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Հանդեսում ներառված է 2025 թ. ապրիլի 22-ին Հյուսիսային համալսարանում կազմակերպված «Կանաչ տնտեսության մարտահրավերները կայուն զարգացման համատեքստում» խորագրով միջազգային գիտաժողովի նյութերի ընտրանին

ԵՐԵՎԱՆ

ՀՅՈՒՍԻՍԱՅԻՆ ՀԱՄԱԼՍԱՐԱՆԻ ՀՐԱՏԱՐԱԿՉՈՒԹՅՈՒՆ

2025

Հրատարակության է երաշխավորել Հյուսիսային համալսարանի գիտական խորհուրդը

Գոհար Պետրոսյան, իրավագիտության դոկտոր, դոցենտ «Միջազգային հանցագործություն և արդարադատություն» մագիստրոսական ծրագրի ղեկավար, Նյու-Յուրք Սիթի համալսարան ԱՄՆ

Մերգեյ Զմիյակ, տնտեսագիտության դոկտոր, դոցենտ, «Միջազգային տնտեսություն և միջազգային տնտեսագիտական հարաբերություններ» ամբիոնի վարիչ, Դոնեցկի պետական տեխնիկական համալսարան, Դոնեցկի Ժողովրդական Հանրապետություն

Նինո Ապցիաուրի, պատմագիտության դոկտոր, դոցենտ, Իվանե Ջավախիշվիլիի անվան Թբիլիսիի պետական համալսարան, խորհրդական, Արտաքին գործերի նախարարություն, Վրաստան

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Իլուտա Արբիդանե, Տնտեսագիտության դոկտոր, պրոֆեսոր, տնտեսագիտության դոկտոր, պրոֆեսոր, Ռեզեկնեի տեխնոլոգիական ակադեմիա, Լատվիա

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НАУЧНЫЙ ЖУРНАЛ СЕВЕРНОГО УНИВЕРСИТЕТА

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GREEN FINANCE AS A DRIVER OF SUSTAINABLE DEVELOPMENT AND ITS IMPLEMENTATION IN RA

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Abstract

In the face of today's global and local challenges—such as environmental protection and combating climate change—these issues have become integral to economic policy. In this context, green financing gains special importance as a set of financial mechanisms aimed at promoting sustainable development and funding environmentally responsible projects. The objective of this research is to examine the role of green financing in the sustainable development process, evaluating its current application and future prospects in the Republic of Armenia.

The study analyzes the main instruments of green financing (green loans, bonds, subsidies, and tax incentives), explores international experience, and reviews existing green financing initiatives and market characteristics in Armenia. Particular attention is paid to current challenges, including regulatory gaps, limited access to financial resources, and lack of professional expertise. The paper also emphasizes the role of financial technologies, public policy, and international cooperation in advancing green finance.

Research findings indicate that while green financing in Armenia is still in its formative stage, it holds significant potential to become a stable and environmentally responsible driver of economic growth. The study

concludes with a set of recommendations aimed at strengthening and effectively implementing green finance systems.

GEL code: E5

***Keywords*:** green financing, sustainable development, renewable energy, green bonds, green loans, environmental protection, climate change, energy efficiency, financial instruments, esg investments (environmental, social, governance).

Introduction

The relevance of the article: In today's world, the issues of environmental protection, combating climate change, and ensuring the sustainable development of the economy have become priorities at both global and local levels. In this context, green financing is gaining increasing importance as a combination of financial tools and mechanisms aimed at funding environmentally sustainable projects. It is not limited to the environmental sector alone but has the potential to contribute to the sustainable development of various branches of the economy.

In Armenia, green financing is still at an early stage of development. However, international experience and local initiatives highlight its vast potential. In recent years, there has been growing interest in environmentally friendly investments in the RA, providing a basis for discussing the applicability and efficiency of green financing.

The purpose and objectives of the article: The **purpose** of this work is to assess the role of green financing in sustainable development and evaluate its application level and prospects in the Republic of Armenia.

To achieve the above-mentioned goal, the following **tasks** were targeted in the work:

- Study of the main principles and tools of green financing,
- Identification of international experience in the field of green financing,
- Analysis of the current state and challenges of green financing in the Republic of Armenia,

- Outline of ways for the practical application and development of green financing in the Republic of Armenia.

The research work concludes with the section of conclusions and recommendations, which summarizes the results of the conducted studies and conclusions.

Findings

Green financing is a mechanism for the management and allocation of financial resources aimed at supporting environmental protection, mitigating climate change, and promoting sustainable development. It includes both public and private sector investments directed toward renewable energy, energy efficiency, environmentally clean production, and other green initiatives.

As a concept, **green financing** emerged in the late 20th century when global discussions began to seriously address climate change and the depletion of environmental resources. However, its foundations can be traced back to the 1970s and 1980s, when various countries began considering the development of environmentally friendly economic systems (Thu Truong, Trung Chinh Dang 2025).

Green financing is also crucial because it supports the creation of new opportunities for green businesses, job growth, and skill development, thereby positively impacting macroeconomic indicators.

In 2007, the European Investment Bank (EIB) launched the initial "green bonds" project, contributing to the promotion of the green bonds market. However, during the first seven years, the development of this market remained relatively limited. It was only in 2013 that the green bond market began to surge, and since then, it has experienced rapid growth.

Table 1

"Phases of Green Finance Development"[1]

Early Phases (1970–1990)	**1972:** The UN held the first global conference on environmental issues in Sweden (Stockholm Conference), marking the beginning of sustainable development discussions[2]	**1987:** "Our Common Future" report (Brundtland Report) introduced the concept of sustainable development for the first time—economic growth that does not compromise future generations' needs.[3]	**1992:** At the Earth Summit in Rio, the UN adopted "Agenda 21," emphasizing the importance of new financial mechanisms.
Modern Green Finance Development (1997–2010)	**1997:** Kyoto Protocol was signed, obliging developed countries to reduce carbon emissions[4]	**2007:** First issuance of green bonds by the European Investment Bank (EIB), a crucial step in the	**2009:** COP15 in Copenhagen discussed new financing mechanisms for combating climate change.[6]

[1] The table was compiled by the author based on the following articles: https://docs.un.org/en/A/CONF.48/14/Rev.1, file:///C:/Users/PC/Downloads/our_common_futurebrundtlandreport1987.pdf, https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf, (29.03.25)

[2] "United Nations Conference on the Human Environment, 5-16 June 1972, Stockholm", https://www.un.org/en/conferences/environment/stockholm1972, (29.03.25)

[3] "1987: Brundtland Report", https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html, (29.03.25)

[4] "Kyoto Protocol" international treaty, 1997, https://unfccc.int/resource/docs/convkp/kpeng.pdf, (29.03.25)

		evolution of green financial tools.[5]	
New era (after 2010)	**2015:** The Paris Agreement was signed, obligating countries to reduce carbon emissions.	**2015:** UN Sustainable Development Goals (SDGs) were introduced, several of which directly relate to green financing.	**2020-s:** Green finance has become a core direction in international markets, with ESG (Environmental, Social, Governance) investments forming a main investment strategy.

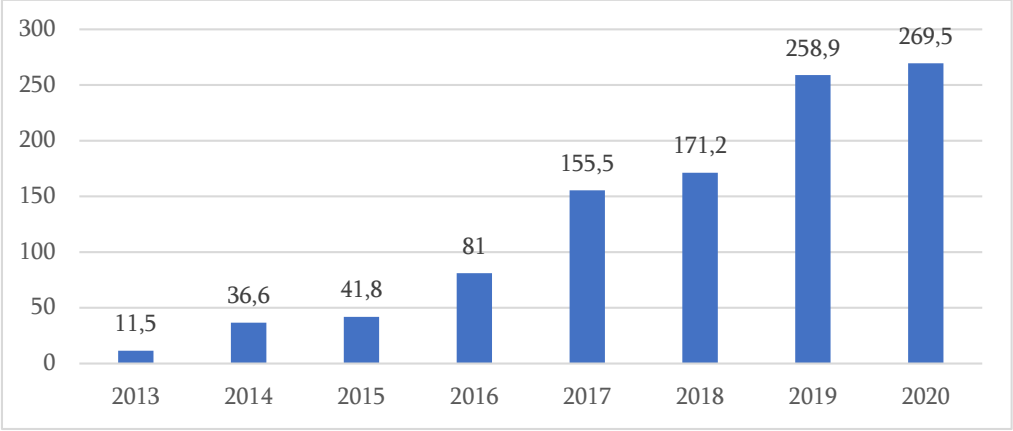

Chart 1. **"Annual Total Issuance of Green Bonds (Trillion USD)"**[7]

[6] "15th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change", https://www.c2es.org/content/cop-15-copenhagen/, (29.03.25)

[5] "15 years of EIB green bonds: leading sustainable investment from niche to mainstream", https://www.eib.org/en/press/all/2022-308-15-years-of-eib-green-bonds-leading-sustainable-investment-from-niche-to-mainstream#:~:text=On%20July%205th%202007,of%20social%20and%20sustainability%20bonds., (29.03.25)

Since 2014, global green bond issuance has steadily increased, reaching a peak in 2020 at $269.5 trillion. This upward trend reflects the growing recognition of the importance of funding sustainable projects and initiatives. The success and expansion of the green bond market highlight the potential to raise capital for sustainability and create a stable financial ecosystem. From a geographical perspective, the top five countries in terms of green bond issuance are the United States, Germany, France, China, and the Netherlands.

