ISSN 2560-421X
UDK 33+502/504

ECONOMICS

of Sustainable Development

1

Vol. X
Niš, 2026

ECONOMICS OF SUSTAINABLE DEVELOPMENT
ЕКОНОМИКА ОДРЖИВОГ РАЗВОЈА

ДРУШТВО ЕКОНОМИСТА “ЕКОНОМИКА” НИШ
SOCIETY OF ECONOMISTS “EKONOMIKA”, NIS

The Journal is issued three times a year. Year X, I-IV 2026, Vol. 1

ECONOMICS
OF SUSTAINABLE DEVELOPMENT

PUBLISHER: Society of Economists "Ekonomika", Nis

EDITORIAL BOARD

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NIKOLA TATAR

Prepress & Cover:
MILAN D. RANDJELOVIĆ

Address:
"EKONOMIKA", Society of Economists
18000 Nis, Maksima Gorkog 5/36

Phone: +381 (0)18 4245 763; 211 443
e-mail: zoki@medianis.net; ekonomika@sbb.rs
WEB: http://www.ekonomika.org.rs

Bank Account: 160-19452-17

Printed by:
"MEDIVEST"
18000 Niš
Copies: 200

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ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 10, January-April 2026, №. 1
UDK 33+502/504
ISSN 2560-421X

Ljiljana Bonić[1]
Snežana Radukić[2]
Bojan Krstić[3]
Jovana Milenović[4]
Faculty of Economics, University of Niš

P. 1-27
ORIGINAL SCIENTIFIC PAPER
DOI: 10.5937/ESD2601001B
Received: September 12, 2025
Accepted: January 8, 2026

THE IMPACT OF FINANCIAL PERFORMANCE ON KEY ENVIRONMENTAL PERFORMANCE OF HOTELS IN SERBIA WITH ENVIRONMENTALLY SUSTAINABLE PRACTICES

Abstract

This study examines 47 hotels in Serbia that implement environmentally sustainable practices and are listed on the Etic Hotels platform. The analysis draws on data for key environmental performance indicators (carbon footprint and Etic Green Score) sourced from the Etic Hotels website and the hotels' official websites, as well as financial statement data for 2023 obtained from the Serbian Business Registers Agency (APR). The research has two primary objectives: (a) to assess whether Serbian hotels listed on the Etic Hotels platform exhibit relatively stronger or weaker environmental performance, and (b) to evaluate the influence of operational efficiency indicators-specifically profitability and cost-efficiency on key environmental performance measures, including carbon footprint and the Etic Green Score.

The stated objectives were addressed using (a) cluster analysis, which enabled the classification of hotels in Serbia into two groups "green" (more environmentally sustainable) and "red" (less environmentally sustainable) and (b) multiple linear regression to investigate the relationships between financial performance and environmental performance indicators. All statistical analyses were conducted using the STATA/SE 13 software package.

The results of the analysis revealed the following: (a) "green" hotels dominate the Etic Hotels database (39 out of the 47 observed hotels). These hotels are characterized by a carbon footprint below the sample average (≈14.14 kgCO2e) and an above-average Etic Green Score (≈6.19/10). In contrast, eight hotels fall into the "red" cluster, exhibiting below-average environmental performance. (b) There is no statistically significant effect of financial performance, specifically profitability (ROA and ROE) and cost-efficiency (total cost-efficiency (TCE) and operating cost-efficiency (OPE)) on carbon footprint. However, ROE and OPE show a positive and statistically significant effect on the Etic Green Score, whereas

[1] ljiljana.bonic@eknfak.ni.ac.rs, ORCID ID 0000-0003-3877-8400

[2] snezana.radukic@eknfak.ni.ac.rs, ORCID ID 0000-0001-5636-2893

[3] bojan.krstic@eknfak.ni.ac.rs, ORCID ID 0000-0003-4597-6819

[4] jovana.milenovic@eknfak.ni.ac.rs, ORCID ID 0000-0001-9718-0383

TCE has a negative and statistically significant effect. ROA, however, does not have a statistically significant effect on the Etic Green Score.

The findings for 2023 indicate that among the 47 hotels in Serbia, there is an awareness of the importance of environmental performance and a willingness to report on it. However, this practice remains underdeveloped, as it is not yet widespread among all hotels in Serbia, 441 of which are listed on the website of the Ministry of Tourism and Youth. It is expected that the introduction of mandatory sustainability reporting regulations, aligned with green transition trends, by 2030 will support the full establishment of environmental and broader sustainability reporting practices within the Serbian hotel industry. This development would represent an initial step toward implementing new models of circular and regenerative sustainable business practices in the Serbian hotel sector.

Key words: *hotels, profitability, cost-efficiency, environmental performance, environment*

JEL classification: *Q56, L83, M21, M41*

УТИЦАЈ ФИНАНСИЈСКИХ ПЕРФОРМАНСИ НА КЉУЧНЕ ЕКОЛОШКЕ ПЕРФОРМАНСЕ ХОТЕЛА У СРБИЈИ СА ЕКОЛОШКИ ОДРЖИВИМ ПРАКСАМА

Апстракт

Истраживањем у овом раду је обухваћено 47 хотела са еколошком одрживом праксом у Србији који се налазе на Etic hotels сајту. Коришћени су подаци о кључним еколошким перформансама (карбонски отисак анд перформанса Etic green скор) са Etic hotels сајта и сајтова хотела, као и подаци из финансијских извештаја посматраних хотела са АПР-а за 2023. годину, са циљем: а) утврдити да ли су на Etic hotels сајту присутни хотели из Србије са бољим или лошијим кључним еколошким перформансама и б) испитати утицај финансијских перформанси (перформанси профитабилности и економичности) на кључне еколошке перформансе (царбон фоотпринт и етиц греен сцоре) ових хотела.

Постављени циљеви су реализовани применом а) кластер анализе (што је омогућило разврставање хотела у Србији у два кластера "зелени" - еколошки одрживији хотели и "црвени" - еколошки мање одрживи и б) вишеструке линеарне регресије за испитивање постојања утицаја између финансијских перформанси и еколошких перформанси. Наведене технике спроведене су коришћењем софтверског пакета STATASe 13.

Резултати извршеног истраживања су показали следеће: а) на сајту Etic hotels доминирају "зелени" хотели (39 од испитаних 47), као и да њих карактерише карбонски отисак испод просечне вредности (≈14,14kgCO2e) и виша перформанса Etic green скор од просечне вредности (≈ 6,19/10), док 8 хотела припада "црвеном" кластеру са еколошким перформансама испод просечних вредности; и б) не постоји статистички значајан утицај финансијских перформанси и то рентабилности (укупних средстава и сопствених средстава) и економичности (укупне и пословне економичности) *на карбонски отисак, док постоји позитиван статистички значајан утицај рентабилности сопствених средстава и пословне економичности на перформансу Etic green скор, и негативан статистички значајан утицај укупне економичности на перформансу Etic green скор, док рентабилност укупних средстава у контексту утицаја на перформансу Etic green скор није значајна.*

Резултати истраживања за 2023. годину указују да је у 47 хотела у Србији присутна свест о значају еколошких перформанси и да извештавају о њима, али да је оваква пракса још увек у развоју јер није присутна у свим хотелима у Србији, којих има 441 на сајту Министрства за туризам и омладину. Очекује се да ће увођење обавезне примене релевантне регулативе за извештавање о одрживости, која прати трендове зелене транзиције, до 2030. године омогућити да извештајна пракса о еколошким и другим одрживим перформансама заживи у хотелијерству у Србији. Ово би био први корак ка увођењу нових модела циркуларног и регенератвног одрживог пословања у хотелима у Србији.

Кључне речи: *хотели, профитабилност, економичност, еколошке перформансе, животна средина*

Introduction

Globally, awareness of the importance of environmental protection is increasing, with particular attention to issues such as ozone layer depletion, climate change, and global warming. In the tourism sector, the principles of environmentally sustainable business practices must be integrated across all tourism entities, especially hotels, which are often significant environmental polluters. Consequently, hotels should implement environmental performance management systems, adopt effective environmental policies, strategies, projects, activities, and measures for environmental preservation, and continuously monitor and analyze their outcomes. Increasing demand for the green transition has led to the evolution of hotel concepts from "eco" hotels to "green" hotels, and currently to "sustainable" and "regenerative" hotels. Large international hotel chains have recognized the significant role of environmentally sustainable business practices in enhancing operational efficiency. However, the management of many hotels does not consistently link improvements in environmental performance to business efficiency. Improvements in environmental performance are reflected in corporate image and reputation, which in turn can influence financial performance, including profitability, economic efficiency, and profits. Conversely, increasing revenues and profits over time can drive profitability growth while providing opportunities to allocate a larger portion of net profit toward investments in ecological initiatives, sustainable development, and regenerative business practices. The principles of regenerative business in the tourism sector remain a significant challenge for "green" hotels, which are expected to provide services that contribute to the revitalization and regeneration of local communities, enhance destination value, and promote economic prosperity.

The research presented in this paper is both theoretical and empirical in nature. The theoretical component reviews prior studies examining the relationship between operational efficiency in the tourism and hospitality sector and environmental performance, environmental preservation, and the regeneration of local communities. Additionally, the theoretical research includes the systematization and analysis of documents and regulations-global, European, professional, and Serbian national-relevant to reporting on environmental and other sustainability performance indicators of hotels in Serbia. Reporting on environmental sustainability in accordance with relevant regulations, together with the establishment of systems for managing the environmental aspects of sustainable development, contributes to the preservation of the natural environment, as well as the social, cultural, and economic characteristics of tourism destinations. The empirical component assesses the level of sustainability of Serbian hotels listed on the Etic Hotels platform and identifies the dominant group-those that are more environmentally sustainable versus those that are less sustainable. The second part of the empirical research examines the impact of financial performance on key environmental performance indicators for hotels listed on the Etic Hotels platform for 2023, based on the expectation that hotels with higher profitability and cost-efficiency will exhibit superior environmental performance compared with less efficient hotels.

In line with the research objectives, the paper is organized into four main sections in addition to the introduction and conclusion: a literature review summarizing prior studies; an analysis of the conceptual and regulatory framework for reporting on environmental and other sustainability performance indicators; a description of the sample and research methodology; and the presentation and discussion of research results.

1. Literature review

In today's global economy, sustainable development and environmental responsibility have emerged as central principles of corporate operations. This is particularly evident in the tourism and hospitality sector-an industry heavily dependent on natural resources-where there is a growing need to align economic efficiency with environmental protection, specifically the ecological performance of hotels. Hotels play a key role in the green transformation process, yet they are also significant consumers of energy, water, and materials, and generators of waste and CO_2 emissions. Consequently, assessing operational efficiency alongside ecological performance has become essential for understanding hotel competitiveness and business sustainability (Bruns-Smith et al., 2015), as well as for enhancing their environmental and social impact.

Numerous studies indicate that operational efficiency contributes not only to improved financial performance but also to enhanced environmental performance in hotels. Dias et al. (2024) report that environmental certification provides hotels with multiple benefits, ranging from cost reductions and strengthened brand image to increased competitiveness. Radović et al. (2023) confirm that hotels in Serbia holding the Green Key certificate achieve higher business excellence rankings and lower risk levels. Similar conclusions were drawn by Stanišić et al. (2019), who emphasize that profitability indicators are directly linked to environmental initiatives and investments in new technologies that enhance energy efficiency and overall eco-efficiency.

In examining the determinants of operational efficiency, authors such as Agiomirgianakis et al. (2012, 2013) and Škuflić and Mlinarić (2015) emphasize the importance of internal resources, including financial resources (sources of financing), natural resources (capitalization and size), and intangible resources (intellectual capital and innovation). The efficient use of these resources is particularly critical in the hotel industry, as hotels are characterized by a high proportion of fixed, capital-intensive costs, which require rational management and careful cost planning. Dmitrić et al. (2019) demonstrate that hotels with greater liquidity and more efficient working capital management achieve higher profitability, while Pervan and Višić (2012) emphasize that increased asset utilization contributes to higher profitability.

Operational efficiency is commonly measured using indicators such as return on assets (ROA), labor productivity, and total asset turnover ratio (Dmitrić et al., 2019; Škuflić and Mlinarić, 2015), further incorporating eco-indicators, including energy consumption per guest, waste generation per overnight stay, and the share of renewable energy sources in total consumption (Campos et al., 2024). The integration of economic and environmental indicators enables a comprehensive assessment of business performance and has emerged as a key criterion for sustainable operations in the hotel sector.

Recent literature shows a growing interest in the intersection of environmental sustainability and operational efficiency. Lin et al. (2023) and Chen (2019) analyze the efficiency of “green” hotels in the EU, indicating that investments in green technology may temporarily reduce operational efficiency, but in the long term contribute to greater value creation and enhance the hotel’s reputation. Robinson et al. (2016) and Balaji et al. (2019) emphasize that hotels with environmental labels achieve higher average daily room rates and a stronger brand image, although they may experience lower occupancy rates. These findings underscore the importance of balancing economic and environmental objectives in hotel management.

In the context of Serbia, Stanišić et al. (2019) and Radović et al. (2023) confirm that hotels implementing environmental sustainability practices-including energy efficiency, recycling, and optimization of resource consumption-achieve superior outcomes in terms of cost efficiency and guest satisfaction. These findings confirm that environmental responsibility should not be regarded merely as a cost, but rather as an investment in long-term competitiveness.

Further research (Campos et al., 2024; Ekmekçi and Ersoy, 2025) indicates that the key determinants of environmental performance include fossil fuel usage, energy and water consumption, and waste management. The implementation of measures-including the adoption of renewable energy sources, optimization of resource consumption, and recycling-enables hotels to simultaneously reduce their environmental footprint and enhance operational efficiency.

The literature review suggests a significant interdependence between hotels’ environmental performance and the financial outcomes of operational efficiency. Environmental performance in the hospitality industry constitutes a key aspect of sustainable business, as it enables the reduction of negative environmental impacts through the efficient management of essential resources, including energy, water, and waste. The adoption of green technologies and international certifications not only enhances the hotel’s image and reputation but also facilitates cost reduction and increased profitability (Radović and Čerović, 2021; Arbelo et al., 2025). Successful implementation, however, requires a strategic approach, ongoing management education, and systematic monitoring of sustainable development standards to prevent "greenwashing" (Legrand et al., 2017; Elhoushy et al., 2025). Although initial costs are involved, the long-term benefits are manifold, ranging from reduced operational expenses to the creation of additional value through improved resource management and the sustainable development of the tourism sector. These practices further contribute to environmental protection objectives and the promotion of green tourism, consistent with sustainable development principles (Radović and Čerović, 2021; Arbelo et al., 2025; Bruns-Smith et al., 2015).

2. Conceptual and Regulatory Framework for Reporting on Environmental Performance in Hotels in Serbia

The green transition in the tourism and hospitality sector has progressed globally from the "green" phase (late 20th to early 21st century), through the "sustainable" phase (2015–2020), to new approaches emphasizing circular and regenerative tourism and hospitality (post-2020).

The United Nations Environment Programme (UNEP) Annual Report 2024, *We are all in this together* (UNEP, 2024), indicates that countries worldwide must exhibit greater ambition and implement actions at the national level to enhance environmental performance, with business entities-including hotels-playing a central role in this process. This underscores the increasing recognition of the importance of reporting on environmental performance, both at the national level and within individual business entities.

Environmental performance reporting, as a component of non-financial performance reporting, emerged during the final decade of the 20th century (Krstić, 2022). Its purpose is to provide insight into the activities undertaken by business entities, including hotels, with the objective of balancing operational activities and their environmental impacts (Spasić, 2020). Environmental performance reporting is increasingly integrated into emerging concepts of corporate reporting, developed to complement financial reporting, including business reporting, integrated reporting, non-financial performance reporting, and sustainability reporting. Consequently, numerous international, professional, and national organizations are engaged in the adoption of guidelines and the development of regulations aimed at ensuring, directly or indirectly, that sustainability performance reporting becomes an integral component of mandatory annual reporting for business entities, including hotels.

2.1. The Concept of Sustainable Development and the Regulatory Framework for Reporting on Environmental Performance in Hotels in Serbia

By adopting the UN Agenda 2030 (UN, 2015), United Nations member states committed to implementing and achieving the 17 Sustainable Development Goals (SDGs), which are derived from the Millennium Declaration and the Millennium Development Goals 2000–2015 (UN, 2000). Sustainable development entails a long-term commitment to enhancing living conditions across the economic, social, and environmental dimensions. In implementing Agenda 2030, the UN has encouraged not only member states but also numerous international organizations, institutions, and various national actors to support the global achievement of the SDGs.

In Serbia, *documents supporting sustainable development and establishing the regulatory framework for reporting on environmental and other sustainability performance in hotels* can be classified into four levels: (a) global documentantion, (b) European documents and regulations, (c) professional regulations, and (d) national legal documents and regulations (Table 1).

Table 1: Documents and Regulatory Framework for Reporting on Environmental and Other Sustainability Performance Relevant to Hotels in Serbia

I Global documentation	
A) General Documentation:	***B) Hotel-Oriented Documentation:***
• Kyoto Protocol (1997) • GHG Protocol (2011) • Paris Agreement (2015) • Agenda 2030 (2015)	• Global Code of Ethics for Tourism (2015) • Framework Convention on Tourism Ethic (2020) • Net-zero Roadmap for Travel and Toursim (2021) • Guiding Principles for Sustainable Investment in Tourism (2025)
II European Documents and Regulations	
A) General European Documents and Regulations	***B) Hotel-Oriented Documentation:***
• European Green Deal (EGD) (2019) • EU Taxonomy (2020) • European Climate Law (2021) • Directive EU CSRD 2022/2464 (2022) • European sustainability reporting standards (ESRS) (2023) • Directive EU CSDDD 2024/1760 (2024) • Omnibus COM 81 and 80 (2025)	• European Agenda for Tourism 2030 (2022) • European Travel Commission (ETC) Strategic Framework 2030 (2022) • Urban Agenda for the EU Sustainable Tourism Partnership action plan 2024 (2024) • New EU Tourism Strategy set for release in early 2026 (2025)
III Professional Regulations	
• ISO standards of the International Organization for Standardization • GRI standards • IFRS Accounting Standards S1 i S2 (2023) • Key International standards on auditing (ISAs: 701, 706 i 720) • International standard on assurance engagements (ISAE) 3000	
IV Documents and Legal Regulations in Serbia	
• Green Agenda for the Western Balkans (2020) • Climate Change Law of Serbia (2021) • Law on Accounting (2021) • Environmental Protection Law (2024) • Toursim Development Strategy of the Republic of Serbia for the period 2016 – 2025. • Rulebook micro and other legal entities (2020) • Guidelines for non-financial reporting in Serbia (2025)	

Source: Table compiled by the authors

Global documentation consists of instruments adopted by the United Nations and other international organizations that primarily aim to initiate the development of national sustainable development strategies. The Kyoto Protocol (UN, 1997) did not succeed in establishing a foundation for sustained progress in combating climate change, thereby requiring a revised approach. Of particular relevance for measuring carbon footprints and performance related to reducing air pollution worldwide is the Greenhouse Gas

Protocol (GHG Protocol), which defines the principles and methodologies for measuring and reporting emissions across three categories: Scope 1, Scope 2, and Scope 3 (GHG Protocol, 2011). This protocol represents the most widely used methodology for GHG accounting, although it is not the sole reporting framework available. The UN Paris Agreement, drafted in 2015 and signed in 2016, is based on a voluntary commitment endorsed by countries worldwide. Agenda 2030, adopted in 2015, further reinforces the importance of sustainable development through its 17 Sustainable Development Goals (SDGs) (UN, 2015), which emphasize a long-term commitment to improving living conditions across economic, social, and environmental dimensions. For development to be sustainable, growth must be inclusive, ensuring that no one is left behind.

Global regulations relevant to hotels include documents that establish, within an international context: (a) an ethical framework (UN WCTE, 2015; UN WTO, 2020), (b) a framework for decarbonization, environmental performance measurement, and sustainability reporting (UN WTTC, 2021), and (c) a framework for investment in the tourism and hospitality sector (UN Tourism, 2025). *The 2021 Net-Zero Roadmap for Travel and Tourism* (UN WTTC, 2021) was developed by the World Travel & Tourism Council (WTTC) as a proposed target framework for the travel and tourism sector. This document outlines an action framework for decarbonization, guiding principles, key levers, and a set of potential measures for hotels.

European regulations on sustainability reporting are mandatory for EU member states, although Serbia also adopts and implements these regulations, as it does with global frameworks. Foremost among these is the European Green Deal of 2019, which aims to achieve the objectives of the Paris Agreement (European Commission, 2019). The *EU Taxonomy*, established under Regulation 2020/852, provides a classification system for environmentally sustainable economic activities, helping to mitigate the risks of greenwashing and guiding investors in directing capital toward activities essential for the green transition. The EU Taxonomy also serves as a tool for financial and non-financial entities to plan and communicate their business strategies, transition pathways, and investment or lending activities aimed at facilitating the shift to a low-carbon economy (Regulation EU 2020/852, 2020). This regulation is complemented by the European Climate Law, adopted in 2021, which legally enshrines the European Green Deal's goal for the economy and society to achieve climate neutrality by 2050. The law further establishes an intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030 relative to 1990 levels (Regulation EU 2021/1119 – European Climate Law, 2021). Additionally, in 2021, the European Commission published its climate action plan, the Fit for 55 package (European Commission, 2021).

With the adoption of the EU Directive in 2022-*the Corporate Sustainability Reporting Directive* (CSRD) - sustainability reporting became formally regulated (Directive EU 2022/2464, 2022). This directive consolidates and replaces Directive EU 2013/34 on financial reporting and Directive EU 2014/95 on non-financial reporting. In 2024, the EU adopted the Corporate Sustainability Due Diligence Directive. The directive aims to ensure that companies operating within the internal market contribute to sustainable development and facilitate the transition toward a sustainable economy and society (Directive EU 2024/1760, 2024). The directive also seeks to reduce financial and administrative burdens for small and medium-sized enterprises. Between the adoption of these two directives, the European Commission published the *European Sustainability*

Reporting Standards (ESRS) in 2023. The ESRS comprise twelve standards covering reporting principles and requirements, including several focused on climate and pollution. These standards require companies listed on stock exchanges with more than 500 employees to submit their 2024 sustainability report in 2025. From 2025 onwards, the obligation to apply the standards will extend to other large companies and, beginning in 2026, to small and medium-sized enterprises.

However, the objectives set by these directives were substantially modified with the adoption of the Omnibus package of measures in 2025 (Omnibus COM 81 and 80). By raising the threshold for mandatory sustainability reporting to companies with more than 1,000 employees and an annual turnover exceeding €450 million, approximately 80% of companies were exempted from the obligation to disclose sustainability-related information (European Commission, 2025a; European Commission, 2025b). Consequently, the potential of the CSRD and CSDDD Directives to encompass a broader share of the market and supply chain was diminished. The removal of the reporting obligation for medium-sized companies, focusing solely on the largest entities, can be interpreted as a regression in promoting transparency, sustainability, and corporate accountability, which the CSRD and CSDDD Directives originally sought to enhance. In October 2025, the European Parliament rejected the negotiating mandate for the Omnibus package, which had previously been approved by the Council of the European Union in February of the same year, thereby delaying its implementation and further progress in simplifying the CSRD and CSDDD Directives (European Parliament, 2025). The next stage involves a new vote at the Plenary Session of the European Parliament, scheduled for November 2025, after which negotiations between the European Parliament, the European Commission, and the Council of the EU may commence.

