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Sustainability-oriented clustering of Ukrainian regions in the context of green finance instruments

Zrównoważone klastrowanie regionów Ukrainy w kontekście instrumentów zielonego finansowania

ABSTRACT

This article examines the distribution of environmental, social, and governance (ESG) risks across Ukrainian regions amid ongoing structural challenges and war-related disruptions. By applying a cluster analysis of ESG indicators, the study identifies three distinct groups of regions, low-, medium-, and high-risk clusters, and proposes tailored green finance instruments for each. The research problem addressed is the lack of a comprehensive framework that integrates ESG risk assessment with region-specific financial solutions. The study seeks to fill this gap by aligning green finance mechanisms with the differentiated needs of Ukrainian regions, thereby supporting sustainable recovery, institutional convergence with the European Union, and long-term resilience.

Keywords: ESG risks, sustainability-oriented clustering, green bonds, Ukrainian regions, cluster analysis.

STRESZCZENIE

W niniejszym artykule analizuje się rozkład ryzyk środowiskowych, społecznych i zarządzania (ESG) w regionach Ukrainy w kontekście trwających wyzwań strukturalnych i zakłóceń związanych z wojną. Poprzez zastosowanie analizy klastrowej wskaźników ESG, badanie identyfikuje trzy odrębne grupy regionów, klastry o niskim, średnim i wysokim ryzyku, oraz proponuje dostosowane do każdej z nich instrumenty zielonego finansowania. Problem badawczy polega na braku kompleksowych ram integrujących ocenę ryzyka ESG z regionalnymi rozwiązaniami finansowymi. Badanie ma na celu wypełnienie tej luki poprzez dostosowanie mechanizmów zielonego finansowania do zróżnicowanych potrzeb regionów Ukrainy, wspierając w ten sposób zrównoważoną odbudowę, konwergencję instytucjonalną z Unią Europejską i długoterminową odporność.

Słowa kluczowe: ryzyka ESG, klastrowanie zorientowane na zrównoważony rozwój, zielone obligacje, regiony Ukrainy, analiza klastrowa.

1. INTRODUCTION

Ukraine is currently experiencing a profound intersection of systemic structural weaknesses and war-driven crises, which amplify environmental, social, and governance (ESG) risks. These risks are unevenly distributed across regions, creating significant disparities in institutional capacity, resilience, and sustainability outcomes.

Unfortunately, there is a lack of a comprehensive, region-specific framework for clustering ESG risks and aligning them with tailored financial instruments that can foster sustainable recovery and integration into the European Union's sustainability agenda.

The article seeks to identify and cluster Ukrainian regions

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according to risks associated with environmental, social, and governance (ESG) dimensions, and to propose tailored green finance instruments for each cluster, in line with the European Union's regulatory and sustainability framework.

The methodology adopted in this study combines a comprehensive mixed-methods approach. Quantitative data were sourced from the World Bank, the State Statistics Service of Ukraine, the NBU, and regional authorities. Cluster analysis was applied to ESG indicators (environmental, social, and governance) to group regions by risk level.

2. LITERATURE REVIEW

Evaluations of environmental, social, and governance (ESG) dimensions constitute an essential tool for assessing the sustainability profile of companies and financial instruments. Such assessments measure both the degree of exposure to sustainability-related risks and the extent of an entity's external impact on society and the natural environment. Depending on the methodology applied by rating agencies, the outcomes of these evaluations may be expressed as ratings, scores, valuations, or opinions (European Commission, 2024).

According to the EU taxonomy for sustainable activities (European Commission, 2020), there are several distinct categories of ESG ratings.

First, they may be designed as aggregate indices that integrate all three dimensions (E, S, and G), as pillar-specific ratings that focus on a single component (e.g., environmental), or as subfactor ratings that address narrower issues, such as climate-related risks (European Commission, 2024).

Second, ESG assessments can be constructed through a double-materiality perspective, which simultaneously captures risks and impacts, or through a single-materiality perspective, which addresses only one dimension. In addition, some methodologies are explicitly aligned with global normative frameworks, such as the United Nations Sustainable Development Goals (Department of Economic and Social Affairs, 2024).

Third, ESG ratings may be derived through expert-driven analysis, relying on qualitative judgment, or generated automatically through quantitative, data-based approaches (European Commission, 2020).

While ESG rating providers constitute the primary source of these assessments, a growing number of financial institutions have developed proprietary ESG evaluation models for internal or market-facing use.

The role of ESG ratings has become increasingly salient in the context of sustainable finance. For investors, these ratings form an integral component of responsible investment strategies, enabling them to account for ESG-related risks and impacts in portfolio allocation. For corporations, ESG ratings serve both as a risk-management tool, identifying operational vulnerabilities and opportunities, and as a benchmarking tool to evaluate performance relative to industry peers.

Recognizing their significance, the European Union has recently adopted a regulatory framework governing ESG rating activity. The overarching aim of this initiative is to guarantee that market participants have access to reliable and comparable information concerning both the objectives (what is measured) and the methodologies (how it is measured) underlying ESG ratings. By institutionalizing such transparency, the EU seeks to mitigate greenwashing practices, reinforce market confidence, and promote a genuine transition towards sustainable investment.

More concretely, the ESG Ratings Regulation introduces obligations to enhance the transparency of methodologies, strengthen the governance and independence of rating providers, and establish more stringent disclosure standards. Importantly, the Regulation amends the Sustainable Finance Disclosure Regulation (SFDR) to ensure that financial institutions producing in-house ESG ratings disclose the same level of methodological detail as specialized providers. Furthermore, ESG rating agencies offering services in the European market must now be formally authorized and supervised by the European Securities and Markets Authority (ESMA). These requirements are expected to improve the accountability of ESG rating providers, increase consistency in evaluation practices, and minimize potential conflicts of interest in the rating process. CSRD (Directive (EU) 2022/2464) replaces NFRD and mandates double materiality and ESRS-based reporting for large and listed companies (phased-in by FY2024–2028).

