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Sustainability, Volume 16, Issue 1 (January-1 2024) – 469 articles

Cover Story (view full-size image): This paper explores building-integrated greenery (BIG) systems, including green roofs and facades, as eco-beneficial solutions. Despite benefits, adoption is slowed by high costs and economic barriers. A key challenge is the lack of standardized metrics to measure BIG's city-level impact, which is crucial for investors and policymakers. The paper addresses this by introducing comprehensive indicators from frameworks like CICES and the NBS impact evaluation handbook. These indicators contribute to establishing a 'sustainability factor' for the cost-benefit analysis of BIG projects using local data. A case study on a 3500 m² green roof in Lleida, Spain, demonstrates that its benefits in urban horticulture, CO₂ capture, and recreational areas significantly outweigh the costs, offering key insights for policy and investment decisions. [View this paper](#)

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A Sustainable Cost-Benefit Factor for Building-Integrated Greenery Systems

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A Sustainable Cost-Benefit Factor for Building-Integrated Greenery Systems

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Michał Strach, Krzysztof Różanowski, Jerzy Pietrucha and Jarosław Lewandowski
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Jesus Puma-Cahua, Germán Belizario, Wilber Laqui, Roberto Alfaro, Edilberto Huaquisto and Elmer Calizaya
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Article: Effects of Organic Fertilizers on the Quality, Yield, and Fatty Acids of Maize and Soybean in Southeast Kazakhstan

Maxat Toishimanov, Zhulduz Suleimenova, Nurgul Myrzabayeva, Zhanna Dossimova, Aksholpan Shokan, Serik Kenenbayev, Gulvira Yessenbayeva and Assiya Serikbayeva
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Juliana Cheboi, Henry Greathead, Thobela Nkukwana and Marshall Keyster
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Simon N. Leonard, Deborah Devis, Belinda MacGill, Paul Unsworth, Jill Colton and Sam Fowler
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María Ángeles García-Gil, Francisco-Ignacio Revuelta-Domínguez, María-Inmaculada Pedrera-Rodríguez and Jorge Guerra-Antequera
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Article: Computational Thinking with Scratch: A Tool to Work on Geometry in the Fifth Grade of Primary Education

Álvaro Molina-Ayuso, Natividad Adamuz-Povedano, Rafael Bracho-López and Manuel Torralbo-Rodríguez
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Xianghua Cai, Donghao Zhang and Yuanying Jin
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Article: Relationship between the Latent Profile of Online Socially Regulated Learning and Collaborative Learning Motivation

Xiaodan Wang, Xin Wang, Tinghui Huang, Limin Liu, Xiaohui Chen, Xin Yang, Jia Lu and Hanxi Wang
Sustainability **2024**, *16*(1), 181; DOI: [10.3390/su16010181](https://doi.org/10.3390/su16010181)

Article: Exploring the Acceptance and User Satisfaction of AI-Driven e-Learning Platforms (Blackboard, Moodle, Edmodo, Coursera and edX): An Integrated Technology Model

Raneem Rashad Saqr, Sabah Abdullah Al-Somali and Mohammad Y. Sarhan
Sustainability **2024**, *16*(1), 204; DOI: [10.3390/su16010204](https://doi.org/10.3390/su16010204)

Article: Teacher Digital Competence Analysis in Block Programming Applied to Educational Robotics

Enrique Sánchez-Rivas, Coral Ruiz-Roso Vázquez and Julio Ruiz-Palmero
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Article: Students' Psychological Analysis for Classroom Teaching Strategies of Art Songs Based on STEAM Education

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Tourism, Culture, and Heritage

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Pablo Jesús Huerta-Viso, Germán Llorca Abad and Lourdes Canós-Darós
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Article: Projected Summer Tourism Potential of the Black Sea Region
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Article: What Is the Most Influential Authenticity of Beliefs, Places, or Actions on the Pilgrimage Tourism Destination Attachment?
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Article: The Role of Awareness of Consequences in Predicting the Local Tourists' Plastic Waste Reduction Behavioral Intention: The Extension of Planned Behavior Theory
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Article: Sustainable Biocomposites Based on Invasive *Rugulopteryx okamurae* Seaweed and Cassava Starch
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Alexandra Afonso, Carlos Ribeiro, Maria João Carvalho, Tânia Correia, Pedro Correia, Mariana Regato, Idália Costa, Annabel Fernandes, Adelaide Almeida, Ana Lopes and Fátima Carvalho
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Article: Purification of Pesticide-Contaminated Water Using Activated Carbon from Prickly Pear Seeds for Environmentally Friendly Reuse in a Circular Economy
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Review: Sustainability Assessment Indicators in Land Transportation
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Sustainability **2024**, *16*(1), 48; DOI: [10.3390/su16010048](https://doi.org/10.3390/su16010048)

Article: Estimation Method of Regional Tank-Washing Wastewater Quantity Based on Multi-Source Data

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Miroslav Vujić, Martin Gregurić, Luka Dedić and Daniela Koltovska Nečoska
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Article: Quantifying Individual PM_{2.5} Exposure with Human Mobility Inferred from Mobile Phone Data

Zhaoping Hu, Le Huang, Xi Zhai, Tao Yang, Yaohui Jin and Yanyan Xu
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Yikang Rui, Yannan Gong, Yan Zhao, Kaijie Luo and Wenqi Lu
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Ilona Jacyna-Golda, Nadiia Shmygol, Natalia Gavkalova and Mariusz Salwin
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Tomislav Letnik, Katja Hanžič, Matej Mencinger and Drago Sever
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Tavishi Priyam, Tao Ruan and Qin Lv
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Yancun Song, Kang Luo, Ziyi Shi, Long Zhang and Yonggang Shen
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Article: A Bidirectional Grid-Friendly Charger Design for Electric Vehicle Operated under Pulse-Current Heating and Variable-Current Charging

Ningzhi Jin, Jianjun Wang, Yalun Li, Liangxi He, Xiaogang Wu, Hewu Wang and Languang Lu
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Zhujun Gu and Maimai Zeng
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Article: Determining the Scale to Ensure Locality and a Sense of Belonging in the Housing Redevelopment Process: Bursa Hürriyet Neighborhood Field Study

Sibel Ersoy, Nilüfer Taş and Murat Taş
Sustainability **2024**, *16*(1), 10; DOI: [10.3390/su16010010](https://doi.org/10.3390/su16010010)

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Article: Legal Tools for Blue-Green Infrastructure Planning—Based on the Example of Poznań (Poland)

Patryk Antoszewski, Dariusz Świerk, Michał Krzyżaniak and Adam Choryński
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Article: Total Cost of Ownership Analysis of Fuel Cell Electric Bus with Different Hydrogen Supply Alternatives

Zhetao Chen and Hao Wang
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Article: Calculation Method of Material Accumulation Rate at the Front of Trunk Glaciers Based on Satellite Monitoring

Zhang Wang, Kaiheng Hu, Zhengzheng Li, Changhu Li and Yao Li
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Article: The Impact of Groundwater Burial Depth on the Vegetation of the Dariyabui Oasis in the Central Desert

Yunbao Bai, Yuchuan Guo, Huijing Wang, Ning Wang, Xuan Wei, Mingtong Zhou, Tiantian Lu and Zihui Zhang
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Marta Nalej and Elzbieta Lewandowicz
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Article: Improvement of the Methodology for the Assessment of the Agro-Resource Potential of Agricultural Landscapes

Zhumakhan Mustafayev, Akhmetkal Medeu, Irina Skorintseva, Tatiana Bassova and Gulnar Aldazhanova
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Lin Li, Jiading Wang, Qi Gu and Dengfei Zhang
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Article: The Active Role of Job Crafting in Promoting Well-Being and Employability: An Empirical Investigation

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Stylianos Syropoulos, Kyle Fiore Law and Liane Young
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Article: Influence of Depth on CO₂/CH₄ Sorption Ratio in Deep Coal Seams

Barbara Dutka
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Article: Long-Term Anaerobic Digestion of Seasonal Fruit and Vegetable Waste Using a Leach-Bed Reactor Coupled to an Upflow Anaerobic Sludge Bed Reactor

Achilleas Kalogiannis, Vasileios Diamantis, Alexandros Eftaxias and Katerina Stamatelatou
Sustainability **2024**, *16*(1), 50; DOI: [10.3390/su16010050](https://doi.org/10.3390/su16010050)

Article: Sustainable Development of a Direct Methanol Fuel Cell Using the Enhanced LSHADE Algorithm and Newton Raphson Method

Manish Kumar Singla, Jyoti Gupta, Mohammed H. Alsharif, Abu Jahid and Khalid Yahya
Sustainability **2024**, *16*(1), 62; DOI: [10.3390/su16010062](https://doi.org/10.3390/su16010062)

Article: Supercapacitors as Key Enablers of Decarbonization and Renewable Energy Expansion in Poland

Andrzej Nowrot and Anna Manowska
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Article: Enhancing the Fuel Properties of Spent Coffee Grounds through Hydrothermal Carbonization: Output Prediction and Post-Treatment Approaches

Chau Huyen Dang, Gianluigi Farru, Claudia Glaser, Marcus G. Fischer and Judy A. Libra
Sustainability **2024**, *16*(1), 338; DOI: [10.3390/su16010338](https://doi.org/10.3390/su16010338)