European regulations addressing environmental and sustainable practices in hotels include two key agendas: the European Tourism Strategy and the European Standards for Sustainability Reporting. The European Tourism Agenda 2030 (2022) is based on the European Commission's Transition Pathway for Tourism and outlines a programme of actions to be implemented by EU member states, the European Commission, and stakeholders within the tourism ecosystem. The Urban Agenda for the EU Sustainable Tourism Partnership Action Plan 2024 provides a set of activities to be implemented specifically by EU member states, cities, and tourism entities. Together, these agendas form the foundation of the EU Tourism Strategy 2022, while the adoption of a new EU Tourism Strategy is expected in early 2026.

Professional regulation applicable to all business entities, including hotels, and related to the measurement, reporting, and verification of information on environmental and other sustainability performance includes:

- *ISO standards* of the International Organization for Standardization provide a scientific and technological foundation that supports the development of legal, environmental, safety, and health frameworks. The certification of a product or service according to an ISO standard ensures reliability, quality, and safety, thereby enhancing the confidence of users of tourism services. Within the hotel industry, the following standards are particularly significant: ISO 14001 Environmental Management System, ISO 50001 Energy Management System, ISO 9001 Quality Management System, ISO/IEC 20000-1 Service Management, among others;

- *GRI Standards* – Global Reporting Initiative (GRI) standards are the most widely adopted standards for sustainability reporting in the hospitality industry. The first version of the standard was published in 2016, and a revised version was released in 2021, now consisting of *universal standards, thematic standards*, and *sector-specific standards*;
- *Accounting standards* – The IFRS Foundation, in cooperation with the International Accounting Standards Board (IASB) and the International Sustainability Standards Board (ISSB), has developed two standards: IFRS S1 – *General Requirements for Disclosure of Sustainability-related Financial Information*, and IFRS S2 – *Climate-related Disclosures*.
- *Auditing standards* – The key International Standards on Auditing (ISAs), which facilitate external verification of environmental and other sustainability-related performance information and have been adopted by the International Auditing and Assurance Standards Board (IAASB), include: ISA 701 – *Communicating Key Audit Matters in the Independent Auditor's Report*; ISA 706 – *Emphasis of Matter Paragraphs and Other Matter Paragraphs in the Independent Auditor's Report*; and ISA 720 – *The Auditor's Responsibilities Relating to Other Information in Documents Containing Audited Financial Statements*. Additionally, the International Standard on Assurance Engagements (ISAE) 3000 – *Assurance Engagements Other Than Audits or Reviews of Historical Financial Information* – is also relevant for verifying sustainability-related information

In Serbia, global and European documents and regulations have served as the foundation for adopting national laws and strategies related to environmental sustainability, as well as for reporting by business entities on environmental and other sustainability performance. The Green Agenda for the Western Balkans, signed in 2020, represents a regional development strategy designed to assist Western Balkan countries in addressing the challenges of climate change and the green transition, and to align national environmental regulations with European standards and norms. The Agenda defines five priority areas requiring action from Western Balkan countries: 1) decarbonization, 2) circular economy, 3) combating water, air, and soil pollution, 4) sustainable food production, and 5) biodiversity, including the protection and restoration of natural ecosystems (Green Agenda for the Western Balkans, 2020). The Tourism Development Strategy 2016–2025 encompasses an analysis of the current state and level of tourism development, a comparative assessment of tourism in competitor countries, an evaluation of strengths and weaknesses in the tourism sector, a business mission, vision, and development objectives, the identification of priority tourism products, a proposal of key tourist destinations, an assessment of impacts on cultural heritage and natural resources, and a proposal for a comprehensive tourism development policy. Regarding environmental sustainability, Serbia has adopted the Law on Climate Change 2021 (Sl. glasnik RS, 26/2021) and the Law on Environmental Protection 2024 (Sl. glasnik RS, 135/2004, 36/2009, 72/2009, 43/2011, 14/2016, 76/2018, 95/2018, and 94/2024).

Also, the Law on Accounting (Sl. glasnik RS, 73/2019 and 44/2021) introduces the obligation to report on sustainable development for large entities, which includes large hotels with more than 500 employees. An exception to the obligation to disclose non-financial information is provided to dependent legal entities that are included in the parent company's consolidated annual report. Also, if they want, small and medium-sized entities, including hotels, can compile a report on sustainable development on a voluntary basis. Micro legal entities apply the by-law issued by the minister in charge of finance - Rulebook on the method of recognition, valuation, presentation, and disclosure of positions in individual financial reports of micro and other legal entities (Rulebook micro and other legal entities) (Sl. glasnik RS, 89/2020). In October 2025, the Ministry of Finance issued an Explanation regarding the guidelines for non-financial reporting in Serbia (https://www.mfin.gov.rs/upload/media/kQoEF9_691ed576a394b.pdf), which is a starting point for improving sustainability reporting and aligning with ESRS. The guidelines do not have a binding character, but they are a recommendation for entities for use in order to facilitate the transition to the mandatory reporting model adopted by the European Commission and support for improving the quality, clarity and relevance of the disclosure of non-financial information.

Although Serbia currently lacks an officially adopted Environmental Protection Strategy, the Ministry of Environmental Protection published a draft version in September 2024, covering the period 2024–2033 and referred to as the Green Agenda of the Republic of Serbia. Large business entities in Serbia, including hotels, most frequently report on sustainable development in accordance with global professional standards (GRI Standards) or accounting standards (IFRS S1 and S2), while also considering the requirements of European directives.

The CSRD (EU 2022/2464) obliges large companies to report on sustainable development beginning with the 2025 fiscal year, while listed small and medium-sized enterprises (SMEs) with fewer than 250 employees are required to comply starting in the 2026 fiscal year. In contrast, the CSDDD (EU 2024/1760) alleviates financial and administrative burdens for SMEs while establishing mandatory due diligence for all reporting entities to prevent and remediate adverse impacts on human rights and the environment.

The Omnibus package of measures from February 2025 (Omnibus COM (2025) 81 and 80) exempts 80% of enterprises from the obligation to report on sustainable development under the EU CSRD (2022/2464) by postponing the reporting requirement for companies scheduled to begin reporting in 2026 or 2027, namely small and medium-sized enterprises (SMEs). Additionally, the package introduces the concept of dual materiality for taxonomy reporting. Consequently, its temporary postponement in October 2025 has added further complexity to the implementation of sustainability reporting obligations in both the EU and Serbia.

2.2. Circularity and Regenerativity: Emerging Approaches to Sustainable Business in the Serbian Hospitality Industry, where Sustainable Development Reporting is Imperative

The circular economy is closely associated with the sustainable economy model (Goss et al., 2024). It constitutes an economic system in which production resources, waste, emissions, and energy outflows are significantly minimized by slowing, closing, and extending energy and material cycles throughout production processes (life cycles). Within a circular economy, emphasis is placed on innovative thinking across all stages of production and service delivery (design thinking), systems thinking, prolonging product lifespans, and recycling. This is achieved primarily through product design that maximizes longevity, as well as through maintenance, servicing, and end-of-life recycling. When a product reaches the end of its life, its constituent materials continue to circulate through recycling. The EU aims to establish a circular and climate-neutral economy by 2050, which has prompted the introduction of a range of regulations in recent years, including ecodesign requirements and the right to repair. Numerous plans, strategies, directives, and regulations have been adopted across EU countries to facilitate the transition to a circular economy (see Table 7), and these measures are also monitored by Serbia. This framework clearly demonstrates that reporting on sustainable performance is an essential component of circular economy development, including within the hotel industry.

Table 2: Documents and regulations in the EU related to the circular economy

Plans and frameworks:	***Strategies:***
• Circular action plan (2015, 2020)	• Plastics strategy (2018)
• Clean Energy For All Europeans (2016)	• Pharmaceuticals strategy for Europe (2020)
• A New Industrial Strategu for Europe (2020)	• EU's chemicals strategy for sustainability (2020)
• Beating cancer plan (2020)	• EU's biodiversity strategy for 2030 (2020)
• Hydrogen strategy (2020)	• European industrial strategy (2021)
• Pharmaceuticals strategy for Europe (2020)	• EU strategy for sustainable and circular textiles (2022)
• EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' (2021)	• European Agenda for Tourism 2030 (2022)
• Circular economy Monitoring framework (2018, 2023)	• AI Strategy plan (2025)
• Consultation on Circular Economy Act (2025)	
Laws:	
Nature Restoration Law (2024)	
Directives:	***Regulations:***
• Directive (EU) 2018/851 on Waste Framework directive	• Regulation (EU) 2018/858 New End-of-Life Vehicle Regulation
• Directive (EU) 2018/852 on packaging and packaging waste	• Regulation (EU) 2023/1542 Batteries Regulation (2023)
• Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment	• Regulation (EU) 2023/2055 - EU microplastics restriction (2023)
• Directive (EU) 2023/2413 for promotion of energy from renewable sources	• Regulation (EU) 2024/1157 on shipments of waste (2024)
• Delegated Directive (EU) 2023/544 amends the ELV (End-of-Life Vehicle) Directive 2000/53 as regards the exemptions for the use of lead in aluminium alloys for machining purposes, in copper alloys and in certain batteries	• Regulation (EU) 2024/1781 a framework for the setting of ecodesign requirements for sustainable products (ESPR) (2024)
• Directive (EU) 2024/825 Green Claims Directive for empowering consumers for the green transition through better protection against unfair practices and through better information	• Regulation (EU) 2025/40 on packaging and packaging waste (2025)
• Directive (EU) 2024/1799 on repair of goods	

Source: Table compiled by the authors

The Circular Economy Package in the EU was adopted with the objectives of enhancing global competitiveness, promoting sustainable economic growth, and creating new employment opportunities. It comprises two EU action plans for the circular economy (2015 and 2020), encompassing measures across the entire life cycle of products, from production and consumption to waste management and the market for secondary raw materials. Building on the 2015 Circular Economy Action Plan, the 2020 Circular Economy Action Plan (CEAP II) focuses on resource-intensive sectors with high potential for circularity, including tourism and hospitality. The plan aims to retain resources within economic cycles for as long as possible and address key product value chains, including electronics and information and communication technologies (ICT), batteries and vehicles, packaging, plastics, textiles, and food. The circular economy model is designed to minimize the use of natural resources and energy while reducing waste generation, pollution, and other negative environmental impacts. These action plans have served as the foundation for the adoption of numerous strategies, laws, directives, and regulations within the EU, providing detailed guidance to member states for the development of a circular economy.

In the context of Serbia's transition to a circular economy, the Roadmap for Circular Economy in Serbia 2020 was adopted, identifying the following priority sectors: (a) manufacturing, (b) agriculture and food, (c) plastics and packaging, and (d) construction. Tourism and hospitality were not included among the priority sectors. Several related strategies have also been adopted, including the Energy Development Strategy of the Republic of Serbia until 2025 with projections until 2030 (2015), the Sustainable Urban Development Strategy of the Republic of Serbia until 2030 (2019), and the Industrial Development Strategy of the Republic of Serbia for the period 2021–2030 (2020). The Waste Management Act was adopted in 2023. Public consultations on the Circular Economy Law commenced in 2025, with the adoption of this significant legislation expected in 2026. This indicates that the development of a circular economy in Serbia is still in progress.

With the adoption of the New Urban Agenda 2016 (UN, 2016) and related documents, the circular economy evolved into a demand for a regenerative sustainable economy, focusing not only on reducing environmental pollution but also on restoring and enhancing natural resources and ecosystems, promoting social equity, and supporting economic vitality (Čegar et al., 2014). The regenerative economic model aims to overcome the extractive nature of traditional capitalism - focused on profit maximization - and instead, prioritizes resource replenishment, environmental preservation, and the well-being of communities. A central component of this model is systemic thinking, circularity, and an integrative approach that balances environmental, social, and economic factors in the delivery of production and services.

Viewed through the lens of the regenerative economy, the hotel industry has emerged as a critical sector that prioritizes the restoration and enhancement of natural ecosystems, promotes social equity, and fosters long-term economic sustainability. According to Kohut et al. (2024), the principles of the regenerative economy that can be applied in the hotel industry include the following:

a) Systems thinking, which requires a holistic perspective that recognizes the interconnectedness of environmental, social, and economic systems. This approach encourages long-term, sustainable, and resilient business practices rather than short-term profit maximization.

b) Circularity: In the hotel industry, circularity involves minimizing waste, utilizing renewable energy sources, reducing environmental degradation and pollution, maximizing resource efficiency, leveraging digital technologies, fostering collaboration, and networking among stakeholders, and promoting the reuse and recycling of resources.

c) Equity and inclusiveness: These principles aim to reduce inequalities by promoting social inclusion and ensuring that the benefits of regeneration reach all segments of society, particularly vulnerable and marginalized communities.

d) Regenerative hospitality practices: These practices not only aim to prevent harm but also actively seek to regenerate ecosystems and resources, thereby enhancing natural and social capital over time.

The development of a regenerative hotel industry in accordance with the principles of regenerative sustainable development remains in its early stages and is still a novel concept within Serbian hotel practice. Even hotels in Serbia that belong to large international chains-such as the Radisson Collection Old Mill, IN Hotel, Hilton, and Radisson Red Arena-although holding Green Key and other relevant certifications, have not yet fully met the requirements of circular and regenerative sustainable development. Circular and regenerative practices in the hotel industry primarily involve the adoption and implementation of appropriate regulatory frameworks, including regulations for reporting environmental and other performance metrics, as well as innovative business approaches and collaboration with local communities. To date, hotels in Serbia have not fully achieved the fundamental prerequisites necessary for the implementation of regenerative sustainable practices.

3. Sample Description and Research Methodology

The aim of this paper is twofold: (a) to determine whether the Etic hotels website (https://etichotels.com) is dominated by hotels from Serbia with higher or lower key environmental performance, as measured by carbon footprint and Etic green score, and (b) to examine the impact of financial performances, including profitability and cost-efficiency performance, on the key environmental performance of Serbian hotels that report on environmental sustainability. In accordance with the aim of this research, the following hypotheses were formulated:

H1: The Etic Hotels website is dominated by hotels in Serbia with higher key environmental performance.

H2: Financial performance, including profitability and cost-effectiveness, has a positive impact on the carbon footprint (Model 1)

H2/a: Profitability performance (ROA and ROE) has a positive impact on the carbon footprint.

H2/b: Cost-efficiency performance (total cost-efficiency - TCE and operating cost-efficiency - OPE) has a positive impact on the carbon footprint.

H3: Financial performance (profitability and cost-efficiency performance) has a positive impact on the etic green score (Model 2).

H3/a: Profitability performance (ROA and ROE) has a positive impact on the etic green score.

H3/b: Cost-efficiency performance (total cost-efficiency (TCE) and operating cost-efficiency - OPE) has a positive impact on the etic green score.

Return on Assets (ROA) is calculated by dividing operating income by total assets. Return on Equity (ROE) is calculated by dividing net income by shareholders' equity. Total cost-efficiency (TCE) is ratio total revenues to total expenditures (costs). Operating cost-efficiency (OPE) is ratio operating revenues to operating expenditures (costs). The research utilized secondary data for 2023 obtained from the Etic Hotels website, from the websites of individual hotels regarding their key environmental performance, and from the financial statements of hotels for 2023 available on the website of the Business Registers Agency (https://pretraga.apr.gov.rs/).

On the website of Etic hotels ETIC, hotels that have aligned their operations with the Hotels Green Standard (EHGS) are promoted. The EHGS was established to ensure responsible and sustainable travel. Etic Hotels is an online platform that leverages artificial intelligence and machine learning to systematically analyze large volumes of publicly available hotel data worldwide, enabling tourists to make informed and responsible decisions. The EHGS certification process constitutes a structured assessment of the sustainability performance of travel and tourism businesses and their supply chain partners. Hotels can monitor improvements and document achievements that contribute to sustainability certification and effective hotel management. The EHGS comprises 44 core criteria and more than 380 indicators of compliance. Applicable indicators vary depending on the type of certification, geographical region, and local factors. The standard is updated biannually. The EHGS is harmonized with other internationally recognized sustainability certification programs. This harmonization process ensures the maintenance of fundamental criteria while simultaneously addressing regional issues through the adoption of locally developed standards.

The EHGS is founded on four certification pillars aligned with etic, environmental, and social values. The first pillar addresses the environment and evaluates the hotel's commitment to conserving resources, minimizing environmental impact, and prioritizing energy-saving practices. The second pillar focuses on social responsibility, aiming to empower local communities through fair trade, labor law compliance, and community engagement. This pillar ensures that hotels contribute to local economic development, promote cultural preservation, and uphold etic treatment of their workforce. The third pillar focuses on cultural heritage and site protection, thereby advocating for cultural diversity and preservation. The fourth pillar, of particular significance, relates to sustainable management and evaluates the hotel's adherence to sustainable management systems, health and safety standards, legal compliance, employee training, and high-quality customer experiences. Collectively, the pillars of the Etic Hotels Green Standard allow tourists to participate in the green transition within the tourism industry by selecting EHGS-certified accommodations.

The selection of hotels from Serbia for the Etic Hotels survey was based on key environmental performance metrics: carbon footprint and etic green score.

The ETIC Green Standard incorporates the methodology for calculating the carbon footprint of a hotel stay. The carbon footprint associated with a stay is determined using the Cornell Hotel Sustainability Benchmark Index and the most recent greenhouse gas (GHG) conversion factors published by the UK government in 2022. This methodology provides accurate information regarding the environmental impact of tourist stays at hotels. At the core of the methodology is an algorithm that considers several parameters, including country of stay (region or city), hotel rating, number of rooms occupied, and duration of the visit. Using this approach, an accurate estimate of the carbon footprint generated by a tourist's hotel stay can be obtained. With reliable information on the carbon footprint of a hotel visit, tourists can make informed decisions consistent with their values and contribute to a greener future. Hotels on the Etic Hotels website are classified according to the following certification levels:

1. Gold – with a Etic Green Score of 8.0 or higher (8–10)
2. Silver – with a Etic Green Score of at least 6.0 (6–8)
3. Bronze – with a Etic Green Score below 6.0 (4–6).

Additionally, the selection of hotels from Serbia on the Etic Hotels website was also based on the carbon footprint, an environmental performance metric that allows travelers to choose accommodations aligned with values promoting a more sustainable future. Hotels on the Etic Hotels website are ranked according to their carbon footprint across four levels:

- Carbon footprint level 0–20 tCO2
- Carbon footprint level 20–30 tCO2
- Carbon footprint level 30–40 tCO2
- Carbon footprint level 40–50 tCO2.

Hotels from Serbia with environmental performance corresponding to a Silver certification of the Etic Green Score (6–8) and a carbon footprint level of 0–20 tCO2 O_2 were selected for the study. The final sample comprises 47 hotels implementing environmental sustainability practices in Serbia (Table 3)[5].

Table 3: List of hotels in the research sample

No	Green Hotels	Environmental Performance		Financial Performance			
				Profitability Performance		Cost- Efficiency Performance	
		Carbon footprint (kgCO2e)[6]	Etic Green Score (/10)	ROA (%)	ROE (%)	TCE	OPE
	Hotel Radisson Collection Old Mill	13,70	5,40	1,65	/	0,96	1,22
	IN Hotel	13,82	6,10	24,06	21,29	1,53	1,54
	Hotel Mona	13,19	5,90	7,42	11,64	1,20	1,34
	Hotel Hilton	15,39	6,10	7,72	42,10	1,17	1,29
	Hotel Mercure Excelsior	14,43	5,60	6,10	4,45	1,14	1,18
	Radisson Red Arena hotel	/	/	/	/	0,12	0,14
	Crowne Plaza Delta Hospitality	15,68	5,80	5,19	3,89	1,07	1,31

[5] The initial sample comprised 67 hotels, as listed on the Etic Hotels website. Of these, 20 hotels were excluded from the analysis due to the unavailability of the required 2023 financial statements, namely the balance sheet and income statement.

[6] On the Etic Hotels website, the carbon footprint is reported in tCO2, whereas on the individual websites of the selected hotels it is reported in kgCO2e (kilograms of carbon dioxide equivalent).

Hotel Indigo Profileonplus doo	13,76	6,10	5,00	4,48	1,26	1,51
Courtyard Bg. City Center by Marriott	13,37	5,40	5,02	5,42	1,02	1,02
Belgrade Art Hotel	13,23	6,10	5,33	5,82	1,11	1,11
Garni Hotel Royal Crown	13,74	6,10	6,30	5,53	1,04	1,04
Hotel Ema	15,65	6	8,28	/	1,00	1,00
Aveny	13,27	6,4	12,55	23,57	1,17	1,17
Hotel Helvetia	14,41	6,2	/	/	0,99	0,99
Sky hotel Belgrade	12,97	6,6	4,44	4,83%	1,09	1,09
Mark Hotel Belgrade	12,96	6,1	/	33,89	1,05	1,05
Mama Shelter Belgrade	15,25	6,6	16,69	77,99	1,03	1,03
Abba Hotel	15,58	6,2	4,05	12,53	1,11	1,11
Hotel Tesla Smart Stay	13,2	6	23,63	59,52	1,12	1,12
88 Rooms Hotel	14,65	6	/	/	0,12	0,12
Golden Tulip Zira Belgrade	13,22	6,6	2,43	295,12	1,01	1,01
Square Nine Hotel	15,39	6	1,56	2,85	1,09	1,09
Saint Ten Hotel	14,78	6,4	14,81	22,61	1,21	1,21
Hotel Moskva Belgrade	13,83	6	5,44	14,56	1,38	1,38
Envoy Hotel	15,67	6,2	7,06	21,78	1,04	1,04
Xenon	14,06	6,2	24,50	24,50	1,23	1,23
Heritage Hotel	15,38	6,6	24,50	24,50	1,23	1,23
Euro Garni Hotel	12,93	6,2	5,90	6,27	1,14	1,14
Hotel M Beograd	14,1	6,4	5,56	4,96	1,14	1,14
Hotel Prag	15,23	6,1	9,77	9,58	1,16	1,16
Nova City Hotel Signature Collection	14,64	6,6	23,57	70,73	1,20	1,20
Sterling Hotel	14,26	6,4	3,15	/	1,00	1,00
Zepter Hotel Vrnjacka Banja	14,35	6,1	9,80	/	1,01	1,01
Grey Hotel Kopaonik	14,52	6,4	/	/	0,45	0,45
Viceroy Kopaonik	14,03	6,9	/	/	0,59	0,59
Ambasador Hotel	14,7	6,1	7,16	9,33	1,11	1,11
Centar Hotel	15,01	6,2	62,64	58,35	1,45	1,45
Hotel Leopold I	14,15	6,2	/	486,08	2,30	2,30
Hotel ABC	13,38	6,6	17,99	29,26	1,12	1,12
Hotel Putnik	13,42	6,2	/	0,05	0,57	0,57
Hotel Prezident	13,35	6,1	/	/	0,99	0,99
Hotel Palisad	13,13	6,5	2,04	0,91	1,03	1,03
Hotel Mir	13,2	6,1	2,38	2,06	1,05	1,05
Hotel Srbija Lux	15,57	6,2	25,02	35,88	1,05	1,05
Mona Plaza	13,46	6	2,75	0,10	1,03	1,03
Hotel Olimp	13,09	6,8	/	22,10	1,57	1,57
Hotel Iris	13,52	6,1	3,22	3,15	1,11	1,11

Source: Table compiled by the authors

Considering the aim of the research and the significance of the relationship between financial performance and environmental outcomes, this paper applies methodological procedures typical of the social sciences and a systematic analysis of the research problem. To achieve the stated research objectives and test the proposed hypotheses, the following methods are employed:

a) Cluster analysis – Hotels in Serbia were grouped into two clusters (more environmentally sustainable "green" hotels and less environmentally sustainable "red" hotels) based on their environmental performance, thereby testing Hypothesis H1.

b) Multiple linear regression – This method was employed to examine the impact of financial performance (profitability and cost-efficiency rations) on environmental performance, thus testing Hypotheses H2 and H3.