In July 2025, the Commission tabled a CSRD quick-fix to streamline/clarify parts of the framework pending Omnibus changes (SFDR). SFDR (2019/2088) governs financial-market participants' sustainability disclosures and product classifications; reviews/RTS updates continued through 2024–2025.

According to the evaluation of ESG risk, it is necessary to indicate the relevant rules and standards. ESRS (European Sustainability Reporting Standards), SFDR (Sustainable Finance Disclosure Regulation) set the content and granularity of disclosures, including how to perform the double-materiality assessment; EFRAG also issued Implementation Guidance (IG 1) on materiality (2024). EU Taxonomy Regulation (2020/852) defines sustainable activities and alignment metrics used across CSRD/SFDR/Pillar 3 (climate/environmental objectives via delegated acts).

Avramov et al. (2022) analyzed the asset-pricing and portfolio implications of an important barrier to sustainable investing: uncertainty about corporate ESG profiles. In equilibrium, the market premium increases and demand for stocks declines in response to ESG uncertainty.

Berg et al. (2022) provided and decomposed it into scope/measurement/weight effects – a fundamental risk to comparability and risk-pricing. Authors investigated the divergence in environmental, social, and governance (ESG) ratings across six prominent ESG rating agencies: Kinder, Lydenberg, and Domini (KLD), Sustainalytics, Moody's ESG (Vigeo-Eiris), S&P Global (RobecoSAM), Refinitiv (Asset 4), and MSCI. Analyses of the reasons for measurement divergence detected a rater effect where a rater's overall view of a firm influences the measurement of specific categories.

Christensen et al. (2022) predicted and found that greater ESG disclosure is associated with greater ESG rating disagreement. Their findings highlight that ESG disclosure generally ex-

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acerbates disagreement in ESG ratings rather than resolving it.

Our research aims to investigate ESG-related risks across different regions of Ukraine. Following the identification and assessment of these risks, the study will analyze both the feasibility and the necessity of applying various instruments and strategies to mitigate them. It should be emphasized that, under the current circumstances, it is not possible to act proactively or preventively; rather, the focus is on managing and reducing risks that have already materialized or are highly likely to occur in the near future.

Within each of the three principal ESG dimensions – environmental, social, and governance – the analysis will focus on the categories of risk most relevant and pressing to the Ukrainian context. This approach will enable the selection of the most critical risk factors that require targeted policy interventions, regulatory responses, or managerial tools.

In addition, the study seeks to provide a structured framework for evaluating how regional variations–such as differences in infrastructure resilience, socio-economic conditions, environmental vulnerability, and institutional capacity–affect both the scale and the nature of ESG risks. By incorporating this regional perspective, the research will contribute to a more nuanced understanding of sustainability challenges in Ukraine, while also highlighting the need for differentiated risk management and mitigation strategies.

Ultimately, the findings are expected to support policymakers, businesses, and civil society stakeholders in developing evidence-based approaches to address ESG risks effectively, thereby strengthening both regional sustainability and Ukraine's long-term integration into the European regulatory and economic space.

3. METHODOLOGY AND DATA SOURCES

The empirical assessment of ESG risks in Ukrainian regions relies on a mixed-methods approach that integrates quantitative indicators, publicly available statistical information, and expert-based evaluation.

1. State Statistics Service of Ukraine – regional socio-economic data, including unemployment rates, internal migration indicators, access to public services (education, healthcare, housing), and ecological statistics. Data were extracted from regional statistical bulletins and annual publications (2024).

2. National Bank of Ukraine (NBU) – reports and analytical materials related to sustainable finance, ESG risk monitoring, green credit instruments, and financial sector vulnerability. The study relies primarily on NBU annual reports, analytical reviews, and publications on green finance (2023).

3. World Bank Open Data – indicators on environmental degradation, climate vulnerability, industrial emissions, and infrastructure damage resulting from military actions (2024). For consistency, only datasets that contain regional (sub-national) information were used, including the Climate Change Knowledge Portal and Ukraine Economic Updates (2024).

These sources were selected to reflect the full spectrum of ESG dimensions at the regional level and to guarantee data accessibility for independent verification.

Each ESG pillar includes six risk categories representing the most relevant sustainability challenges for Ukrainian regions.

Environmental risks: air and water pollution, industrial waste, climate change impacts, ecological disaster zones, forest fires, and war-related destruction of environmental infrastructure.

Social risks: internal displacement, unemployment, inequality and discrimination, access to education, access to housing, and access to healthcare.

Governance risks: transparency and reporting; the existence of sustainable development plans; the rule of law; diversity and inclusion; the digitalization of services; and the regional investment climate.

Indicators were selected based on relevance, data availability, and alignment with international ESG frameworks, including the EU Taxonomy, ESRS, and Sustainable Finance Disclosure Regulation (SFDR).

The normalized values were then transformed into a five-point ordinal risk scale where: 0 = no risk; 1 = low risk; 2 = moderate risk; 3 = high risk; 4 = critical risk.

Threshold values (breakpoints) were determined based on quartile distribution (Q1, Q2, Q3) across all 24 regions. This ensures that risk scores reflect each region's relative position within the national context.

Qualitative characteristics were converted into quantitative ones through expert analysis. Data normalization was performed using the maximum and minimum values for each indicator, as well as using well-known normalization formulas.

No weighting scheme was applied. All ESG indicators were assigned equal weight to maintain methodological transparency and avoid subjective bias in risk prioritization.

Clustering method: after scoring all indicators, a hierarchical clustering analysis was performed to group regions according to their overall ESG risk structure. Ward's method was used as the clustering algorithm, combined with Euclidean distance as the similarity measure. This technique minimizes intra-cluster variance and is commonly used in sustainability research.

Three clusters were identified: green (low ESG risk), blue (medium ESG risk), and red (high ESG risk).

This classification supports differentiated recommendations for green finance instruments tailored to regional needs.

4. MAIN MATERIALS AND RESULTS

As already mentioned above, each region of Ukraine was evaluated from 0 to 4 for each of the following six environmental ESG risk categories, where 0 = no risk and 4 = critical risk. This matrix serves as the basis for clustering regions by their ESG risk profiles (Table 1).