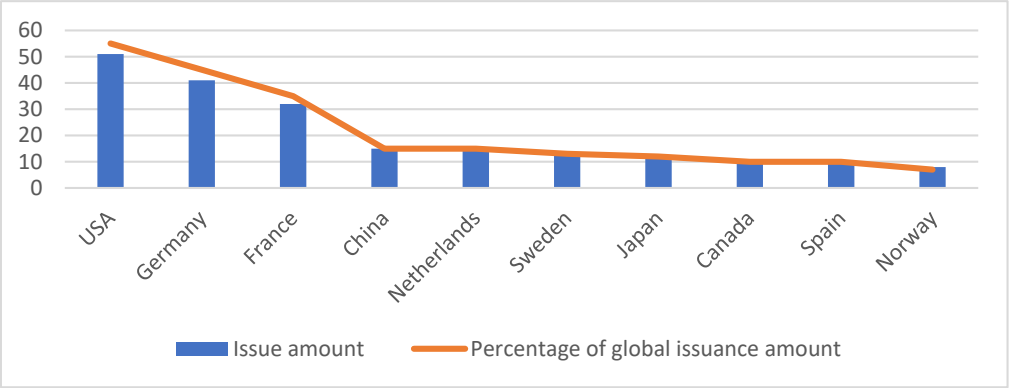

Chart 2. **"Distribution of Green Bond Issuance by Country (Trillion USD)"**[8]

Green finance gained new momentum in 2015 after the signing of the Paris Climate Agreement, which aimed to tackle the global challenges posed by climate change. To implement this agreement, $3–6 billion of investments are required annually by 2050. Since developing countries often lack such financial capabilities, developed nations assist them through funding. Since 2016, Armenia has also been a part of this agreement.

Today, green financing holds significance not only from an environmental but also from an economic perspective, helping countries

[7] The chart was compiled by the author based on data from Climate bonds.net, (29.03.25)

[8] The chart was compiled by the author based on data from Climate bonds.net, (29.03.25)

reduce carbon emissions, develop innovative technologies, and stimulate sustainable economic growth.

Green financing mechanisms may vary depending on the source of funding, beneficiaries, and project scale. Below are the key instruments commonly used globally and in Armenia (Savastano M., Tshughuryan A., 2025):

- **Green loans** – Special loans provided to businesses and individuals implementing sustainable development initiatives. These loans often offer lower interest rates, extended repayment terms, and support projects in energy efficiency and renewable energy.
- **Green bonds** – Instruments through which governments and companies raise capital specifically for environmentally friendly projects. These are considered innovative financial tools and offer stable returns for investors, contributing to green infrastructure development.
- **Government subsidies and tax incentives** – Many countries offer financial incentives for green businesses, such as tax benefits, subsidies for renewable energy production, and funding for environmental protection initiatives.
- **International funding sources** – Numerous global organizations and foundations fund green projects, such as:
  - *Green Climate Fund* – supports developing countries in combating climate change,
  - *World Bank's Climate Investment Fund* – provides funding for sustainable development programs,
  - *International Finance Corporation* – finances energy efficiency projects.

In conclusion, **green financing is a strategic tool** that enables the integration of economic growth with environmental protection. It helps states and businesses invest in environmentally responsible solutions and comply with international environmental standards.

Green financing in Armenia is still in its formative stage; however, some progress has been made in recent years. The primary investments are concentrated in renewable energy, energy efficiency, and environmental protection programs.

The roots of green financing in Armenia can be traced back to the 1990s, following the country's independence, when the Republic began to integrate with international environmental and financial institutions.

As a small developing country, Armenia was initially heavily dependent on international aid and credit programs. However, the country's geographic position, environmental issues, and energy security gradually encouraged the development of green finance initiatives. In 2009, the Armenian government developed its *first national sustainable development strategy*, which included programs for green energy and environmental protection.

By the 2010s, the first public and private financial programs aimed at developing a green economy had been formed in Armenia. Since 2017, green finance tools have become more active in the Armenian banking system. In recent years, green financing has gained more attention in Armenia. In 2021, the Armenian government announced the *National Program for the Development of Renewable Energy*, which aimed to ensure that 15% of the country's electricity would come from renewable sources by 2025.

The Central Bank of Armenia also began exploring the possibility of issuing green bonds that could attract international investors.

As a result, Armenia's first green bonds were issued by Ameriabank in 2020, with a nominal value of 1 million euros. [9] The green bond issuances in Armenia are summarized in Table 2 below.

[9] «GEFF-ի Գործընկերն առաջինը Հայաստանում արժանացավ կայուն ֆինանսավորման մրցանակին», https://ebrdgeff.com/armenia/am/geff-pfi-wins-the-1st-sustainable-finance-award-in-armenia/, (28.03.25)

Table 2

"Green Bond Issuances in the RA"[10]

Issuer	Issue Date	Nominal Value	Coupon Rate (%)	Period (months)	Redemption Date
Ameriabank CJSC	03.12.2020	1 million euros	3.05	60	26.11.2025
	14.02.2022	100 USD	3.50	27	14.05.2024
	14.02.2022	100,000 AMD	9.50	27	14.05.2024
"Electric Networks of Armenia" CJSC	15.07.2024	100 USD	7.25	48	15.07.2028
	01.08.2024	100 USD	7.25	60	01.08.2029

Green bonds refer to any type of bond instrument through which the raised funds (or their equivalent) are used—either partially or fully—exclusively for financing or refinancing new and/or existing "green" projects. The Green Bond Principles (GBP) are designed to help issuers finance environmentally safe and sustainable projects that contribute to a zero-emissions economy and environmental protection. The first green bonds in the world were issued in 2007 by the European Investment Bank, followed a year later by the World Bank. Since then, many governments and corporations have entered the market to fund *green projects*.

[10] The table was compiled by the author based on data from the Armenian Stock Exchange: https://amx.am/am/pages/green-social-bonds, (28.03.25)

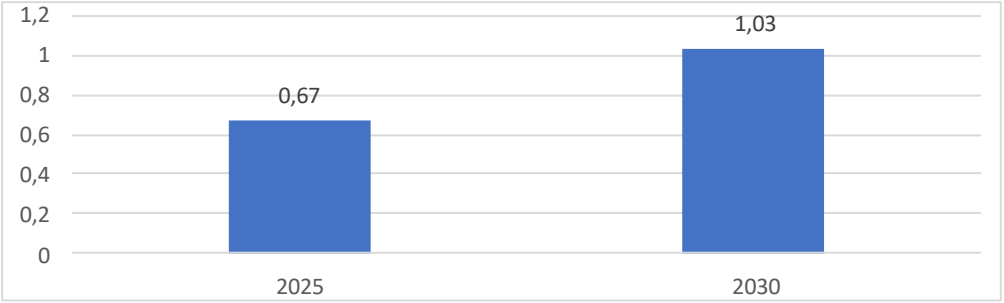

Chart 3. **"Size of the Green Bond Market (2025–2030, in trillion USD)"**[11]

The size of the green bond market is projected to reach $0.67 trillion by 2025 and is expected to grow to $1.03 trillion by 2030. Over the past ten years, the green bond market has seen significant growth due to the focus on sustainability and climate change.

The market has attracted a wide range of investors, including institutional investors, pension funds, and retail investors. Green bonds offer a way to attract sustainable investments, as investors increasingly incorporate ESG (Environmental, Social, and Governance) criteria into their investment plans.

Thus, green bond issuance can be a promising tool for Armenia, but its success depends on clear legislative frameworks, reliable mechanisms for investors, and a long-term strategy. If the government and financial sector develop appropriate policies, green bonds could play a significant role in the sustainable development of Armenia's economy.

As for **green loans**, these are financial instruments provided under the condition that the loan funds are used solely for environmental improvement. Green loans often come with favorable conditions compared to traditional loans, such as lower interest rates, longer terms, or extended repayment periods.

In conclusion, the expansion of green loans could promote Armenia's

[11] The chart was created by the author based on "Green Bonds Market Size and Share Analysis - Growth Trends and Forecast (2025 – 2030), https://www.mordorintelligence.com/industry-reports/green-bonds-market", (28.03.25)

integration into international financial markets and strengthen its position as a center for sustainable financing. For Armenia, this opens up new prospects, particularly in renewable energy development and climate change mitigation efforts.

The prospects for developing green financing in Armenia can be viewed across several key directions, especially considering that green financing involves the allocation of financial resources to projects that support environmental protection, energy efficiency, sustainable development goals, and climate change mitigation.

In Armenia, green financing can act as a **catalyst for the development of sustainable business models**. Certain sectors of the Armenian economy—such as energy, agriculture, transport, and mining—must transition toward eco-compatible models. Businesses that implement energy-efficient technologies, low-emission production processes, or sustainable agricultural practices can seek access to green loans or other financial resources, such as:

- **Green loans and infrastructure financing** for renewable energy sources, water resource management, and low-emission industries,
- **Promotion of green investments** in Armenia's energy efficiency and renewable energy programs.

The government can also play a vital role in promoting green financing by steering relevant initiatives through proper policies and legislation. For the Armenian government, it is crucial to **encourage the engagement of green finance** in areas such as energy efficiency, climate change adaptation, and environmental incentives through:

- Establishing **institutional frameworks** for green finance, including regulatory standards for green loans,
- Implementing **climate-adaptive public programs** supported by green financing mechanisms.