All analyses were conducted using the STATASe 13 software package.

4. Research Results and Discussion

Cluster analysis is a method in which units are grouped according to similarity, ensuring that units within a cluster are as similar as possible while units in different clusters are as distinct as possible. Grouping is based on the values of multiple variables for each observation unit. There are two main types: hierarchical, in which a dendrogram is generated based on the calculated distances between units to provide a graphical representation of the similarity structure, and non-hierarchical, in which the number of clusters is predetermined and units are iteratively assigned to cluster centers until the distribution stabilizes. The hierarchical approach thus emphasizes structural representation, whereas the non-hierarchical approach allows a more flexible formation of a finite number of clusters (Newbold et al., 2010).

Prior to conducting cluster analysis, it is essential to assess the degree of correlation among the observed variables (Table 3). When a high correlation exists between the indicators, data normalization and careful selection of the clustering method are justified.

Table 3: Pearson's correlation coefficient for selected variables

	Carbon Footprint ($kgCO_2e$)	Etic Green Score (/10)	ROA	ROE	TCE	OPE
Carbon Footprint ($kgCO_2e$)	1,0000					
Etic Green Score (/10)	0,142 (0,346)	1,0000				
ROA	0,094 (0,578)	-0,170 (0,314)	1,0000			
ROE	0,076 (0,655)	-0,166 (0,326)	0,149 (0,409)	1,0000		
TCE	-0,019 (0,900)	0,114 (0,450)	0,590** (0,0000)	0,623** (0,0000)	1,0000	
OPE	0,006 (0,966)	0,249*** (0,095)	0,408* (0,012)	0,577** (0,0000)	0,981** (0,0000)	1,0000

Note: The p-value of the (), *Correlation is significant at the 0,01 level,
**Correlation is significant at
the 0,05, ***Correlation is significant at the 0,1
Source: Author's calculation in StataSe 13

The correlation analysis results indicate that there is no interdependence between the profitability performance indicators (ROA and ROE) and the carbon footprint, nor between the cost-effectiveness performance indicators (TCE and OPE) and the carbon footprint. Similarly, no correlation was observed between profitability performance indicators (ROA and ROE) and the Etic Green Score, whereas a slight correlation exists between financial performance indicators at a 10% significance level, suggesting the presence of environmental practices in the surveyed hotels. When examined together, the indicators of profitability performance and business economy performance exhibit a strong and statistically significant interdependence.

The next step of the research involved conducting cluster analysis to group hotels based on their Carbon Footprint and Etic Green Score. This approach allows for the identification of homogeneous groups of hotels that differ in environmental performance, providing a foundation for more detailed analysis of their characteristics and insights into the relationship between business efficiency and environmental sustainability. The optimal number of clusters was determined using a non-hierarchical cluster analysis (K-means method). The results of the 2023 K-means cluster analysis indicate that hotels were grouped into two clearly differentiated clusters according to their level of environmental sustainability. The first cluster, representing more environmentally sustainable ("green") hotels in Serbia, includes 39 out of the 47 hotels in the sample and is characterized by a carbon footprint below the average value (≈14.14 kgCO_2 e) and an Etic Green Score above the average value (≈6.19/10). The second cluster, representing less environmentally sustainable ("red") hotels in Serbia, includes 8 hotels with environmental performance below average, specifically a carbon footprint above the average value and an Etic Green Score below the average value. Accordingly, the optimal carbon footprint values for cluster classification are approximately 14 for the Carbon Footprint and 6 for the Etic Green Score, which distinguish "green" hotels from "red" hotels. In accordance with this:

- *The first cluster of more environmentally sustainable ("green") hotels in Serbia comprises the following establishments:* IN Hotel, Hotel Mona, Hotel Hilton, Hotel Mercure Excelsior, Radisson Red Arena hotel, Crowne Plaza Delta Hospitality, Hotel Indigo Profileonplus doo, Courtyard Belgrade City Center by Marriott, Belgrade Art Hotel, Garni Hotel Royal Crown, Hotel Ema, Aveny, Hotel Helvetia, Sky hotel Belgrade, Mark Hotel Belgrade, Mama Shelter Belgrade, Abba Hotel, Hotel Tesla Smart Stay, 88 Rooms Hotel, Golden Tulip Zira Belgrade, Hotel Moskva Belgrade, Envoy Hotel, Xenon, Heritage Hotel, Euro Garni Hotel, Hotel M Beograd, Hotel Prag, Nova City Hotel Signature Collection, Sterling Hotel, Zepter Hotel Vrnjacka Banja, Grey Hotel Kopaonik, Centar Hotel, Hotel ABC, Hotel Putnik, Hotel Prezident, Hotel Palisad, Hotel Mir, Hotel Srbija Lux, Mona Plaza, Hotel Olimp, Hotel Iris and
- *The second cluster of less environmentally sustainable ("red") hotels in Serbia comprises the following establishments:* Hotel Radisson, Collection Old Mill, Square Nine Hotel, Saint Ten Hotel, Viceroy Kopaonik, Ambasador Hotel and Hotel Leopold I.

The results support Hypothesis H1, indicating that the Etic Hotels website is predominantly composed of hotels from Serbia with superior key environmental performance, reflecting their commitment to sustainable business practices and the mitigation of negative environmental impacts.

Following the formation of clusters, multiple linear regression was conducted to examine the impact of financial performance (profitability and economic performance) on environmental performance, thereby testing Hypotheses H2 and H3, as well as their sub-hypotheses (H2/a, H2/b, H3/a, and H3/b). Prior to the analysis of the regression results, Table 4 presents descriptive statistics for the selected variables to illustrate their characteristics. For this purpose, the following descriptive measures were calculated: arithmetic mean, standard deviation, minimum, and maximum values.

Table 4: Descriptive statistics of selected variables

Variable	N	Mean	Standard deviation	Minimum	Maximum
Carbon Footprint (kgCO_2e)	46	14,14391	0,892797	12,93	15,68
Etic Green Score (/10)	46	6,193478	0,3108427	5,4	6,9
ROA	37	0,1093787	0,1158804	0,0155546	0,6263546
ROE	37	0,3950517	0,902701	0,0005389	4,860833
TCE	47	1,076351	0,3338472	0,1240874	2,304839
OPE	47	1,098894	0,3425178	0,1240874	2,304839

Source: Calculation of authors in the software package StataSe 13

The descriptive statistics presented in Table 4 indicate notable differences among the observed variables, both in terms of mean values and the range and variability of the results. The Carbon Footprint averages 14.14 kgCO2e, with a relatively low variability (SD = 0.892797), indicating a stable series with minor fluctuations, as confirmed by the difference between the minimum and maximum values (2.75). The Etic Green Score averages 6.19/10, with relatively low variability (SD = 0.3108427), indicating a stable series with minor fluctuations, as reflected by the difference between the minimum and maximum values (1.5).

Regarding financial ratios, the ROA averages 10.94% with a standard deviation of 0.11 and a range of 1 to 62%. ROE averages 39% with a standard deviation of 0.902701 and a wide range of 0.0005 to 4.860, indicating the existence of some "green" hotels with exceptionally high ROE values. TCE and OPE exhibit very similar results, with averages values of 1.07 and 1.09 and comparable standard deviations (0.3338472 and 0.3425178), with both variables sharing the same range of 0.12 to 2.30, confirming their correlation and near-identical trends. These results indicate that, within the sample of 47 "green" hotels, hotels with stable environmental performance but marked heterogeneity in financial performance can be clearly distinguished.

Model validation was conducted using diagnostic tests for heteroscedasticity, autocorrelation, and multicollinearity. Heteroscedasticity was assessed using the Breusch-Pagan test, which examines whether the variance of residuals varies across countries or over time. Multicollinearity was evaluated using the Variance Inflation Factor (VIF), which identifies high correlations among independent variables that could compromise the reliability of the estimates, while the normality of the data was tested using the Shapiro-Willk test. The results of these diagnostic tests are presented in Table 5.

Table 5: Results of tests to verify the validity of the model

Test	p-value		Conclusion	
	Model 1	*Model 2*	*Model 1*	*Model 2*
Breusch -Pagan	0,9230	0,7926	There is no heteroscedasticity	There is no heteroscedasticity
VIF	3,94	3,94	No serious multicollinearity	No serious multicollinearity
Shapiro-Wilk W test for normal data	0,03399	0,03399	There is a problem of data normality	There is a problem of data normality

Source: Calculation of authors in the software package StataSe 13

To address the issue of data normality, Driscoll-Kraay standard errors were employed. The results are presented in Table 6.

Tabela 6: Results of linear regression analysis

Model 1 (ROA, ROE, TCE, OPE → Carbon)		*Model 2* (ROA, ROE, TCE, OPE → Etic)	
Independent variable	**Dependent variable** (Carbon)	**Independent variable**	**Dependent Variable** (Etic)
Constant	2,730913	Constant	1,857317
ROA	0,0234474 (0,314)	*ROA*	0,0004112 (0,963)
ROE	0,005879 (0,517)	*ROE*	0,0115826 (0,010)
TCE	-0,3831221 (0,171)	*TCE*	0,2099387 (0,082)
OPE	0,2807515 (0,238)	*OPE*	-0,2479564 (0,026)
Prob > F	0,1430	Prob >F	0,0118

Source: Calculation of authors in the software package StataSe 13

The results of the regression analysis, with the carbon footprint specified as the dependent variable (Model 1), indicate that none of the analyzed financial indicators exerts a statistically significant effect. Specifically:

- ROA ($\beta = 0.023$; $p = 0.314$), and ROE ($\beta = 0.0058$; $p = 0.517$), do not have a significant effect on the carbon footprint, indicating that *the H2/a hypothesis is not supported***.**
- TCE ($\beta = -0.383$; $p = 0.171$) and OPE ($\beta = 0.281$; $p = 0.238$) also do not have a significant impact on the carbon footprint, suggesting that *the H2/b hypothesis is not supported.*
- The overall model result (Prob > F = 0.1430) confirms that the model is not statistically significant, implying that the variability of the hotels' carbon footprint is not explained by their financial performance.
- These findings suggest that the financial performance of hotels operates independently of their environmental performance in terms of carbon dioxide

emissions. This may be attributed to limited commitment to implementing regulatory frameworks for greenhouse gas reduction, partial adoption of standardized energy efficiency measures, or the perception that CO_2 emissions are not yet considered a key indicator of business success in the hotel industry.
- Therefore, it can be concluded that *the H2 hypothesis is not supported.*

In contrast, in Model 2, where the Etic Green Score is specified as the dependent variable, the results indicate that the model is statistically significant (Prob > F = 0.0118). Specifically:
- A notable result is the positive and statistically significant effect of ROE (β = 0.0116; p = 0.010) on the Etic Green Score, indicating that "green" hotels with a higher return on equity tend to achieve higher Etic Green Scores a 1% increase in ROE corresponds to an increase of 0.012% in the Etic Green Score). ROA in the model is not statistically significant (p > 0.05). Therefore, *the H3/a hypothesis is partially supported.*
- OPE exhibits a negative but statistically significant effect (β = - 0.248; p = 0.026), whereas TCE demonstrates a positive effect at the 10% significance level (β = 0.210; p = 0.082). Accordingly, the *H3/b hypothesis is partially supported.*
- The results indicate that sustainability, as measured by the Etic Green Score, is primarily influenced by profitability, whereas excessive focus on business economy may conflict with environmental and ethical practices. This indicates that financially stronger hotels have greater capacity to invest in sustainable and ethical initiatives, but a strong emphasis on cost reduction may limit the adoption of green practices, as short-term efficiency is prioritized over long-term sustainability.
- It can be concluded that *the H3 hypothesis is partially supported.*

Based on the regression analysis, it can be concluded that a hotel's financial performance does not significantly influence its carbon footprint, indicating that carbon dioxide emissions are not associated with profitability or cost-effectiveness. This suggests that financial and environmental CO2 objectives operate independently, likely due to insufficient commitment by hotels to implement regulatory frameworks aimed at reducing greenhouse gas emissions and applying energy efficiency measures within the hotel sector. However, the analysis reveals a significant positive relationship between profitability performance (ROE) and the Etic Green Score, indicating that more profitable hotels possess greater capacity and willingness to implement environmentally and ethically responsible initiatives. Although financial performance does not account for variations in the carbon footprint, it remains relevant for promoting sustainable and ethical practices in the hotel industry. The results further indicate that hotels in Serbia must prioritize the achievement of positive environmental and social outcomes alongside profit and financial performance in long-term management strategies.

Conclusion

Considering the imperative requirements for the development of circular and regenerative sustainability in the hotel industry, the results of this study can be interpreted as moderately unsatisfactory. The research indicates that hotels in Serbia report key environmental performance data on the Etic Hotels website. Testing of H1 revealed no statistically significant effect of profitability performance (ROA and ROE) or cost-efficiency (TCE and OPE) on the carbon footprint. This finding is concerning for Serbian hotels, as it would be expected that hotels with higher profitability and superior business efficiency would invest more in environmental performance, thereby reducing their carbon footprint. Testing of H2 demonstrated a statistically significant positive effect of ROE, a statistically significant negative effect of OPE, and a marginally significant positive effect of TCE on the Etic Green Score, whereas ROA did not have a significant impact. These results suggest that higher ROE holders can positively influence the Etic Green Score, reflecting their interest in supporting environmentally responsible initiatives. TCE also exhibits a positive effect on the Etic Green Score at the threshold of statistical significance, while OPE generated through hotel operations shows a negative statistical effect.

These findings suggest that hotels in Serbia have not yet developed adequate models of circular and regenerative business. The current importance of regenerativity in the hotel industry requires the translation of regenerative economy principles into practical regenerative applications within the sector. Regenerative practices in the hospitality industry should be built on: (a) a regulatory framework established by the Government of Serbia that promotes regenerative business practices, including the encouragement of renewable energy use, the implementation of stricter environmental standards, and the adoption of circular business models; (b) innovation across business operations, supply chains, and service delivery to align with regenerative principles, such as the utilization of renewable energy, the design of products for durability and recyclability, and the development of business models emphasizing services rather than ownership; and (c) collaboration with local communities to co-create shared visions and locally tailored, sustainable solutions. The key challenges to achieving regenerative hospitality in Serbia include the need for changes in stakeholder behavior, the transition from linear to circular business models, and potential resistance stemming from established business practices. Nevertheless, the hospitality industry also presents significant opportunities, including fostering innovation, conserving natural resources, and contributing to the development of more equitable societies.

The primary limitation of this study lies in the collection of data required to calculate business efficiency performance, as obtaining financial statements from all hotels registered with APR proved challenging, particularly for hotels operating as branches without a legal obligation to publish financial statements. Consequently, the sample of monitored hotels (47) was smaller than the total number of hotels listed on the Etic Hotels website (67). Furthermore, the study is cross-sectional, including only data for 2023, which limits its analytical depth. Additionally, the sample comprises only hotels listed on the Etic Hotels website, whereas the competent Ministry of Tourism reports a total of 441 hotels in Serbia. Therefore, the results for 2023 cannot be generalized to the entire hotel population in Serbia. Considering that only large hotels are currently required to prepare sustainability reports under the Accounting Act of 2021, and that the implementation of EU directives is postponed (following the adoption of the Omnibus package in February 2025 and its subsequent return to the EU Parliament in October 2025), medium and small enterprises are likely to be included at a later stage. These factors indicate that the first prerequisite for the development of regenerative practices in Serbian hotels has yet to be fully realized.

Future research could focus on analyzing the trend of the impact of financial performance on key environmental performance in Serbian hotels over multiple consecutive accounting periods. Furthermore, with the implementation of mandatory sustainability reporting for not only large but also medium and small hotels, and their disclosure alongside financial statements, it will be possible to examine the relationship between financial performance and environmental performance across different hotel categories, as well as potential differences between these groups. Finally, as regenerative hospitality practices continue to develop in Serbia, paralleling global trends, there is an opportunity to investigate the specific characteristics of regenerative practices in Serbia and neighboring countries.

Acknowledgements: This research is part of the 101136834 – CROSS-REIS – HORIZON-WIDERA-2023-ACCESS-03 project, funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the European Research Executive Agency can be held responsible for them.

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ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 10, January-April 2026, №. 1
UDK 33+502/504
ISSN 2560-421X

Muhammad Nouman Latif[1]
PhD Economics Scholar, Ibn Haldun University, Istanbul

Nataša Živaljević Luxor[2]
PE Institute for urban planning, Niš

Tamara Rađenović[3]
Faculty of Occupational Safety, University of Niš

P. 29-42
ORIGINAL SCIENTIFIC PAPER
DOI: 10.5937/ESD2601029N
Received: July 12, 2025
Accepted: September 10, 2025

ASSESSING THE SOCIO-ECONOMIC IMPACTS OF URBAN GREEN SPACES ON COMMUNITY WELL-BEING AND ENVIRONMENTAL JUSTICE: A CASE STUDY OF THE CITY OF NIŠ

Abstract

This study explores the impact of Urban Green Spaces (UGSs) on community well-being and environmental justice in Niš, Serbia. Conducted within the framework of TransformERS (CA 22156), the research focuses on the socio-economic effects of UGSs. UGSs play a crucial role in public health, social cohesion, and economic activities, as demonstrated by numerous studies. However, disparities in access and quality remain a significant challenge, particularly in marginalized urban areas. To evaluate the benefits of UGSs in Niš, this study utilizes a community-wide survey alongside spatial analysis through GIS software to assess real-world conditions. The findings indicate that 37% of the city's area consists of green spaces, including forests, green belts, parks, and lawns. A Structural Equation Model (SEM) is employed to analyze the complex relationships within the study. The results reveal a weak direct link between UGSs and community well-being. However, demographic factors and environmental justice serve as key mediators, clarifying the connection. To enhance community well-being through urban green spaces, policymakers should prioritize reducing income inequality and eliminating barriers that restrict access to UGSs.

Key words: *Urban Green Spaces (UGSs), Structural Equation Models (SEM), Community Well-Being, Environmental Justice*

JEL classification: *Q51, Q56, Q58*

[1] muhammad.latif@stu.ihu.edu.tr, ORCID ID 0000-0002-3055-7729

[2] nluxor@gmail.com, ORCID ID 0000-0002-6008-3712

[3] tamara.radjenovic@znrfak.ni.ac.rs, ORCID ID 0000-0003-1632-7772

ПРОЦЕНА ДРУШТВЕНО-ЕКОНОМСКИХ УТИЦАЈА УРБАНИХ ЗЕЛЕНИХ ПОВРШИНА НА ДОБРОБИТ ЗАЈЕДНИЦЕ И ЕКОЛОШКУ ПРАВДУ: СТУДИЈА СЛУЧАЈА ГРАДА НИША

Апстракт

Ова студија истражује утицај урбаних зелених површина (УЗП) на добробит заједнице и еколошку правду у Нишу, Србија. Спроведено у оквиру пројекта TransformERS (CA 22156), истраживање се фокусира на социо-економске ефекте УЗП-а. Урбане зелене површине имају кључну улогу у јавном здрављу, друштвеној кохезији и економским активностима, што је потврђено бројним студијама. Међутим, неједнакост у приступу и квалитету ових простора и даље представља значајан изазов, нарочито у маргинализованим урбаним подручјима. Како би се процениле користи УЗП -а у Нишу, ова студија користи свеобухватну анкету на нивоу заједнице у комбинацији са просторном анализом путем GIS софтвера ради процене стварног стања на терену. Резултати показују да 37% површине града чине зелене површине, укључујући шуме, зелене појасеве, паркове и травњаке. За анализу сложених односа у оквиру студије примењен је Структурни модел једначина (СЕМ). Резултати показују слабу директну повезаност између УЗП-а и добробити заједнице. Међутим, демографски фактори и еколошка правда играју кључну улогу као посредници, јасније објашњавајући ову везу. Како би се унапредила добробит заједнице кроз урбане зелене површине, доносиоци одлука требало би да дају приоритет смањењу доходовне неједнакости и уклањању препрека које ограничавају приступ УЗП.

Кључне речи: *урбане зелене површине (УЗП), модели структурних једначина (СЕМ), добробит заједнице, еколошка правда*

Introduction

In today's world, climate change stands as one of the greatest challenges, and UGSs play a crucial role in mitigating its effects. UGSs are an essential component of urban planning and development, offering not only environmental benefits but also contributing to economic growth and social well-being. These green spaces include parks, gardens, urban forests, and green corridors, all of which help regulate air quality, control temperatures, and reduce the urban heat island effect (Kabisch et al., 2016). In addition to public green infrastructure, sustainability-oriented innovations in the private sector – such as the rise of green hotels – also contribute to the broader goals of sustainable urban development and competitiveness improvement (Jovanović, 2019).

Beyond their environmental impact, UGSs serve as spaces for physical activity, social interaction, and relaxation, significantly improving both the mental and physical health of urban residents (Hartig et al., 2014). Research in developed countries shows that equitable access to well-distributed green spaces is strongly linked to higher levels of individual happiness and life satisfaction, even after controlling for socio-demographic factors (Kwon et al., 2021). Moreover, they boost local economies by increasing property values, attracting tourists, and creating jobs in urban planning and environmental management (Haaland & van den Bosch, 2015). As the third-largest city in Serbia, Niš is experiencing rapid urban growth, making the preservation and expansion of UGSs critical for maintaining a sustainable and livable urban environment. This research examines the socio-economic impact of UGSs in Niš and investigates their contribution to the overall well-being of its residents.

UGSs are increasingly recognized as essential for urban sustainability and social justice, offering free and accessible spaces for people of all socio-economic backgrounds (Jennings et al., 2017). However, many studies highlight disparities in access to green spaces, with low-income and marginalized communities often having limited availability of these essential resources (Rigolon, 2016; Loughran, 2014). European-level analyses further confirm that both access and quality of green spaces tend to be poorer in disadvantaged neighborhoods (EEA, 2022). UGS are increasingly recognized as crucial contributors to urban sustainability and public health worldwide (Li et al., 2023). Disparities in access and quality persist, with socio-economic inequities shaping urban residents' exposure to green infrastructure (EEA, 2022; Csomós et al., 2021).

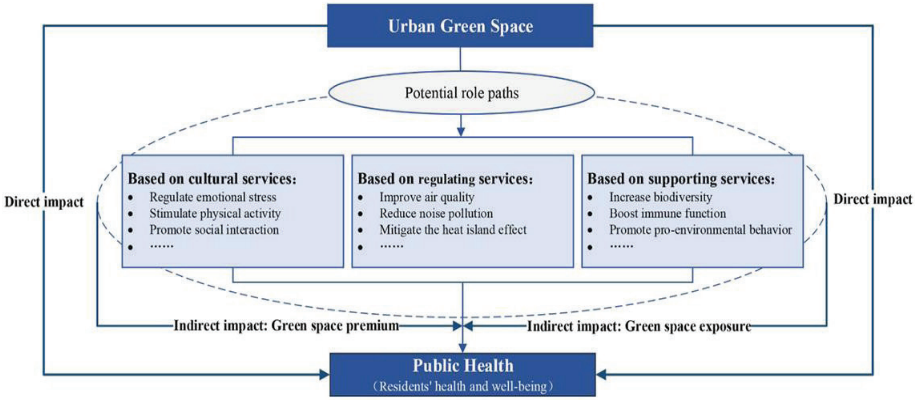
In the city of Niš, Serbia, similar patterns have been identified, highlighting the urgency of integrating environmental justice into UGS planning (Mitrović et al., 2024). In Niš, historical significance and population growth have contributed to unequal distribution of UGSs, raising concerns about environmental justice (Anguelovski et al., 2020). The fair distribution of environmental benefits and burdens is a key principle of environmental justice (Schlosberg, 2013). Marginalized communities often face greater environmental and health risks, including limited park access, poor infrastructure, and exposure to pollution (Heynen et al., 2006). These inequalities widen socio-economic gaps and restrict access to green spaces for disadvantaged groups.