Article: Holistic Assessment of Decarbonization Pathways of Energy-Intensive Industries Based on Exergy Analysis

Matthias Leisin and Peter Radgen
Sustainability **2024**, *16*(1), 351; DOI: [10.3390/su16010351](https://doi.org/10.3390/su16010351)

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Hamed Sadaghian, Behrooz Dadmand, Majid Pourbaba, Soheil Jabbari and Jung Heum Yeon
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Article: Experimental Investigation on the Effect of Salt Solution on the Soil Freezing Characteristic Curve for Expansive Soils

Haiven Yu, Fengfu Hao, Panpan Yi, Qin Zhang and Tiantian Ma
Sustainability **2024**, *16*(1), 363; DOI: [10.3390/su16010363](https://doi.org/10.3390/su16010363)

Article: Exploring the Relationships between Tradeoffs and Synergies among Island Ecosystem Service Bundles: A Study on Zhoushan Archipelago Located on the Southeast Coast of China

Yang Xiao, Huan Zhang, Ke Ma, Hadinnapola Appuhamilage Chintha Crishanthi Perera, Muhammad Zahir Ramli and Yuncheng Deng
Sustainability **2024**, *16*(1), 394; DOI: [10.3390/su16010394](https://doi.org/10.3390/su16010394)

Article: Sustainable Process to Recover Metals from Waste PCBs Using Physical Pre-Treatment and Hydrometallurgical Techniques

Suruchi Kumari, Rekha Panda, Ranjit Prasad, Richard Diaz Alorro and Manis Kumar Jha
Sustainability **2024**, *16*(1), 418; DOI: [10.3390/su16010418](https://doi.org/10.3390/su16010418)

Article: A Study of the Physical and Mechanical Properties of Yellow River Sediments and Their Impact on the Reclamation of Coal-Mined Subsided Land

Huang Sun, Zhenqi Hu and Shuai Wang
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Air, Climate Change and Sustainability

Review: Strategies for OPC Paste Carbonation: Relationship between Microstructure, Performance and Net CO₂ Balance

André Silva, Rita Nogueira and José Alexandre Bogas
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Article: Emission Characteristics of Particle Number from Conventional Gasoline and Hybrid Vehicles

Ying Zhang, Xinping Yang and Mingliang Fu
Sustainability **2024**, *16*(1), 12; DOI: [10.3390/su16010012](https://doi.org/10.3390/su16010012)

Article: Coordination Relationship of Carbon Emissions and Air Pollutants under Governance Measures in a Typical Industrial City in China

Junjie Wang, Juntao Ma, Sihui Wang, Zhuozhi Shu, Xiaoqiong Feng, Xuemei Xu, Hanmei Yin, Yi Zhang and Tao Jiang
Sustainability **2024**, *16*(1), 58; DOI: [10.3390/su16010058](https://doi.org/10.3390/su16010058)

Article: Experimental Investigation and Mechanism Analysis of Direct Aqueous Mineral Carbonation Using Steel Slag

Fuxia Zhu, Longpeng Cui, Yanfang Liu, Liang Zou, Jili Hou, Chenghao Li, Ge Wu, Run Xu, Bo Jiang and Zhiqiang Wang
Sustainability **2024**, *16*(1), 81; DOI: [10.3390/su16010081](https://doi.org/10.3390/su16010081)

Article: Spatiotemporal Variability in Rainfall Erosivity and Its Teleconnection with Atmospheric Circulation Indices in China

Chenxi Liu, Manyu Dong, Qian Liu, Zhihua Chen and Yulian Wang
Sustainability **2024**, *16*(1), 111; DOI: [10.3390/su16010111](https://doi.org/10.3390/su16010111)

Article: Multi-Site and Multi-Pollutant Air Quality Data Modeling

Min Hu, Bin Liu and Guosheng Yin
Sustainability **2024**, *16*(1), 165; DOI: [10.3390/su16010165](https://doi.org/10.3390/su16010165)

Article: Infiltration of Outdoor PM_{2.5} Pollution into Homes with Evaporative Coolers in Utah County

Darrell B. Sonntag, Hanyong Jung, Royce P. Harline, Tyler C. Peterson, Selah E. Willis, Taylor R. Christensen and James D. Johnston
Sustainability **2024**, *16*(1), 177; DOI: [10.3390/su16010177](https://doi.org/10.3390/su16010177)

Article: Ammonia Volatilization from Pig Slurries in a Semiarid Agricultural Rainfed Area

Diana E. Jiménez-de-Santiago, Jonatan Ovejero, Montserrat Antúnez and Angela D. Bosch-Serra
Sustainability **2024**, *16*(1), 238; DOI: [10.3390/su16010238](https://doi.org/10.3390/su16010238)

Article: Modeling the Effect of Green Roofs for Building Energy Savings and Air Pollution Reduction in Shanghai

Yuanfan Zheng and Liang Chen
Sustainability **2024**, *16*(1), 286; DOI: [10.3390/su16010286](https://doi.org/10.3390/su16010286)

Article: Comparison of Climate Change Effects on Wheat Production under Different Representative Concentration Pathway Scenarios in North Kazakhstan

Zhanassyl Teleubay, Farabi Yermekov, Arman Rustembayev, Sultan Topayev, Askar Zhabayev, Ismail Tokbergenov, Valentina Garkushina, Amangeldy Ilgilmanov, Vakhtang Shelia and Gerrit Hoogenboom
Sustainability **2024**, *16*(1), 293; DOI: [10.3390/su16010293](https://doi.org/10.3390/su16010293)

Article: Application Study on the Activated Coke for Mercury Adsorption in the Nonferrous Smelting Industry

Yang Zheng, Guoliang Li, Jiayan Jiang, Lin Zhang and Tao Yue
Sustainability **2024**, *16*(1), 421; DOI: [10.3390/su16010421](https://doi.org/10.3390/su16010421)

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Article: Determinants of Small Mammals' Body Condition in *Eucalyptus* Dominated Landscapes

Beatriz C. Afonso, Gonçalo Matias, Daniela Teixeira, Rita Pereira and Luis M. Rosalino
Sustainability **2024**, *16*(1), 128; DOI: [10.3390/su16010128](https://doi.org/10.3390/su16010128)

Article: Impacts of Environmental Factors on Over-Wintering Aquatic Bird Communities in Yamzho Yumco Lake, China

Lei Xu, Le Yang, Cai Lu, Qing Zeng, Shengling Zhou, Yongbing Yang, Shansi Liu, Zhaxijie Li, Yifei Jia and Guangchun Lei
Sustainability **2024**, *16*(1), 254; DOI: [10.3390/su16010254](https://doi.org/10.3390/su16010254)

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Article: Spatial Distribution and Sources of Growth of Dairy Farming in the State of Pará, Brazil

Amanda Mendonça de Oliveira, Marcos Antônio Souza dos Santos, Jamile Andrea Rodrigues da Silva, Wânia Mendonça dos Santos, Thomaz Cyro Guimarães de Carvalho Rodrigues, Wellington Conceição da Silva, Sheryle Santos Hamid and José de Brito Lourenço-Junior

Sustainability **2024**, *16*(1), 122; DOI: [10.3390/su16010122](https://doi.org/10.3390/su16010122)

Article: Sustainable Recovery of Antioxidant Compounds from Rossa Di Tropea Onion Waste and Application as Ingredient for White Bread Production

Valeria Imeneo, Amalia Piscopo, Simone Santacaterina, Alessandra De Bruno and Marco Poiana

Sustainability **2024**, *16*(1), 149; DOI: [10.3390/su16010149](https://doi.org/10.3390/su16010149)

Article: Application of Plant Ingredients for Improving Sustainability of Fresh Pasta

Jana Zahorec, Dragana Šoronja-Simović, Jovana Petrović, Zita Šereš, Meta Sterniša, Antun Jozinović, Drago Šubarić, Durdica Ačkar, Jurislav Babić and Sonja Smole Možina

Sustainability **2024**, *16*(1), 209; DOI: [10.3390/su16010209](https://doi.org/10.3390/su16010209)

Article: Sustainable Strategies for the Recovery and Valorization of Brewery By-Products—A Multidisciplinary Approach

Alina Soceanu, Simona Dobrinias, Viorica Popescu, Alina Buzatu and Anca Sirbu

Sustainability **2024**, *16*(1), 220; DOI: [10.3390/su16010220](https://doi.org/10.3390/su16010220)

Article: Environmental Indicators of Vegan and Vegetarian Diets: A Pilot Study in a Group of Young Adult Female Consumers in Poland

Rita Góralska-Walczak, Klaudia Kopczyńska, Renata Kazimierzczak, Lilliana Stefanovic, Michał Bieńko, Michał Oczkowski and Dominika Średnicka-Tober

Sustainability **2024**, *16*(1), 249; DOI: [10.3390/su16010249](https://doi.org/10.3390/su16010249)

Adult Female Consumers in Poland

Rita Góralska-Walczak, Klaudia Kopczyńska, Renata Kazimierzczak, Lilliana Stefanovic, Michał Bieńko, Michał Oczkowski and Dominika Średnicka-Tober

Sustainability **2024**, *16*(1), 249; DOI: [10.3390/su16010249](https://doi.org/10.3390/su16010249)

Article: Effect of Cooking on Phenolic Compound Content and In Vitro Bioaccessibility in Sustainable Foods: A Case Study on Black Beans