The development of **financial technologies (FinTech)** in Armenia further enables the acceleration of green financing processes. FinTech companies can introduce innovative solutions that make green finance more accessible to clients and investors by:

- Creating **dedicated digital platforms** for green financing that connect commercial banks, investors, and clients more efficiently,

- **Automating green loan and leasing processes** to ensure faster and more effective transactions.

To advance green financing in Armenia, **market-level reforms** are necessary. Financial institutions must begin assessing which projects qualify for green loans and ensure their environmental compliance. To support this:

- **Banks, insurance companies, and investment funds** should be provided with the necessary regulatory tools and incentives to issue green loans,
- Development of a **green loan market** that also supports small and medium enterprises (SMEs).

Armenia could also benefit from **enhanced cooperation with international organizations** to support green finance programs and attract appropriate financial resources.

In summary, green financing in Armenia has significant development potential, driven by the introduction of modern financial models, the activation of sustainable development projects, and goals centered on environmental improvement. In this context, **collaboration between the state and the private sector**, along with technological advancement, can stimulate the green financing process and help transform Armenia's economy toward more sustainable and environmentally friendly models.

Conclusions

Summarizing the research work, the following conclusions can be presented:

- In recent years, green financing has become a key component of sustainable development, serving as an important tool for continuous growth and environmental protection in the context of geopolitical and economic challenges.
- Green financing acts as a stimulus for sustainable economic development, contributing to environmental protection and the long-term progress of businesses.

- The main instruments of green financing include green bonds, green loans, subsidies, and tax incentives. These tools help investors direct their resources toward sectors that support environmental preservation.
- In Armenia, green financing is still at an early stage of development. Certain challenges are encountered when investing in green finance, such as the lack of specific tools, insufficient application of environmental policies, and limited resources. In addition, the absence of financing for green projects and a lack of specialized education make it difficult to ensure sustainable growth in this field.
- Despite these challenges, Armenia has considerable potential for developing green financing. Encouraging sustainability and environmental protection can increase investment flows, thereby contributing to economic growth.

Based on the research findings, the following recommendations are proposed:

1. **Development of legislation promoting the green financing system and coordination of processes** – The establishment of a legal framework for green financing tools in Armenia will lay the foundation for attracting investments, particularly by encouraging the spread of green bonds and loans.
2. **Government support and policy** – The formation of a national green financing strategy will stimulate investments through the use of tax incentives and public support to promote environmental investments.
3. **Improving capacity, education, and raising public awareness** – Well-designed programs aimed at educating professionals and economic actors in both the public and private sectors can also serve as a stimulus. It is equally important to inform the population about green financing directions to encourage investment flows in the sector, which will contribute to the improvement of the environment.
4. **Promotion of international cooperation** – It is a priority to promote international collaboration and the exchange of experience with other countries that already have well-established green financing systems.

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Արմենուհի Սհերյան
Հայաստանի եվրոպական համալսարան
Իլուտա Արբիդանե
Ռեզեկնեի տեխնոլոգիական ակադեմիա
Ջուլիետա Հակոբյան
Հայաստանի եվրոպական համալսարան

Ժամանակակից գլոբալ և տեղական մարտահրավերների պայմաններում՝ ինչպես շրջակա միջավայրի պահպանությունը, այնպես էլ կլիմայական փոփոխությունների դեմ պայքարը դարձել են տնտեսական քաղաքականության անբաժանելի բաղադրիչներ: Այս համատեքստում նոր արժեք է ստանում **կանաչ ֆինանսավորումը**՝ որպես այնպիսի ֆինանսական մեխանիզմների համախումբ, որոնք ուղղված են կայուն զարգացման խթանմանը և էկոլոգիապես պատասխանատու նախագծերի ֆինանսավորմանը: Տրված հետազոտությունը նպատակ ունի ուսումնասիրել կանաչ ֆինանսավորման դերը կայուն զարգացման գործընթացում՝ գնահատելով դրա ներկայիս կիրառելիության աստիճանն ու զարգացման հեռանկարները ՀՀ-ում:

Վերլուծվել են կանաչ ֆինանսավորման հիմնական գործիքները (կանաչ վարկեր, պարտատոմսեր, սուբսիդիաներ և հարկային արտոնություններ), ուսումնասիրվել է միջազգային փորձը և դիտարկվել են ՀՀ-ում գործող կանաչ ֆինանսավորման նախաձեռնություններն ու շուկայի առանձնահատկությունները: Անդրադարձ է կատարվել նաև կանաչ ֆինանսավորման ոլորտում առկա մարտահրավերներին՝ իրավական կարգավորման, ֆինանսական ռեսուրսների հասանելիության և մասնագիտական պատրաստվածության տեսանկյունից:

Հիմնաբառեր - կանաչ ֆինանսավորում, կայուն զարգացում, վերականգնվող էներգիա, կանաչ պարտատոմսեր, կանաչ վարկեր, շրջակա միջավայրի պաշտպանություն, կլիմայի փոփոխություն, էներգաարդյունավետություն, ֆինանսական գործիքներ

THE ROLE OF ARTIFICIAL INTELLIGENCE IN SUSTAINABLE DEVELOPMENT AUDITING

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Abstract: This article explores the transformative role of Artificial Intelligence (AI) in sustainable development auditing, highlighting its potential to enhance transparency, accuracy, and efficiency in evaluating environmental, social, and governance (ESG) practices. As organizations increasingly align their operations with the United Nations Sustainable Development Goals (SDGs), traditional auditing methods often fall short in handling the complexity and scale of sustainability data. AI-driven tools—ranging from machine learning algorithms to natural language processing—enable real-time monitoring, automated data analysis, and predictive risk assessment. The article examines practical applications of AI in environmental, social, and governance audits, supported by real-world examples, and discusses both the benefits and ethical challenges associated with its use.

GEL code: M41, M42

Keywords: Artificial Intelligence (AI), Sustainable Development, Auditing, ESG, Sustainable Development Goals (SDGs).

Research goal: The primary goals of this research are to investigate how artificial intelligence technologies are currently being applied in the auditing of sustainable development practices, particularly in ESG (Environmental, Social, and Governance) domains, to evaluate the effectiveness of AI tools in improving the accuracy, timeliness, and transparency of sustainability audits, to identify the challenges and risks associated with the implementation of AI in auditing processes, including

ethical concerns, data integrity, and regulatory compliance, to propose strategic recommendations for audit institutions, policymakers, and organizations seeking to adopt AI-driven solutions in sustainability auditing.

Research novelty: This research offers a novel contribution by bridging the gap between artificial intelligence (AI) technologies and sustainable development auditing—a field traditionally dominated by manual and retrospective analysis. It highlights real-time, data-driven auditing approaches enabled by AI, such as predictive analytics, anomaly detection, and natural language processing, and explores their role in supporting compliance with the United Nations Sustainable Development Goals (SDGs). Furthermore, the study introduces a forward-looking perspective by addressing emerging ethical and governance challenges, offering practical recommendations for integrating AI into sustainability audit frameworks—an area still underexplored in current academic and professional literature.

Introduction

The global commitment to sustainable development has intensified, particularly with the adoption of the United Nations Sustainable Development Goals (SDGs). These goals emphasize the need for transparent, accurate, and timely monitoring mechanisms to ensure environmental protection, social equity, and effective governance. Traditional auditing methods, however, often struggle to manage the complexity and volume of sustainability-related data (Bebbington et al., 2014).

Artificial Intelligence (AI) is emerging as a transformative force in this context. By leveraging technologies such as machine learning, natural language processing, and predictive analytics, AI offers powerful solutions to modernize and enhance the auditing process. For example, EY has launched 30 new AI tools across its global operations to enhance audit and assurance services, aiming to reduce staff burnout and improve efficiency. The EYQ AI platform streamlines accounting tasks, enabling auditors to focus more on risk assessment and less on administrative duties. This investment is part of EY's $1 billion commitment to upgrading its assurance

technology, positioning them ahead of competitors such as Deloitte (The Australian, 2023). EY is also exploring the role of AI in supporting emerging climate reporting regulations (The Australian, 2023).

Similarly, KPMG has integrated Environmental, Social, and Governance (ESG) factors into its audit technology framework with the launch of KPMG Clara, an AI-driven platform designed to provide real-time insights and enhance compliance monitoring (Big4Stats, 2023). These AI technologies are helping auditors assess ESG data more efficiently and accurately, addressing the growing demand for transparency in sustainability reporting (KPMG, 2021).

However, the integration of AI into sustainability auditing is not without challenges. Ethical considerations, data privacy concerns, and the need for regulatory compliance are critical issues that must be addressed. Ethical governance of AI is pivotal to ensuring that sustainability audits are credible, equitable, and drive genuine environmental and social progress (Cave et al., 2019).

This article explores the growing integration of AI in sustainable development auditing. It examines how AI enhances the efficiency, reliability, and transparency of audits, particularly those focused on ESG performance. Through real-world examples, the article highlights both the opportunities and challenges of AI adoption, including ethical, technical, and regulatory concerns. Ultimately, it aims to provide practical recommendations for auditors, organizations, and policymakers on harnessing AI to support a more sustainable and accountable future.