Niš is uniquely positioned within Serbia's broader urban development initiatives, which aim to expand public green spaces and promote social equity. When considering community well-being, this concept encompasses physical health, mental health, and economic stability - all of which are positively influenced by accessible and well-maintained UGSs (Markevych et al., 2017). UGSs provide spaces for recreation and exercise, encouraging an active lifestyle and reducing the risk of diseases such as obesity and cardiovascular conditions (James et al., 2015). Furthermore, green environments help alleviate stress, anxiety, and depression, promoting overall psychological well-being (Beyer et al., 2014; Gubić and Wolff, 2022). UGSs support local economies through tourism, maintenance jobs, and increased property values, contributing to economic stability (Wolch et al., 2014).

Model for UGSs by Yang et al. (2022) presented in Figure 1 also advocates that UGSs directly regulate emotional stress, stimulate physical activity, and promote social interactions based on cultural service. Furthermore, based on regulating services, UGSs improve the air quality index, reduce noise pollution, andmitigate the heat island effect. Based on supporting services, UGSs increase biodiversity, boost immune function, and promote pro-environmental behavior.

Like many cities in Southeastern Europe, Niš faces major urbanization challenges, including the loss of green spaces, population growth, and widening socio-economic inequalities (Živanović et al., 2022). Despite efforts by the local administration to preserve and expand UGSs, disparities in access to these areas remain a significant concern for residents. Vujović et al. (2021) also emphasize the importance of environmental justice and social equity, highlighting the uneven distribution of green spaces across different socio-economic groups.

Figure 1: Model of UGSs affecting public health



Source: Yang et al. (2022)

This research is part of the broader TransformERS (CA 22156) initiative, which aims to develop transformative solutions to societal challenges through research and innovation. A key focus of TransformERS is sustainable urban development, emphasizing the integration of green infrastructure while addressing issues of social equity and environmental justice.

Accordingly, this study seeks to answer the following key questions:

- How are UGSs distributed in Niš, and how do they relate to socio-economic inequalities?
- What role does environmental justice play in the planning and management of UGSs in Niš?
- How do UGSs impact the socio-economic well-being of Niš residents?

By exploring these aspects, the research aims to contribute to more equitable and sustainable urban planning strategies.

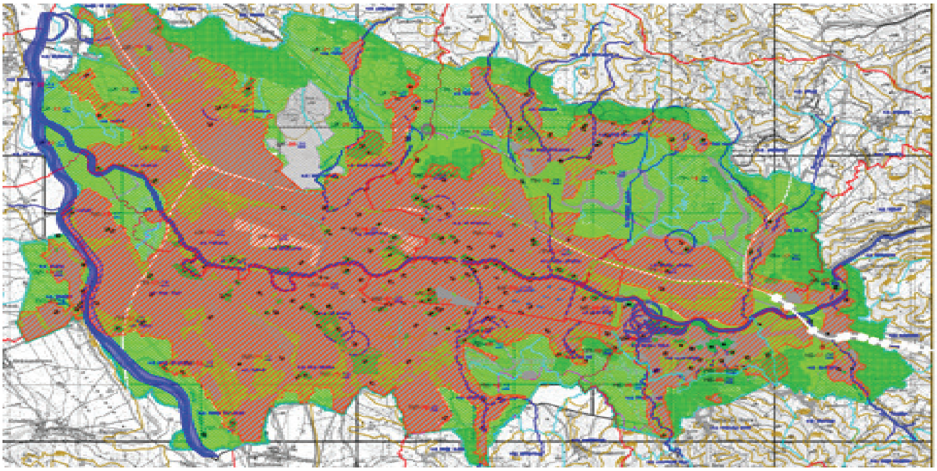
Data and Discussion

Serbia is situated in Southeastern Europe, with Niš being one of its most historically and culturally rich cities. As the third-largest city in Serbia, Niš is well-managed and serves as both a cultural hub and an economic center. Its strategic location and scenic landscape attract tourists from across the world, particularly from Europe.

The city has a total population of approximately 260,237 and spans an area of 596.78 square kilometers. Of this, 9.51% is designated for parks and green spaces, providing residents with accessible natural areas that contribute to environmental quality and overall well-being. Additionally, forests cover 27% of the total area, reinforcing Niš's reputation as an eco-friendly and green city. Meanwhile, 63% of the land is allocated for construction and urban development, making Niš a compelling case study for examining the socio-economic impacts of UGSs (Figure 2).

After analyzing the spatial dimensions of Niš, we proceeded to validate this data by comparing it with on-the-ground realities. This involved conducting GIS-based spatial analysis, and community surveys to ensure the accuracy of the reported figures regarding green space distribution, urban development, and land use patterns. By integrating empirical observations with documented data, we aimed to identify potential discrepancies and assess the actual accessibility and quality of UGSs across different areas of the city.

Figure 2: Proposed City Plan for Niš

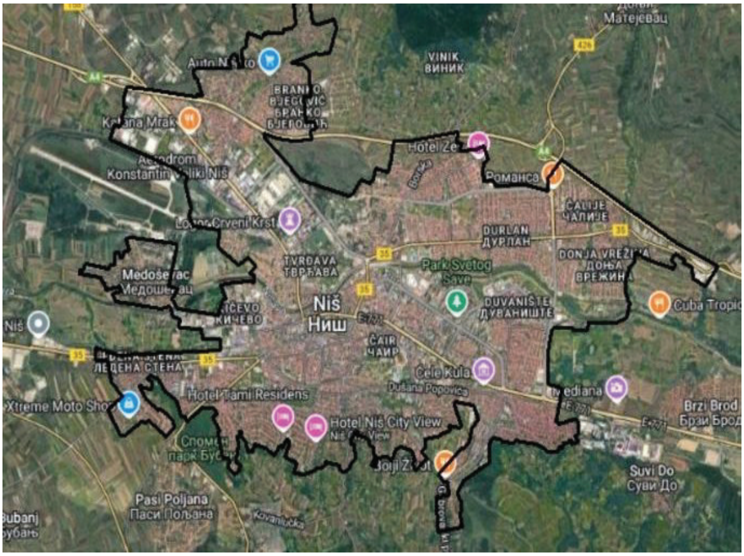


Source: Local Administration Niš

To analyze the land use distribution in Niš, we utilized a satellite image from Google Maps (Figure 3) and applied GIS software to assess the city's structural composition. This analysis classified the area into three key categories:

- Built-up areas – including residential buildings, commercial properties, and industrial sites
- Water bodies – primarily the Nišava River, which flows through the city
- Green spaces – comprising forests, farms, agricultural land, and other vegetation

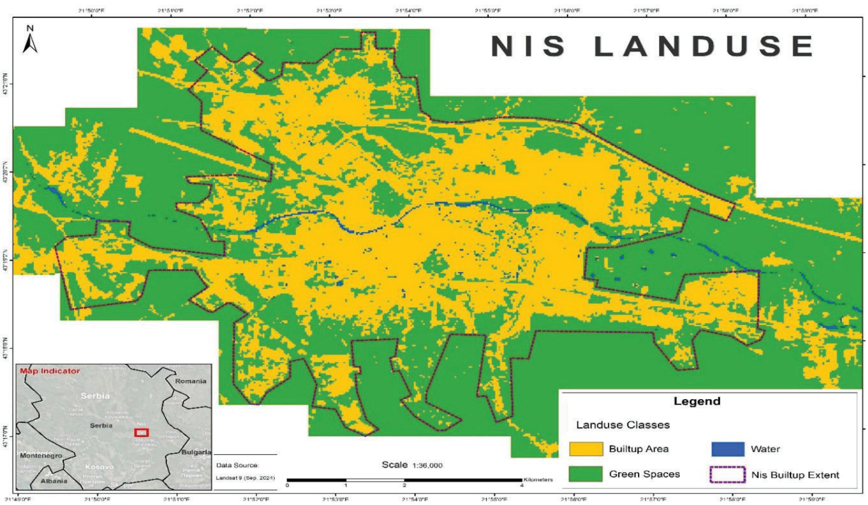
Figure 3: Satellite image from Google Map of the City of Niš



Source: Google Map

The findings reveal that 37.6% of the total land area in Niš is covered by green spaces, providing vital environmental and social benefits for residents. Meanwhile, 61.5% of the land is designated for urban development, including housing, businesses, and industrial infrastructure. Additionally, 0.9% of the area is occupied by the Nišava River, which plays an essential role in shaping the city's urban landscape (Figure 4).

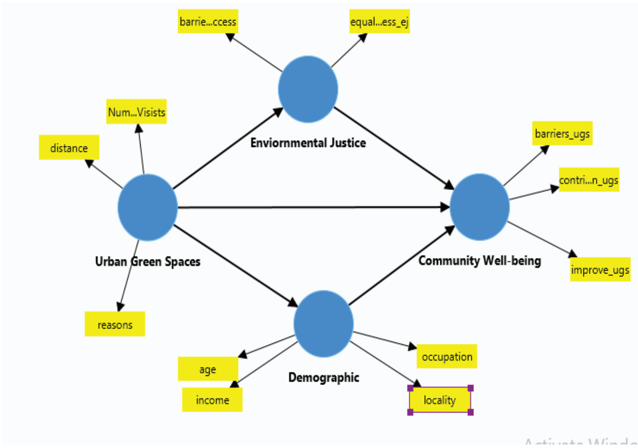
Figure 4: Land use analysis of the City of Niš with GIS software



Source: GIS software

A comprehensive survey was conducted in Niš, Serbia to assess environmental justice and community well-being. The survey, illustrated in Figure 5, aimed to analyze the impact of various factors by gathering public perceptions of UGSs.

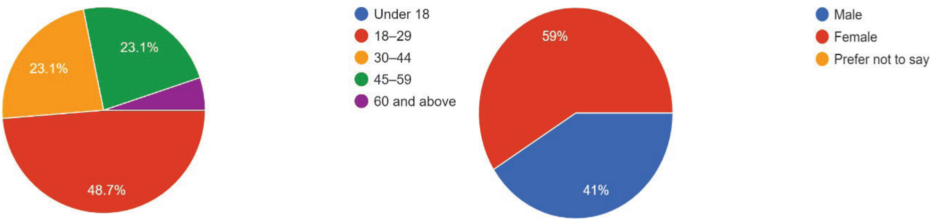
Figure 5: Theoretical Frame Work



Source: Authors

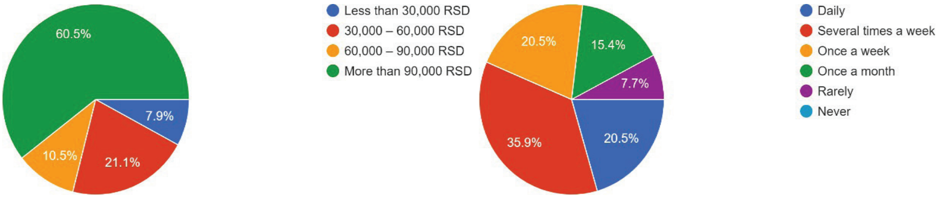
A total of 150 participants took part in the survey, with 120 providing complete responses. Among them, 59% were female and 41% were male, reflecting a balanced gender representation. In terms of age distribution, 48.7% of respondents were between 18 and 29 years old, while 51.3% were 30 years or older (Figure 6). This indicates that concerns about health and the environment are shared across different age groups in Niš.

Figure 6: Respondents age group and gender



The survey also provided valuable insights into the socio-economic status of the respondents. The data revealed that 60.5% of participants earn approximately 770 euros per month, which is nearly twice the minimum wage set by the Government of Serbia (Figure 7). While this income level is lower than that of developed countries, it is higher than the average earnings in neighboring Balkan nations. This financial status may impact residents' ability to prioritize health and environmental concerns, as individuals with higher incomes often have greater access to green spaces and healthier lifestyles compared to those with limited financial resources.

Figure 7: Respondents according to income and frequence of visiting UGS



The survey results indicate that the majority of Niš residents prioritize their health, with 56.4% of respondents visiting green spaces daily or several times a week. However, a small percentage (7.7%) reported visiting these areas only rarely (Figure 7).

When asked about their preferred green spaces, the majority (61.5%) stated that they frequent parks, making them the most popular choice. The second most-visited location was the riverbank (20.5%), highlighting the community's strong connection to nature and preference for outdoor environments.

Methodology

In our study, the data is measured on an ordinal scale, making the Structural Equation Model (SEM) the most suitable analytical approach. SEM is particularly effective for examining complex relationships between different types of variables, including latent, control, and observed variables.

To begin, we define and construct the latent variables, which represent underlying concepts that cannot be directly measured. These include (Table 1: Selection of latent variables):

- Community Well-being (CWB)
- Environmental Justice (EJ)
- Urban Green Spaces (UGS)

By using SEM, we can analyze the interactions between these variables and better understand their influence on community well-being and environmental justice. The choice of SEM is supported by recent work demonstrating its ability to capture both direct and indirect effects in socio-ecological systems (Tuominen et al., 2022; Park, 2023; Bonilla-Bedoya et al., 2020). Furthermore, optimization-based frameworks are increasingly applied to identify spatially equitable UGS placements, providing methodological inspiration for future research (Pinto et al., 2025).

Table 1: Selection of latent variables

Community well-being (CWB)		Environmental Justice (EJ)	
X1	UGS contribution to well-being	Y1	Barriers faced by some group
X2	How UGS improves quality of life	Y2	Obstacles to visit UGS
X3	Problems / Barriers to visit UGS		
Urban Green Spaces (UGS)			
Z1	Number of visits	Z3	Distance to nearest UGS
Z2	Reason to visit UGS		

Source: Authors

We define the hypothesized relationships between latent constructs using a SEM approach. The relationships are represented as follows:

$$CWB=\beta 1\cdot UGS+\varepsilon_1 \quad (1)$$

Here, β_1 represents the effect of Urban Green Spaces (UGS) on Community Well-being (CWB), while ε_1 is the error term, capturing the unexplained variance.

$$EJ=\beta 2\cdot UGS+\varepsilon_1 \quad (2)$$

In this equation, β_2 indicates the effect of UGS on Environmental Justice (EJ), and ε_2 is the corresponding error term.

$$CWB=\beta 3\cdot EJ+\varepsilon_1 \quad (3)$$

Here, β_3 represents the impact of Environmental Justice on Community Well-being, with ε_3 as the associated error term.

In our model, observed variables are linked to their respective latent variables, with λ serving as the factor loading. The measurement equations are as follows:

For Community Well-being (CWB):

$$X1=\lambda 11\cdot CWB+\delta 1 \quad (4)$$
$$X2=\lambda 12\cdot CWB+\delta 2 \quad (5)$$
$$X3=\lambda 13\cdot CWB+\delta 3 \quad (6)$$

where λ_{11}, λ_{12}, and λ_{13} are factor loadings for CWB, and δ_1, δ_2, and δ_3 represent measurement errors.

For Environmental Justice (EJ):

$$Y1=\lambda 21\cdot EJ+\delta 5 \quad (7)$$
$$Y2=\lambda 22\cdot EJ+\delta 6 \quad (8)$$

where λ_{21} and λ_{22} are factor loadings for EJ, and δ_5 and δ_6 represent measurement errors.

For Urban Green Spaces (UGS):

$$Z1=\lambda 31\cdot UGS+\delta 9 \quad (9)$$
$$Z2=\lambda 32\cdot UGS+\delta 10 \quad (10)$$
$$Z3=\lambda 33\cdot UGS+\delta 11 \quad (11)$$

where λ_{31}, λ_{32}, and λ_{33} are factor loadings for UGS, and δ_9, δ_{10}, and δ_{11} denote measurement errors.

To enhance the model's accuracy, we introduce control variables such as Gender, Income, Occupation, and Locality, resulting in the following equations:

$$CWB=\beta 1\cdot UGS+\beta 4\cdot Income+\beta 5\cdot Occupation+\varepsilon_1 \quad (13)$$
$$EJ=\beta 2\cdot UGS+\beta 6\cdot Gender+\beta 7\cdot Locality+\varepsilon 2 \quad (14)$$

By integrating both structural and measurement models, we obtain the following framework:

$$CWB=\beta 1\cdot UGS+\beta 3\cdot EJ+\beta 4\cdot Income+\beta 5\cdot Occupation+\varepsilon_1 \quad (15)$$
$$EJ=\beta 2\cdot UGS+\beta 6\cdot Gender+\beta 7\cdot Locality+\varepsilon 2 \quad (16)$$

With the corresponding measurement equations:

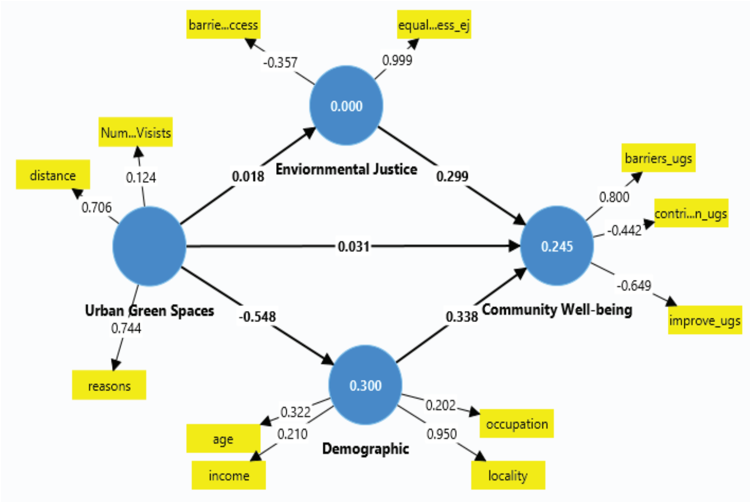
$X1=\lambda 11\cdot CWB+\delta 1,\quad X2=\lambda 12\cdot CWB+\delta 2,\quad \ldots$
$Y1=\lambda 21\cdot EJ+\delta 5,\quad Y2=\lambda 22\cdot EJ+\delta 6,\quad \ldots$
$Z1=\lambda 31\cdot UGS+\delta 9,\quad Z2=\lambda 32\cdot UGS+\delta 10,\quad \ldots$

Results

We used SmartPLS for the analysis, and the results presented in Figure 8 reveal several key insights. The path coefficient between Urban Green Spaces (UGS) and Community Well-being (CWB) is 0.031, which is very weak. This suggests that UGS alone does not have a strong direct impact on CWB in our study. Instead, its influence may be mediated through Environmental Justice (EJ), requiring further investigation. The coefficient between demographic factors and UGS is -0.548, indicating that certain groups, such as lower-income individuals and rural residents, may have reduced access to UGS. These findings are consistent with empirical studies documenting systematic disparities in green space access for disadvantaged populations (De Vries et al., 2020; Csomós et al., 2021; Zhang and Luo, 2024; Hoseini et al., 2025), supporting the robustness of our SEM-based analysis. For example, people living in rural or suburban areas may have fewer green spaces nearby or need to travel longer distances to reach them. Likewise, individuals with lower incomes might prioritize other basic needs over accessing UGS, highlighting demographic disparities in green space availability. The path coefficient between Environmental Justice (EJ) and UGS is 0.018, suggesting that the mere presence of UGS does not guarantee environmental justice. Similar studies in Belgrade and elsewhere emphasize that UGS quality – not just quantity – matters for well-being (Simović et al., 2023). Moreover, recent work has confirmed that psychological and physical activity pathways critically link green space accessibility and mental health (Dong et al., 2024).

This finding underscores the existence of barriers – such as inequitable distribution, accessibility issues, or socio-economic constraints – that prevent certain communities from fully benefiting from UGS. The path coefficient between CWB and demographic factors is 0.338, indicating that age, income, locality, and occupation significantly impact community well-being. This means that individuals with higher incomes or those living in urban areas generally experience greater well-being advantages compared to disadvantaged groups. Lastly, the path coefficient between EJ and CWB is 0.299, demonstrating that equal access to UGS and the removal of barriers positively contribute to community well-being. This finding highlights the importance of addressing obstacles to UGS access to enhance overall well-being in urban communities.

Figure 8: SmartPLS results



Source: Authors

The study indicates that while UGS alone does not strongly influence CWB, ensuring equitable access and removing barriers related to environmental justice can significantly improve community well-being. Policymakers should focus on reducing disparities in access to green spaces to promote a more inclusive and sustainable urban environment.

Conclusion and Recommendations

The results indicate that Urban Green Spaces (UGS) do not have a significant direct impact on Community Well-being (CWB) or Environmental Justice (EJ). Instead, their influence is indirectly mediated by factors such as demographic characteristics and environmental justice. This suggests that policies aimed at improving community well-being through UGS should prioritize equitable access and address demographic disparities.

To enhance both environmental justice and well-being, policymakers should focus on: ensuring accessibility of UGS for low-income and rural residents, improving the quality and safety of green spaces, and involving communities in decision-making processes to better align UGS development with local needs.

The strong negative relationship between UGS and demographic factors highlights the need to eliminate barriers that prevent certain groups from accessing green spaces. Targeted interventions could include: enhancing transportation to UGS for residents in remote or underserved areas, creating new green spaces in neighborhoods with limited access, and designing inclusive programs that address the specific needs of diverse demographic groups.

The moderate positive relationship between Environmental Justice and Community Well-being underscores the importance of fairness and inclusivity in UGS planning. Policies should focus on: ensuring equal access to green spaces for all residents, addressing barriers such as safety concerns, poor maintenance, and lack of amenities. By prioritizing equity in UGS planning and reducing access disparities, policymakers can significantly enhance both environmental justice and overall community well-being.

Recent research underscores that participatory governance frameworks can help achieve fairer outcomes in UGS planning (Xia et al., 2024; Zhang & Kumar, 2024). Moreover, evidence from Balkan and global contexts shows that economic inequality shapes both the expansion and distribution of green infrastructure (Huang et al., 2023). Optimization-based planning tools provide new opportunities for policymakers to balance efficiency and equity in green space provision (Pinto et al., 2025).

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ЭЕ
ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 10, January-April 2026, №. 1
UDK 33+502/504
ISSN 2560-421X

Danijela Pantović[1]
Andrija Milutinović[2]
University of Kragujevac, Faculty of Hotel Management and Tourism in Vrnjačka Banja, Vrnjačka Banja, Serbia

Tadeja Jere Jakulin[3]
UP Faculty of Tourism Studies Turistica, Portorož, Slovenia

P. 43-56
ORIGINAL SCIENTIFIC PAPER
DOI: 10.5937/ESD2601043P
Received: May 23, 2025
Accepted: November 11, 2025

TOURISTS' PERCEPTION OF THE IMPORTANCE OF GASTRONOMY AND SUSTAINABLE TOURISM PRACTICES: LESSONS FROM SERBIA

Abstract

Sustainable gastronomic tourism represents a unique opportunity to connect food, local gastronomy and ecotourism in order to create a holistic tourist experience. This study examines the attitudes of tourists on the promotion of sustainable tourism through awareness of nutrition and environmental conservation. The aim of the research was to examine the perception of gastronomy and its importance in the context of sustainable tourism in Serbia. The research was conducted during the year 2025 on a sample of 52 respondents, using a methodology that included a survey questionnaire and field data collection. Applying principal component analysis (PCA), two key dimensions of tourists' attitudes were identified: "Gastronomic knowledge and interest" and "Ecological and sustainable consumer awareness", which together explain 76.5% of the total variance. The obtained results show that respondents highly value gastronomic and sustainable practices in restaurants, especially those that involve the use of locally grown food, waste reduction and the use of recycled products. On the other hand, measures of a broader socio-ecological character, such as donations and payment of fees aimed at reducing the ecological footprint, received a somewhat lower level of support among respondents.