After identifying the most relevant environmental risks in Ukraine, it is necessary to provide a numerical assessment of each risk across all regions of the country. To conduct this ranking, a combination of reliable, officially recognized data sources was used, including the World Bank, the official website of the

Table 1. Description of main six environmental ESG risk categories in Ukraine

Risk Category	Description / Indicators	Assessment Scale (0–4)
Air/Water Pollution	Air quality levels, industrial emissions, water contamination and wastewater treatment	0 – no pollution; 4 – critical air/water pollution
Industrial Waste and Soil Contamination	Accumulation of hazardous waste, toxic spills, ineffective waste management, soil degradation	0 – no contamination; 4 – severe and widespread contamination
Climate Change Impact	Frequency of extreme weather events, temperature anomalies, droughts, floods	0 – no impact; 4 – severe and frequent climate-related disruptions
Presence of Ecological Disaster Zones	Existence of areas classified as ecological disaster zones (e.g., toxic industrial legacy, radiation)	0 – no ecological disaster; 4 – multiple critical disaster zones
Extent of Forest Fires and Area of Affected Territories	Number, frequency and size of forest fires, percentage of territory affected	0 – no fires; 4 – large-scale, recurrent fires with significant damage
Degree of infrastructure destruction due to the war	Damage to water supply, energy, environmental monitoring systems and waste infrastructure	0 – no damage; 4 – severe destruction with critical disruption of services

Source: developed by authors.

State Statistics Service of Ukraine, and the results of officially validated, published national research studies. Such an integrated approach ensures both the credibility and the comparability of the data applied in the analysis. The scoring system reflects regional disparities in exposure to environmental risks. It provides a structured basis for clustering regions by their ESG profiles.

The results of the assessment are presented in Table 2, which shows the distribution of scores across Ukrainian regions for each selected environmental risk category. Table 2 provides a transparent and methodologically consistent framework that underpins further analysis of sustainability challenges and guides the selection of appropriate green finance instruments tailored to regional needs.

The results of the assessment and clustering are illustrated in Figure 1.

The histogram illustrates the distribution of Ukrainian regions by environmental risk levels within the ESG assessment framework. The maximum possible score is 24 points (the worst-case scenario). Even the lowest result (7 points (≈30% of the maximum)) highlights that environmental risks remain significant nationwide.1. Regions with the lowest risk (green cluster, 7–

Table 2. ESG risk assessment in Ukraine (Environmental Pillar)

Region	Air/Water Pollution	Industrial Waste and Soil Contamination	Climate Change Impact	Presence of ecological disaster zones	Extent of forest fires and area of affected territories	Degree of infrastructure destruction due to the war	Total points
Vinnytsia	4	3	3	2	1	2	15
Volyn	2	1	1	1	1	1	7
Dnipropetrovsk	3	4	2	3	3	3	18
Donetsk	4	4	2	2	4	4	20
Zhytomyr	2	2	4	2	2	1	13
Zakarpattia	2	1	2	1	1	1	8
Zaporizhzhia	3	4	3	4	3	3	20
Ivano-Frankivsk	1	3	2	1	1	1	9
Kyiv	4	3	2	4	3	2	18
Kirovohrad	1	3	4	3	2	2	15
Luhansk	3	2	4	2	4	4	19
Lviv	4	3	4	1	1	1	15
Mykolaiv	3	2	3	4	4	3	19
Odesa	4	2	3	2	2	3	16
Poltava	2	1	3	2	1	2	11
Rivne	2	2	2	4	2	1	13
Sumy	2	2	2	2	3	3	14
Ternopil	2	1	2	1	4	1	11
Kharkiv	2	2	4	2	4	4	18
Kherson	4	2	3	2	4	4	19
Khmelnytskyi	1	1	2	4	1	1	10
Cherkasy	2	2	3	3	2	2	14
Chernivtsi	4	1	2	3	1	1	12
Chernihiv	1	1	2	2	1	1	8

Source: developed by authors based on (Belousova, 2024; Volkotrub, 2023; World Bank, 2024a).

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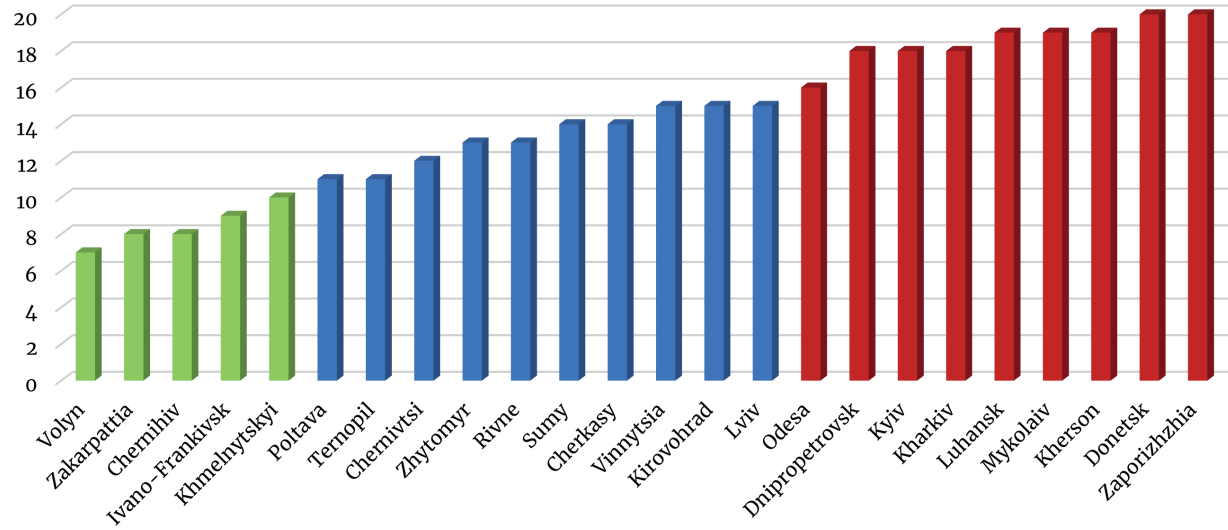

Figure 1. Main cluster of Ukraine regions depends of Environmental Pillar as a part of ESG risk.
Source: developed by authors.