Francesca Melini, Silvia Lisciani, Emanuela Camilli, Stefania Marconi and Valentina Melini

Sustainability **2024**, *16*(1), 279; DOI: [10.3390/su16010279](https://doi.org/10.3390/su16010279)

Article: Feasibility of Meat Loss and Waste Estimates Based on Meat Consumption and Availability

Paolo C. Colombani and Thomas A. Brunner

Sustainability **2024**, *16*(1), 458; DOI: [10.3390/su16010458](https://doi.org/10.3390/su16010458)

Editorial: Is Food Consumption Sustainable? Clues from Case Studies All over the World

Philippe Burny, Ruxandra Malina Petrescu-Mag and Dacina Crina Petrescu

Sustainability **2024**, *16*(1), 291; DOI: [10.3390/su16010291](https://doi.org/10.3390/su16010291)

Health, Well-Being and Sustainability

Review: Promoting Subjective Well-Being and a Sustainable Lifestyle in Children and Youth by Strengthening Their Personal Psychological Resources

Katharina Voltmer and Maria von Salisch

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Review: The Impacts of Health Decentralization on Equity, Efficiency, and Effectiveness: A Scoping Review

Rafaela Oliveira, Gonçalo Santinha and Teresa Sá Marques

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Article: Socio-Economic Vulnerability Assessment for Supporting a Sustainable Pandemic Management in Austria

Vanessa Streifeneder, Stefan Kienberger, Steffen Reichel and Daniel Hölbling

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Article: Perceived Health and Nomophobia among Young Adults: The Mediating Role of Depression and Stress

Venetia Notara, Elissavet Vagka, Areti Lagiou and Charalambos Gnardellis

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Yoko Kamata, Seonghwan Yoon, Taecheol Lee and Jung Eun Kang

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Georgios Tsekouropoulos, Anastasia Vasileiou, Greta Hoxha, Avraam Dimitriadis and Ioannis Zervas

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Yael Kochan and Stav Rosenzweig

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Article: Sustainable Healthcare Resilience: Disaster Preparedness in Saudi Arabia's Eastern Province Hospitals

Noora A. AlDulijand, Ahmed M. Al-Wathinani, Mohammed A. Abahussain, Mohammad A. Alhallaf, Hassan Farhat and Krzysztof Goniewicz

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Article: Implementation of the UN's Sustainable Development Goals (SDGs) among the Member Cities of the "Healthy Cities Network" in Israel

Milka Donchin, Lia Gurewitz and Sima Lissa Wetzler
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Hazards and Sustainability

Review: Unveiling the Seismic Performance of Concentrically Braced Steel Frames: A Comprehensive Review

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Article: Insight into the Evolutionary Mechanism of the Rear Fissure of Landslides That Conform to the Three-Section Mechanism

Peng Tang, Guoqing Chen and Siqing Qin
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Article: Community Resilience after Disasters: Exploring Teacher, Caregiver and Student Conceptualisations in Indonesia

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Article: Bottom-Up Initiatives for Sustainable Mountain Development in Italy: An Interregional Explorative Survey

Veronica Polin, Laura Cavalli and Matteo Spinazzola
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Article: Urban Traffic Accident Features Investigation to Improve Urban Transportation Infrastructure Sustainability by Integrating GIS and Data Mining Techniques

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Article: An Infinite Slope Model Considering Unloading Joints for Spatial Evaluation of Coseismic Landslide Hazards Triggered by a Reverse Seismogenic Fault: A Case Study of the 2013 Lushan Earthquake

Gao Li, Mingdong Zang, Shengwen Qi, Jingshan Bo, Guoxiang Yang and Tianhao Liu
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Article: Comparative Study of Deep Neural Networks for Landslide Susceptibility Assessment: A Case Study of Pyeongchang-gun, South Korea

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Article: Resource Disposal and Products of Fly Ash from Domestic Waste Incineration in Zhejiang Province, China: Migration and Change of Hazardous Heavy Metals

Shuping Pan, Jun Li, Hongping Gong, Zhanheng Zhu, Shunan Xu, Caiping Jiang and Wenxiang Cai
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Article: Investigation of the Deterioration of Basu Granite Mechanical Properties Caused by Freeze–Thaw Cycles in High-Altitude Mountains in the Eastern Part of the Tibetan Plateau, China

Jixin Liu, Changbao Guo, Tianye Deng and Sanshao Ren
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Article: Challenges in Developing Wildfire Understanding from Wildfire Information through Spatial Planning Processes

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Review: Reviewing the Cost–Benefit Analysis and Multi-Criteria Decision-Making Methods for Evaluating the Effectiveness of Lithium-Ion Batteries in Electric Vehicles

Danijela Barić, Silvestar Grabušić, Martina Jakara and Marko Emanović
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Article: Microbial Organic Fertilizer Improved the Physicochemical Properties and Bacterial Communities of Degraded Soil in the North China Plain

Dongze Niu, Min Yu, Chuanyang Xu, Yongjiang Wang, Chunyu Li, Dongmin Yin, Sasa Zuo and Jianjun Ren
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Article: Cleaner Chips: Decarbonization in Semiconductor Manufacturing

Prashant Nagapurkar, Paulomi Nandy and Sachin Nimbalkar
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Article: Sustainable Dyeing and Functional Finishing of Cotton Fabric by *Rosa canina* Extracts

Raziye Atakan, Inés Martínez-González, Pablo Díaz-García and Mariés Bonet-Aracil
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Article: Surface Modification of Recycled Polyester Fiber and Performance Evaluation of Its Asphalt Mastic and Mixture

Lei Xia, Dongwei Cao, Hongliang Zhang, Mingming Zhang, Lingyan Shan, Haiyan Zhang and Taiwei Wang
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Article: Numerical Study of Potential Delayed Ettringite Formation in Cemented Nuclear Wasteforms

Abubaker Danfour, Janez Perko, Suresh Seetharam, Quoc Tri Phung, Diederik Jacques and Ozlem Cizer
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Article: A Framework for Assessing Hydrochars from Hydrothermal Carbonisation of Agrowaste with the Use of MCDA: Application with the Hierarchical SMAA-PROMETHEE Method

Panagiotis Isigonis, Salvatore Corrente and Stergios Vakalis
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Neringa Vilkaite-Vaitone and Vilma Tamuliene
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Article: Company Perspectives on Circular Economy Management, Assessment and Reporting in the Kymenlaakso Region in Finland

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Article: Economic Strategy for Developing the Oil Industry in Mexico by Incorporating Environmental Factors

Tatyana Semenova and Juan Yair Martínez Santoyo
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Article: Leakage Diffusion Modeling of Key Nodes of Gas Pipeline Network Based on Leakage Concentration

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Sustainability **2024**, *16*(1), 91; DOI: [10.3390/su16010091](https://doi.org/10.3390/su16010091)

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Article: The Use of Pre-Wetting to Improve the Mechanical Behavior of Masonry Mortar Elaborated with Crushed Oyster Shell

René Sebastián Mora-Ortiz, Ebelia Del Angel-Meraz, Sergio A. Díaz, Emmanuel Munguía-Balvanera, Francisco Magaña-Hernández, Justino Alavez-Ramírez, Mayra Agustina Pantoja Castro and Jazmin del Rosario Torres-Hernández
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Xue Zhou, Yajian Ke, Jianhui Zhu and Weiwei Cui
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Gebeyehu Jalu, Goshu Dasalegn, Gurudutta Japee, Anita Tangl and Anita Boros
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Editorial: Afterword for the Special Issue “Circular Economy Strategies for Sustainable Development: Applications and Impacts”

Ana Ramos
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Green Building

Review: Application of Biopolymers as Sustainable Cladding Materials: A Review

Touha Nazrun, Md Kamrul Hassan, Md Delwar Hossain, Bulbul Ahmed, Md Rayhan Hasnat and Swapan Saha
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Review: Digital Data Management Practices for Effective Embodied Carbon Estimation: A Systematic Evaluation of Barriers for Adoption in the Building Sector

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Article: Unraveling the Complex Interplay of Sustainability, Investments, and Economic Indicators

Karime Chahuán-Jiménez, Rolando Rubilar-Torrealba, Hanns de la Fuente-Mella and Claudio Elórtégui-Gómez
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Balaji Kalluri, Vishnupriya Vishnupriya, Pandarasamy Arjunan and Jay Dhariwal
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Zuoyong Li, Tianlei Chen, Qing Chai, Danyi Shen and Chuangzhou Wu
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Lin-Rui Jia, Qing-Yun Li, Jie Yang, Jie Han, Chi-Chung Lee and Jian-Heng Chen
Sustainability **2024**, *16*(1), 148; DOI: [10.3390/su16010148](https://doi.org/10.3390/su16010148)

Article: A Multi-Objective Optimization Method for the Design of a Sustainable House in Ecuador by Assessing LCC and LCEI

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Article: Sustainability Transition Framework: An Integrated Conceptualisation of Sustainability Change

Emina Kristina Petrović
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Paola Lassandro, Anna Devitofrancesco, Alice Bellazzi, Alessio Cascardi, Giulia De Aloysio, Luca Laghi and Roberto Malvezzi
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Article: Timber-Based Strategies for Seismic Collapse Prevention and Energy Performance Improvement in Masonry Buildings