Key words: *gastronomy, sustainable tourism, local food, Serbia*

JEL classification: *Z30, Q50*

ПЕРЦЕПЦИЈА ТУРИСТА О ЗНАЧАЈУ ГАСТРОНОМИЈЕ И ПРАКСАМА ОДРЖИВОГ ТУРИЗМА: ИСКУСТВА ИЗ СРБИЈЕ

Апстракт

Одрживи гастрономски туризам представља јединствену могућност повезивања исхране, локалне гастрономије и екотуризма у циљу стварања холистичког

[1] danijela.durkalic@kg.ac.rs, ORCID ID 0000-0001-8605-8614

[2] milutinovicandrija222@gmail.com, ORCID ID 0009-0005-0203-9659

[3] tadeja.jerejakulin@upr.si, ORCID ID 0000-0003-1849-8444

туристичког искуства. Ова студија испитује ставове туриста о унапређењу одрживог туризма кроз свест о исхрани и очувању животне средине. Циљ истраживања био је да се испита перцепција гастрономије и њен значај у контексту одрживог туризма у Србији. Истраживање је спроведено током 2025. године на узорку од 52 испитаника, применом методологије која је обухватила анкетни упитник и теренско прикупљање података. Применом анализе главних компоненти (PCA) идентификоване су две кључне димензије ставова туриста: „Гастрономско знање и интересовање“ и „Еколошка и одржива свест потрошача“, које заједно објашњавају 76,5% укупне варијансе. Добијени резултати показују да испитаници високо вреднују гастрономске и одрживе праксе у ресторанима, посебно оне које подразумевају употребу локално узгојене хране, смањење отпада и коришћење рециклираних производа. С друге стране, мере ширег социо-еколошког карактера, попут донација и плаћања накнада усмерених на смањење еколошког отиска, добиле су нешто нижи ниво подршке међу испитаницима.

Кључне речи: *гастрономија, одрживи туризам, локална храна, Србија*

Introduction

Contemporary trends in tourism increasingly emphasize the importance of sustainability, local identity and authentic experiences that connect tourists with the destination in a wider context. In this context, sustainable gastronomy becomes a key element of the tourist offer because it simultaneously promotes local food products, cultural heritage and a responsible attitude towards the environment (Rinaldi, 2017). Tourists today, in addition to enjoying taste and food, are characterized by a conscious experience that reflects their values and contributes to the preservation of natural resources (Adongo et al., 2018). Knowledge about food and developed environmental awareness thus become important factors that shape the perception and choice of tourists when it comes to the gastronomic offer.

Accordingly, the research in this paper aims to examine how tourists perceive the importance of gastronomy, personal knowledge about food and the application of principles of sustainable restaurant practices. A special focus is placed on understanding attitudes about the importance of local food, recycling, energy efficiency and other measures that contribute to the preservation of the environment. The results of the research are expected to confirm the importance of gastronomy and the gastronomic experience for tourists, as well as that tourists perceive sustainable gastronomic practices as a significant factor of the further development of tourism.

The structure of the paper includes several related chapters. After the introduction, the theoretical framework on sustainable and gastronomic tourism follows; then the research methodology, the results of the factor analysis and the interpretation of the obtained findings are presented. At the end of the paper, concluding considerations and recommendations for the development of sustainable gastronomic tourism in Serbia will be presented.

Theoretical Background

Gastronomic tourism

Gastronomic tourism, as an increasingly dynamic segment of the wider tourism industry, connects travelers with the destination's cultural heritage through its gastronomy. This experience goes beyond the pure enjoyment of the taste and aesthetic experience of food, as it allows visitors to become familiar with traditional practices, techniques and authentic ingredients that shape the cultural and identity character of a certain area (Adekunle et al., 2024).

Food as a travel motivator is still an under-researched area, especially when it comes to the factors that encourage tourists to choose trips based on gastronomic experiences (Kumar, 2024). Researchers agree that consumption values influence preferences, purchase decisions and perceptions regarding the cultural and social significance of traditional specialties (Dwivedi & Jha, 2024), a topic that is still not sufficiently covered in the literature. Recent research indicates that key actors in tourism are intensively committed to promoting safe and hygienically correct gastronomic events, supporting private businesses, developing culinary centers, improving infrastructure and promoting regional cuisines, thereby contributing to the development of gastronomic tourism and strengthening the local identity of destinations.

In the context of new trends, gastronomy plays an important role in green tourism, whose goals include nature conservation, cultural heritage protection, and the development of social responsibility (Hjalager, 2020; Okumus, 2021). Chefs and restaurateurs increasingly focus on the use of local and seasonal ingredients, which positively affects both the community and the environment, while also attracting tourists (Ellis et al., 2018; Sims, 2009). Using ingredients produced locally reduces energy and fuel consumption for transportation and, consequently, greenhouse gas emissions (Hall & Gössling, 2016; Filimonau & De Coteau, 2019). Moreover, such practices support local households and small producers, safeguard traditional recipes, and culinary techniques, and thus preserve intangible cultural heritage (Björk & Kauppinen-Räisänen, 2016; López-Bellido et al., 2014).

Gastronomy is also widely recognized as an important generator of authenticity and sustainable tourist experiences, as local food symbolically reflects the identity of a place and meets the demand for authenticity in travel experiences (Sims, 2009). Research on younger populations shows that Generation Z perceives traditional cuisine as a bridge to the culture and traditions of a destination (Gheorghe et al., 2021). According to Gheorghe et al. (2021), gastronomic tourism is becoming increasingly attractive to younger generations, who view traditional cuisine as a way to connect with local culture and heritage. On the other hand, Hernández-Rojas et al. (2022) highlight the strong link between gastronomic experience and destination loyalty, confirming that high-quality and authentic gastronomy can have a decisive impact on tourists' repeat visits. The literature also points to the importance of linking gastronomy with sustainable practices. Hall and Gössling (2016) emphasize that local food contributes to reducing the ecological footprint of tourism through the use of seasonal and regional products. Similarly, Sims (2009) highlights that the "farm-to-table" concept connects tourism with agriculture, strengthening local communities and contributing to the diversification of rural economies.

In the context of green tourism, gastronomy is particularly significant, as it promotes the use of locally sourced ingredients, supports small-scale producers (Baysal

& Bilici, 2024), and encourages environmentally friendly culinary practices. Studies also highlight that tourists increasingly seek authentic food experiences that reflect local traditions while aligning with sustainable and responsible tourism principles, making traditional gastronomy a key driver of both cultural preservation and eco-conscious travel (Adekunle et al., 2024).

Sustainable gastronomy

In this context, the concept of sustainable gastronomy further reinforces these objectives by offering a green culinary approach that integrates environmental, cultural, and social dimensions of tourism. Green gastronomy represents a culinary approach focused on environmental protection, the nurturing of local culture, and the improvement of social well-being through the responsible use of food resources. This concept emphasizes the importance of using local products, environmentally friendly production methods, efficient waste management, and the preservation of traditional culinary heritage (Bajrami et al., 2025).

According to López-Bellido et al. (2014), green gastronomy is an integrated culinary practice that develops ecological awareness, supports the local economy, and preserves cultural heritage through sustainable food choices. Such an understanding not only influences the way food is produced and served but also has an educational role, as it raises consumer awareness about the importance of sustainability in everyday life (Agustiani et al., 2025).

Modern trends encompassing all spheres of life, including gastronomy, impose on hospitality establishments the need for creative and improved menus that meet tourists' expectations and desires. As guests increasingly pay attention to the origin and method of preparation of dishes, restaurateurs must adapt their offerings to new criteria. In contemporary times, gastronomy was often associated with the health impact of food, the representation of a region's cultural identity, and the harmonious pairing of dishes and beverages.

Green gastronomy also involves the application of environmentally friendly methods of food production, reduction of waste, and encouragement of recycling and composting (Filimonau & De Coteau, 2019; Agustiani et al., 2025). In this way, it can contribute to the preservation of natural resources, pollution reduction, and biodiversity protection (Hall & Gössling, 2016; López-Bellido et al., 2014). At the same time, the use of local ingredients promotes the safeguarding of culture and tradition, strengthening tourists' awareness of the importance of heritage and nature conservation (Björk & Kauppinen-Räisänen, 2016; Sims, 2009; Dimitrijević, 2025). This enables visitors to connect more closely with the local community and its customs, enhancing both authenticity and sustainability of the tourism experience (Hernández-Rojas et al., 2022).

The Importance of Sustainable Gastronomic Tourism for Serbia

Serbia, as a country rich in tradition and culture, has a strong foundation for the development of gastronomic offerings in all its regions. Historical circumstances that shaped people's diets and habits serve as a source of engaging culinary narratives that can attract visitors. Tourism and hospitality play a vital role in Serbia's economy, which makes it necessary to follow modern trends and continuously improve offerings. An increasing number of restaurants in Serbia are turning toward green tourism practices—relying on local ingredients or even producing part of the food themselves. This represents a significant advantage, as Serbia, in addition to its natural beauty and preserved environment, can also offer authentic local products through the lens of sustainability and eco-approaches (Pavličić, 2023). However, research addressing the intersection of gastronomy and sustainable or green tourism in Serbia remains relatively scarce.

Existing studies mainly emphasize the role of traditional cuisine in rural and cultural tourism development, particularly through gastronomic events, wine routes, and village households (Vujko et al., 2020; Gajić et al., 2025). This highlights the need for more systematic research that would explore how traditional gastronomy can be strategically integrated into green tourism models to enhance both sustainability and destination competitiveness.

Recent research expands this foundation: Paunić et al. (2024) examine the "gastronomic identity" of Serbia and Bosnia-Herzegovina, highlighting factors like cultural heritage and gastro-tourism events that foster sustainability. Similarly, Kalenjuk Pivarski et al. (2024) focus on the Srem region, underscoring authenticity, event quality, and food offerings as critical factors for tourism development. Additionally, Stošić et al. (2025) explore how pairing local food and wine enhances sustainability in hospitality highlighting environmental and economic benefits of reduced food miles and authentic experiences.

In the context of Serbia and the region, research (Vujko et al., 2020) indicates that traditional cuisine has considerable potential in the development of rural tourism, particularly through gastronomic events, rural households, and wine routes. However, it is emphasized that there is a need for more systematic promotion and the integration of gastronomic resources into green tourism in order to achieve greater recognition in the international market.

Materials and Methods

Sample and Participants. The research was conducted during August 2025 on the territory of the Republic of Serbia. The sample included 52 respondents of different gender and age structures, thus ensuring diversity in terms of demographic characteristics and level of experience in the field of tourism and gastronomy. Tourists were first asked if they were interested in traditional gastronomy, and then they started giving answers. The research was conducted through a survey questionnaire, which was distributed through direct contact at tourist locations. The relatively small number of participants is a result of the exploratory nature of the study and the short data collection window, yet the responses provided a sufficient basis for descriptive analysis of attitudes, opinions, and experiences related to sustainable gastronomy.

Data Collection Procedure. A structured survey questionnaire was used as the basic research instrument. The questionnaire was designed with the aim of examining tourists' knowledge of food, their environmental awareness and perception of sustainable gastronomy. It consisted of closed questions rated using a seven-point Likert scale (Hossain et al., 2024), ranging from 1 (strongly disagree) to 7 (strongly agree). Choosing a seven-point scale proved to be the optimal approach because it provides a balanced relationship between measurement precision and ease of answering. The seven-point scale allows a fine enough discrimination between the respondents' attitudes, without burdening the participants with too many options (Russo et al., 2021). Also, research has shown that mean values on seven-point scales have a stronger correlation with empirically observed levels of significance compared to five-point scales, that is, seven-point scales result in stronger connections with statistical indicators (Dawes, 2002).

Study Description. The survey instrument was adapted from previously validated research tools (Gheorghe et al., 2021; Hernández-Rojas et al., 2022) and carefully adjusted to reflect the specific socio-cultural and gastronomic characteristics of Serbia. The SPSS (v.23) software package is used for testing in this study.

Research Results

The results of the research provide insights into the demographic profile of respondents, the reliability of the applied measurement scales, and tourists' knowledge, motivations, and perceptions of traditional gastronomy in the context of sustainable tourism practice in Serbia. The analysis begins with the demographic characteristics of the sample, followed by the evaluation of measurement reliability, and finally explores the attitudes of tourists toward gastronomy and sustainable practices. After the demographic analysis, PCA analysis will be performed to confirm the relationships and groupings between the observed variables.

The demographic profile of respondents shows a predominance of younger generations and highly educated participants, which is consistent with findings that younger cohorts, particularly Generation Z, demonstrate a stronger orientation toward authentic and environmentally responsible tourism practices (Gheorghe et al., 2021; Hernández-Rojas et al., 2022). The reliability of the applied scales was confirmed through Cronbach's alpha coefficients, which indicate high internal consistency and support the validity of subsequent interpretations.

Table 1: Demographic profile of the respondents

	Frequency (%)
Gender	
Male	46.2
Female	53.8
Age (year)	
18-25	51.9
26-35	19.2
36-45	13.5
46-55	11.5
>55	3.8
Education	
Secondary/high school	17.3
University degree	51.9
Master's degree	21.2
PhD	9.6
Region	
Belgrade	11.5
Vojvodina	5.8
Region of Šumadija and Western Serbia	63.5
Region of Southern and Eastern Serbia	19.2

Monthly income	
<52.000 RSD	21.2
53.000-80.000 RSD	11.5
81.000-100.000 RSD	23.1
>100.000 RSD	23.1
no statement	21.2

Source: Authors' calculation

When it comes to the demographic statistics of the respondents (Table 1), it can be seen that 52 respondents from the territory of the Republic of Serbia participated in the research. The sample was balanced in terms of gender (53.8% women and 46.2% men). The most numerous age group consisted of respondents aged 18 to 25 (51.9%), while the participation of those over 55 was the least (3.8%). Most of the participants have higher education (51.9% university degree, 21.2% master's degree, 9.6% doctorate, while 17.3% completed high school). The largest number of respondents comes from the Šumadija Region and Western Serbia (63.5%), while the smaller number comes from Southern and Eastern Serbia (19.2%), Belgrade (11.5%) and Vojvodina (5.8%).

Table 2: Reliability statistics

Question group	Cronbach's alpha
Knowledge	0.869
Importance of green practices in restaurants	0.911

Source: Authors' calculation

The reliability of the scales was assessed using Cronbach's alpha coefficient (Nannally, 1978). The results indicate that both question groups have high internal consistency (Table 2). Specifically, the "Knowledge" scale achieved a value of α = 0.869, while the "Importance of green practices in restaurants" scale reached an even higher reliability level (α = 0.911). Both coefficients exceed the recommended threshold of 0.70 (Nunnally, 1978), indicating that the items within each scale are mutually consistent and adequately measure the observed constructs. The obtained values, which range between 0.80 and 0.95, point to very good to excellent reliability, without indications of potential item redundancy (George & Mallery, 2003). Accordingly, both scales can be considered reliable measurement instruments for further analysis.

Table 3: Knowledge and motivation of the gastronomy of the Republic of Serbia (%)

	Frequency (%)
How well do you know the food and cuisine of the Republic of Serbia? - I know very well - I know well - I know moderately - I don't know at all	 15.4 32.7 46.2 5.8

Have you ever traveled solely with the aim of experiencing the local cuisine of a destination? - Yes - No	40.4 59.6
Can a positive gastronomic experience motivate you to visit that destination again? - Yes - No	94.2 5.8

Source: Authors' calculation

The results shown in Table 3 indicate that the majority of respondents have a moderate to good knowledge of the gastronomy of the Republic of Serbia. The largest percentage of respondents (46.2%) assessed that they know Serbian food and cooking moderately, while 32.7% stated that they know them well, and 15.4% very well. A smaller number of participants (5.8%) stated that they do not know local gastronomy at all. When it comes to the motivation for travel, 40.4% of the respondents stated that they traveled solely for the gastronomic experience, while the majority (59.6%) had not yet done so. However, almost all participants (94.2%) stated that a positive gastronomic experience would motivate them to visit a certain destination again, which confirms the importance of gastronomy as an important factor of tourist loyalty and repeat visits. The obtained results are in accordance with previous research that indicate the growing importance of gastronomy as a motivational factor in tourism. Namely, earlier studies have confirmed that positive gastronomic experiences significantly influence the formation of an emotional bond with the destination and can represent a key incentive for repeat visits (Kovalenko et al., 2023). Similarly, research conducted by Kumar (2024) and Okumus et al. (2020) shows that culinary is increasingly becoming the main motive for travel, especially among younger generations who strive for authentic and sustainable experiences (Guzel & Apaydin, 2016).

Table 4: Response statistics

Question	N	Minimum	Maximum	Mean	Std. Deviation
K1	52	1.00	7.00	5.3654	1.54703
K2	52	1.00	7.00	5.0577	1.88298
K3	52	1.00	7.00	4.8654	1.72671
I1	52	1.00	7.00	5.9615	1.66817
I2	52	1.00	7.00	5.8846	1.55493
I3	52	2.00	7.00	6.1538	1.24278
I4	52	1.00	7.00	5.5385	1.68571
I5	52	1.00	7.00	5.6346	1.60915

Note: Questions with K - refer to knowledge and questions with I- refer to importance (K1 - How important is it that the gastronomic experience leads to the overall satisfaction of your trip?; K2 - I am interested in food and cuisine in general; K3 - I have good knowledge about food and cooking in general; I1 - It is important for restaurants to reduce energy consumption and the amount of waste; I2 - It is important that restaurants use biodegradable or recycled products; I3 - It is important that restaurants serve locally grown food; I4 - It is important that restaurants donate to environmental projects; I5 - It is important that restaurants pay fees to reduce their environmental footprint).

Source: Authors' calculation

The descriptive statistics of the respondents' knowledge (K1–K3) and perceptions of the importance of sustainable gastronomic practices (I1–I5) are presented in Table 4. The results indicate that participants generally have a moderate to high level of interest in and knowledge about gastronomy, with mean scores of 5.37 (K1), 5.06 (K2), and 4.87 (K3) on a 7-point scale. This suggests that respondents are engaged with the culinary aspects of tourism, particularly in relation to overall trip satisfaction and general interest in food (Sims, 2009).

Regarding the importance of sustainability measures in the gastronomic experience, participants rated practical, direct sustainability practices the highest. Serving locally grown food (I3; M = 6.15) and reducing energy consumption and waste (I1; M = 5.96) were considered most important, followed by the use of biodegradable or recycled products (I2; M = 5.88), and other direct practices such as supporting local initiatives (I5; M = 5.63) which is consistent with previous findings on the growing ecological awareness of consumers in hospitality contexts (Han & Hyun, 2017). In contrast, activities with a more indirect socio-ecological impact, such as donations to environmental projects (I4; M = 5.54) and paying environmental fees (I5; M = 5.63), received comparatively lower importance ratings.

In order to investigate the latent dimensions that shape the perception of knowledge about gastronomy and the importance of ecological and sustainable practices among tourists, PCA - Principal Component Analysis is carried out. PCA enables the identification of latent factors that group similar attitudes and perceptions of respondents, facilitating further interpretation of the relationship between knowledge, motivation and environmental awareness in the context of sustainable gastronomy.

Table 5: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.804
Bartlett's Test of Sphericity	Approx. Chi-Square	297.273
	df	28
	Sig.	.000

Source: Authors' calculation

PCA goodness-of-fit check of the data showed that the conditions were met. The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy was 0.804, which is considered a "good" level (Kaiser, 1974) and indicates that the sample is sufficient to conduct PCA. Bartlett's test of sphericity was significant ($\chi^2(28) = 297.273$, $p < 0.001$), suggesting that there were significant correlations between the variables and that the data were suitable for factor analysis. These results confirm that PCA is a justified method for further investigation of the latent dimensions of knowledge and environmental awareness among respondents.

The results of PCA (Total Variance Explained with Initial Eigenvalues) show that the first component explains 58.03% of the total variance, and the second 18.48%. After Varimax rotation, the first two components together explain 76.51% of the variance, indicating that the two latent dimensions sufficiently summarize the main patterns in respondents' attitudes. The first component reflects knowledge and interest in gastronomy, while the second represents ecological and sustainable awareness.

Table 6: Rotated factor coefficients (Component Matrix)

	Component	
	1	2
K1	0.615	0.619
K2	0.749	0.511
K3	0.66	0.597
I1	0.789	-0.363
I2	0.818	-0.307
I3	0.757	-0.038
I4	0.863	-0.344
I5	0.811	-0.363

Source: Authors' calculation

The results of the rotated factor matrix show the distribution of the variables by two main components. Variables K1–K3 (knowledge and interest in gastronomy) and I1–I5 (importance of ecological and sustainable practices) have high loadings on the first component, which indicates the existence of a dominant factor that unites respondents' attitudes towards gastronomy and sustainability. Varimax rotation enabled a clear separation of factors, and convergence was achieved in three iterations.

Figure 1: Scree Plot

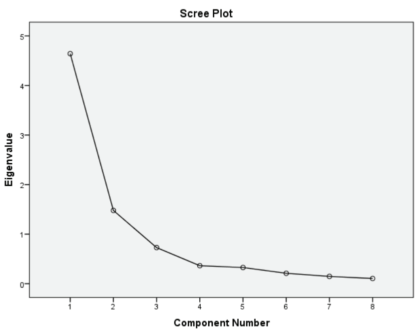
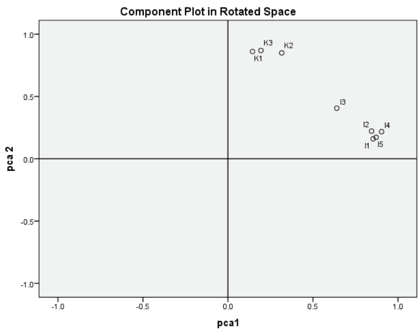


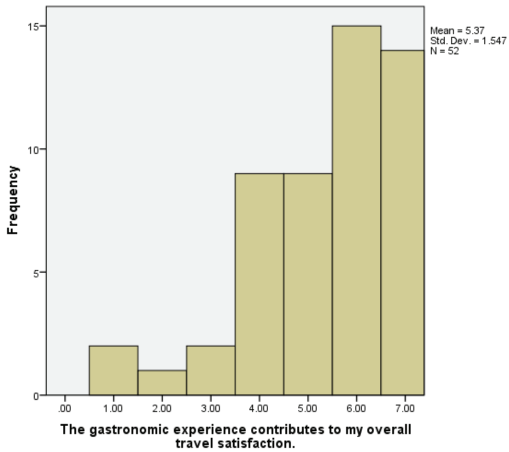
Figure 2: Component plot in rotated space



Source: Authors' calculation

For the final visual result, it is important to display both the Scree Plot and the Component plot in rotated space (Figure 1 and Figure 2). Based on the images shown, two components were observed, which together explain 76.5% of the total variance. In the first component, statements I1–I5, which refer to the ecological and sustainable practices of the restaurant, have a high loading. This factor reflects the opinion of the respondents on the importance of environmental responsibility of catering facilities. The second component related to interest and knowledge about gastronomy and cooking reflects the respondents' personal involvement and motivation towards gastronomy.