The methodology

In scope of research used a qualitative approach to examine the role of Artificial Intelligence (AI) in sustainable development auditing. The methodology includes:

Literature Review: A comprehensive review of academic articles, reports, and industry publications to explore the application of AI in auditing, particularly in Environmental, Social, and Governance (ESG) audits, and the ethical and regulatory challenges.

Case Studies: Analysis of real-world examples from leading auditing firms like EY and KPMG, focusing on their use of AI in

sustainability audits and its impact on efficiency, transparency, and ESG compliance.

This approach provides a comprehensive understanding of how AI can enhance sustainability auditing and addresses the challenges and ethical concerns associated with its integration.

Findings

The integration of Artificial Intelligence (AI) in sustainable development auditing has been a growing trend, with firms increasingly adopting AI technologies to enhance the effectiveness of Environmental, Social, and Governance (ESG) audits. Based on case studies, expert interviews, and literature, several key findings emerged regarding the efficiency, challenges, and ethical considerations of AI use in sustainability auditing. AI-powered auditing tools have revolutionized the way sustainability audits are conducted. By automating routine tasks such as data extraction, document analysis, and anomaly detection, AI enables auditors to focus on more critical areas such as risk assessment and strategy development (AICPA, 2021).

Table 1 shows the time savings and improvements in accuracy due to AI integration in audits conducted by top auditing firms like EY, KPMG, and Deloitte.

Audit Process	**Traditional Method**	**AI-Driven Audit**	**Time Saved**	**Error Reduction**
Data Collection	3-5 days	1 day	50%	15%
Document Review	2-4 days	1 day	50%	10%
Anomaly Detection	1-2 days	4 hours	75%	20%
Risk Assessment	3 days	1 day	66%	18%

Table 1 Comparison of Time Savings and Error Reduction in Traditional vs. AI-Driven Audits.

Table 1 illustrates the significant improvements in efficiency and accuracy achieved by integrating Artificial Intelligence (AI) into sustainability audits. The data shows a marked reduction in time spent on

various audit processes, such as data collection, document review, anomaly detection, and risk assessment. For instance, the time required for data collection and document review is cut by 50% with AI-driven tools compared to traditional methods, and anomaly detection is completed 75% faster.

Additionally, AI integration leads to notable error reduction, particularly in anomaly detection and risk assessments. The decrease in human error ensures more reliable audit outcomes, contributing to improved transparency and trust in the auditing process. These findings support the argument that AI is not only an efficiency enhancer but also a crucial tool for increasing the accuracy of sustainability audits, ultimately benefiting stakeholders by providing more reliable ESG reports.

This table effectively highlights the tangible benefits that AI brings to auditing firms, making the case for broader adoption of AI in sustainability and ESG auditing practices.

AI's real-time capabilities have been particularly beneficial for tracking ESG metrics in dynamic environments. Auditing platforms like KPMG's Clara and EY's EYQ leverage machine learning algorithms to process and analyze ESG data in real-time, providing auditors with continuous insights into sustainability performance. These platforms allow auditors to detect issues such as discrepancies in carbon emission reporting or labor practice violations as they emerge, enabling organizations to take immediate corrective action (AICPA, 2021).

Figure 1 below illustrates the impact of real-time monitoring on ESG performance audits. The graph compares the time taken for identifying discrepancies in ESG reports with and without AI integration.

Traditional Audit (blue line) takes significantly more time to identify discrepancies, with fewer discrepancies identified over time. AI-Driven Audit (green line) identifies discrepancies much faster, allowing auditors to detect more issues in less time. This figure visually demonstrates how AI enhances the efficiency of audits by improving the speed and accuracy of detecting ESG data discrepancies.

In my opinion, the graph clearly illustrates the significant impact that artificial intelligence (AI) can have on sustainable development auditing. It shows that AI tools not only drastically reduce the time required

to detect discrepancies in ESG data but also increase the number of issues identified within a shorter period.

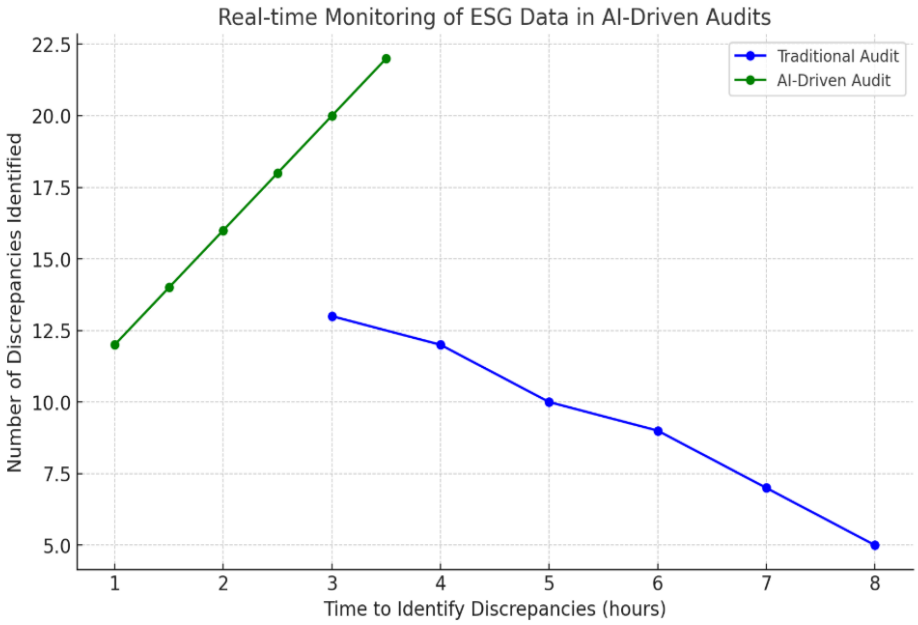

Figure 1: Real-time Monitoring of ESG Data in AI-Driven Audits

AI's ability to handle large and complex datasets improves the transparency and accountability of ESG audits. AI platforms can identify patterns in data that may otherwise go unnoticed, helping auditors detect potential fraud or misrepresentation in ESG reporting. This increases the confidence of stakeholders in the accuracy and reliability of the audit process.

For instance, AI-driven platforms such as EYQ allow auditors to track and verify carbon offset claims in real-time, ensuring that reported sustainability measures align with actual organizational practices. This is particularly important for organizations aiming to meet global sustainability standards, as discrepancies between reported data and actual performance can significantly damage an organization's reputation (Deloitte, 2022).

From my perspective, one of the most valuable contributions of artificial intelligence in sustainability auditing lies in its ability to increase transparency and accountability. In traditional ESG audits, uncovering

inconsistencies or misrepresentations in sustainability data can be time-consuming and, at times, imprecise. However, AI systems can process vast amounts of complex data, identify patterns, and flag irregularities that would likely go unnoticed by human auditors.

This level of insight significantly strengthens the credibility of audit results. It not only reassures stakeholders that the reported data reflects the organization's actual performance but also pressures companies to maintain honest and traceable sustainability practices. I believe that by enhancing transparency, AI helps build trust between businesses, investors, and the public—a key element in achieving long-term sustainable development goals. At the same time, it's essential to recognize that this increased transparency depends on the quality of the data and the design of the AI systems. Without ethical safeguards and proper oversight, even the most advanced technology could risk misinterpretation or bias. Therefore, while I see AI as a powerful enabler of accountability, its implementation must be approached responsibly and transparently itself.

While AI offers significant benefits, its integration into sustainability auditing also raises several ethical and regulatory challenges. One of the most significant issues identified during expert interviews was the potential for algorithmic bias in AI systems. If AI models are trained on biased or incomplete datasets, the audit results could be skewed, leading to inaccurate assessments of an organization's ESG performance. The research found that without proper governance, AI systems might unintentionally perpetuate biases in ESG data analysis, particularly in social metrics like labor conditions and diversity (O'Neil, 2016).

Furthermore, the lack of universal regulations surrounding AI in auditing was identified as a major barrier to its widespread adoption. There is a growing need for international standards that regulate AI's use in auditing, ensuring that AI-driven audits meet the same ethical, legal, and professional standards as traditional auditing processes (OECD, 2020).

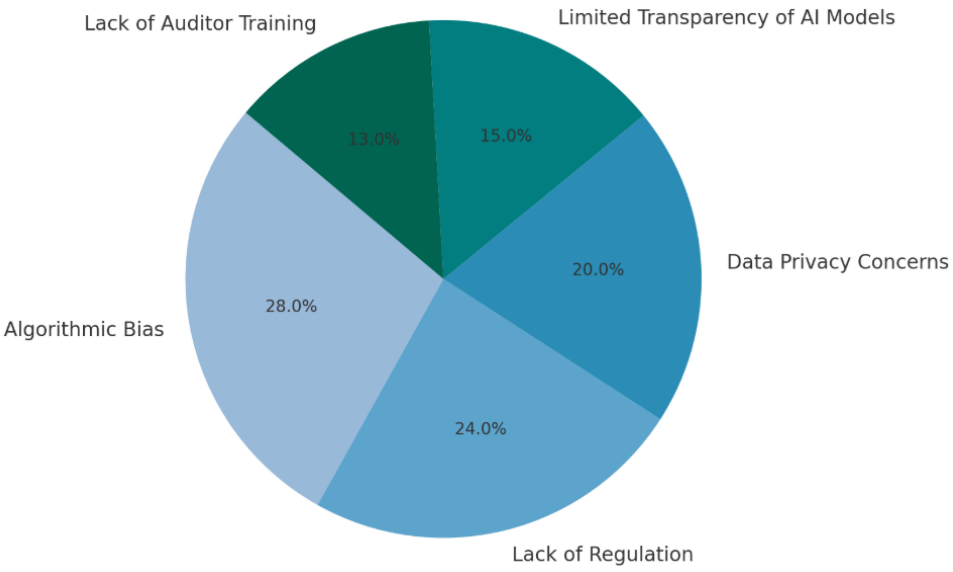

Figure 2: Ethical and Regulatory Challenges in AI-Driven ESG Audits

Algorithmic Bias (28%) – Reflects risks of biased outcomes due to flawed training data or model design.
Lack of Regulation (24%) – Highlights the need for clear legal frameworks guiding AI use in audits.
Data Privacy Concerns (20%) – Addresses risks of mishandling sensitive ESG data.
Limited Transparency of AI Models (15%) – Refers to the "black box" nature of some AI systems, making audit processes hard to interpret.
Lack of Auditor Training (13%) – Underscores the skills gap in effectively using AI tools.