Davide Cassol, Maja Danovska, Alessandro Prada and Ivan Giongo
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Article: Optimal Planning of Urban Building-Type Integrated Energy Systems Considering Indoor Somatosensory Comfort and PV Consumption

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Soil Conservation and Sustainability

Article: Biochar-Assisted Phytoremediation Potential of Sewage Sludge Contaminated Soil

Olga Anne, Ieva Mockevičienė, Danutė Karčauskienė, Regina Repšienė, Gintaras Šiaudinis, Karolina Barčauskaitė and Greta Žilė
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Article: Analytical and Finite-Element-Method-Based Analyses of Pile Shaft Capacity Subjected to Rainfall Infiltration

Gerardo Davin Aventian, Alfredo Satyanaga, Aizhan Sagu, Bakytkul Serikbek, Gulnur Pernebekova, Bakhyt Aubakirova, Qian Zhai and Jong Kim
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Article: Spatial Distribution of Soil Carbon and Nitrogen Content in the Danjiangkou Reservoir Area and Their Responses to Land-Use Types

Bo Xu, Yuefen Li and Yi Liu
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Sustainable Forestry

Article: A Comparative Study of Stem Rot Severity in Mature Deciduous Trees in Latvia

Jānis Liepiņš, Kaspars Liepiņš, Andis Lazdiņš, Roberts Matisons and Āris Jansons
Sustainability **2024**, *16*(1), 144; DOI: [10.3390/su16010144](https://doi.org/10.3390/su16010144)

Article: Balancing Forest Regulations and Stakeholder Needs in Latvia: Modeling the Long-Term Impacts of Forest Management Strategies on Standing Volume and Carbon Storage

Daiga Zute, Valters Samariks, Guntars Šņepsts, Jānis Donis and Āris Jansons
Sustainability **2024**, *16*(1), 280; DOI: [10.3390/su16010280](https://doi.org/10.3390/su16010280)

Article: Effects of Stand Density on Growth, Soil Water Content and Nutrients in Black Locust Plantations in the Semiarid Loess Hilly Region

Bochao Zhai, Meimei Sun, Xiaojuan Shen, Yan Zhu, Guoqing Li and Sheng Du
Sustainability **2024**, *16*(1), 376; DOI: [10.3390/su16010376](https://doi.org/10.3390/su16010376)

Waste and Recycling

Article: Impact of Policy Design on Plastic Waste Reduction in Africa

Isaac Omondi and Misuzu Asari
Sustainability **2024**, *16*(1), 4; DOI: [10.3390/su16010004](https://doi.org/10.3390/su16010004)

Article: Brazil's Formal E-Waste Recycling System: From Disposal to Reverse Manufacturing

Danieli Braun Vargas, Lucila Maria de Souza Campos and Mônica Maria Mendes Luna
Sustainability **2024**, *16*(1), 66; DOI: [10.3390/su16010066](https://doi.org/10.3390/su16010066)

Article: Resource and Greenhouse Gas Reduction Effects through Recycling of Platinum-Containing Waste

HyeonJeong Hwang, Tackkwan Kweon, HongYoon Kang and YongWoo Hwang
Sustainability **2024**, *16*(1), 80; DOI: [10.3390/su16010080](https://doi.org/10.3390/su16010080)

Article: Co-Digestion-Based Circular Bio-Economy to Improve Biomethane Generation and Production of Nutrient-Enriched Digestate in Bangladesh

Chayan Kumer Saha, Mst. Lucky Khatun, Jannatoon Nime, Kawnish Kirtania and Md. Monjurul Alam
Sustainability **2024**, *16*(1), 104; DOI: [10.3390/su16010104](https://doi.org/10.3390/su16010104)

Article: Sustainable Medical Waste Management Using an Intuitionistic Fuzzy-Based Decision Support System

Konstantinos Kokkinos, Evangelia Lakioti, Konstantinos Moustakas, Constantinos Tsanaktsidis and Vayos Karayannis
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Article: Activated Carbon Fabricated from Biomass for Adsorption/Bio-Adsorption of 2,4-D and MCPA: Kinetics, Isotherms, and Artificial Neural Network Modeling

Raid Alrowais, Mahmoud M. Abdel daiem, Basheer M. Nasef and Noha Said
Sustainability **2024**, *16*(1), 299; DOI: [10.3390/su16010299](https://doi.org/10.3390/su16010299)

Article: Evaluation of Incinerator Performance and Policy Framework for Effective Waste Management and Energy Recovery: A Case Study of South Korea

Younghyun Kwon, Suyoung Lee, Jisu Bae, Sein Park, Heesung Moon, Taewoo Lee, Kyuyeon Kim, Jungu Kang and Taewan Jeon
Sustainability **2024**, *16*(1), 448; DOI: [10.3390/su16010448](https://doi.org/10.3390/su16010448)

Sustainable Oceans

Article: Insights into the Relative Abundance, Life History, and Ecology of Oceanic Sharks in the Eastern Bahamas

Brendan S. Talwar, Edward J. Brooks, Debra L. Abercrombie, Brenda Anderson, Mark E. Bond, Annabelle M. L. Brooks, Demian D. Chapman, Gina M. Clementi, Candace Y. A. Fields, Jim Gelsleichter, R. Dean Grubbs, Lucy A. Howey, Lance K. B. Jordan, Jeremy J. Kiszka, Ryan J. Knotek, Yannis P. Papastamatiou, Cheston T. Peterson, Eric V. C. Schneider, Oliver N. Shipley, Sean Williams, Maggie M. Winchester and Michael R. Heithaus
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Yujie Li, Shengjie Rui, Lingling Li, Zhen Guo and Xingye Sun
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Vincent Y. Chen, Day-Jye Lu and Yu-San Han
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Sustainable Water Management

Article: Heading into the Unknown? Exploring Sustainable Drought Management in the Mediterranean Region

Araceli Martin-Candilejo, Francisco J. Martin-Carrasco, Ana Iglesias and Luis Garrote
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Anna Wachowicz-Pyzik, Anna Sowizdzal, Tomasz Maćkowski and Michał Stefaniuk
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Qin Ma, Xiaojun Yao, Cong Zhang, Chen Yang, Kang Yang, Zhijuan Tian and Jiawei Li
Sustainability **2024**, *16*(1), 211; DOI: 10.3390/su16010211

Article: Human Health Risk Assessment of Heavy Metals and Nitrates Associated with Oral and Dermal Groundwater Exposure: The Poirino Plateau Case Study (NW Italy)

Daniele Cocca, Manuela Lasagna, Enrico Destefanis, Chiara Bottasso and Domenico Antonio De Luca
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Review: Bio-Nanoparticles Mediated Transesterification of Algal Biomass for Biodiesel Production

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Sustainable Economy: The Eco-Branding of an Industrial Region in Kazakhstan

by Lyudmila Davidenko*, Nurzhanat Sherimova, Saule Kunyazova, Maral Amirova and Ansagan Beisembina

Department of Economics, Faculty of Economics of Law, Toraihyrov University, Pavlodar 140008, Kazakhstan

* Author to whom correspondence should be addressed.

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Sustainable Economy: The Eco-Branding of an Industrial Region in Kazakhstan

Lyudmila Davidenko ^{*}, Nurzhanat Sherimova, Saule Kunyazova , Maral Amirova and Ansagan Beisembina

Department of Economics, Faculty of Economics of Law, Toraighyrov University, Pavlodar 140008, Kazakhstan; asanek2010@mail.ru (N.S.); kunjazovas@mail.ru (S.K.); maral.pvl@mail.ru (M.A.); beisembina.ansa@gmail.com (A.B.)

* Correspondence: lyudmila7876@gmail.com

Abstract: In the sustainable economy, consumer preferences are gradually beginning to prioritize environmentally friendly products and services. A sustainable economy is directly linked to the growth of consumer welfare and the environmental culture. The success of environmental projects is largely determined by approaches to the management of complex interconnected objects, which operate in developed industrial regions. In this regard, we formulate the purpose of this study, which is to generalize approaches to and to improve the mechanisms of the ecological branding of the industrial complex of a region through conscious ESG transformation. For this purpose, we have studied the statistics and principles of the management systems of Kazakhstani companies and their stakeholders. The focus was on the Pavlodar industrial region, where metallurgical production, petrochemicals, the agro-industrial sector, the banking sector, and logistics hubs are developed. The vision and the mechanisms that can influence the development of the export potential of products with an “ecological brand” were studied. A survey of export-oriented organizations helped to identify the behavioral attributes of the “new generation eco-consumer”, namely, a conscious desire to reduce the negative impact of production and economic activities on the environment. The theoretical significance of this study helps to reveal the influence of the ecological principles of the organization of modern production on the speed of transition to green technologies. Its practical significance is seen in the formation of a system for measuring the level of readiness of companies to promote the ecological branding of a region’s industry outside its country.

Keywords: sustainable economy; sustainable corporate governance; ESG transformation; eco-branding; consumer satisfaction; industrial economics; stakeholder responsibility



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1. Introduction

The outstripping growth of the capitalization of the information and communication sector, the emergence of digital twins, the diversification of existing industries, and the global goals of sustainable development: these are the prerequisites for new technologies for the management of complex socio-economic systems. The adherence to ESG principles in the majority of Kazakh companies contributes to the expansion of international trade zones. In fact, enterprises need to improve their environmental branding mechanisms. Terminology in the field of sustainable development such as environmental branding and environmental management is fixed in international and national standards and databases. In particular, the Sustainable Development Goals describe in detail the priority areas for the development of society and the establishment of full-fledged economic relations based on the restoration of the ecological balance in the factors of industrial production.