Figure 3. Contribution of gastronomic experience to travel satisfaction



Source: Authors' calculation

Finally, Figure 3 additionally shows the value of the gastronomic experience in contributing to overall travel satisfaction. The distribution of answers (M = 5.37; SD = 1.55) shows that the majority of respondents give high marks, which indicates that gastronomic experiences have an important role in forming a positive impression about travel.

Conclusion

Gastronomy has the potential to become a cornerstone of sustainable tourism development, offering value not only through taste but also by preserving nature, strengthening cultural identity and supporting local economies. The results of this study indicate that visitors attach the greatest importance to sustainability practices that have a direct and tangible impact on their gastronomic experience, such as serving locally grown food, reducing waste and using recycled products. Broader socio-ecological initiatives, although positively perceived, received relatively lower levels of support. These results suggest that tourists prioritize practical and visible sustainability measures that simultaneously enhance authenticity and environmental awareness.

It is also important to note that respondents value sustainability measures directly related to their personal gastronomic experience, such as serving local food and reducing waste. This is in line with Sims (2009), who emphasizes that consumers perceive local food as an authentic part of the tourist experience, as well as Han and Hyun (2017), who confirm the increasing importance of environmental awareness in hospitality decision-making. Findings are in line with previous research stressing the importance of local food as a driver of authenticity and sustainability (Sims, 2009; Hall & Gössling, 2016), while recent national studies confirm that satisfaction with local gastronomy in Serbia increases significantly when authenticity and eco-friendly practices are emphasized (Conić et al., 2025; Vukolić et al., 2024).

Also, the results show that gastronomy plays an important role in the formation of overall travel satisfaction. The majority of respondents believe that the gastronomic experience is an important element of the tourist experience, while the smaller part does not attach such importance to this aspect.

The obtained results indicate that the gastronomic experience significantly contributes to the overall satisfaction with the trip. The distribution of the data shows that the majority of respondents give high marks, which reflects the general consensus on the importance of gastronomy in improving the tourist experience. This suggests that culinary elements, such as local food and restaurant experiences, represent a significant dimension of tourist satisfaction. A smaller number of respondents expressed a lower level of agreement, indicating that, although there are individual differences, gastronomy is widely recognized as an integral part of travel satisfaction.

Despite these insights, the study has limitations. The sample size is relatively small and confined to a single country, limiting the generalizability of the findings. Additionally, while a mixed-methods approach was used, no deeper qualitative analysis was conducted to explore tourists' motivations and experiences in greater detail. Future research should therefore involve larger and more diverse samples, comparative studies across regions, and the perspectives of local producers and hospitality providers to provide a more comprehensive understanding of the role of traditional gastronomy in sustainable tourism. Overall, this study contributes to the literature by empirically demonstrating how sustainability is intertwined in tourists' evaluation of gastronomic experiences. These findings can offer practical guidance for tourism stakeholders and inform them about the development of sustainable tourism strategies.

Acknowledgements: *This research is supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia by the Decision on the scientific research funding for teaching staff at the accredited higher education institutions in 2025 (No. 451-03-137/2025-03/200375 of February 4, 2025).*

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ECONOMICS OF SUSTAINABLE DEVELOPMENT
Vol. 10, January-April 2026, №. 1
UDK 33+502/504
ISSN 2560-421X

Sandra Milanović Zbiljić[1]
Goran Milovanović[2]
University of Niš, Faculty of Economics

Miljana Talić[3]
University of Niš, Innovation Centre

P. 57-71
REVIEW PAPER
DOI: 10.5937/ESD2601057M
Received: October 6, 2025
Accepted: December 15, 2025

SUSTAINABILITY OF MODERN SUPPLY CHAINS

Abstract

The aim of the paper is to, based on the analysis of relevant sources, look at pertinent business dimensions: green supply chains, green innovations, sustainable supply chains, ecological superiority of suppliers, and green initiatives in the supply chain. The connections between these elements and their impact on company performance determine the subject of research. The results of this analysis can assist researchers and practitioners in improving the sustainability of supply chains, reducing environmental impact, encouraging ethical work practices, and promoting responsible procurement. In the era of growing pressures on companies to operate in an environmentally and socially responsible manner, green supply chain integration and sustainable supply chain management are emerging as strategic frameworks for achieving these goals.

Key words: *green supply chain, green innovation, green supply chain integration, sustainable supply chain management, green initiative, performance*

JEL classification: *R4, Q01*

ОДРЖИВОСТ САВРЕМЕНИХ ЛАНАЦА СНАБДЕВАЊА

Апстракт

Циљ рада је да се, на основу анализе релевантних извора, сагледају пословно релевантне димензије: зелених ланаца снабдевања, зелених иновација, одрживих ланаца снабдевања, еколошке супериорности добављача и зелених иницијатива у ланцу снабдевања. Везе између ових елемената и њихови утицаји на перформансе компанија одређују предмет истраживања. Резултати овог рада могу помоћи истраживачима и практичарима при побољшању одрживости ланаца снабдевања, смањењу утицаја на околину, подстицању етичких радних пракси и промовисању одговорне набавке. У условима раста притисака на компаније да раде на еколошки и друштвено одговоран начин, интеграција зеленог ланца снабдевања и управљање одрживим ланцем снабдевања се појављују као стратешки оквири за постизање ових циљева.

Кључне речи: *зелени ланац снабдевања, зелене иновације, интеграција зеленог ланца снабдевања, управљање одрживим ланцем снабдевања, зелене иницијативе, перформансе*

[1] sandra.milanovic@eknfak.ni.ac.rs, ORCID ID 0000-0002-0582-045X

[2] goran.milovanovic1963@yahoo.com, ORCID ID 0000-0002-9758-3606

[3] tmiljana@hotmail.com, ORCID ID 0000-0003-1017-8788

Introduction

To enhance environmental protection, corporations must manufacture their products in a manner that minimizes environmental harm. Pollution, waste, and heightened demand for natural resources are unequivocally responsible for the degradation of planet Earth.

In a period of growing levels of environmental awareness and concern for ethical work practices, companies are increasingly grappling with sustainability issues. Companies that adopt environmentally sustainable practices can achieve lower costs, better environmental performance, and higher levels of competitiveness and profitability compared to those that do not adopt such practices (Asif et al., 2011). These are significant reasons for implementing the Green Supply Chain (GSC) and Green Supply Chain Management (GSCM) concepts. The notion of GSC arose as researchers started to incorporate environmental considerations into the supply chain. This concept focuses only on environmental and economic issues. These days, businesses across all sectors use GSCM to create innovative eco-friendly goods, procedures, and services. In addition, GSCM helps them reduce costs, and improve quality and customer satisfaction.

The worldwide emphasis on environmental and economic accountability has transformed consumer expectations and prompted legislative changes that necessitate firms to be more cognizant of their societal implications. Sustainable supply chain management (SSCM) has emerged as a pivotal strategic concept, facilitating the alignment of profitability with environmental and social accountability for firms. Unlike GSC, which focuses only on environmental and economic issues, SSCM focuses on environmental, economic, and social issues (Gawusu et al., 2022).

The competitiveness of companies increasingly depends on their ability to adapt their strategies to take advantage of new climate changes. Furthermore, companies increasingly base their competitiveness on cooperation with suppliers who are committed to fair work practices and environmental protection standards. Therefore, the aim of the paper is to, based on the analysis of relevant sources, look at business relevant dimensions: green supply chains, green innovations, sustainable supply chains, ecological superiority of suppliers, and green initiatives in the supply chain.

The paper is structured as follows: The first part deals with the theoretical concept of green supply chain and sustainable supply chain. In the second part, the relationship between green supply chain and green innovations is explored. Lastly, the third part of the paper sheds light on the differences between traditional, green, and sustainable supply chain management, thus drawing attention to the importance of contemporary businesses.

1. Literature Review

1.1. Green Supply Chain

The concept of green supply chain (GSC), which has been discussed in the literature for almost three decades, is very important for the competition of companies in the market and the change of the competitive environment in many industries. The growing interest in environmental sustainability, and green and sustainable innovations contributes to the business affirmation of this concept. Consequently, GSC is integrated as an innovative strategy that can provide a company with a competitive advantage.

Starting from the symbol of the Olympic flag (five interwoven circles that symbolize the five continents, the universality of Olympism, and the meeting of athletes from all over the world), some authors created the concept of the Olympic green supply chain. This approach is built on five essential concepts (zero waste in the product life cycle, zero harmful chemicals, zero waste in activities, zero waste of resources, and zero emissions) in addition to green inputs and green outputs. However, these principles are still challenging to put into effect (Lakhal et al., 2009).

In order to ensure environmental compliance and advance environmental competence, GSC is a collection of procedures that integrate supply chain management with environmental concerns (Chu, 2017). It guarantees resource optimization and is regarded as a remedy for supply chain-wide consumption patterns and environmental issues.

One of the most popular operational management techniques for minimizing environmental effect is GSC. To create items that are environmentally friendly for consumers, it mostly uses renewable materials (MahmoumGonbadi et al., 2021). In addition, GSC is a common ecosystem and environmental improvement method applied in various fields to reduce energy consumption and increase growth rates. GSC encourages suppliers and customers to cooperate in the field of ecology to improve environmental and economic performance (Masi et al., 2017). Lastly, GSC enhances performance indicators such as operational efficiency, market share, and organizational image. Aligned with the resource-based view (RBV), GSC represents a difficult-to-imitate capability that builds environmental competencies and addresses stakeholder sustainability priorities across the supply chain (Levi-Bliech & Dahan, 2025).

1.2. Sustainable Supply Chain

The green transition's requirements have grown throughout time in line with the trends established by the idea of sustainable development, which encompasses social as well as ecological and economic aspects. A sustainable supply chain (SSC) is an extension of the earlier idea, which was developed with the goal of minimizing the environmental impact (Beamon, 1999). The concept of sustainable development has also been incorporated into supply chains, which has resulted in the emergence of sustainable supply chains. The sustainability of the supply chain is an important condition of their competitiveness today. Due to the increasingly developed awareness of society about environmental and social problems, companies are faced with the need to introduce changes and create systems that will meet the demands of modern society (Barbosa-Póvoa et al., 2018)

Supply chain sustainability is described as managing the effects on the environment, society, and economy while promoting sound management practices over the course of products' and services' life cycles in UN Global Compact publications (UN Global Compact & BSR, 2015). The goal of SSC is to create long-term environmental, social, and economic value for all stakeholders involved in the process of placing products and services on the market. The literature also states that modern supply chains should implement sustainable practices, not only for economic, but also for moral reasons (Dey et al., 2011). A sustainable supply chain is also described as a strategic integration that strives for the long-term fulfilment of social, environmental, and economic goals (Carter &Easton, 2011). It is defined as a complex network system of different entities that ensure the product gets from the supplier to the customer, including returns, while taking into account environmental, social, and economic impacts (Barbosa-Póvoa et al., 2018). In the literature, there is an opinion that the integration of the concept of sustainability in the entire supply chain and the proactive monitoring of business effects on the indicators of each of the three dimensions of sustainability can have significant benefits for both actors of the supply chain and society (Paulraj, 2011; Veljković et al., 2022). Research in supply chain sustainability has developed along two main trajectories: a performance perspective and a learning perspective. The performance perspective, which has long dominated the field, focuses on measurable outcomes, often assessed through the Triple Bottom Line framework. However, this outcome-driven focus has been criticised for overlooking the deeper processes and dynamics that drive sustainability transitions. In contrast, alternative approaches, such as those grounded in ecologically dominant logic, place stronger emphasis on environmental priorities but may underplay social dimensions of sustainability (Sauer et al., 2022).

In general, sustainability integrated into supply chains should influence the minimization of negative environmental and social consequences, while ensuring good economic performance of supply chain participants (Schaltegger & Burritt, 2014). A sustainable supply chain seeks to continuously improve the environmental, social, and economic performance of the supply chain and keep them in balance (Osei, 2023; Veljković et al., 2022).

2. Green Supply Chain Integration and Green Innovation Implementation

Companies are under pressure from various organizations such as governments, investors, media, and customers to enhance their environmental policies throughout the supply chain and adopt ideas like green innovations (GI) and green supply chain integration (GSCI) (Abbas et al., 2022). Due to these pressures, companies are faster to implement green practices, which contributes to making their business greener. According to Xiong et al. (2025), implementing GSC and GSCM enables firms to reduce emissions and waste, lowering environmental costs and mitigating ecological damage. These efforts can attract government subsidies and policy support, as GSCM promotes environmental responsibility across the supply chain. Firms that demonstrate strong social responsibility often gain public and governmental recognition, further incentivizing green innovation. Since sustainable innovation entails high R&D costs and risks, consistent investment and government subsidies play a vital role in offsetting expenses, reducing financial constraints, and motivating firms to pursue green technology development.

The Green Supply Chain Initiative (GSCI) showcases the degree of strategic cooperation between manufacturers and supply chain partners in managing internal and interorganizational activities to minimize environmental effect (Lo et al., 2018; Kong et al., 2020). In the relevant literature, the division of GSCI into: 1) internal green integration, and external green integration or green supplier integration and green customer integration (Wu, 2013; Mao et al., 2017). Internal green integration means communication, sharing of information resources, and coordination between the company's functional departments to manage the environment (Yu et al., 2014). In order to integrate green suppliers, significant suppliers who supply the resources required for green practices must engage in cooperative environmental efforts, information sharing, and cooperative environmental problem-solving. In order to give businesses the tools they need to implement green practices, green customer integration involves actions like information sharing, environmental collaboration, and cooperative problem-solving with important clients. Employers may better allocate, plan, and execute critical resources required for environmental protection strategies with the support of GSCI as a framework. According to Li et al. (2020), when a company aligns its environmental strategy with the GSCI mechanism, it can enhance its environmental performance and accomplish its strategic objectives.

By using information resources, companies can better manage their supply chain operations, which results in an increase in their environmental performance, competitive advantage, and efficiency (Chae et al., 2017). Based on quality information resources, companies can improve sustainability performance and GSCI.

Company information resources (IR) are one of the factors that affect GSCI. CIR opens up new opportunities for GSCI. A company that integrates activities using internal information technology can increase its efficiency. The environment benefits from the collaboration of GSCI and IR (Lin, 2022). The research of Jasrotia et al. (2024) highlights the transformative role of digital technologies such as blockchain in advancing firms' sustainability performance in the GSC. Achieving these benefits requires collaboration – governments should incentivize green initiatives, regulators must enforce clear environmental policies, and consumers need greater environmental awareness.

In order to explain the competitive position of companies and ways to improve performance, it is possible to combine the concept based on natural resources (Nature resource-based view) with GSCI. How particular GSCI procedures would become strategic assets for the business and boost performance is yet unknown for the scientific community.

Natural resources are becoming scarce, which has increased the significance of GSCI. It follows that GSCI is a useful management tool that can motivate industrial organizations to raise their sustainability. The growing worldwide consciousness about environmental issues is pressuring major businesses to devise strategies for reducing the environmental impact of their products.

The GSCI's dimensions are ever-changing. As a result, more research is required to determine how IR and GSCI and GSCI and GI interact as well as how this affects the company's intended performance. There is ample evidence to support the direct relationship between GSCI and GI. To meet performance goals, it is unclear how businesses will convert their GSCI initiatives into GI, nevertheless.

Large multinational companies are more successful than small ones in implementing the GSCM strategy and improving their environmental performance. They also provide more value to customers than small companies. This strategy allows large multinational companies to improve competitiveness based on reducing energy costs and waste disposal.

In a rapidly changing world, it is difficult to precisely specify the competencies and resources that will decisively influence the cost competitiveness of companies. The GSCM concept represents a formalized approach to sustainability. Since the nineties of the 20th century, when it was first defined, GSCM had the status of an organizational tool or a new ecological philosophy. The globalization of the economy has led to a situation where businesses have gradually merged based on a distinct set of goods and/or services, improving interaction reliability, cutting down on delivery times, and removing extra expenses for end users (Martínez & Mathiyazhagan, 2020).

In addition to the term green innovation, the following terms are often used as synonyms in the literature 'ecological innovation', 'environmental innovation', and 'sustainable innovation'. In any case, these terms show little differences in their descriptive precision, contribute to a better understanding of 'green' innovations, and can be used mostly as synonyms. Nonetheless, the definitions of the phrases given identify six crucial components: (1) the innovation's target: a product, procedure, service, or technique (2) Focusing on the market: satisfying demands and competing in the marketplace (3) environmental aspect: minimize any negative effects (optimal = zero impacts); (4) phase: the entire life cycle needs to be taken into account in order to minimize material flow; (5) impulse: the reduction goal may be environmental or economic; and (6) level: establishing an innovation/green standard for the organization (Schiederig et al., 2011).

Businesses understand the strategic value of environmental conservation as well as how information technology contributes to global warming. Businesses can enhance their reputation and reduce their environmental effect by adopting green innovation and incorporating sustainable practices into their operations.

Environmental issues in industrialized nations are definitely caused by waste, pollution, and growing demand for natural resources (Abdullah & Thurasamy, 2015). Scholars in these nations are becoming increasingly interested in the connection between environmental movements and corporate environmental performance. In reaction to environmental pollution, the depletion of natural resources, and climate change, the international community is putting green industry and supply chain measures into place. But these actions are frequently insufficient or have limited scope, particularly in developing nations where the idea of "going green" is just beginning to take hold. The particular difficulties, prospects, and ramifications of implementing GSCI and procedures like GI are not well studied in these nations (Kitsis & Chen, 2021).

3. Supply Chain Management

3.1. Historical Context of Supply Chain Management

While the term 'supply chain' was first used in the British daily newspaper *The Independent* in 1905, the term network of suppliers, manufacturers, and consumers existed long before that. Historically speaking, the concept of supply chain management (SCM) was created in the eighties of the XX century. It was first used by Keith Oliver in an interview with the British daily *Financial Times* on June 4, 1982, so it is relatively young compared to related concepts such as procurement, logistics, and manufacturing (Mentzer et al., 2001). The last three decades have seen the expansion of supply chains, especially in the consumer electronics, automotive, and textile industries, which has led to the creation of the SCM concept. Effective SCM is a key success factor for companies in today's highly dynamic and competitive business environment, dominated by advances in information technology. SCM requires coordination of the flow of products, services, information, and money between entities in the supply chain, such as suppliers, manufacturers, distributors, and buyers (Anđelković & Milovanović, 2021). The goal of SCM is to maximize value for consumers while enabling companies to reduce costs, streamline business operations, and operate profitably.

With the goal of enhancing the profitability, productivity, and efficiency of the overall flow, traditional supply chain management focuses on the movement of goods and services from one end of the chain to the other. SCM covers the economic functions of the entire value chain of products or services. Management of relationships in the supply chain decisively affects the sustainability and competitiveness of companies in the modern market (Paschina, 2021). Modern SCM leverages advanced technologies such as RFID, IoT, and data analytics to enable real-time tracking, improve inventory accuracy, and foster interoperability across global networks. The integration of socio-technical systems theory highlights the importance of aligning organizational structures, human behavior, and technological infrastructure to achieve supply chain resilience and agility. As supply chains evolve in the digital age, sustainability and risk management become critical components, necessitating adaptive strategies that can handle uncertainties and disruptions in complex environments. Overall, effective SCM is vital for maintaining competitive advantage, reducing costs, and ensuring customer satisfaction in an increasingly interconnected world (Zhang, Lin & Esfahbodi, 2025).

The demand for a more responsible approach to supply chain management (SCM) emerged when managers and researchers began to pay attention to the environmental and social ramifications of corporate activities. Businesses' business philosophies underwent a dramatic shift at the start of the twenty-first century when they began to emphasize the value of ethical labor practices and environmental management. Changes in regulations (such as new labor laws and environmental laws) have made supply chains more dependent on sustainability. Under these conditions, SSCM started to be applied to match corporate operations with sustainable objectives. Businesses now view sustainability as a strategic endeavor rather than only a compliance requirement.

3.2. Green Supply Chain Management

The concept of GSCM is broad and there is no clear holistic definition to describe it. Nevertheless, based on the definitions of some authors, GSCM can be safely defined as the integration of environmental concerns into inter-organizational supply chain management practices during the product life cycle (Luthra et al., 2014). It can be also differentiated as internal and expetrnal GSCM. Internal GSCM is driven by organizational values, leadership, and resources, focusing on implementing sustainable practices through policies, training, and employee engagement. It builds internal capabilities that support sustainability goals, emphasizing culture and intra-firm learning, with entrepreneurial orientation encouraging innovation in environmental management. In contrast, external GSCM is shaped by market demands, regulations, and customer expectations. Firms respond to these external pressures through compliance, eco-labeling, and collaboration with suppliers. While internal GSCM develops green competencies from within, external GSCM aligns supply chain activities with external sustainability standards. Together, they foster comprehensive environmental management across the supply chain (Ahmed et al., 2024).

According to Luther et al. (2014), GSCM entails applying environmental management concepts to every step of the customer order cycle, including design, sourcing, production, assembly, packaging, transportation, and distribution. This is a new paradigm where businesses may increase their environmental efficiency and increase market share while lowering their environmental risks and impacts.

Operations managers are adopting more and more health, safety, and environmental practices, particularly those who want to enhance the environmental performance of their company's operations (Duijm et al., 2008). Comparable to the evolution of the GSC idea, during the past three decades, GSCM coverage in scholarly papers has grown geometrically. Research has indicated that the comparative significance of these activities dates back to the late 1960s, when the environmental issue first surfaced. But the GSCM wasn't established or formalized until after the 1990s (Sarkis et al., 2011).

In contrast to conventional supply chain management, green supply chain management (GSCM) is defined by the development of "greener" products, the choice and acquisition of "greener" raw materials, as well as "greener" manufacturing, distribution, and post-purchase services. When creating GSC practices, two strategies should be taken into account: (1) a collaboration-based strategy and (2) a monitoring-based strategy. A monitoring-based strategy suggests that the sourcing business establishes criteria for assessing vendors and their goods. In order to improve a supplier's environmental performance while concentrating on long-term objectives, a collaborative strategy necessitates direct customer involvement (Lee, 2008).

A small number of companies have integrated green practices into their supply chains. The literature has not yet clearly established a comprehensive list of green practices and explained what constitutes a green supply chain practice. In addition, some authors confused the terms 'green' and 'sustainability' in the literature review on GSCM (Sarkis et al., 2011). A comprehensive list of green practices is essential for managers, policymakers, and academics for future research in this area.

In the academic literature, the terms 'green' and 'sustainable' are sometimes used interchangeably, to emphasize their impact on the economy, society, and the environment. The concept of GSCM is the result of the impact of the 'quality revolution' of the 1980s and the 'supply chain revolution' of the 1990s. These two transformative processes have generated significant challenges in supply chains. The discipline of GSCM itself is gaining more and more popularity, as it points to the fact that remanufacturing and environmental efficiency can enable a company to improve its standard operations. As GSC can be seen as a logistics structure that should guarantee companies to achieve global production and distribution of products in an environmentally friendly way, to achieve such a goal, companies must invest in designing and optimizing the planning of their logistics structures, taking into account the trade-off between profit and environmental impact (Sarkis et al., 2011).