10 points): Volyn, Zakarpattia, Chernihiv, Ivano-Frankivsk, Khmelnytskyi. These regions are characterized by a lower concentration of heavy industry, relatively clean natural environments, and a high share of forests and agricultural land. While they represent the least risky areas, their scores still indicate notable ecological challenges at the national level.

2. Regions with medium risk (blue cluster, 11–16 points): Poltava, Ternopil, Chernivtsi, Zhytomyr, Rivne, Sumy, Cherkasy, Vinnytsia, Kirovohrad, Lviv, Odesa. This cluster represents the largest group of regions, mostly in central and western Ukraine. They show a mixed risk structure, combining agricultural areas with moderate environmental pressure and industrial centers facing localized ecological issues. The medium-risk scores reflect challenges such as air pollution in industrial hubs, water contamination, deforestation, and infrastructure degradation caused by the war. The blue cluster can be considered a transition zone: with adequate environmental governance, risks can be contained, but neglect may push these regions toward high-risk levels.

3. Regions with the highest risk (red cluster, 17–21 points): Dnipropetrovsk, Kyiv, Kharkiv, Luhansk, Mykolaiv, Kherson, Donetsk, Zaporizhzhia. These are highly industrialized and urbanized areas with strong environmental pressures. The situation is aggravated by the ongoing war, which has caused large-scale infrastructure destruction, industrial accidents, soil degradation, and water pollution. These regions are approaching the upper end of the risk scale (over 80% of the maximum score) and therefore require urgent attention.

Ukraine faces systemic environmental risks, as even the least affected regions show relatively high scores. The red cluster reflects areas with acute industrial and war-driven ecological crises. The blue cluster is critical for future dynamics: it represents the balance point between relatively stable conditions and potential escalation into high-risk categories.

Overall, targeted regional strategies and international support are necessary to mitigate ESG-related environmental risks across Ukraine.

The next step in our research will be selecting the most relevant social risks within the framework of conducting ESG risk diagnostics in Ukraine. Table 3 illustrates the description of these risks. Each region of Ukraine was evaluated on a scale of 0 to 4 for each of the following six social ESG risk categories, where 0 = no risk and 4 = critical risk. This matrix serves as the basis for clustering regions by their ESG risk profiles.

The results of the assessment are presented in Table 4, which shows the distribution of scores across Ukrainian regions for each selected social risk category. Table 4 provides a transparent and methodologically consistent framework that underpins further analysis of sustainability challenges and guides the selection of appropriate green finance instruments tailored to regional needs.

The results of the social risk assessment and clustering are illustrated in Figure 2.

Figure 2 illustrates the distribution of social risks across Ukrainian regions. The maximum score is 24 points (worst-case scenario), while the minimum is around 5 points.

1. Regions with the lowest risk (green cluster): Kyiv, Lviv, Ivano-Frankivsk, Dnipropetrovsk, Kharkiv, Chernivtsi, and Vinnitsa had the lowest risk scores (5–10 points). These results reflect relatively favorable socio-economic conditions, better access to healthcare and education, and stronger infrastructure. Kyiv and Lviv stand out as the most socially resilient regions due to their economic strength and cultural development.

2. Regions with a medium level of risk (blue cluster): Ternopil, Odesa, Zhytomyr, Volyn, Zakarpattia, Rivne, Khmelnytskyi, Cherkasy, and Poltava regions. Their scores (11–13 points) indicate moderate social risks, often related to uneven access to public services, migration flows, and regional economic

Table 3. Description of main six social ESG risk categories in Ukraine

Risk Category	Description / Indicators	Assessment Scale (0–4)
Internal Displacement and Migration	% of IDPs, infrastructure pressure, employment of displaced people	0 – no IDPs; 4 – high IDP share and infrastructure stress
Unemployment rate	Reflects social instability that can affect consumer demand, labor availability, and corporate reputation	0 – low level of unemployment; 4 –high level of unemployment
Social Inequality and Discrimination Risk	Inequality in access to jobs, healthcare, education (women, disabled, veterans)	0 – no inequality; 4 – widespread systemic inequality
Access to Quality Education	Number of damaged schools, teacher shortages, % of students without stable access to learning	0 – full access; 4 – severe disruptions
Access to Housing	reflects social inequality and living standards, influencing community stability and corporate responsibility	0 – stable; 4 – crisis-level of access
Access to Healthcare	Hospital destruction, shortage of medical personnel/medicine, remoteness from healthcare	0 – good access; 4 – critical lack of care

Source: developed by authors.

Table 4. ESG risk assessment in Ukraine (Social Pillar)

Region	Displacement & Migration	Unemployment rate	Inequality and Discrimination	Education Access	Access to housing	Healthcare Access	Total points
Vinnytsia	1	2	2	1	2	2	10
Volyn	0	3	2	2	2	3	12
Dnipropetrovsk	2	2	2	1	2	0	9
Donetsk	4	4	4	4	4	4	24
Zhytomyr	1	2	3	2	2	2	12
Zakarpattia	0	3	2	2	2	3	12
Zaporizhzhia	3	2	3	3	4	4	19
Ivano-Frankivsk	0	2	1	2	1	2	8
Kyiv	2	1	1	0	1	0	5
Kirovohrad	3	4	2	2	3	3	17
Luhansk	4	4	4	4	4	4	24
Lviv	0	1	2	1	1	0	5
Mykolaiv	3	3	3	3	3	3	18
Odesa	2	2	2	2	2	1	11
Poltava	2	3	3	1	2	2	13
Rivne	1	2	2	2	2	3	12
Sumy	4	3	3	2	4	4	20
Ternopil	1	3	2	1	2	2	11
Kharkiv	4	1	1	0	3	0	9
Kherson	4	3	3	3	4	3	20
Khmelnytskyi	1	3	2	2	2	2	12
Cherkasy	2	2	2	2	2	2	12
Chernivtsi	0	2	2	1	2	2	9
Chernihiv	3	3	2	2	3	3	16

