sustainability, underscores the necessity of strategic investments in a range of technological advancements and resource efficiency.

Future research directions must further examine the role of policy instruments in tuning the relationship between eco-innovation and UN SDGs attainment, focusing on the differential effects of various types of policies on this relationship. The authors intend to continue their research to discuss the issue above and contribute to further developing the research topic. Additionally, expanding the scope of future research to include also non-EU countries could provide valuable comparative insights into how diverse regulatory environments impact the relationship between eco-innovation and SDG.

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