In the context of global industrial development with the use of digital systems for managing production processes and supply chains, individual states are adopting national strategies to achieve carbon neutrality. Kazakhstan’s economy has a raw material orientation. In the context of economic destabilization, there is an increased desire to increase

the depth of the processing of extracted resources to master new principles of production organization and product sales. Quality tools are regulated by the Environmental Code of the Republic of Kazakhstan, a new document that was adopted in 2021.

By studying the activities of industrial companies in recent years, especially during the COVID-19 pandemic and post-pandemic period, when there was a disruption in traditional supply chains, we explore the hypothesis of whether the environmental branding system can contribute to the strengthening of ESG principles. Is the systematization of approaches needed to promote green branding, green production, and green finance?

We suggest that eco-branding can accelerate the ESG transformation by motivating producers to engage in clean production. In this regard, we consider it appropriate to emphasize the link between the sustainable economy and ESG. To arrive at the desired results, let us consider green integration and its actors. In this case, by “green” integration we understand the process of integration interaction between the subjects of the green economy represented by companies and their stakeholders, which strive for long-term social development, the preservation of economic growth, and environmental responsibility.

In this regard, it is expedient to achieve the research objective in the form of generalization of and improvement in the current techniques and mechanisms of the ecological branding of the industrial complex of the region under study. To realize this goal, it is important to solve the following tasks:

- firstly, to systematize the main scientific and methodological techniques of ESG transformation and eco-branding based on the collection and processing of the specialized literature;
- secondly, to characterize the current state of the regional industrial ecosystem in relation to the leading industrial region of the Republic of Kazakhstan—Pavlodar Oblast—a region with high potential for cross-border linkages;
- thirdly, to lay the foundation for prospective studies on the digitalization of green integration programs based on the eco-branding of industrial products.

The choice of the mechanisms for promoting the environmental branding of the region as a research topic is conditioned by the growing competition in the markets of finished products and intermediate consumption in the manufacturing industries. Despite the financial problems and instability of the external environment, the competitive advantages of any region increase manifold in the case of using “green” technologies, from the extraction and processing of raw materials to the sale of finished products that meet high environmental standards [1]. Working with companies’ sustainability reporting allows for the systematizing of companies’ activities, the assessing of their achievements, and the formation of a scientific and methodological basis for promoting ESG mechanisms. Researchers are trying to find a balance between theory and practice in the management of complex socio-economic systems. Such objects include large industrial complexes and small firms that form cluster links with them. Under modern conditions, it becomes important to consider the level of sustainability of enterprises when they formulate their own growth strategy, taking into account environmental, social, and governance indicators [2].

For an objective reflection of the state of the R&D base, let us focus on the approaches to ESG transformation. The first approach can be classified as large-scale digitalization, which strengthens production and business links with direct and indirect market players. This puts an overlay on business processes in a green economy. They must be aligned with carbon neutrality objectives. In this case, environment, social responsibility, and governance (ESG) and green technology innovation are at the center [3–5]. When it comes to large industrial complexes that may be linked by technological integration, it is important to respect the basics of the circular economy, i.e., cleaning, reducing, and recycling waste, which has a direct impact on brand reputation and financial performance [6]. Meanwhile, the digitalization of logistics systems helps to establish supply chain management and helps to support the brand with digital warehouses.

The second approach to ESG transformation is categorized as green integration relationships, which positively influence company branding, complement the environmental

management system, and improve green processes [7]. Scholars argue that the development of green marketing strategies plays a major role in the degree of the satisfaction and loyalty of professional buyers in a B2B environment [8]. In particular, the modern flourishing of the fashion industry is associated with the opening of lines for the production of “green” cosmetics, such as sewing clothes from environmentally friendly materials. In this case, the essence of the circular economy is manifested through product design and resource efficiency along the entire value chain. However, one should not overlook the possibility of the risks of misleading consumers with knowingly misleading marketing tools. In the face of unfair competition, these are used to achieve business performance and sales growth using green design elements [9]. With the development of ecological consumption, the marketing of environmentally friendly products is favorably reflected in the image of socially responsible organizations. This is indeed an obvious fact, as the practice of developing an environmental image using green marketing tools aims at encouraging consumers to make environmentally friendly purchases, which helps to reduce the risks of an unfavorable environmental situation in the regions [10].

The third approach related to ESG transformation and ecological branding is the formation of an ecosystem of the Industry 4.0 format. Despite the challenges of the modern economy, there are objective prerequisites for the integration and technological transformation of enterprises in industrial sectors. For them, opportunities are opening up for the continuous planning and control of projects that develop according to scenarios of the production and realization of a product with “green” characteristics. Further opportunities also arise for the extraction of “green” income [11]. Researchers conclude that new types of ecosystems are increasingly taking on the characteristics of technological innovation, particularly in the knowledge-intensive and high-risk energy industry, which has environmental and social responsibilities to society [12,13]. Indeed, the gradual decline in commodity dependence is encouraging the economy to open new industrial facilities for accommodating high-level technological upgrading [14]. One can agree with this view, for example, for the Kazakh economy, where the sectoral specialization of industrial regions is shifting to manufacturing. This helps to get closer to the final consumer but, at the same time, requires strengthening the branding of the finished products [15]. According to experts, ecological branding should be the tool to be used to connect all stages of the production and marketing of high-tech products that meet environmental standards. Under conditions where the sustainable growth of companies and regions where industrial facilities of integrated structures are located becomes a necessity for solving environmental, social, and governance (ESG) problems, corporate strategies for the digital transformation of companies are beginning to be successfully implemented [16].

For the completeness of this study, we systematized the main scientific and methodological approaches of ESG transformation and environmental branding.

2. Review of the Literature

In order to achieve sustainable growth by entering global markets, companies are obliged to build their production management process according to standards. It is important to have documentation that authorizes and confirms the quality of products, so the management system of companies must move to the level of international certification [17]. This applies to emerging markets, so for industrial companies in Kazakhstan that supply raw materials and finished products abroad, one of the main conditions is presenting “green” certifications. The task of scientists and specialists is to join efforts and improve such mechanisms. The accumulated world experience shows that this can be achieved in different ways, e.g., by improving technological management, using digital tools, and managing human resources and capital [18–22].

A review of the research base on eco-branding and ESG transformation in existing industrial facilities helps to conclude that for each country these processes take place under special conditions. The reasons may be the general state of the world economy, the available resource base, the level of development of economic relations, the practice of

possible to conduct a survey of the implementation of ESG principles in business entities in the region of Pavlodar and related cross-border regions.

In parallel with the analysis of the questionnaire report, the collection method was used, which made it possible to study materials on the transformation of ESG management at the level of the companies, public services, banking institutions, educational organizations, and public associations.

The comparative method helped to analyze the potential for innovation activities of the participants of “green” technological integration. When using the method of strategic planning and forecasting, the issues relative to modelling relationships for promoting environmental branding between Kazakh companies and their foreign partners were considered. This method differs favorably from other traditional methods of analytical work. It helped to reveal to what extent Kazakh companies are ready for transformation, the use of new tools of production, and the marketing of products that are highly ecological.

The scheme of the presented research is connected by logical links:

- A review of theoretical and methodological approaches in the field of ESG transformation and ecological branding.
- The selection of a region with a developed industrial profile, a transport and logistics interchange, the presence of large, medium, and small firms in the manufacturing industry, and an agro-industrial complex.
- Conducting a thematic survey of business entities and their stakeholders to determine the prospects for sustainable development on the basis of a sound environmental policy in the field of the production and sale of finished products.

The object of this study regarding sustainable development problems was the industrial complex of the Republic of Kazakhstan in the Pavlodar region. It is a cross-border region with a diversified economic structure. The products of industrial companies in the Pavlodar region are exported to Eurasia and Europe. This region comprises more than 7% of all Kazakh industrial production, including 61.1% of all coal mining, 76.1% of ferroalloys production, 44.3% of electricity generation, 41.7% of gasoline production, and 100% of alumina and primary aluminum production [36]. There are functioning enterprises for coal mining, electricity generation, the production of gasoline and diesel fuel, the production of ferroalloys, alumina and primary aluminum, machine building, the processing and canning of meat, the production of meat products, and the production of dairy products. In total, there are 185 different industrial enterprises in the region, including 15 backbone enterprises. Industrial facilities employ more than a quarter of the region’s working population and generate about 43% of the Gross Regional Product.

Of interest are the data from the open report on the survey of managers and chief specialists of companies, which was conducted in the period September–October 2023 [37]. The report presents a study of industrial companies in the Pavlodar region that export products. Stakeholders of industrial exporting companies were interviewed to ensure the completeness of information on ESG and industrial eco-branding trends. Overall, representatives of the public sector of the economy participated in the survey, as well as financial institutions; small-, medium-, and large-sized enterprises in the industrial and agro-industrial, education, trades and services, and construction spheres; and coal mining and energy, metallurgy, petrochemicals, and outsourcing companies (Table A1). The survey was divided by the territorial location of representatives of the Pavlodar and Kyzylorda regions and of Astana city (Figure A1). The Kyzylorda region and the city of Astana are home to related industrial facilities and the main offices of some Pavlodar companies. The questionnaire was distributed online via email. The respondents’ answers were analyzed using different methods. In particular, we conducted frequency analysis for questions where respondents were presented with several answer options to choose from. The questions using a scale score were analyzed using the average of all scores [37].