Source: developed by authors based on Derzhstat nazvav rehiony z naivyschym rivnem bezrobittia. (2020, October 4), (State Statistics Service of Ukraine, 2024)

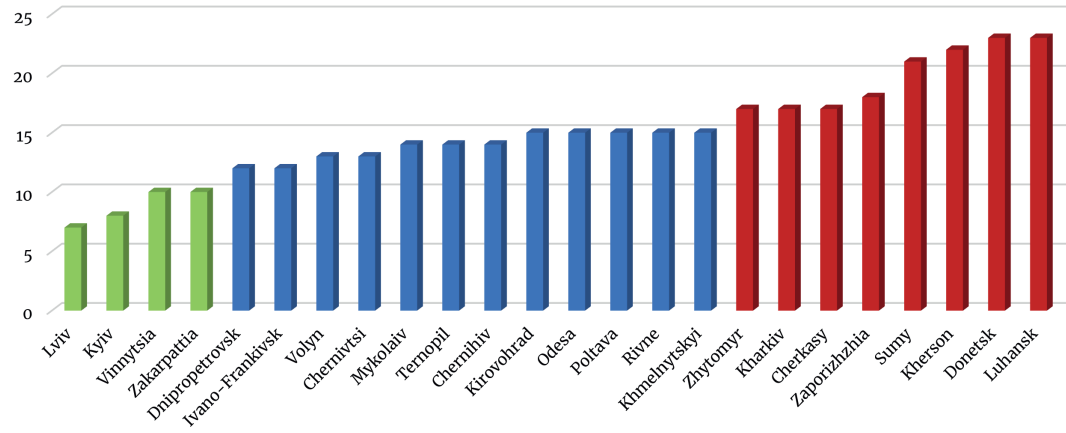

Figure 2. Main cluster of Ukraine regions depends of Social Pillar as a part of ESG risk.
Source: Developed by authors.

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disparities. Nevertheless, their situation is more balanced compared to the eastern part of the country.

3. Regions with the highest level of risk (red cluster). The highest social risks are observed in Kirovohrad, Mykolaiv, Zaporizhzhia, Sumy, Kherson, Donetsk, and Luhansk regions. Their scores range from 16 to 24 points, with Donetsk and Luhansk reaching the highest levels (almost 25 points). These regions are heavily affected by ongoing military actions, destruction of social infrastructure, forced migration, and a severe decline in living standards.

In summary, the most favorable social environment is found in Kyiv and Lviv regions, while the most critical situation is in the eastern regions, particularly Donetsk and Luhansk. The medium-risk (blue) cluster highlights regions where social challenges are significant but still manageable, requiring targeted state support and development programs.

The next step is to analyze the third component of ESG risks: the governance aspect. The most relevant types of this risk were selected, and approaches to its assessment were proposed.

Each region of Ukraine was evaluated on a scale of 0 to 4 for each of the following six governance ESG risk categories, where 0 = no risk and 4 = critical risk. This matrix serves as the basis for clustering regions by their ESG risk profiles (Table 5).

The results of the assessment are presented in Table 6, which illustrates the distribution of scores across Ukrainian regions for each selected governance risk category. Table 6 provides a transparent and methodologically consistent framework that underpins further analysis of sustainability challenges and guides the selection of appropriate green finance instruments tailored to regional needs.

The results of the social risk assessment and clustering are illustrated in Figure 3.

Figure 3 illustrates the distribution of Governance-related ESG risks across Ukrainian regions, divided into three distinct clusters (green – low risk, blue – medium risk, red – high risk). This differentiation highlights significant regional disparities in institutional capacity, transparency, and resilience of governance systems.

1. Low-Risk Cluster (green cluster): Lviv, Kyiv, Vinnytsia, Zakarpattia. These territories demonstrate the lowest governance risks, which indicates relatively stronger institutional capacity, more effective decision-making mechanisms, and higher levels of administrative transparency. Western regions, such as Lviv and Zakarpattia, benefit from closer integration with European practices and from decentralization reforms that have strengthened local self-government. Similarly, the Kyiv region reflects the central role of national-level governance institutions.

2. Medium-Risk Cluster (blue cluster): Dnipropetrovsk, Ivano-Frankivsk, Volyn, Chernivtsi, Mykolaiv, Ternopil, Chernihiv, Kirovohrad, Odesa, Poltava, Rivne, Khmelnytskyi, Zhytomyr. These regions fall into the intermediate risk category, reflecting mixed governance outcomes. On the one hand, decentralization reforms have contributed to enhanced regional management. On the other hand, governance challenges persist, including bureaucratic inefficiency, limited transparency in resource allocation, and uneven enforcement of anti-corruption measures. Importantly, these regions do not face the same acute governance breakdown as those in the high-risk cluster, but they remain vulnerable to systemic inefficiencies.

3. High-Risk Cluster (red cluster): Kharkiv, Cherkasy, Zaporizhzhia, Sumy, Kherson, Donetsk, Luhansk. These regions face the highest governance risks, shaped by two interlinked factors: structural governance weaknesses and the destructive impact of ongoing military conflict. Donetsk and Luhansk, being at the epicenter of the war, exhibit critically weakened governance capacity, undermined institutions, and a collapse of local administrative effectiveness. Similarly, Kherson, Zaporizhzhia, and Sumy suffer from instability, governance disruptions, and heightened corruption risks. Kharkiv and Cherkasy, though somewhat less exposed, still face elevated risks due to their geographical proximity to conflict zones and the fragility of governance under pressure.