GSCM is attracting the attention of people from science and business practice because of its potential for pollution mitigation and resource conservation. Increasing the awareness of managers and policymakers about environmental responsibility increases the need to implement the concept of GSCM. Companies that implement this concept reduce their negative impact on the environment by reducing emissions, pollution, waste, and the use of natural resources (Wang et al., 2013).

3.3. Sustainable Supply Chain Management

In order to find ways to behave sustainably, companies implement the concept of triple-bottom-line reporting. The concept was created by John Elkington in 1994. It integrates three company reports into its corporate culture, strategy, and business operations: (1) the Profit report, (2) the People report, and (3) the Environmental Responsibility report. The reports reveal ways in which companies are improving the sustainability of their operations (Alhaddi, 2015). Similar to this, supply chain sustainability is a multifaceted idea with implications for the environment, society, and economy. Reducing the environmental impact of supply chain operations, which calls for actions like cutting back on energy use, waste production, and material procurement responsibly, can lessen the environmental component of sustainability. The social dimension of sustainability requires social responsibility, which is achieved by ensuring ethical work practices and respecting workers' rights. In addition to the environmental and social dimensions, the economic dimension of sustainability is very important, as companies must remain profitable while implementing sustainable practices (Arowoshegbe et al., 2016).

In addition to companies, consumers are also trying to find ways to behave sustainably. Consumers in various markets have changed their purchasing behavior in favor of environmentally friendly products. They are becoming more aware of the environmental impact of their purchasing decisions and are beginning to take more into account when gathering information to make those decisions (Mayer et al., 2022). Companies are responding to this trend by implementing a sustainability strategy. There are two goals of such a strategy: (1) alignment with the company's goals, mission, or values, and (2) building, maintaining, or improving the company's reputation (Galpin et al., 2015).

As a result, the SSCM can be viewed as a collection of managerial techniques that prioritize the environment, take into account every stage of the product's value chain, and adopt a multidisciplinary viewpoint that covers the full life cycle of the product (Gupta & Palsule-Desai, 2011). According to Seuring and Müller (2008), supply chain chain management (SSCM) entails managing capital, information, and material flows as well as cooperating amongst businesses along the chain while upholding the objectives of the economic, ecological, and social dimensions of sustainable development. These goals stem from the demands placed on businesses by their stakeholders and customers. According to Ahi and Searcy (2013), supply chain coordination (SSCM) is the process of creating coordinated supply chains by voluntarily integrating economic, environmental, and social dimensions with important inter-organizational business systems. These systems are meant to effectively and efficiently manage the flows of capital, information, and materials related to the acquisition, production, and distribution of goods and services, to satisfy stakeholders' demands both now and in the future, and to increase the organization's profitability, competitiveness, and resilience. This term covers several aspects of efficacy, efficiency, and coordination. It presents a supply chain model with the goal of enhancing the chain's environmental performance through the application of best practices (Kalyar et al., 2019). These consist of distribution, production, material selection and procurement, and product design.

Furthermore, SSCM signifies a significant shift in the management of supply chain operations and procedures. It includes a variety of methods and ideas that go beyond making money and cutting expenses. It should minimize the impact on the environment, support ethical work practices, and encourage responsible procurement all while optimizing supply chain operations. It makes it possible for sustainable practices to spur innovation, lower risk, and enhance brand reputation, turning sustainability into a competitive advantage rather than an expensive liability. Under such circumstances, businesses, and the environment benefit

(Paschina, 2018). On the other hand, primary barriers to adopting SSCM include technological incompatibilities, data management challenges, and the lack of advanced eco-efficiency technologies. These obstacles hinder effective integration of digital tools, limit real-time environmental decision-making, and impede the development of sustainable product designs. Addressing these barriers requires concerted efforts to improve technological interoperability, develop supportive data-sharing protocols, and advance eco-friendly innovations within supply chains (Han & Li, 2025).

SSCM affects businesses differently depending on their size and industry. It is possible to ascertain how SSCM addresses current sustainability challenges and what benefits it offers businesses in terms of lowering environmental impact, enhancing moral work practices, and guaranteeing responsible procurement by investigating best practices, case studies, and emerging trends. According to Primadasa et al. (2025), SSCM enhances operational efficiency and resilience by aligning business activities with environmental and social goals, reducing waste, ensuring regulatory compliance, and improving transparency and risk management. It also drives cost savings, strengthens brand reputation, and fosters trust among stakeholders. By integrating circular economy principles, SSCM enables firms to optimize resources and gain a competitive advantage in sustainability-driven markets.

In an era where globalization and sustainability are becoming more and more important, SSCM plays a transformative and integrative role by tying together corporate social responsibility and worldwide initiatives to save the environment and improve business operations. SSCM has a big impact on businesses, thus it is critical to grasp it holistically. Sustainability plays a crucial role in the success of its businesses when it is integrated into the supply chain.

Conclusion

Businesses that embrace green innovation and incorporate sustainable practices into their operations can boost efficiency, minimize negative environmental effects, and enhance their reputation. The performance of companies and the use of GI are significantly positively correlated with the adoption of GSCI. Environmentally relevant processes and product innovations enable companies to improve business performance. By using information technologies, companies can more successfully generate green innovations, and increase environmental performance and competitive advantage.

As businesses work to connect their operations with social and environmental responsibility, interest in the concepts of sustainable supply chain management and green supply chain integration is growing. Businesses need to apply GSCM if they want to gain and keep a competitive edge. The application of GSCM is expanding in response to a rise in environmental awareness and concern. Furthermore, GSCM is frequently perceived as a sophisticated and methodical approach utilized by businesses globally to attain environmental sustainability.

SSCM assists businesses in addressing contemporary sustainability issues. Businesses are embracing green practices more and more in addition to satisfying stakeholder demands and enhancing the sustainability of their operations.

By managing products, promoting sustainable growth, and minimizing pollution, a business can acquire a competitive edge by making a positive impact on sustainable development. It may enhance its green image by cutting waste, which would help sway consumer decisions to buy.

Acknowledgment: This research is part of the 101136834 – CROSS-REIS – HORIZON-WIDERA-2023-ACCESS-03 project, funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency. Neither the European Union nor the European Research Executive Agency can be held responsible for them.

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ECONOMICS OF SUSTAINABLE DEVELOPMENT

Vol. 10, January-April 2026, №. 1
UDK 33+502/504
ISSN 2560-421X

Andrea Andrejević Panić[1]
Slobodan Cvetanović[2]
Educons University, Faculty of Business Economics, Sremska Kamenica, Serbia

P. 73-92
REVIEW PAPER
DOI: 10.5937/ESD2601073A
Received: July 26, 2025
Accepted: November 15, 2025

THE EVOLUTION OF HELIX MODELS AND THEIR CONTRIBUTION TO THE DEVELOPMENT OF INNOVATION ECOSYSTEMS

Abstract

This paper explores the evolution of helix innovation models, progressing from the Triple Helix (3TH) through the Quadruple Helix (4QH) to the Quintuple Helix (5QH), and examines their contribution to the development of innovation ecosystems (IES). Building on theoretical insights and institutional practices, it highlights the increasingly significant role of key actors in shaping, consolidating, and enhancing the efficiency of IES. The findings indicate that the integration of civil society within the 4QH model and the inclusion of the natural environment within the 5QH model have had a substantial impact on the evolution of IES. Furthermore, the growing levels of collaboration, inclusiveness, and sustainability characteristic of helix models enhance innovation capacity, strengthen social responsibility, and ensure the long-term resilience and sustainability of contemporary IES. In other words, the contribution of the helix approach to IES development lies not only in expanding the number of actors but also in their interdependence, ability to generate synergy, and capacity to address challenges of inclusiveness and sustainability.

Key words: *innovation, helix innovation models, innovation ecosystems*

JEL classification: *031, 032*

ЕВОЛУЦИЈА ХЕЛИКС МОДЕЛА И ЊИХОВ УТИЦАЈ НА РАЗВОЈ ИНОВАЦИОНИХ ЕКОСИСТЕМА

Апстракт

Рад истражује еволуцију хеликс иновационих модела, напредујући од троструког хеликса (Triple Helix – 3TH), преко четвороструког хеликса (Quadruple Helix - 4QH), до петоструког хеликса (Quintuple Helix - 5QH), и испитује њихов допринос развоју иновационих екосистема – ИЕС (Innovation Ecosystems - IES). Ослањајући се на теоријска сазнања и институционалне праксе, рад наглашава све значајнију улогу кључних актера у хеликс иновационим моделима у обликовању, консолидацији и унапређењу ефикасности функционисања ИЕС. Налази показују да је интеграција цивилног друштва унутар модела 4QH и укључивање природног окружења

1 andrea.andrejevic@educons.edu.rs, ORCID ID 0000-0003-4688-3171

2 prof.cvet@gmail.com, ORCID ID 0000-0001-9589-979X

унутар модела 5QH имала значајан утицај на еволуцију ИЕС. Даље, растући степен сарадње, инклузивности и одрживости, који карактерише хеликс моделе, унапређује иновациони капацитет, јача друштвену одговорност и обезбеђује дугорочну отпорност и одрживост савремених ИЕС. Другим речима, допринос хеликс приступа развоју ИЕС није само у проширењу броја актера, већ и у њиховој међузависности, способности за генерисање синергије и капацитету да одговоре на изазове инклузивности и одрживости.

Кључне речи: *иновације, хеликс иновациони модели, иновациони екосистеми*

Introduction

Since the 1980s, a prominent place in the study of knowledge creation and transfer processes within the context of innovation has been occupied by the so-called helix models. The origins of these models trace back to the mid-1990s with the emergence of the 3TH concept, which brought together universities, industry, and government within a single analytical framework. Soon afterward, this structure evolved into the 4QH through the inclusion of civil society as a fourth actor, and later into the 5QH with the addition of the natural environment as a fifth dimension-signaling a growing plurality of stakeholders. This evolutionary path reflects the rising complexity of innovation processes and underlines the importance of engaging a broader range of participants in shaping sustainable innovation strategies. The IES can be understood as an intricate network of organizations, activities, and relationships whose interaction enables the generation and diffusion of new ideas. Functioning as a dynamic system, it relies on institutional support, spatial proximity, shared objectives, and continuous adaptability-all of which underpin sustainable innovation. In today's knowledge-driven societies, innovation success depends not only on individual actors but on the cohesion and resilience of the entire ecosystem that connects them.

The most recent development in innovation ecosystems is the concept of the fractal innovation ecosystem. It refers to an agglomeration of resources operating within a regime of collaboration, co-specialization, and co-evolution, aimed at enhancing the efficiency and effectiveness of knowledge and innovation creation, allocation, and utilization (Carayannis & Campbell, 2009). The structural architecture and topology of these ecosystems are manifested through innovation networks and knowledge clusters, grounded in the principles of proximity, attraction, density, and similarity. Their evolutionary dynamics give rise to self-similar structures, confirming the fractal nature of such ecosystems. This self-similarity enables multi-level innovation efficiency and increases the likelihood of strategic knowledge discovery, as well as the assessment and optimization of innovation processes (Ivanova & Leydesdorff, 2015).

This review paper provides a comprehensive analysis of the evolution of helix innovation models, with particular emphasis on their role in enhancing both the conceptual and practical design of IES. The primary objective of the study is to address the key research question: "How have helix models evolved, and in what ways do they contribute to the shaping and improvement of innovation ecosystems?"

Through a systematic examination of relevant scientific and professional literature, the study identifies the key actors, their interrelationships, and the institutional transformations resulting from the implementation of the helix approach, as well as their contribution to the development, adaptability, and long-term sustainability of IES. Special attention is given to differentiating individual helix models and evaluating their theoretical and practical significance in the context of understanding and improving innovation processes in the contemporary economy, while simultaneously providing an overview of potential directions for future research and application.

Helix innovation models serve as essential theoretical lenses for studying the dynamics of modern IES. Their development illustrates an ever-more intricate interplay among academia, industry, government institutions, civil society, and the natural environment. Over recent decades, these models have become a cornerstone for formulating innovation policies in economies pursuing inclusiveness, sustainability, and stronger cross-sector cooperation. Yet, despite extensive descriptive literature, there remains a shortage of deeper analyses exploring actor interdependencies, institutional frictions, and implementation challenges. Moreover, international policy papers often adopt helix terminology without adequate theoretical grounding or critical discussion. In this context, the contribution of this paper lies in the development of a conceptual model that links the evolution of key actors and the thematic focuses of helix models-collaboration, social inclusiveness, and ecological sustainability-with their direct and indirect impacts on the development of innovation ecosystems.

The study is based on a qualitative methodology encompassing two complementary analytical dimensions. The first dimension involves a theoretical literature analysis, examining studies related to the 3TH, 4QH, and 5QH models. Sources were selected according to predefined criteria of relevance, temporal coverage (1993–2025), methodological rigor, and academic citation, enabling the identification of actors, their interrelationships, and the institutional transformations arising from the application of the helix approach. The second dimension involves a review of institutional practices through the analysis of strategic documents, policies, and reports issued by key international actors, such as the OECD and the European Commission, with a particular focus on mechanisms of collaboration in practice. This methodological framework allows for an integrated consideration of both theoretical and practical aspects of the phenomenon, systematically addressing the research question and providing a deeper understanding of the role of helix models in the development of IES.

Based on the conducted analysis, a conceptual model has been developed that illustrates the interdependence of industry, academia, government, civil society, and the natural environment, identifies thematic focuses within the 3TH, 4QH, and 5QH models, and proposes guidelines for designing IES that foster actor collaboration, enhance social inclusiveness, and address the increasingly urgent demands of ecological sustainability. In doing so, the paper not only synthesizes existing knowledge but also contributes to the advancement of both theoretical and practical understanding of this complex phenomenon.

Although this research does not contain empirical testing, its methodological design allows for future expansion-most notably through comparative case studies examining the application of 4QH and 5QH frameworks across different regions. Accordingly, the paper outlines a comparative perspective on IES dimensions rooted in sustainability and participatory governance, contrasting the experiences of Scandinavian and Southeast European countries. This comparison helps clarify how core elements of helix models influence ecosystem performance and serves to validate the theoretical propositions discussed here. Future studies could further incorporate quantitative indicators measuring the depth and effectiveness of cooperation among helix actors.

1. Theoretical Framework: Understanding Helix Innovation Models and the Concept of IES

The conceptual foundations of helix innovation models and IES are grounded in evolutionary economics, which provides a solid theoretical base for examining their structure, functionality, and co-evolution. This approach recognizes innovation as a dynamic and complex process shaped by institutions, culture, and adaptive policymaking that encourages collaboration among diverse stakeholders. In doing so, it both clarifies the principles behind helix models and reinforces their practical relevance for advancing innovation ecosystems.

Unlike the neoclassical paradigm-built on assumptions of rational actors, equilibrium, and linear innovation trajectories-evolutionary economics stresses that technological and institutional progress follows historically specific paths and unfolds through uncertainty and non-linearity (Nelson & Winter, 1982). Actors learn through interaction and experimentation, while innovation is influenced by social norms, policy environments, and cultural factors that determine how knowledge circulates and cooperation takes place (Edquist, 1997).

From this standpoint, technological change co-evolves with institutional and social settings; innovation occurs under conditions of limited rationality and continuous adjustment. It is thus a socially embedded, institutionally mediated process-an understanding vital to grasping the complexity of contemporary IES. The evolutionary lens allows for a richer exploration of helix models and the IES concept, highlighting multilayered collaboration among universities, firms, government bodies, civil society, and the environment. Their co-evolution mirrors core evolutionary principles such as network interaction and experiential learning.

Key assumptions underpinning this perspective include:

- the non-linear and interactive character of innovation,
- the co-development of knowledge, institutions, and technology,
- the necessity of flexible, adaptive, and context-sensitive innovation policies, and
- the view of innovation as a socially rooted process that extends beyond market boundaries.

Evolutionary economics contributes to the understanding of the development of the IES concept by recognizing the importance of historical and cultural context in shaping innovation capacities. It highlights the role of informal networks and social capital in knowledge creation and transfer, and promotes learning as a central driver of innovativeness. Its emphasis on nonlinearity, complexity, and adaptive learning enables the formulation of more effective and flexible innovation policies adapted to diverse societal contexts.

The concept of IES began to take shape and gain prominence in the early 2000s, drawing significantly on Moore's (1993) work on business ecosystems. Its theoretical foundations can be traced to the ideas of national innovation systems (Freeman, 1992). After 2010, IES became an integral part of innovation policies in economically advanced countries, with a focus on linking actors in the processes of knowledge creation, exchange, and commercialization (OECD, 2019).

The theory of helix models offers an approach that situates the creation and commercial valorization of knowledge within a broader, transdisciplinary context-one in which innovation users also play a significant role. In an environment marked by increasing diversity and heterogeneity of innovation processes, creativity, and networking among actors from all segments of society become increasingly important in the creation and commercialization of knowledge and innovations.

2. Evolution of Helix Innovation Models

The 3TH model is one of the most influential conceptual frameworks for understanding contemporary IES. Developed by Etzkowitz & Leydesdorff (1996), it emerged in response to the growing need of modern societies to integrate the activities and relationships of universities, industry, and government. Its goal is to foster innovation and economic development more effectively.

Each actor plays a distinct role and contributes unique resources, while their joint engagement is essential for the successful development of innovations. Universities generate knowledge and educate skilled personnel; industry transforms this knowledge into products and services; and government provides the institutional and regulatory framework that enables their cooperation.

The 3TH model transcends traditional linear models of knowledge transfer by establishing dynamic, nonlinear, and multilayered networks of communication and co-creation that stimulate innovation. Collaboration within this model extends beyond formal partnerships, encompassing informal networks, cultural interactions, and joint initiatives. This fosters synergy and accelerates innovation cycles.

Knowledge creation is a multidisciplinary process that facilitates the translation of theoretical insights into practical applications. Such interaction contributes to the development of innovations that are better aligned with market demands and societal challenges.

The 4QH model is based on the assumption that universities, industry, government, and civil society are guided by principles of open knowledge circulation, continuous learning, and mutual communication and collaboration (Cvetanović et al., 2025). These spiral linkages foster multidimensional relationships that enable the transformation of knowledge into marketable innovations. Within this framework, civil society acts as a catalyst for initiatives that enhance the design, alignment, and operational efficiency of public institutions, universities, and enterprises-along with their strategies, policies, and practices.

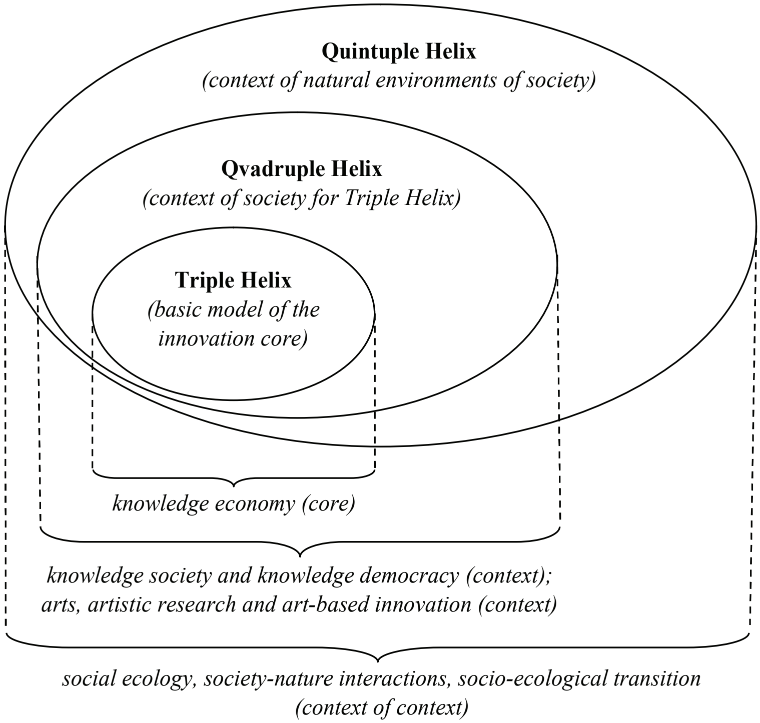
The 4QH model has a significant impact on the organization of research and development at the regional level. Its core premise is that markets should serve societal interests, while society should prioritize the well-being of its citizens. This model emphasizes the role of individuals in innovation processes. Carayannis & Campbell (2009) argue that the coexistence of plural knowledge systems in developed democracies gives rise to knowledge clusters that form coherent configurations, unconstrained by geographic or sectoral boundaries-particularly in the context of social media.

The model broadens the dynamics of IES by incorporating civil society and media into the processes of knowledge creation, transfer, and commercialization. This approach promotes an open and participatory culture of innovation in which citizens, local communities, and non-governmental organizations play an active role in defining socially relevant innovation priorities. The implementation of the 4QH framework within the *Living Labs* concept across Europe demonstrates that participatory forms of innovation significantly contribute to the development of sustainable urban solutions and the responsible governance of emerging technologies (Olbertz, 2025; Starkbaum, 2024).

The 5QH model further advances our understanding of contemporary innovation systems by positioning sustainability and social engagement at the core of knowledge generation and exchange. It directs innovation toward holistic development that intertwines technological advancement, social equity, and ecological responsibility. A central premise of the 5QH framework is that innovation should not be understood merely as a technical or economic outcome but as a socially and environmentally embedded process. In this model, innovation emerges through the co-creation of five interdependent actors-universities, industry, government, civil society, and the natural environment-who jointly address complex global challenges such as climate change, sustainable energy, and inclusive growth (Carayannis et al., 2012). By integrating diverse knowledge bases-scientific, technological, traditional, and local-the model fosters the creation of solutions that are not only effective but also enduring and context-sensitive. Recent European research underscores the importance of systematically aligning the objectives of the green transition and the circular economy with helix innovation models, giving rise to what has been termed the *eco-helix* approach (van Bueren, 2025).

Carayannis and Campbell (2009) emphasize the multifaceted benefits of helix models in promoting economic growth, improving regional competitiveness, and addressing environmental challenges (see Figure 1). The original 3QH model was based on the interplay among universities, industry, and government, highlighting their collective role in driving innovation and fostering economic development. The more advanced helix frameworks expand this foundation by introducing new dimensions to the innovation process. The 4QH model stresses the importance of continuous, interactive collaboration among stakeholders and investors, ensuring that citizens remain central participants in innovation activities. Building on this, the 5QH model embeds sustainability principles deeply within the processes of knowledge creation and innovation, marking a decisive step toward more inclusive and ecologically conscious innovation paradigms.

Figure 1: The benefits of helix models in the terms of economic growth, attractiveness, and addressing environmental challenges



Source: Carayannis et al., 2012.

When viewed as a whole, the 3TH, 4QH and 5QH models together outline a comprehensive framework for an innovation paradigm that is inclusive, participatory, and environmentally responsible-one that reflects the key values of the 21st century. The next stage in the evolution of these helix models is being shaped by several transformative forces: the pervasive digital transformation of economies and societies, the accelerated progress of artificial intelligence, and the growing adoption of open innovation practices. Collectively, these developments suggest that the future trajectory of innovation ecosystems will hinge on how effectively helix models are contextualized, digitalized, and integrated with the principles of sustainability.

The digital era has significantly enhanced the potential of helix models. Advances in digital technologies have expanded their capabilities, enabling greater dynamism and adaptability in fostering innovation. Digital platforms, collaborative tools, big data, and artificial intelligence facilitate faster and more efficient knowledge exchange among the key actors of helix models (Carayannis et al., 2019). Moreover, digital transformation has enabled the emergence of new actors-such as startups, user communities, and innovation networks-actively engaged in creating knowledge and transforming it into marketable innovations. As a result, the complexity of innovation ecosystems has steadily increased, along with their capacity to generate sustainable and inclusive solutions.