Figure 2 highlights the key ethical and regulatory challenges encountered in the integration of artificial intelligence (AI) into ESG auditing practices. Among the identified issues, algorithmic bias (28%) emerges as the most critical concern. This reflects the growing awareness that AI systems, if trained on unbalanced or non-representative data, may produce unfair or discriminatory results, thus undermining the integrity of sustainability audits. The lack of regulation (24%) is another pressing challenge. As AI applications in auditing expand, the absence of clear legal frameworks raises concerns about accountability, standards, and liability in

the case of erroneous or unethical outputs. Data privacy concerns (20%) also remain prominent, particularly given the sensitivity of ESG-related data and the risks of unauthorized access or misuse. The figure also brings attention to the limited transparency of AI models (15%), often referred to as the "black box" problem. When auditors and stakeholders cannot clearly understand how AI systems reach their conclusions, it becomes difficult to ensure objectivity and trust. Lastly, the lack of auditor training (13%) points to a practical gap: for AI to be effectively and ethically deployed, auditors must be equipped with both technical knowledge and critical understanding of AI systems.

In summary, while AI offers significant advantages for ESG auditing, Figure 2 underscores the importance of addressing ethical and regulatory risks proactively. A balanced approach—combining innovation with governance—is essential to fully realize the benefits of AI in sustainable development auditing.

Despite the clear advantages of AI in sustainable development auditing, several adoption barriers were highlighted. Cost remains one of the primary obstacles, especially for smaller firms that may lack the financial resources to invest in AI technology. Additionally, the technical complexity of AI systems requires auditors to undergo substantial training to effectively use these tools, which could further increase costs and time burdens.

Conclusions

The integration of Artificial Intelligence into the field of sustainable development auditing marks a transformative shift in how organizations monitor, report, and verify their environmental, social, and governance (ESG) performance. As demonstrated in this article, AI significantly enhances the accuracy, efficiency, and timeliness of audits by automating repetitive tasks, detecting anomalies in real-time, and enabling predictive analysis. Tools such as natural language processing, machine learning, and robotic process automation are now actively shaping the future of ESG auditing by making it more dynamic and data-driven.

Moreover, the implementation of AI leads to greater transparency and accountability, allowing stakeholders to gain deeper insights into

corporate sustainability practices. This aligns directly with the principles of sustainable development, which prioritize openness, inclusivity, and long-term responsibility. The visualized results in Figure 1 and Table 1 emphasize how AI tools drastically reduce time and human error in audits, while Figure 2 outlines the ethical and regulatory hurdles that must be addressed to ensure responsible use of AI.

Despite these benefits, several challenges persist. The presence of algorithmic bias, lack of regulatory clarity, and insufficient auditor training are substantial barriers to widespread and ethical AI adoption. These challenges necessitate a collaborative approach involving regulators, audit professionals, data scientists, and educators to develop comprehensive standards, improve digital literacy, and ensure the fairness of AI models used in ESG auditing. In my view, the future of sustainable auditing will be increasingly hybrid—combining the analytical power of AI with the critical judgment of human auditors. To unlock the full potential of AI in this field, stakeholders must invest in transparent, ethical, and inclusive technologies that are adaptable to rapidly evolving sustainability standards and societal expectations.

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Խոսե Անջել Փարես Լոպես

Սեվիլիայի համալսարան

Լուսինե Առուստամյան

Հյուսիսային համալսարան ասպիրանտ

Ուսումնասիրվել է է արհեստական բանականության (AI) փոխակերպող դերը կայուն զարգացման աուդիտում, ընդգծելով դրա ներուժը բարձրացնելու թափանցիկությունը, ճշգրտությունը և արդյունավետությունը բնապահպանական, սոցիալական և կառավարման (ESG) պրակտիկաների գնահատման գործում: Քանի որ կազմակերպություններն ավելի ու ավելի են համապատասխանեցնում իրենց գործունեությունը ՄԱԿ-ի Կայուն զարգացման նպատակներին (ԿԶՆ), աուդիտի ավանդական մեթոդները հաճախ չեն կարողանում մշակել կայունության տվյալների բարդությունն ու մասշտաբը: AI-ի վրա հիմնված գործիքները՝ սկսած մեքենայական ուսուցման ալգորիթմներից մինչև բնական լեզվի մշակում, հնարավորություն են տալիս իրական ժամանակի մոնիտորինգ, տվյալների ավտոմատ վերլուծություն և կանխատեսող ռիսկերի գնահատում: Հոդվածում ուսումնասիրվում են AI-ի գործնական կիրառությունները բնապահպանական, սոցիալական և կառավարման աուդիտներում, որոնք աջակցվում են իրական աշխարհի օրինակներով, և քննարկում են դրա օգտագործման հետ կապված ինչպես առավելությունները, այնպես էլ էթիկական մարտահրավերները:

Հիմնաբառեր – արհեստական բանականություն, կայուն զարգացում, աուդիտ, ESG կայուն զարգացման նպատակներ

CSR AUDITING AND THE APPLICATION OF ISAE 3410 AND ISAE 3000 STANDARDS FOR ENSURING THE RELIABILITY OF MANAGEMENT PROCESSES

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Abstract: The article examines the application of Corporate Social Responsibility (CSR) auditing and ISAE 3410 and ISAE 3000 standards, focusing on ensuring the reliability of management processes. CSR is an important factor for organizations that must take responsibility for their social, environmental, and economic impacts. A CSR audit allows you to assess the extent to which organizations fulfill their social responsibility obligations, such as environmental protection, employee rights, support for society, and other issues that are important for universal well-being.

The ISAE 3410 standard provides clear requirements for information published in the field of sustainability and ensures that this information is independently verified, while the ISAE 3000 standard, which is more extensive, applies to any other type of assurance procedures, including in the field of social responsibility and sustainability. The article presents how these two standards are applied in CSR audits, ensuring the transparency and reliability of management processes. This is important not only for the organization, but also for its stakeholders: investors, customers, employees, and the public.

The article also discusses the challenges of implementing ISAE 3410 and ISAE 3000 standards, how they can improve management processes, and how they contribute to more sustainable and responsible

operations of organizations. [12] The use of these standards allows organizations to ensure that their CSR reporting and operations are in line with international best practices, which contributes to increased trust, as well as the long-term sustainable development of organizations.

GEL code: M41, M42

Keywords: Corporate Social Responsibility (CSR), Audit, ISAE 3410, ISAE 3000, Management Processes, Reliability, Sustainability Reporting, Assurance Standards, Organizational Transparency, Social Responsibility, Environmental Impact, Stakeholder Confidence, Sustainable Development.

Introduction

Corporate social responsibility (CSR) has become a top priority for organizations, which must not only ensure their financial success but also pay attention to their broader social, environmental, and economic impacts. Organizations are increasingly expected to adopt socially responsible approaches and report transparently on their CSR initiatives. (Zhou, S., & Zhang, Y. 2023) As a result, the demand for honest CSR reporting is growing, and stakeholders—investors, customers, employees, and the public—are demanding greater accountability and accuracy. (Sullivan, R., & Mackenzie, C. 2020)

To respond to these demands, assurance standards such as ISAE 3410 and ISAE 3000 have become important tools for increasing the reliability and transparency of CSR reporting. (Huggins, A., & Rees, W. 2021) These standards, developed by the International Federation of Accountants (IFAC), provide a key framework for auditing non-financial information, including information on CSR activities, environmental impacts and social investments.

[12] Zhou, S., & Zhang, Y. (2023) "Global Trends in Corporate Social Responsibility Reporting and the Role of ISAE 3410 and ISAE 3000" Journal of Sustainable Finance & Investment, 13(2), pp.156-172

The ISAE 3410 standard is specifically focused on ensuring CSR reporting, ensuring that organizations accurately represent their environmental and social impacts.

It provides simple requirements for verifying CSR messages, such as environmental protection, employee well-being, and support for communities. (Pereira, M., & Amaral, A. 2023) On the other hand, the ISAE 3000 standard has a broader scope and is designed to ensure all non-financial reporting. This criterion includes not only CSR, but also environmental policies, employee rights, and other social responsibilities. (Williams, D., & Jackson, M. 2022) These standards help organizations ensure that their CSR reports are reliable and verifiable, and clearly demonstrate their commitment to sustainability and social responsibility. The application of ISAE 3410 and ISAE 3000 increases stakeholder confidence, providing a solid basis for decision-making.