Western Ukraine stands out as the most resilient in terms of governance, supported by institutional reforms, decentralization, and proximity to European Union governance standards. Central Ukraine falls into an intermediate risk zone, where gov-

Table 5. Description of main six governance ESG risk categories in Ukraine

Risk Category	Description / Indicators	Assessment scale (0–4)
Transparency and Reporting	Assessment of quality, frequency, and accessibility of public reporting on regional activities, including stakeholder engagement and accountability	0 – fully implemented, comprehensive reporting. 4 – no transparency or reporting.
Existence and implementation of regional sustainable development plans	Evaluation of whether regional sustainable development plans exist, are effectively implemented, aligned with national strategies, and achieve sustainability goals	0 – fully developed and effectively implemented. 4 – no plans or implementation.
Rule of law and compliance	Level of adherence to laws, regulations, and compliance standards in the region	0 – full compliance, strict enforcement. 4 – no compliance enforcement.
Board diversity and inclusion	Representation of gender, age, and minority groups in regional governance or company boards	0 – Full diversity and inclusion practices 4 – no diversity
Level of digitalization of local services	Availability and efficiency of digital public services, e-governance systems	0 – fully digitalized and integrated services. 4 – no digital services.
Investment Climate in the Region	Favorability of the regional environment for investment: political stability, regulations, incentives.	0 – very attractive, stable, supportive environment 4 – extremely unfavorable.

Source: Developed by authors.

Table 6. ESG risk assessment in Ukraine (Governance Pillar)

Region	Transparency and reporting	Existence and implementation of regional sustainable development plans	Rule of law and compliance	Board diversity and inclusion	Level of digitalization of local services	Investment climate in the region	Total points
Vinnytsia	1	2	2	1	2	2	10
Volyn	1	2	2	2	3	3	13
Dnipropetrovsk	2	2	3	3	1	1	12
Donetsk	4	4	4	4	4	3	23
Zhytomyr	2	3	4	3	2	3	17
Zakarpattia	1	1	1	1	3	3	10
Zaporizhzhia	2	4	4	3	3	2	18
Ivano-Frankivsk	2	1	3	3	2	1	12
Kyiv	2	1	1	2	1	1	8
Kirovohrad	2	3	2	2	3	3	15
Luhansk	4	4	4	4	4	3	23
Lviv	1	1	2	1	1	1	7
Mykolaiv	2	3	2	2	2	3	14
Odesa	3	2	3	4	2	1	15
Poltava	3	3	3	3	2	1	15
Rivne	2	2	4	3	2	2	15
Sumy	3	3	4	4	4	3	21
Ternopil	2	2	3	3	2	2	14
Kharkiv	3	3	4	4	2	1	17
Kherson	4	4	4	4	3	3	22
Khmelnytskyi	2	3	2	2	3	3	15
Cherkasy	3	3	3	3	2	3	17
Chernivtsi	1	2	1	3	3	3	13
Chernihiv	2	3	2	1	3	3	14

Source: developed by authors based on (European Business Association, 2024; Transparency International Ukraine, 2024).

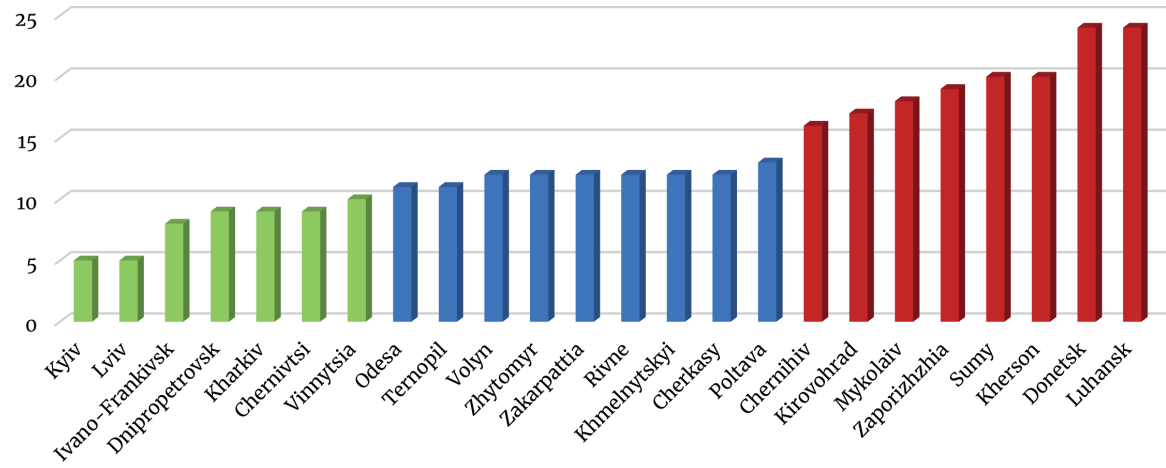

Figure 3. Main cluster of Ukraine regions depends of Governance Pillar as a part of ESG risk
Source: developed by authors.

ernance is moderately effective but remains vulnerable to systemic challenges and uneven reform implementation. Eastern and Southern Ukraine represent the most fragile governance environment, heavily affected by conflict, weak institutional resilience, and heightened corruption risks. This distribution reveals a clear geopolitical and conflict-related divide in governance risks: the further east and south, the higher the governance challenges. At the same time, Western regions appear more stable and institutionally secure. Table 7 presents the total amount of all risks based on the ESG risk assessment in Ukraine.

To ensure clearer generalization and enhance understanding and interpretation of the distribution of regions across Ukraine's ESG risk components, Figure 4 has been developed. This diagram provides a comprehensive analysis of each region's classification within a specific cluster. It is important to emphasize that the regions are ranked in a sequential order, from least to most risky, based on the aggregated score across all risk categories.

The integrated ESG risk assessment across Ukrainian regions reveals pronounced territorial disparities, driven both by structural factors and the devastating impact of the ongoing war (Figure 5).