Digital transformation represents a profound and ongoing process of change through which organizations, institutions, and societies harness digital technologies to redefine business models, generate new value, and improve overall efficiency. Within the framework of IES, it serves as a driving force that connects a wide array of actors-from academia and industry to the public sector and citizens-thus fostering an integrated environment for co-creation and the practical application of knowledge (Vial, 2019). In such ecosystems, digital infrastructure functions as a pivotal resource, enabling agile experimentation and the rapid iteration of innovation processes (Autio et al., 2018).

However, the significance of digital transformation extends well beyond its technological aspects. It encompasses profound cultural and organizational adjustments, including the cultivation of digital competencies, the transformation of educational systems, the redefinition of leadership roles, and the enhancement of digital literacy. Together, these shifts nurture the rise of "digitally mature" innovation ecosystems that are capable of addressing challenges of sustainability, global competitiveness, and social inclusion (European Commission, 2020; Kane et al., 2019). Looking ahead, digital transformation will serve not merely as a technological enabler but as a strategic and systemic force connecting open innovation, artificial intelligence, and sustainable development-underpinning the evolution of resilient, cooperative, and inclusive knowledge-based societies.

Artificial Intelligence (AI) increasingly occupies a central position in the evolution of modern IES, transforming the ways in which knowledge is created, shared, and applied within the global economy. As a set of technologies designed to emulate human cognitive functions-learning, reasoning, language comprehension, and decision-making-AI accelerates innovation cycles and deepens collaboration among ecosystem participants (Brynjolfsson & McAfee, 2017; Russell & Norvig, 2021). Its integration across sectors such as research, education, healthcare, and industry supports the emergence of "intelligent ecosystems," characterized by continuous interconnections between data, knowledge, and innovation (Chesbrough, 2020).

Beyond simply improving the efficiency of innovation processes, AI fundamentally reshapes their structure and the nature of relationships among actors. Through applications such as big data analytics, predictive modeling, and personalized learning, innovation ecosystems become increasingly adaptive, effective, and capable of addressing complex societal issues. The future development of IES will depend largely on the capacity of societies to integrate AI technologies ethically and securely. Among the key challenges are data protection, algorithmic transparency, accountability in automated decision-making, and the prevention of bias or misuse (Floridi & Cowls, 2021). Equally important is the establishment of robust regulatory and educational frameworks that strengthen human capabilities and build public trust in intelligent systems (European Commission, 2021).

Open innovation forms the third cornerstone of contemporary IES. Departing from the notion that organizations can rely solely on internal resources, open innovation promotes active engagement with external partners-including universities, research institutions, startups, users, and even competitors (Chesbrough, 2003). It is built on a reciprocal flow of knowledge, allowing organizations not only to absorb external ideas and technologies but also to share their own innovations in the co-creation of value (West & Bogers, 2017).

The role of open innovation will grow even more crucial in the transition toward sustainable, digital, and green economies. By bridging diverse sectors and stakeholders, it enables the joint creation of solutions to complex global challenges-ranging from energy efficiency and climate adaptation to digital inclusion and the development of future skills. Hence, open innovation evolves beyond a technological approach into a strategic framework for socially responsible transformation.

Its greatest strength lies in the ability to merge internal and external sources of creativity and expertise, creating a dynamic, flexible system that promotes entrepreneurship, accelerates technology diffusion, and enhances economic resilience amid global change (Chesbrough & Bogers, 2014). In the years ahead, this capacity to transcend organizational and sectoral boundaries through collaboration will remain a decisive factor in ensuring both the competitiveness and sustainability of innovation ecosystems.

3. Development of the IES Concept

The origins of the IES concept can be traced to theories on national innovation systems and the notion of the business ecosystem (Moore, 1993). In today's landscape, the development of IES relies on linking local capacities with global flows, embracing digital transformation, and promoting open innovation-recognized as key drivers of sustainable economic growth.

The IES refers to a dynamic web of interlinked participants, resources, and processes that collaborate to foster the creation and commercialization of new ideas. IES represent complex, geographically embedded entities where research institutions, entrepreneurs, business enterprises, investors, and the public sector engage in joint activities based on aligned interests and complementary resources. This inter-institutional connectivity contributes to the development of a resilient social infrastructure founded on mutual trust, thereby enabling accelerated knowledge exchange, efficient resource allocation, and the promotion of collective progress (Budden & Murray, 2025).

Drawing inspiration from the functioning of natural ecosystems, the central actors within the IES include entrepreneurs, academic researchers, early-stage ventures, universities, investors, established companies, public agencies, and market intermediaries. Within this constantly evolving framework, innovations emerge through intensive exchange and collaboration among these diverse stakeholders (Davis et al., 2023).

According to Adner (2017), the IES can be understood as an organized structural setting in which the coordination of activities and the management of interdependencies play a decisive role in achieving innovation outcomes. The performance of individual firms is only part of the equation; equally important is the quality of relationships and collaborative mechanisms that bind the ecosystem together. With the rise of digital technologies, the IES has been reshaped to enable novel forms of cooperation and value creation by integrating digital platforms with physical infrastructures (Nambisan et al., 2018). Jacobides et al. (2018) emphasize the evolutionary and network-driven nature of IES, highlighting the diversity of roles assumed by its actors and the importance of leadership in orchestrating collective action.

Unlike national or regional innovation systems, which are typically anchored in institutional frameworks and formalized collaboration at the policy level, IES tend to be more fluid and practice-driven. They bring together startups, accelerators, investors, and end users into interactive communities characterized by horizontal connections and informal knowledge-sharing mechanisms (Granstrand & Holgersson, 2020). Operating across multiple levels and often extending beyond national borders, IES connect local clusters with global networks, offering enhanced flexibility and adaptive capacity to address complex societal and technological challenges (OECD, 2019).

Contemporary innovation policies across the EU are increasingly embracing the concept of IES as dynamic constellations of actors, resources, and interlinked relationships. Since 2007, major international organizations-including the OECD and the World Bank-have integrated ecosystem-oriented perspectives into their innovation policy frameworks, highlighting the importance of connectivity, collaboration, and stakeholder interaction. Flagship EU initiatives such as *Horizon Europe* (2021–2027), with a budget surpassing €95 billion, and the *European Green Deal,* which envisions achieving climate neutrality by 2050, illustrate a decisive shift toward mission-driven innovation that prioritizes green and digital transitions. These strategies are primarily grounded in the 3TH model-linking universities, industry, and government-while increasingly incorporating elements of the 4QH by recognizing citizens and civil society as proactive participants in innovation processes. However, despite political discourse emphasizing inclusiveness and sustainability, implementation practices often reveal persistent gaps. Citizens are still too frequently positioned as passive beneficiaries rather than active co-creators, and sustainability tends to be interpreted narrowly through a technological lens, neglecting wider social dimensions. Bridging this gap requires reinforcing institutional capacities and developing participatory mechanisms that genuinely enable all stakeholders to contribute within the IES framework.

In the global context, growing scholarly attention has been directed toward China's innovation ecosystem, reflecting the country's exceptional achievements in international economic performance. China's IES is underpinned by a strong state-led policy framework, agile industrial structures, and rapidly expanding academic capabilities, with artificial intelligence technologies playing a pivotal role in shaping innovation outcomes (Zhu, 2024). Increasingly, Chinese enterprises are forming strategic alliances and partnerships aimed at accelerating the development of indigenous AI tools, illustrating a localized and adaptive manifestation of helix-based innovation dynamics (Reuters, 2025).

The strength of innovation IES lies in their ability to generate synergies through open innovation practices and self-regulating feedback loops. Physical proximity, as exemplified by innovation districts, accelerates knowledge transfer, while blended public and private funding supports the scaling of innovations and the integration of global resources (Pereira & Bittencourt, 2025). IES function as layered systems in which collaboration, institutional support, digital connectivity, and continuous adaptation form the pillars of long-term viability. In this context, success is defined by the ecosystem's collective performance rather than by individual achievements.

In the contemporary economy, IES are positioned as essential mechanisms for driving economic growth and securing competitive advantage. Their capacity to foster interfirm collaboration, facilitate knowledge exchange, and stimulate technological development has made them a focal point of interest among scholars and practitioners. Within technology-driven markets, companies rely on product innovation as a strategic tool for accessing new markets and business opportunities, focusing their efforts on identifying and developing innovative solutions. Accordingly, industrial sectors are placing growing emphasis on the institutional promotion of ecosystems that enable cooperation and the creation of added value among key stakeholders (Sotirofski, 2024).

Discussion

Knowledge transfer within the 3TH model occurs through networks and collaborative channels that integrate both formal and informal information flows. The model enables two-way knowledge exchange between universities, industry, and government, thereby facilitating more rapid adaptation and practical application of innovations (Etzkowitz & Leydesdorff, 1996). Industry leverages scientific knowledge to develop products and services, while government provides the regulatory framework and financial support necessary for further development. Digital infrastructure and modern tools further reinforce this process, enabling global connectivity and interactive real-time communication (Carayannis & Campbell, 2009). In this way, knowledge is not only efficiently exchanged but also continuously refined and enriched through feedback loops and joint co-creation.

The functions of the 3TH model in innovation processes are reflected in its capacity to enhance synergy among diverse actors, eliminate barriers, and accelerate innovation cycles. By combining resources, expertise, and experience, the model creates conditions for innovations that arise spontaneously or through unexpected combinations of existing ideas and technologies-outcomes that would be unlikely within isolated sectors. The role of the state as mediator and regulator ensures the sustainability and inclusiveness of innovation processes. As a networked system, the 3TH model fosters rapid learning through collaboration and proximity among key actors. Participants are encouraged to approach knowledge creation and commercialization from their respective perspectives, representing three interconnected domains of equal importance within the national innovation network. Moreover, the model promotes active engagement in an open environment where knowledge and innovations circulate freely.

A fundamental novelty introduced by the 3TH model-which has made an undeniable contribution to the evolution of innovation ecosystems-is based on two key postulates: system openness and the balance between differentiation and integration (Xue & Gao, 2022). System openness introduces the principle of *equifinality*, which suggests that desired outcomes can be achieved regardless of initial conditions, provided that innovative approaches to problem definition and solution-seeking are adopted. This principle implies that developmental success is not exclusively determined by starting circumstances. In essence, it enables economically less developed environments to improve their performance by enhancing their capacity for innovation.

Maintaining the balance between differentiation and integration requires an open environment in which intentions and knowledge circulate freely, fostering the emergence of new ideas and their transformation into innovations, driven by principles of mutual support and collaborative engagement (Cai & Lattu, 2022). The 3TH framework emphasizes the interaction among universities, industry, and government, leading to the affirmation of hybrid organizations and multi-layered innovation networks.

The 4QH model refers to civil society, whose core components include culture and media. Culture, as an element of civil society, encompasses shared value systems, prevailing attitudes, and foundational assumptions held by members of the community. By nature, culture is collective rather than individual, yet it is not universal-it reflects the norms and values accepted by the majority within a given society (Cao et al., 2025). Culture is internalized through socialization processes and expressed through behavior, manifesting in organizational routines, communication styles, and innovation practices. An organization's innovation culture is profoundly shaped by the environment in which it operates, including the broader socio-cultural context and dominant value systems (Boneto et al., 2022).

In any society, this culture must emerge from the ways in which its economic foundations-primarily enterprises-function. To remain competitive and advance, enterprises must be capable of offering new products, processes, technologies, organizational approaches, business models, and managerial practices aligned with contemporary realities. The 4QH model is closely linked to the rise of digitalization and the expansion of digital capital in contemporary society. The ubiquitous use of digital technologies has brought profound changes to human interaction. Advances in this domain have enabled entirely new modes of collaboration and communication among economic and social actors, reshaping social structures in ways reminiscent of the industrial and digital revolutions of the 19th and 20th centuries (Ochoa Pacheco & Coello-Montesel, 2023).

Research increasingly confirms that civil society plays a critical role in ensuring socially responsible innovation and promoting diverse participation in knowledge creation within IES. In this light, the 4QH framework becomes a vital instrument for inclusive innovation, incorporating not only universities, enterprises, and government but also the public as genuine agents of change. By doing so, the 4QH model fosters social legitimacy and cultural coherence through participatory collaboration and iterative feedback. However, the model is not without limitations. A notable weakness lies in its methodological foundations, particularly the lack of robust quantitative metrics. Critics argue that the inclusion of an additional helix without clearly defined theoretical justification may render the role of civil society conceptually ambiguous (Cai & Lattu, 2022).

By leveraging the synergistic potential of the 5QH model, a sustainable knowledge-based society is envisioned-one that operates in harmony with nature. Innovation has emerged as a central catalyst for advancing sustainable development, with collaboration among ecosystem participants recognized as a foundational condition for its realization. Within the 5QH framework, intermediary entities serve a strategic function by forging connections and enabling institutional partnerships. Through their integrative role, these actors support the dissemination of innovative practices and contribute meaningfully to the establishment of resilient innovation ecosystems aligned with the objectives of sustainable development (Turkina, 2023).

Achieving sustainability requires that each subsystem possess specific forms of capital necessary for networked functioning, knowledge generation, and innovation commercialization. The 5QH model not only links innovation with ecological factors but also promotes the principles of the green economy and circular economy as central to sustainable development. The integration of ecological components ensures that innovations are socially and economically sustainable, emphasizing responsible natural resource management, environmental protection, and biodiversity (Meshram, 2024). In short, incorporating the logic of the 5QH model into IES reflects a deliberate consideration of environmental imperatives, underscoring the role of environmentally sustainable innovation, circular economy principles, and climate resilience as key dimensions for addressing global ecological challenges.

The model presupposes that each of the five segments possesses the resources necessary for generating scientifically and socially relevant knowledge. Knowledge functions as both input and output within interconnected subsystems, enabling continuous circulation that creates favorable conditions for its valorization through innovation (Carayannis et al., 2022). By linking economic activity with ecological management through the coordinated efforts of actors within the 5QH model, IES activities are aligned with the United Nations Sustainable Development Goals.

The integration of different helix models enables IES to evolve into globally connected networks of knowledge and innovation, capable of addressing the multifaceted demands of contemporary society. Table 1 presents the key actors, the main focus of the helix models, and their impact on the development of IES.

In the 3TH model, the existence of democracy is not inherently necessary for knowledge production and innovation; however, the 4QH model explicitly incorporates democratic principles. Its construction, design, and architecture clearly demonstrate that a 4QH innovation system cannot function without a democratic context. Media and culture-based public spheres provide a democratic lens through which knowledge creation and innovation are interpreted and legitimized. The 5QH model extends the 4QH by integrating elements of the natural environment, social ecology, and the socio-ecological transition, thereby deepening the systemic scope of innovation ecosystems.

Table 1: Key Actors, Main Focus of Helix Models, and Impact on IES

Model	Key Actors	Focus	Key Impact on IES
3TH	University, Industry, Government	Innovation through actor collaboration	Increasing innovation capacity through joint projects. Development of research centers and incubators. Government incentives accelerate market entry of innovations.
4QH	+ Civil society	Inclusiveness, social legitimacy	Innovations adapted to user needs. Greater social acceptance and reduced risk of failure. Media accelerates innovation diffusion. Increased transparency and social responsibility.
5QH	+ Natural environment	Sustainability	Steering innovations toward sustainable development. Development of green technologies and circular economy. Linking economic growth and resource conservation. Response to ecological and climate challenges.

Source: Authors

Although the 3TH, 4QH, and 5QH models provide a robust theoretical framework for the development of IES, their implementation is not universally successful. In contexts characterized by authoritarian regimes and weak institutions, the fundamental assumptions of these models are undermined, leading to limitations in their functionality and effectiveness. In authoritarian regimes, the state often assumes a dominant role in innovation processes, suppressing the autonomy of universities, industry, and civil society. Instead of horizontal collaboration and knowledge exchange, vertical control prevails, where innovations are directed toward political objectives rather than societal needs. Universities become instrumentalized, industry is subordinated to state interests, and civil society is often marginalized or repressed. Such a structure prevents the formation of synergies among actors, which is crucial for the successful functioning of helix models.

In addition to political constraints, weak institutions further complicate the application of the helix approach. In countries with low levels of institutional capacity, problems such as corruption, lack of transparency, inefficient administration, and legal insecurity are prevalent. These factors undermine trust among actors and hinder the coordination of innovation activities. Without stable and reliable institutions providing a framework for collaboration, helix models remain theoretical constructs with limited practical applicability. Similar findings are confirmed by recent research, which shows that the rationalist approach of the 3TH model often conflicts with local governance structures and cultural norms, particularly in contexts where state dominance suppresses the possibility of horizontal collaboration (Agbebia et al., 2024).

Within the 4QH framework, civil society emerges as the fourth dimension complementing academia, industry, and government. Civil society organizations play a vital role in empowering citizens to engage actively in public policy debates, innovation processes, and broader social transformation. They serve as watchdogs of institutional performance, advocate for transparency and accountability, and safeguard collective interests. By engaging a diversity of social groups, civil society ensures that innovation remains socially grounded, addressing real community needs and producing outcomes beneficial to society as a whole. This sphere also includes the media, arts, and cultural sectors, which influence public perception, stimulate critical dialogue, and foster creative approaches to societal challenges (Cvetanović et al., 2025).

The 4QH model has found growing application in the context of regional development, providing a platform for inclusive participation and multi-sectoral collaboration. Building upon this, the 5QH model extends the framework by recognizing the natural environment as an equal and active stakeholder. The inclusion of this ecological dimension strengthens the sustainability of innovation processes and enhances the overall capacity of IES to respond effectively to complex challenges facing contemporary societies.

Table 2: Comparative Framework for 4QH and 5QH Models: Scandinavian Countries vs. Southeast European Countries

Dimension	Scandinavian countries	Southeast European countries	Indicators
Institutional Collaboration	Stable clusters, PPP models, joint R&D programs	Project-based, weak institutionalization	Joint projects, clusters, co-patents
Civil Society (4QH)	Active, participatory, focused on sustainability	Limited involvement, top-down innovation	Platforms, engagement, co-creation
Environmental Sustainability (5QH)	Green innovation central to policy	Secondary priority, fragmented implementation	Green index, eco R&D, ecological footprint
Knowledge Transfer	Universities as innovation brokers	Weak absorption capacity in industry	Co-publications, spin-offs, patent citations
Innovation Governance	Stable, long-term, transparent policies	Unstable frameworks, reliant on EU funding	Policy continuity, R&D % of GDP
Social & Cultural Context	High trust, collaborative, egalitarian	Low trust, fragmented, weak coordination	Social capital, collaboration attitudes

Source: Authors

The degree to which these key attributes have been implemented is illustrated in Table 2, which presents a comparative analysis of two European regions: Scandinavia-where IES are highly advanced-and Southeast Europe, where significant developmental gaps remain. The comparative framework highlights both quantitative and qualitative indicators that help assess the maturity and effectiveness of IES in the observed regions.

A comparative examination of the 4QH and 5QH dimensions across Scandinavian and Southeast European regions reveals substantial disparities in the maturity of IES. Scandinavian countries display strong institutional cooperation, an active and engaged civil society, and well-integrated environmental policies-all of which contribute to sustainable and inclusive innovation development.

In contrast, Southeast European nations continue to grapple with challenges such as fragile institutional frameworks, limited civic engagement, and insufficiently developed mechanisms for knowledge transfer and ecological sustainability. These observations underscore that the effective implementation of helix models within modern IES requires more than the formal adoption of conceptual frameworks. It calls for a genuinely democratic environment, well-functioning institutions, and a societal openness that encourages participation from a diverse range of actors.

Absent these foundational conditions, helix models risk remaining largely declarative-symbolic rather than transformative-failing to exert tangible influence on social and economic progress. Future research should therefore focus on developing measurable indicators to assess the performance and impact of helix models in various contexts, as well as on identifying policy measures that advance inclusive and sustainable innovation practices.

Research Limitations

While this paper enriches the theoretical and conceptual understanding of helix models and their significance for the evolution of IES, several methodological constraints must be recognized. The study relies primarily on a qualitative approach and on secondary data analysis, without empirical testing to validate the underlying assumptions or to enable a quantitative evaluation of actor relationships. Although this method allows for an in-depth and interpretative exploration of the topic, it limits the generalizability of the conclusions.

Moreover, the reference materials, academic works, policy strategies, and institutional reports, reflect the particular standpoints of influential stakeholders such as the OECD and the European Commission. These perspectives may introduce certain biases in the portrayal of institutional realities. Additionally, while the comparative exploration of the 4QH and 5QHmodels in differing regional contexts (e.g., Scandinavia and Southeast Europe) provides valuable conceptual direction, it has not yet been empirically tested.

To address these gaps, future studies should adopt a mixed-methods approach that combines qualitative and quantitative techniques, incorporates comparative case studies, and applies empirical indicators to verify and operationalize the proposed conceptual framework. Such an approach would foster a more holistic understanding of both the practical applicability and the effectiveness of helix models in shaping and advancing innovation ecosystems.

Conclusion

The functioning of contemporary IES is predominantly based on the integration of the key characteristics of the 3TH, 4QH, and 5QH models. The 3TH model emphasizes synergistic collaboration among universities, industry, and government, enabling efficient knowledge exchange and accelerating innovation. The 4QH model extends this framework by incorporating civil society and users as active participants, directing innovations toward real societal needs and ensuring their social legitimacy. The 5QH model further integrates the natural environment and sustainability principles, highlighting the necessity for environmentally responsible innovations and contributions to the circular economy. Together, these models offer a holistic and evolutionary approach to understanding the “physiology” of contemporary IES.

Through the development of an integrated conceptual framework, this paper demonstrates that the contribution of the helix approach to the development of IES lies not only in expanding the number of actors but also in their interdependence, capacity to generate synergy, and ability to address challenges of inclusiveness and sustainability. By analyzing strategic documents of international organizations and existing theoretical approaches, key points of tension in institutional practices, as well as potentials for improving the quality of IES functioning, have been identified. The proposed framework provides not only a theoretical systematization but also practical guidelines for designing IES that incorporate a broader range of social and ecological requirements. The aim of the framework is to systematize existing helix approaches and offer a new perspective that allows a deeper understanding of the role of various actors in the development of IES.

In future research, this model can serve as a basis for comparative analyses of IES at national and local levels, as well as for the development of new helix configurations that integrate digital technologies, cultural sectors, or the specificities of local communities as equal actors in the complex processes of knowledge creation, transfer, and commercialization.

Future research should aim to conduct comparative case studies examining the practical implementation of the 4QH and 5QH models within the contexts of Scandinavia and Southeast Europe. In addition, developing conceptual maps or correlation diagrams that visualize the interconnections among key actors within IES would provide valuable analytical insight. Such efforts would not only facilitate the empirical validation of the theoretical framework proposed in this study but also enhance its practical applicability in the formulation and refinement of innovation policy strategies.

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I would like thank on contribution with the aim of quality of papers in
ECONOMICS OF SUSTAINABLE DEVELOPMENT
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ECONOMICS of Sustainable Development = Економика одрживог развоја / editor in chief Zoran Simonović. - [Štampano izd.]. - Vol. 1, br. 1 (2017)- . -Niš : Society of Economists "Ekonomika", 2017- (Niš : Medivest). - 24 cm

Tri puta godišnje. - Drugo izdanje na drugom medijumu: Economics of Sustainable Development (Online) = ISSN 2560-4406
ISSN 2560-421X = Economics of Sustainable Development

COBISS.SR-ID 235783436