Taken together, the classification of approaches to sustainable economic development for meeting consumer demand for environmentally friendly products contributes to an improvement in the eco-branding of economic entities and the region.

4. Description of the Economic Situation in the Region: Challenges to Change

According to official statistics, industrial production in the Pavlodar region in January–September 2023 totaled USD 4.5 billion, 0.4% higher than in the corresponding period in 2022. Mining and quarrying increased by 4.6%; production in the industries supplying electricity, gas, steam, hot water, and conditioned air increased by 2.1%; water supply, waste collection, waste treatment and disposal, and pollution elimination activities increased by 0.6%; and manufacturing decreased by 1.4% [36].

Environmental innovations require improvements in both products and business processes. The current situation, with the development and implementation of environmental innovations in Kazakhstan’s enterprises in the non-resource sector of the economy, can be classified as requiring a reassessment of the value system in view of modern environmental challenges. Diagnostics of the key problems in sustainable development for improvements in the ecological branding of the studied industrial complex give a general picture in the Pavlodar region [37]. According to the criterion of “group of entities to which the organization belongs”, i.e., according to their main activity, the survey respondents can be categorized as follows: commercial legal entities (37.8%), non-profit legal entities (17.8%); branches and representative offices of Kazakh legal entities (6.6%); small- and medium-sized businesses (28.9%); and individual business entities (8.9%) (Table 2).

Table 2. Systematization of general data of economic entities in the region of Pavlodar, Republic of Kazakhstan, in % of respondents’ population.

Criterion	Evaluation Category	Share of Responses in Total, %
Group of subjects to which the organization belongs	Commercial legal entities	37.8%
	Non-profit legal entities	17.8%
	Branches and representative offices of Kazakh legal entities	6.6%
	Small- and medium-sized businesses	28.9%
	Individual business entities	8.9%
Class of entities by average annual number of employees	Small businesses (up to 100 people)	40%
	Medium-sized businesses (from 101 to 250 people)	13.3%
	Large businesses (over 250 people)	46.7%

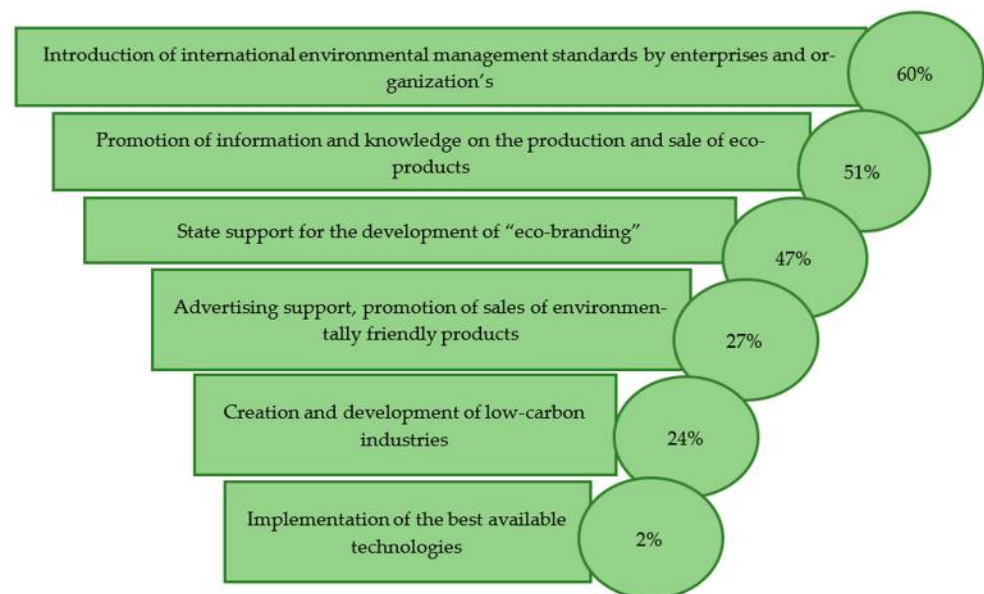
The diversification of industry in the region is associated with the possibility of opening new production facilities. At the moment, one-third of the surveyed entities link their activities with a negative environmental impact. At the same time, the majority of the subjects did not report that they received negative feedback in terms of social responsibility about the environmental impact of their organization. Among the managers, there was the opinion that industrial waste was the most significant among the environmental problems of the region. They believed that it is necessary to form a reserve of industrial (non-hazardous and inert) waste for use in various sectors of the economy.

In general, the country is developing technologies for processing organic waste from sewage sludge at sewage treatment plants, as well as waste from agriculture, poultry farms, and pig breeding (including biogas production) to produce organic fertilizers and use them to improve soil quality. Attention is being paid to the production of plants and equipment for waste collection, transportation, sorting, processing, and utilization (Table 3).

To investigate the connection between eco-branding and the possibility of entering the international market, respondents were asked the following: “What do you think are the relevant attributes characteristic for the development of ‘Eco-branding’ in your region?”. It was suggested they choose several answer options in order to find the priorities for eco-growth by means of the percentage of answers and the total population of respondents. The relationship between regional eco-branding attributes and opportunities to develop the export potential of Kazakh industrial products is shown in Figure 1.

Table 3. Systematization of data in the “Business Processes” block.

Criterion	Evaluation Category	Share of Responses in Total, %
Specific requirements for environmental standards of purchased resources for production and economic activities	Charged	51.2%
	Absent	24.4%
	Difficult to establish	24.4%
The presence and development of an innovative phenomenon in the regional market—“new generation eco-consumer”	Present	40%
	Absent	31.1%
	Difficult to establish	28.9%
Attributes of the behavior of the “new generation eco-consumer”	Conscious endeavor to reduce the negative environmental impact of production and economic activities	80%
	Purchase of products made from recycled materials	40%
	Assistance in the collection of secondary raw materials (“separate” waste) for further processing and the production of environmentally friendly products	60%
	Application of international environmental safety standards by the organization	55.6%
	Fostering moral values in society through the example of a responsible producer and consumer	53.3%

**Figure 1.** Funnel of attributes for the development of eco-branding in the region. The distribution of the responses from business entities in the region of Pavlodar, Republic of Kazakhstan and in partners, in % of respondents' population.

As the research results show, the majority of company managers saw the introduction of the international standards of environmental management, the dissemination of information and knowledge about the specifics of production, and the sale of environmentally friendly products as the main signs of eco-branding development of the industrial complex in the region of Pavlodar.

As a result, the certification of products and the building of a management system in accordance with international environmental standards are expected to help unlock the export potential of products with a national “eco-brand” and facilitate the recognition of eco-products by the international expert community (Figure 2).

An important step in identifying the main challenges to sustainable development is the linkage with ESG principles.