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Table 7. Total amount ESG risk in Ukraine (environmental, social and governance pillars)

Region	Total points			Total amount
	Environmental pillar	Social pillar	Governance pillar	
Vinnytsia	15	10	10	35
Volyn	7	12	13	32
Dnipropetrovsk	18	9	12	39
Donetsk	20	24	23	67
Zhytomyr	13	12	17	42
Zakarpattia	8	12	10	30
Zaporizhzhia	20	19	18	57
Ivano-Frankivsk	9	8	12	29
Kyiv	18	5	8	31
Kirovohrad	15	17	15	47
Luhansk	19	24	23	66
Lviv	15	5	7	27
Mykolaiv	19	18	14	51
Odesa	16	11	15	42
Poltava	11	13	15	39
Rivne	13	12	15	40
Sumy	14	20	21	55
Ternopil	11	11	14	36
Kharkiv	18	9	17	44
Kherson	19	20	22	61
Khmelnytskyi	10	12	15	37
Cherkasy	14	12	17	43
Chernivtsi	12	9	13	34
Chernihiv	8	16	14	38

Source: developed by authors.

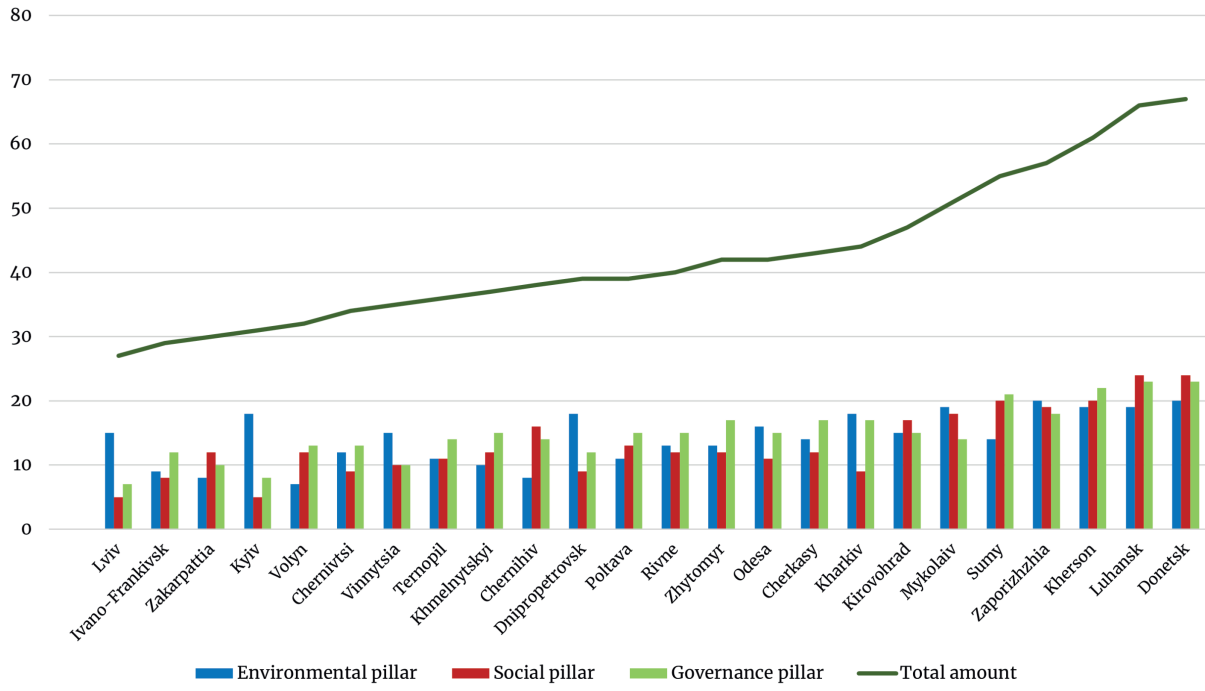

Figure 4. Ranking of Ukrainian regions from the least to the most risky, with a detailed breakdown by Environmental, Social, and Governance (ESG) dimensions. Source: developed by authors.

Environmental Pillar: The environmental analysis demonstrates that even the least exposed regions accumulate relatively high scores (≈30% of the maximum), indicating systemic ecological challenges nationwide. Western and northern regions such as Volyn, Zakarpattia, and Ivano-Frankivsk form the low-risk cluster, benefiting from cleaner environments and a lower concentration of heavy industry. The medium-risk cluster encompasses central regions with mixed profiles, where agricultural and urban activities coexist with localized ecological stress.

The highest environmental risks are concentrated in the east and south (Dnipropetrovsk, Donetsk, Zaporizhzhia, Kherson, and Mykolaiv), where industrial legacies, ecological disaster zones, and severe war-driven infrastructure destruction exacerbate ecological vulnerability.

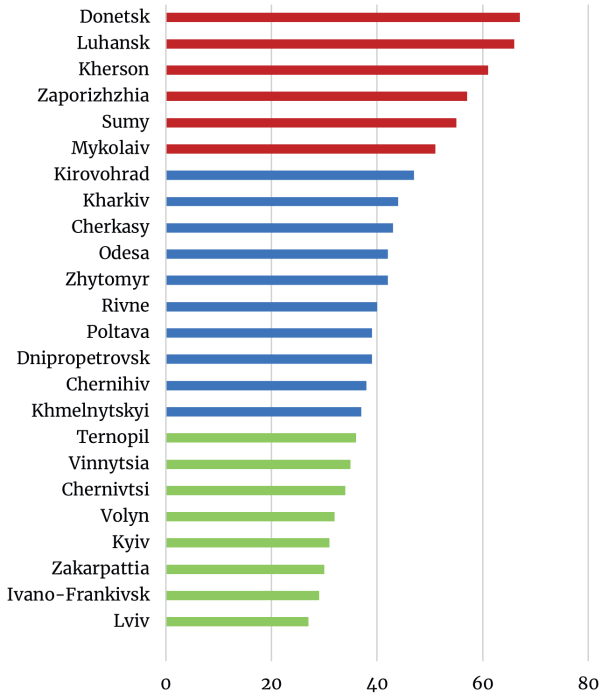

Figure 5. Ranking of Ukrainian regions by ESG risk levels: from the highest to the lowest with cluster differentiation.
Source: developed by authors.