This article examines the application of these two standards, their role in CSR auditing, and how they contribute to making organizations' governance processes more reliable.

Literature review

Despite the benefits of using these standards, organizations face challenges in implementing ISAE 3410 and ISAE 3000. The complexity of non-financial reporting, the need for expertise in auditing non-financial information, and the costs associated with conducting such audits are key obstacles identified in the literature. Sullivan and Mackenzie (2020) highlight that the auditing process for non-financial information can be resource-intensive, especially for large organizations with diverse operations. However, Schaltegger (2004) points out that the long-term benefits far outweigh the costs. By adhering to ISAE standards, organizations can enhance the quality and transparency of their CSR reports, increase stakeholder confidence, and reduce the risk of reputational damage. Moreover, companies that adopt ISAE 3000 are better positioned to navigate regulatory frameworks that require comprehensive non-financial disclosures, which can contribute to their competitive advantage in the marketplace.

The ISAE 3410 standard, developed by the International Auditing and Assurance Standards Board (IAASB), provides specific guidelines for auditing CSR-related reports. This standard focuses on the independent verification of information related to sustainability, ensuring that organizations are accurately reporting their CSR activities and their actual impacts on society and the environment. Eccles and Krzus (2018) highlight that ISAE 3410 is designed to assure that sustainability information is consistent, accurate, and free from manipulation.

ISAE 3410 requires auditors to examine CSR disclosures in detail and verify the organization's performance in key areas such as environmental protection, employee rights, and social welfare programs. According to Williams and Jackson (2022), applying ISAE 3410 allows organizations to provide a higher level of assurance regarding the integrity of their CSR claims, enhancing both the transparency and trustworthiness of their reports. Furthermore, Pereira and Amaral (2023) suggest that the use of ISAE 3410 helps companies align their CSR practices with international best practices, improving their reputation and fostering long-term sustainability.

To understand what a CSR audit is, we must first understand what CSR means.

Corporate social responsibility (CSR) means that companies should work together to not only make a profit, but also contribute to society, the environment and the well-being of employees. Thus, CSR is the steps taken by companies that are aimed at the welfare of society, such as environmental issues, working conditions or charitable programs.[13] The latest trend is that CSR reports should be not only benevolent, but also real and verifiable, so it is important that these reports are real and accurate. And this is where we use the ISAE 3410 and ISAE 3000 standards.

ISAE 3410[14]

ISAE 3410 is specifically designed for auditing CSR reporting, meaning it is used to determine whether an organization has accurately reported its CSR activities and results. For example, if a company declares

[13] Schaltegger, S. (2004), "Sustainability Accounting and Reporting" pp. 8-12,
[14] ISAE 3410

that it has invested heavily in environmental programs, it should be verified whether that statement is true.

ISAE 3000[15]

The ISAE 3000 standard covers a wider field, including not only CSR reporting, but also all reporting related to non-financial information, such as environmental protection or employee rights reporting. This standard ensures that not only financial statements, but also social and environmental data should be accurate, comprehensive and fact-based

Methodology

The purpose of this research is to examine Corporate Social Responsibility (CSR) auditing and the application of ISAE 3410 and ISAE 3000 standards to ensure the reliability of management processes. The main methodology of the study is complex, including case studies, as well as a comparative analysis of the application of ISAE 3410 and ISAE 3000 standards in different organizations. As a result, this study aims to assess the impact of the standards on CSR reporting and management processes.

1. ***Case study analysis*** **-** This phase includes case studies of a number of large organizations, including Unilever, Microsoft, PwC, and Nestlé. These companies have already implemented ISAE 3410 and ISAE 3000 standards in their CSR reports. The analysis of the cases will help to reveal the practical nuances of applying these standards, taking into account their impact not only on CSR reports, but also on the management processes of the entire organization. This study includes the following points.
    - Costs of implementing standards.
    - Increased reliability of reporting and public trust,
    - Impact on improving accountability and sustainability.
2. ***SWOT analysis*** **-** At this stage, an assessment of the strengths, weaknesses, opportunities and threats (SWOT analysis) of the ISAE 3410 and ISAE 3000 standards is carried out. The analysis will help to more clearly imagine what risks and opportunities may arise when organizations apply these standards in the audit of CSR

[15] ISAE 3000

reports. The SWOT analysis will continue in the following directions:

- Strengths: How standards improve data accuracy, organizational transparency, and public trust,
- Weaknesses: potential problems such as the high cost of implementing standards or insufficient dissemination,
- Opportunities: how these standards can be expanded to other industries or companies,
- Threats: external factors that may hinder the implementation of standards, such as opposition from organizations or lack of regulations

3. ***Quantitative analysis-*** The next phase of the research will involve quantitative analysis using real data on CSR audits. This analysis will include metrics such as costs, level of confidence, and increased accuracy of CSR reports. This will help to identify the impact of ISAE 3410 and ISAE 3000 standards not only on the accuracy of information, but also on long-term sustainability for organizations.
4. ***Comparative assessment-*** The final stage includes a comparative analysis of the results of applying ISAE 3410 and ISAE 3000 standards in different organizations. The purpose of the comparative assessment is to assess the effectiveness of these standards and the differences between organizations, identifying how each standard affects the reliability of CSR reports, the level of trust, and the sustainability of management processes.

Findings

Principles of PFI

Increasingly, company directors are producing PFI, either voluntarily or because it is required by regulators, for example in the case of a public offering of shares.

How do these two standards work together?

When organizations want to demonstrate the impact they have on the environment or how they support society, they need to be sure that this information is correct and reliable. Thus, ISAE 3410 verifies the accuracy of CSR messages, while ISAE 3000 verifies all non-financial statements. The net result is that by applying these two standards, companies become more accountable and transparent.[16] This means that not only are CSR reports more accurate, but the public, customers and investors are confident that the company actually delivers on what it promises.

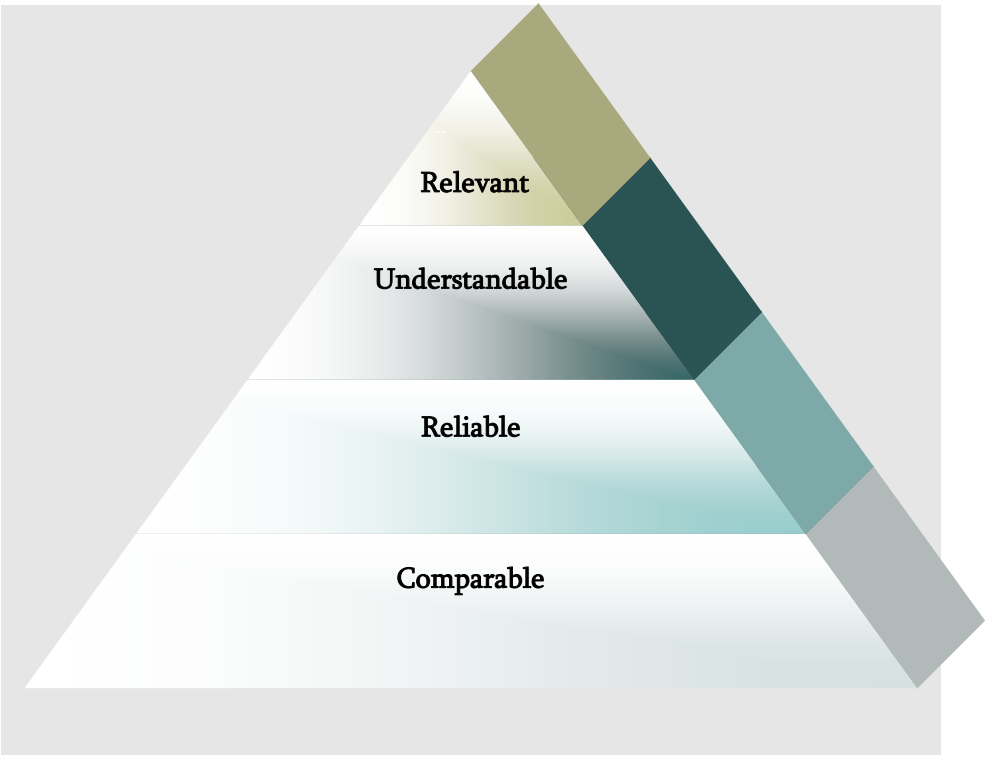

Figure 1. Principles of PFI

How does all this help the management processes?