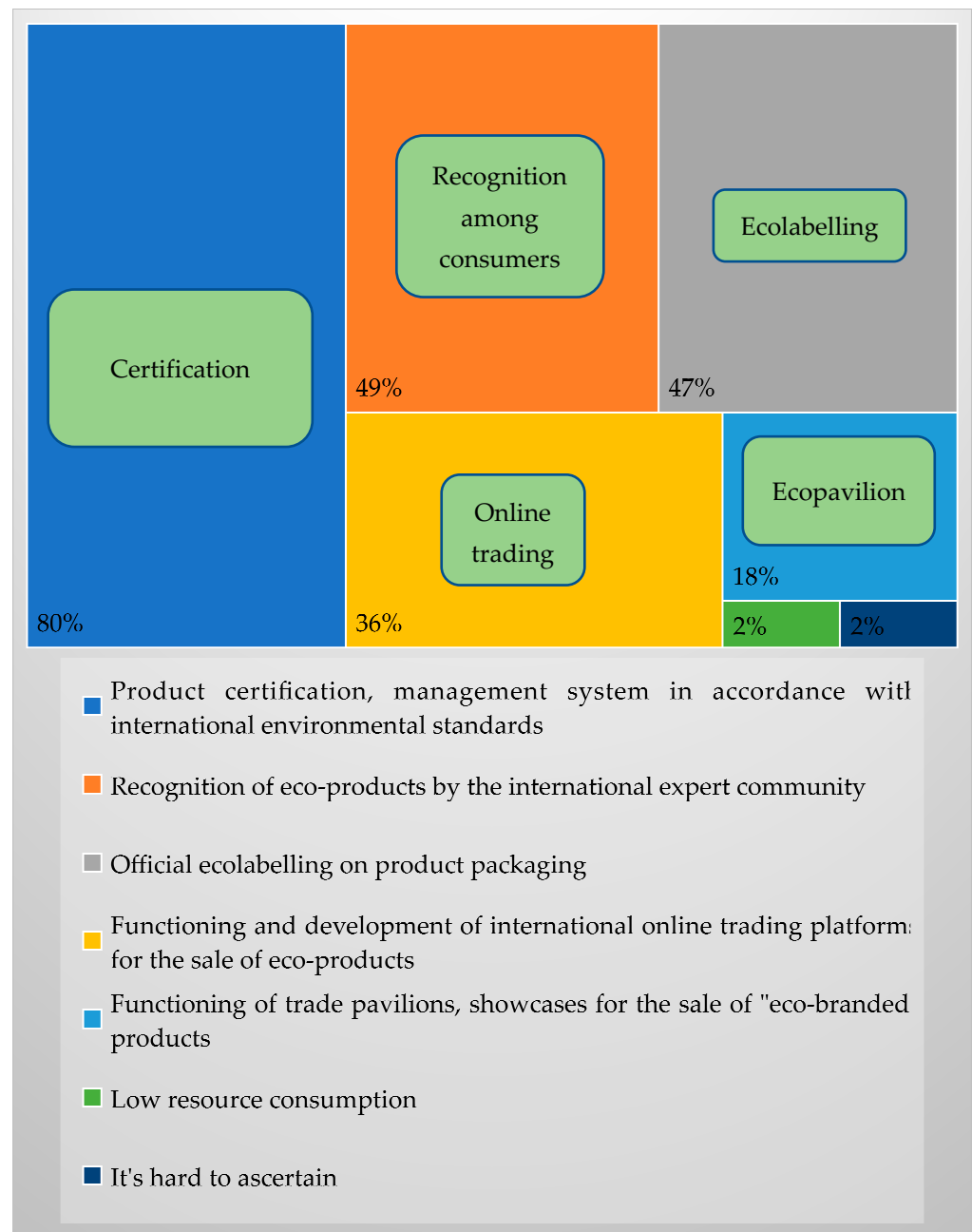


Figure 2. Infomap of tools and mechanisms for the development of export potential of products with an “eco-brand”. The distribution of the responses of economic entities in the region of Pavlodar, Republic of Kazakhstan and in partners, in % of respondents’ population.

4.1. Sustainable Economy and ESG Transformation

By processing the information obtained with the survey, we can draw a conclusion about the importance and prospects of the technological integration of environmentally friendly industries for Kazakhstan and its partners. All large companies have developed and are implementing a Sustainable Development Strategy, which includes a section on compliance with ESG policies. A third of the managers of business entities believed that ESG transformation under the current conditions is proceeding at a fairly high level. However, in total, about 20% of respondents believed that the change in environmental,

social and governance elements is a weak or generally difficult-to-characterize process (Figure 3).

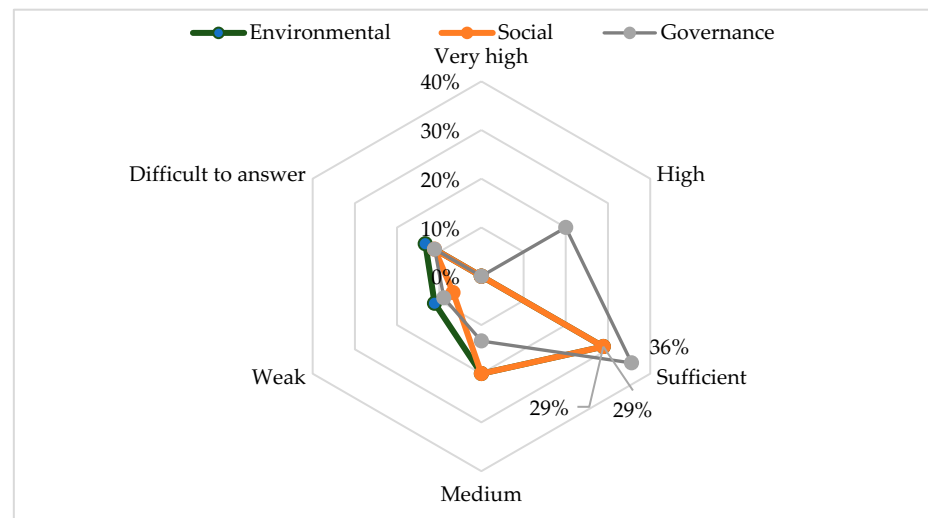


Figure 3. Implementation of ESG principles in organizations. The distribution of the answers of the business entities in the region of Pavlodar, Republic of Kazakhstan and in partners, in % of the total number of respondents.

When characterizing the technological process of the backbone companies in the region of Pavlodar, it is important to focus on the “4R” closed-cycle model: refusal of additional packaging material (“Refuse”), reduction in the amount of waste produced (“Reduce”), recycling resources within the organization (“Reuse”), and transformation of waste into new materials or items (“Recycle”). The circular economy model for Kazakhstani companies plays a major function in the transition to energy saving, resulting in the reduction in hazardous emissions into the external environment. The survey revealed the main elements of the rational production management system. About two-thirds of the managers interviewed expressed that the technological processes in their organizations were fully or partially circular. As a potential threat, we can point out the fact that 7% (“Reduce”), 11% (“Recycle”, “Reuse”), and 16% (“Refuse”) of managers indicated that their organizations did not plan to implement a resource-efficient economy (Figure 4).

Observations show that in the present stage, the ESG transformation of industrial complexes of cross-border regions may face certain barriers:

- Deficiencies in the systemized approach to the technological integration of environmentally friendly production facilities with subsequent certification in accordance with international standards.
- Weakness in the mechanisms for promoting knowledge about domestic ecological products, a lack of interest in network trade in sales, and weakness in setting an adequate price for these products.
- Lack of universal technology for ecologically friendly production.
- Lack of universal technology for ecologically friendly production facilities.

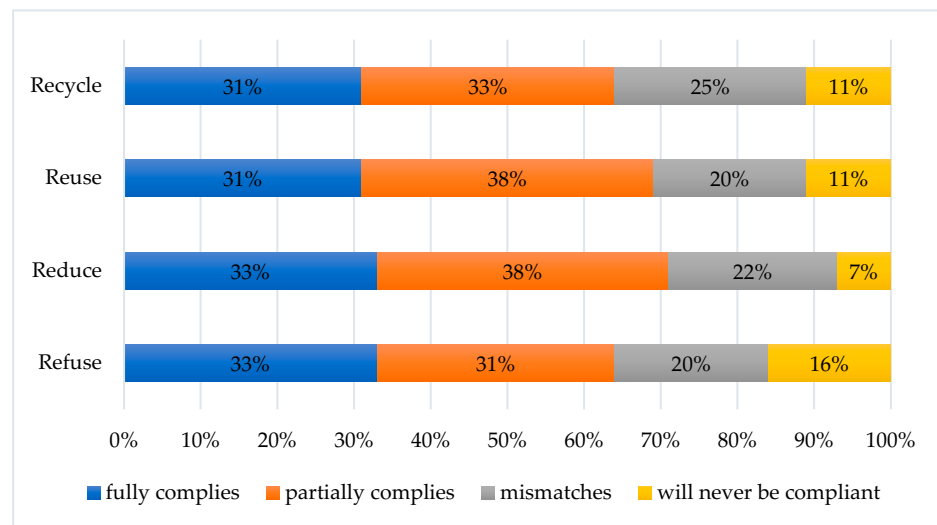


Figure 4. Compliance of organizations with the principles of the closed-cycle economy (4R model). The distribution of the answers of stakeholders and economic entities in the region of Pavlodar, Republic of Kazakhstan to the question: “To what extent does your organization comply with the principles of the circular economy (4R model)?”; in % of the aggregate.

4.2. “Green” Integration and Its Activators

Analyzing different perspectives on the development of a sustainable economy shows that there is a link among all processes. If the processes occur within integrated industrial complexes, we refer to technological integration, the depth of raw material processing, and the output of environmentally friendly products. In cases where companies seek to expand beyond the region and the country, it is important to take into account the existing norms and the standards of product quality. No process is without financing and capital raising, including green lending. These arguments push researchers to look for points of interaction among the economic actors. There is a need to develop mechanisms of interaction among the participants of market relations.

A guide to green integration can be offered as a mechanism to help connect industrial companies with stakeholders to meet consumer demands (Table 4).

Table 4. Interactions among participants in “green” integration.

Stage	Key Partners	Regulatory Framework	Possibility of an International Alliance
Choice of cleaner production type—depth of raw material processing	Regional producers and the Department of Project Activities Support of the Eurasian Development Bank	Environmental Code of the Republic of Kazakhstan Strategy for achieving carbon neutrality by 2060 in the Republic of Kazakhstan	“ESG Market Place” Qaztrade Accelerator—service support for entrepreneurs
	Retail chains Members of the National ESG Club Green Finance Centre of the Astana International Financial Centre	Global Reporting Initiative (GRI)	ESG Disclosure Rating
Submitting and promoting an application for “green” finance	Regional producers Commercial banks members of the National ESG Club	Financial instruments aimed at implementing environmentally friendly, energy-efficient, and low-carbon projects	UNDP program funding International agreements for the supply of raw materials and products

5. Conclusions and Discussion

This study of the sustainability of economic relations due to the interaction of companies and their stakeholders for the benefit of the quality of manufactured products, as well as the purity of the production process, helps to improve the system of the technological integration of industrial companies, as well as cluster formation, since this study considers the exclusive functions of integration interaction.

As this research has shown, Kazakhstani companies strive for sustainable development based on environmental and social principles. In the case of the Pavlodar industrial region, we can conclude that its export orientation helps company managers understand how important it is to comply with clean production organization conditions. At the same time, we see that, along with a positive attitude to external challenges, there are still shortcomings in the general environmental culture, and there are companies that do not plan to implement a resource-saving economy. This can be seen as a certain challenge for stakeholders. That is why in public circles and among scientists there is currently an active search for measures that will help to increase the environmental component in the branding of national manufacturers.