Social Pillar: The social risks show a similarly polarized picture. The green cluster (Kyiv, Lviv, Ivano-Frankivsk, Vinnitsa, and others) enjoys relatively stronger infrastructure, lower unemployment, and better access to healthcare and education. The blue cluster includes a wide range of central and western regions that face moderate challenges, mainly linked to uneven access to public services, internal displacement, and economic disparities. The red cluster (Kirovohrad, Mykolaiv, Zaporizhzhia, Sumy, Kherson, Donetsk, and Luhansk) reveals the most critical conditions, with soaring levels of displacement, social infrastructure collapse, and declining living standards, placing them at the edge of systemic humanitarian crises.

Governance Pillar: Governance risks are also unevenly distributed. The western and central regions (Lviv, Kyiv, Vinnitsa, Zakarpattia) show low governance risk, reflecting comparatively higher transparency, service digitalization, and institutional stability. Most of central Ukraine falls into the medium-risk cluster, where reforms have improved governance structures, but challenges of efficiency and enforcement remain. The highest governance risks are observed in Donetsk, Luhansk, Kherson, and Sumy, where weak institutions, lack of transparency, limited digitalization, and the destructive influence of war undermine governance capacity and create hostile investment climates.

Cross-Pillar Insights. Western regions (Lviv, Zakarpattia, Ivano-Frankivsk, Volyn) generally perform better across all three ESG dimensions, although even here risks remain above international sustainability benchmarks. Central regions exhibit medium risk levels across all three pillars, forming a "buffer zone" where risks are significant but still manageable with effective governance and targeted interventions. Eastern and Southern regions (Donetsk, Luhansk, Kherson, Zaporizhzhia, Mykolaiv, Sumy, Kharkiv) face the highest combined ESG risks, with environmental degradation, severe social instability, and institutional fragility reinforcing each other.

Ukraine's ESG landscape reflects the dual challenge of structural weaknesses and war-driven crises. The findings underscore the need for:

1. Targeted regional strategies – focusing on the most vulnerable eastern and southern oblasts with international reconstruction support, investment incentives, and institutional capacity-building.

2. Strengthening governance and transparency – particularly in medium-risk central regions, to prevent escalation and secure a favorable investment climate.

3. Leveraging resilient regions – western oblasts can serve as sustainability "hubs" and models for post-war recovery, showcasing successful governance and environmental practices.

Table 8 provides recommendations on how green finance instruments can be tailored to the ESG risk clusters identified across Ukrainian regions. These tools aim to support sustainable development, risk mitigation, and post-war recovery.

Low-risk regions (green cluster): municipal green bonds and PPPs are justified because these regions already demonstrate stronger governance capacity, institutional stability, and lower environmental degradation. Such instruments allow them to scale renewable energy, waste management, and green transport initiatives, fostering innovation without major risks of implementation failure.

Medium-risk regions (blue cluster): transition bonds and green credit lines are recommended as they directly address the need to modernize traditional industries and reduce systemic ecological pressure. International financial institutions (EBRD, EIB, IFC) play a key role here by mitigating financing constraints and incentivizing a gradual low-carbon transition.

High-risk regions (red cluster): Green recovery bonds and blended finance mechanisms are considered essential due to war-driven destruction, institutional fragility, and investor risk aversion. By combining donor grants with private capital and insurance guarantees from international organizations (e.g., MIGA), these instruments de-risk investments, rebuild critical infrastructure sustainably, and ensure ecological restoration. This alignment with the EU's Green Deal and resilience strategies underpins their selection as the most appropriate tools for high-risk clusters.

5. CONCLUSIONS

The findings of this study demonstrate that ESG-related risks in Ukraine are systemic yet regionally differentiated. The clustering analysis underscores that western regions, though relatively resilient, still demand innovative financing tools to scale sustainable practices. Central regions, often positioned as transitional, require instruments to mitigate systemic risks, strengthen gov-

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Table 8. Green Finance Instruments for each cluster in Ukraine

Cluster	Main Objective	Recommended Green Finance Instruments
Low-Risk Regions (Green Cluster – e.g., Lviv, Zakarpattia, Ivano-Frankivsk, Kyiv, Vinnitsa, etc.)	Scaling sustainable practices and fostering innovation	- Municipal green bonds for renewable energy, waste management, and green transport projects. - Sustainability-linked loans for companies already aligned with ESG standards. - Public-Private Partnerships (PPP) with international investors to develop green hubs, smart city solutions, and digital sustainability platforms.
Medium-Risk Regions (Blue Cluster – e.g., Zhytomyr, Chernihiv, Poltava, Rivne, Cherkasy, Khmelnytskyi, Odesa, etc.)	Reducing systemic risks and strengthening institutions	- Transition bonds to finance gradual shift from traditional industry to low-carbon technologies. - Green credit lines from IFIs (EBRD, IFC, EIB) to modernize SMEs and industrial facilities. - Climate resilience funds for sustainable infrastructure (energy grids, water supply, logistics).
High-Risk Regions (Red Cluster – e.g., Donetsk, Luhansk, Kherson, Zaporizhzhia, Mykolaiv, Kharkiv, Sumy, etc.)	Recovery and post-war reconstruction with green standards	- Green recovery bonds (state-issued or donor-backed) for rebuilding critical infrastructure sustainably. - Blended finance mechanisms (grants + private capital) to de-risk investments. - Impact investment funds for ecological and social recovery projects (soil remediation, water restoration, recycling of war debris). - Guarantees and insurance instruments from IFIs (e.g., MIGA) to mitigate political and war-related risks.

Source: developed by authors.

ernance, and modernize industrial bases. Meanwhile, eastern and southern regions face the most critical ESG challenges, where war-driven destruction necessitates green recovery bonds, blended finance, and impact investment to rebuild infrastructure and restore ecosystems. The integration of ESG risk assessment with green finance instruments provides a structured pathway for Ukraine's sustainable development and post-war recovery. Moreover, by embedding EU regulatory principles–such as double materiality and transparency–into national strategies, Ukraine can accelerate its institutional convergence with European standards. Overall, this research contributes to the academic debate by offering a practical framework that links ESG risks with green finance instruments, thereby fostering resilience, inclusiveness, and long-term sustainability in Ukraine's regions.

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