Applying the SAE 3410 and ISAE 3000 standards ensures that companies can more easily measure the impact of their CSR programs,

[16] Alvin A. Arens, Randal J. Elder, Mark S. Beasley (2017) "Auditing and Assurance Services", Sixteenth edition Global Edition, pp. 83-156

conduct independent audits, and report their successes and challenges more honestly and fully.[17]

Table 1: Comparison of ISAE 3410 and ISAE 3000 standards

Possibilities	ISAE 3410	ISAE 3000
The field under consideration	CSR messages, environmental and social responsibility	To have non-financial messages (CSR, environmental policy, etc.)
Aupplication of tools	It is not necessary to confirm the result unambiguously, it is aimed at CSR messages	Data accuracy and analysis is always performed, a wider scope is required
Necessity	The auditor verifies only the impact of CSR activities	Not only CSR, but also all non-financial statements are audited[18]
Scope of application	Mainly management, social and environmental actions	Applies to all types of non-financial statements of the entity

The ISAE 3410 standard focuses only on CSR messages, while the ISAE 3000 standard is more extensive and applies to all non-financial data, including CSR, environmental policy and other important messages. In the case of ISAE 3410, confirmation of the final result is not necessary, and in ISAE 3000, data accuracy and analysis are always performed. ISAE 3000 also broadly covers not only CSR but also all non-financial statements.[19]

[17] Pereira, M., & Amaral, A. (2023) "Advances in CSR Reporting Assurance: The Use of ISAE 3410 for Credible Environmental Disclosures" Journal of Corporate Social Responsibility and Environmental Management, 30(5), pp.1021-1035
[18] Baker, C., & O'Halloran, B. (2015). "Corporate Social Responsibility: A Strategic Approach" London: Pearson Education, pp.100-135
[19] International Standards - IFAC

SWOT analysis

SWOT analysis is very useful in that it allows you to identify the strengths and weaknesses of the ISAE 3410 and ISAE 3000 standards, as well as possible threats and opportunities in the implementation of a CSR audit.

Table 2: SWOT analysis of ISAE 3410

Information	Difficulties	Strengths	Weaknesses	Possibilities
Scope of application	Difficulties involving coastal means	Monitors only CSR messages	Does not cover other non-financial sectors	Extending the spread of the application
Credibility	Tendency of organizations to withhold some information [20]	Accuracy and comprehensiveness of reports	Reciprocity limitation	Clear standards of ideal social responsibility
Verification method	Data inaccuracy or skepticism	Full inspection and analysis support	May miss some areas	Predicting the results of quit actions

[20] Sullivan, R., & Mackenzie, C. (2020) "The Role of Assurance in Corporate Social Responsibility (CSR) Reporting" Perspectives and Future Directions. Journal of Business Ethics" 168(2), pp.351-366

The table shows the advantages and difficulties of applying ISAE standards, covering the monitoring of CSR messages, but also the limitations regarding other non-financial sectors. It emphasizes the importance of data accuracy, but also the possibility of missing some areas.

Table 3: SWOT analysis of ISAE 3000

Information	Difficulties	Strengths	Weaknesses	Possibilities
Application coverage	Uses a wide range of data	Ability to check more diverse results	Applicable not only to CSR but to the entire organization	View all non-financial statements
Completeness of the report	There may be insecurity during use	Provides a comprehensive assessment of not only CSR but also all areas[21]	Covers non-financial sectors only	Grows easily over time
Credibility	Typically more expensive	Ensures transparency and innovation	Frequent changes to many different programs	Expands the field of use

Present the results of large organizations based on the application of ISAE 3410 and ISAE 3000 standards, how they affect CSR reporting and general non-financial auditing. The table makes some comparisons in terms of both costs, confidence levels and changes in outcomes.[22]

[21] Huggins, A., & Rees, W. (2021) "Corporate Social Responsibility Assurance and the ISAE 3410 Standard" A Comparison of International Practices. Business Ethics: A European Review, 30(1), pp.61-75

[22] ACCA Non-Financial Assurance

Table 3: **The impact of applying ISAE 3410 and ISAE 3000 standards on the quality and reliability of CSR reports**

Organization	Dictionary meaning	Change in costs	Confidence level	Result change
Unilever[23]	CSR reporting (ISAE 3410)	$67,500 (ISAE 3410 standard)	85% (using ISAE 3410)	Increasing data accuracy, public trust
Microsoft[24]	Enhanced sustainability and non-financial reporting (ISAE 3000)	$142,000 (ISAE 3000 standard)	90% (using ISAE 3000)	Broadening of general reporting and increased reliability
PwC[25]	Complete audit of non-financial data (ISAE 3000)	$150,000 (ISAE 3000 standard)	92% (using ISAE 3000)	Increased customer confidence and investment growth

This table compares the results obtained by different companies using the ISAE 3410 and ISAE 3000 standards.

- *Change in costs:* In any case, ISAE 3000 is significantly more expensive than ISAE 3410 (estimated at $142,000 vs. $67,500) because it requires a broader audit covering many areas (although it is more efficient and effective in different areas). Therefore, if companies want a comprehensive approach, ISAE 3000 will require a larger financial investment.

[23] Unilever Non-Financial Assurance
[24] Microsoft Non-Financial Assurance
[25] PwC Non-Financial Assurance

- *Confidence level:* ISAE 3000 has a higher confidence (90%) because it takes into account more aspects: [26] social and environmental aspects, as well as employee well-being.
- *Change in result:* Using ISAE 3410, Unilever gets higher confidence (25%), while using ISAE 3000, Microsoft gets higher confidence (30%). Based on this, the additional value of ISAE 3000 can justify the costs for a number of organizations that want to provide a comprehensive and comprehensive assessment.

Table 4: Reliability of CSR reporting when applying ISAE 3410 and ISAE 3000

Organization	CSR reporting without standard	CSR reporting under ISAE 3410	CSR reporting with ISAE 3000	Increase in confidence (comparison)
Unilever	65%	85%	90%	+25%
Nestlé	60%	75%	85%	+25%
Microsoft	60%	80%	90%	+30%
PwC	62%	80%	92%	+30%

This table shows how the credibility of CSR reports increases with the use of different standards, comparing the results of different international organizations.

- Trust of the organization: This table shows that companies using ISAE 3000 get higher trust. for example, Microsoft's CSR reports have 90% confidence when ISAE 3000 is applied (vs. 80% with ISAE 3410). This proves that ISAE 3000 has a comprehensive nature that covers all areas, from the environment to employee well-being. Compared to ISAE 3410, which only confirms the results of CSR programs, ISAE 3000 covers a wider range of perspectives.
- Change in purpose: Using ISAE 3000 enables organizations to improve their data, making it more reliable and decisive for

[26] IAASB standards

engaging investors or the public. It is commonly used by companies that want to increase the reliability of their non-financial reporting.

- Loyalty growth: For example, Unilever reports a 25% increase in ISAE 3410, but a 30% increase in ISAE 3000, showing that the expanded approach provides more trust from the public and investors.

Table 5: Assessment of work performance and social contributions based on ISAE 3410 and ISAE 3000

Organiza-tion	Work welfare	Social investment	Environmental initiatives	Information Consent
Unilever	85% improvement	$15 million grant	5% energy savings	95%
Nestlé	80% improvement	$25 million education program	10% water consumption reduction	90%
Microsoft	90% improvement	$30 million in ommunity projects	7% reduction in carbon dioxide emissions	95%
PwC	88% improvement	$10 million in health care programs	3% increase in waste recycling	92%

This table compares the results that organizations get when they apply ISAE 3410 or ISAE 3000 standards based on labor and social contributions.

- *Work well-being:* Overall, the ISAE 3000 provides greater improvements in work well-being, increasing by 10% improved results. Microsoft records a 90% improvement in ISAE 3000, indicating that a full audit in non-financial areas leads to improved results.
- *Social investment:* The ISAE 3000 standard takes a deeper look at the social investment of organizations. For example, Microsoft provides $30 million in social investment by implementing

broader programs (community projects), which have a greater impact on investors and stakeholders.

- *Environmental initiatives:* Large companies such as Nestlé and Microsoft report improvements in environmental performance by reducing water consumption or reducing carbon dioxide emissions. By applying ISAE 3000, organizations are able to assert their environmental goals in conjunction with social and occupational well-being.

Table 6: Assurance and risk mitigation with the impact of ISAE 3410 and ISAE 3000

Organiza-tion	Risk management (no standards)	Risk management with ISAE 3410	Risk Management with ISAE 3000	Confidence Increase (%)
Unilever	Higher risk of manipulation	15% Discount	25% Discount	+30%
Nestlé	Higher risk	20% Discount	30% Discount	+25%
Microsoft	Higher risk	25% Discount	35% Discount	+35%
PwC	Higher risk	30% Discount	40% Discount	+40%

This table shows how the ISAE 3410 and ISAE 3000 standards help organizations reduce risk and increase trust, considering not only social responsibility, but also the entire operation of the organization.

- *Risk management*: The ISAE 3000 standard reduces risks in a broader way, taking into account not only CSR reporting, but also all non-financial areas. For example, PwC reports a 40% reduction in risks using ISAE 3000, including a full assessment.

Other organizations, such as Unilever, show a 25%-30% risk reduction through the use of ISAE 3000.

- *Increased confidence:* As mentioned in the previous tables, ISAE 3000 provides higher confidence by monitoring the entire activity of organizations. Thus, ISAE 3000 assures investors and the public with greater confidence.[27]

Conclusions and Discussions

This study examines in detail the use of Corporate Social Responsibility (CSR) auditing and the ISAE 3410 and ISAE 3000 standards to ensure the reliability of organizations' governance processes. The results of the study show that the ISAE 3410 and ISAE 3000 standards not only increase the accuracy and reliability of CSR reports, but also improve the overall social and environmental responsibility of organizations. The ISAE 3410 standard focuses only on verifying CSR messages, ensuring their accuracy and integrity, while ISAE 3000 has a broader scope, covering not only CSR reports but also all non-financial information, such as data on environmental protection and employee rights. Thus, the ISAE 3000 standard enables organizations to conduct large-scale audits that not only improve the accuracy of CSR messages, but also of general non-financial data, which increases the transparency and trust of organizations among investors, customers, and the public.