As growth points from the position of environmental branding, it is reasonable to consider the following areas of active impact:

- stimulating research interest in economic sustainability and ESG through joint events involving representatives of industrial companies, environmental organizations, scientists, and young people;
- concluding favorable contracts with institutional investors who can provide financial support for the opening of clean production facilities;
- integrated management, accounting, and monitoring of production and consumption waste, including hazardous waste, using artificial intelligence;
- improving logistics, including transport corridors that allow for just-in-time supply chain continuity;
- government subsidization of the introduction of “green” technologies;
- promotion of an environmental culture among industrial companies and their stakeholders.

It is important to note that such measures are in line with the progressive practice of the global green economy. They have support at the state level and should be promoted in our society. Under modern conditions, with the economy undergoing formational shifts, changing global supply chains do not always manage to comply with the rules of ethical business conduct. Ultimately, end consumers suffer the consequences, and energy and natural resources are damaged. This is why scholars agree that in many cases the effectiveness of cleaner production and the promotion of environmentally friendly products could be influenced by green credit policies and low-carbon technological innovation in ESG-certified enterprises [38–40].

We realize that the transition to new technologies, including management technologies such as eco-branding, will require financial support; therefore, international experience is helping us to reassess the criteria for selecting participants in new projects [41–43]. The experiences of countries with developed energy infrastructures are valuable sources of knowledge for Kazakhstan’s economy [44,45].

The eco-branding of quality industrial products is not expected to cease to be at the basis of the choice between super profits and the protection of the ecosystem. How far can our civilization go, and how can we improve contacts among all participants in the technological cycle and the marketing of products? The answers to these questions do not always lie on the surface, as we can see, for example, in the case of the operation of large-scale facilities where platform integration is based on artificial intelligence [46,47]. In the early days, it was important for Kazakhstani industrial companies to overcome the digital divide, as technological breakthroughs are the basis of competitive advantages [48–50]. Digital platforms that ensure the safety of industrial facilities are important for a strategy of environmental care [51–53].

Artificial intelligence technologies facilitate an early response to possible threats of disruption in the process chain and prevent emergency stops and unintentional releases. However, we cannot forget about human factors or the advantages of building human capital [54,55]. In addition to environmental security, threats to food security can be reduced through cases of effective management [56]. The potential to build human capital in achieving environmental sustainability and the potential for productivity growth in modernized environmental industries accompany the global transition to new technologies [57–59]. Collaborative efforts to adopt clean technologies can serve as a green benchmark for development [60,61]. In practice, there will be obstacles to ecological development, which will need to be overcome. At the same time, the eco-branding system helps to develop ESG principles, and eco-branding motivates manufacturers to organize clean production.

Possible Limitations: Why does Kazakhstan, like other global market players, seek to strengthen its competitive advantages? Studies show that industrial companies have additional opportunities due to the inflow of green investments [62]. It is important not to forget that “cheap” resources cannot fully deliver industrial facilities from problems related to the market [63,64]. The global economy shows that the financial component (i.e., the ability to finance operations quickly and coherently), a diversified product range, and efficient production management help to sustain economic growth [65].

Our results indicate that the mechanisms for promoting the eco-branding of the studied region’s industrial complex should help to take a fresh look at the problems of company management in related industries [66–68]. International practices suggest how effective environmental management and branding changes the consumption paradigm [6,69]. However, the cost parameters of products and the lack of government support may be possible limitations to a successful transition to eco-branding [70–72].

Growth prospects: We share the views of scholars who explore the possibilities of accelerating the transformation of socio-economic systems according to ESG principles [73,74]. Based on the results of the survey, company managers are encouraged to engage with advisory support from reputable and leading companies on stock exchanges with experience in ESG optimization [75,76]. This will become increasingly important as the environmental crisis opens up opportunities to enter new markets with products and services of a high environmental standard [77,78].

Despite the accelerated pace of technological growth, we must remain committed to universal human values, care for the world around us, and strive to cultivate an ecological culture of consumption and respect for what our earth has given us. The task of scientists and researchers in the field can be defined as studying the sustainable economy as an opportunity to leave a “green” planet to future generations, because it is thanks to this concept that development programs are adopted by states, financing instruments appear, and individuals with a new view of the world are formed.

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Appendix A

Table A1. Industry affiliation of respondents (selection of one to two main types of activity), in % of respondents' population.

Economic Sector in Which the Organization Operates	Frequency	Percentage of Total Population, %
Agriculture, forestry, and fishery	6	13.3%
Mining and quarrying	5	11.1%
Manufacturing industry	4	8.9%
Electricity, gas, steam, hot water, and conditioned air supply	4	8.9%
Water supply	1	2.2%
Construction	4	8.9%
Wholesale and retail trade	4	8.9%
Transport and warehousing	2	4.4%
Accommodation and catering services	1	2.2%
Financial and insurance activities	2	4.4%
Operations with immovable property	1	2.2%
Professional, scientific, and technical activities	2	4.4%
Administrative and support services activities	1	2.2%
Public administration	2	4.4%
Social security	1	2.2%
Education	2	4.4%
Health care	2	4.4%
Arts, entertainment, and recreation	1	2.2%
Other services	12	26.7%

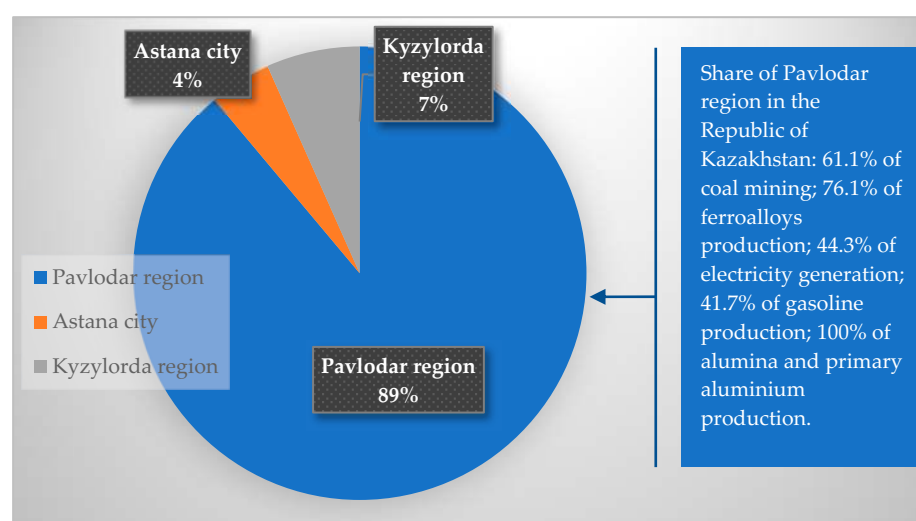


Figure A1. Territorial location of the respondents who took part in the survey on the development of technologies and the promotion of environmental branding of the industrial complex of the region, in % of respondents' population.

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Sustainable Economy: The Eco-Branding of an Industrial Region in Kazakhstan

By Davidenko, L (Davidenko, Lyudmila) [1]; Sherimova, N (Sherimova, Nurzhanat) [1]; Kunyazova, S (Kunyazova, Saule) [1]; Amirova, M (Amirova, Maral) [1]; Beisembina, A (Beisembina, Ansagan) [1]
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Abstract
In the sustainable economy, consumer preferences are gradually beginning to prioritize environmentally friendly products and services. A sustainable economy is directly linked to the growth of consumer welfare and the environmental culture. The success of environmental projects is largely determined by approaches to the management of complex interconnected objects, which operate in developed industrial regions. In this regard, we formulate the purpose of this study, which is to generalize approaches to and to improve the mechanisms of the ecological branding of the industrial complex of a region through conscious ESG transformation. For this purpose, we have studied the statistics and principles of the management systems of Kazakhstani companies and their stakeholders. The focus was on the Pavlodar industrial region, where metallurgical production, petrochemicals, the agro-industrial sector, the banking sector, and logistics hubs are developed. The vision and the mechanisms that can influence the development of the export potential of products with an "ecological brand" were studied. A survey of export-oriented organizations helped to identify the behavioral attributes of the "new generation eco-consumer", namely, a conscious desire to reduce the negative impact of production and economic activities on the environment. The theoretical significance of this study helps to reveal the influence of the ecological principles of the organization of modern production on the speed of transition to green technologies. Its practical significance is seen in the formation of a system for measuring the level of readiness of companies to promote the ecological branding of a region's industry outside its country.

Keywords
Author Keywords: sustainable economy; sustainable corporate governance; ESG transformation; eco-branding; consumer satisfaction; industrial economics; stakeholder responsibility
Keywords Plus: TECHNOLOGY; INNOVATION; COMPANIES; IMPACT

Author Information
Corresponding Address: Davidenko, Lyudmila (corresponding author)
Toraighyrov Univ, Dept Biotechnol, Pavlodar 140008, Kazakhstan
Addresses :
1 Toraighyrov Univ, Dept Biotechnol, Pavlodar 140008, Kazakhstan
E-mail Addresses : lyudmila7876@gmail.com; asanek2010@mail.ru; kunjazovas@mail.ru; maral.pvl@mail.ru; beisembina.ansa@gmail.com

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