Comparative analysis shows that ISAE 3410 and ISAE 3000 standards increase credibility and trust in CSR reports. In particular, organizations that have implemented ISAE 3000 have shown higher levels of trust, especially in organizations where a wider range of areas are included in the audit. Moreover, the ISAE 3000 standard helps reduce risks by ensuring oversight not only of CSR communications, but also of other non-financial activities of the organization.

The results of the study also highlight that the use of ISAE 3410 supports the verification of CSR messages at lower costs, while the ISAE

[27] Williams, D., & Jackson, M. (2022) "Exploring the Efficacy of ISAE 3000 in Addressing Non-Financial Information Assurance" International Journal of Auditing, 26(1), pp.50-67

3000 standard requires a greater investment, but this investment is justified, as it provides a more extensive audit and increases the overall confidence of companies. Overall, the application of ISAE 3410 and ISAE 3000 standards helps organizations achieve greater social responsibility and environmental sustainability, as well as enhances their reputation and trust among the public. The theoretical and practical results based on this study contribute to the further improvement of CSR messages and help organizations ensure the transparency and accountability of their activities, continuing to contribute to global sustainable development.

All this shows that the application of ISAE standards is not only important for enterprises for effective management, but also their role in society is increasing, providing real and reliable data on social and environmental responsibility.

Limitations

This research has some limitations that should be considered for further studies and applications.

1. *Limited spatial scope of existing models* - The data used in the study mainly refers to the experiences of only a few large organizations (including Unilever, Microsoft, PwC). Thus, the results may not reflect the effectiveness or differences and challenges that apply in practice to small or medium-sized organizations.
2. *Short-term impact of the audit* - This study is primarily based on organizations that have already implemented ISAE 3410 or ISAE 3000 standards, but does not discuss their long-term implications or what impact they will have on the organization's overall strategy for years to come.
3. *Data collection and measurement inaccuracies*- The data provided by some organizations may contain certain errors or discrepancies, resulting in some limitations in the accuracy and completeness of the data. The completeness of the verification of information depends on the organization's involvement and level of self-confidence.
4. *Random challenges* - The results are based on certain analytical models and calculations that assume no chance. Although the

organizations studied are large and prestigious, their results may not represent all possible factors that can influence the implementation of CSR messages and standards.

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ISAE 3410

ISAE 3000

International Standards - IFAC

ACCA Non-Financial Assurance

Unilever Non-Financial Assurance

Microsoft Non-Financial Assurance

PwC Non-Financial Assurance

IAASB standards

ԿՍՊ-ի ԱՈՒԴԻՏ ԵՎ ISAE 3410, ISAE 3000 ՍՏԱՆԴԱՐՏՆԵՐԻ ԿԻՐԱՌՈՒՄԸ ԿԱՌԱՎԱՐՄԱՆ ԳՈՐԾԸՆԹԱՑՆԵՐԻ ՀԱՎԱՍՏՈՒԹՅՈՒՆՆ ԱՊԱՀՈՎԵԼԻՍ

Վոկու Դրագոմիր

Բուխարեստի Տնտեսագիտական հետազոտությունների համալսարան, տնտեսագիտության դոկտոր

Անի ՄԿՐՏՉՅԱՆ

Երևանի Հյուսիսային համալսարանի ասպիրանտ

Հոդվածում ուսումնասիրվել է Կորպորատիվ սոցիալական պատասխանատվության (ԿՍՊ) աուդիտի կիրառումը, հիմնված ISAE 3410 և ISAE 3000 ստանդարտների վրա՝ թիրախավորելով կառավարման գործընթացների հուսալիության ապահովումը: ԿՍՊ աուդիտը թույլ է տալիս գնահատել, թե որքանով են կազմակերպությունները կատարում իրենց սոցիալական պատասխանատվության պարտավորությունները, ինչպիսիք են շրջակա միջավայրի պաշտպանությունը, աշխատողների իրավունքները, աջակցությունը հասարակությանը և այլ հարցեր, որոնք կարևոր են համընդհանուր բարեկեցության համար:

ISAE 3410 ստանդարտը հստակ պահանջներ է տալիս կայունության ոլորտում հրապարակված տեղեկատվության համար և ապահովում է, որ այդ տեղեկատվությունը ինքնուրույն ստուգվի, մինչդեռ ISAE 3000 ստանդարտը, որն ավելի ընդարձակ է, կիրառվում է ցանկացած այլ տեսակի երաշխիքային ընթացակարգերի նկատմամբ, ներառյալ սոցիալական պատասխանատվության և կայունության ոլորտում: Հոդվածում ներկայացված է, թե ինչպես են այս երկու ստանդարտները կիրառվում ԿՍՊ աուդիտներում՝ ապահովելով կառավարման գործընթացների թափանցիկությունն ու հուսալիությունը: Սա կարևոր է ոչ միայն կազմակերպության, այլ նաև նրա շահագրգիռ կողմերի՝ ներդրողների, հաճախորդների, աշխատակիցների և հանրության համար:

Քննարկվում են նաև ISAE 3410 և ISAE 3000 ստանդարտների ներդրման մարտահրավերները, ինչպես դրանք կարող են բարելավել կառավարման գործընթացները և ինչպես կնպաստեն կազմակերպությունների ավելի կայուն և պատասխանատու գործունեությանը:

Հիմնաբառեր - Կորպորատիվ սոցիալական պատասխանատվություն (ԿՍՊ), աուդիտ, ISAE 3410, ISAE 3000, կառավարման գործընթացներ, հուսալիություն, կայունության հաշվետվություն, երաշխավորման չափանիշներ, շրջակա միջավայրի վրա ազդեցություն

SUSTAINABILITY ISSUES IN GREEN BUSINESS FRAMEWORK

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Abstract

Entrepreneurship has traditionally been considered a way to create material goods, generate additional profit, and improve people's well-being. Entrepreneurs always pursue private interests when carrying out economic activity, on the one hand, gaining profit in the competitive market and aiming to increase their entrepreneurial capital, on the other hand, by creating material goods or organizing services, contributing to the growing socio-economic needs of people satisfaction. However, by using entrepreneurial services, the population is already making a public demand to preserve the planet Earth, to take care of the surrounding environment, which is often neglected in the course of the business, that appears in the race for profit formation and, unfortunately, does not enter into the enterprise. within the framework of the goals of the owners.

The article presents recommendations for improving green business management, as well as new approaches to assessing sustainable development outcomes.

GEL code: M2

***Keywords*:** Green business, sustainability management, entrepreneurship, green partnership, responsible investments

Introduction

As a result, the business mercilessly "devours" on its way everything, that contributes to the formation of super profits, not sparing people's health, harming nature, recklessly wasting natural resources, and polluting water and air basins with harmful waste. Therefore, in the striving

for super profit, new requirements arise, the purpose of which is the organization of an enterprise, which makes it possible to use socio-economic resources in such a way, that they are transferred to future generations and thus the business becomes continuous as well. in the foreseeable future, having a stable development course.

Today, economic activity is dramatically shifting to the sphere of sustainable business. People are trying to implement management tools, that promote sustainable entrepreneurship. The scope of socially responsible investments is being expanded, and the formats of reports published by organizations are being transformed to inform everyone how successful business activities are in terms of both private interests and public expectations. Both internal and external beneficiaries of the economic activity are already interested in the evaluations of the sustainable development of the organization, and if they are not encouraging, then risks of losing business partners and weakening of competitive positions in the market arise in the organization (Magon, Renata Bianchini 2018).

Fidings

The problems of sustainable development were formed in the 70s of the last century when it became clear to the community of businessmen striving for profit that the relentless exploitation of the subsoil, and the pollution of the surrounding environment would cause catastrophic damage to the planet Earth, which will no longer be possible to intersect, or to re-establish even business. with the resulting super profits. It became obvious, that the activity contributing to the positive growth of people's socio-economic level at the same time contains negative environmental, social, and managerial risks, the mismanagement of which leads to irreversible damages and future instability. And the instability can be formed due to the merciless exploitation of natural resources, their absence, violations of environmental balances, as a result of the instability of the business society (Famiyeh, Samuel 2018).

The concept of sustainable development at the initial stage of its formation was presented as "the exploitation of natural resources at the present moment in such a way as to create an opportunity for future generations to use these resources." In other words, initially, sustainable

development was built based on the principle of intergenerational solidarity, when humanity, satisfying its current demands for natural resources, enables future generations to also satisfy their demands for using natural resources.

In such a case, resource-saving technologies, substitutes, and efficient approaches to natural use are used. From the beginning, the source of inspiration for the implementation of these ideas was the process of using forest wood, when people were well aware that the damages of deforestation should be restored with new tree plantations, which will be a wood resource for the next generations.

In the simplest interpretation, in the case of sustainable development, we strive to transfer the Earth to future generations with the possibilities of natural use, that we once received from our ancestors. Naturally, in this case, stability is mainly related to ensuring a "stable level" of natural resources. Years later, the sustainable development of the business was practically considered by the international community in a broader context, which, in addition to effective land use, also included poverty reduction, access to education, "green energy" use, and climate recovery requirements.

"Sustainable development" in the most comprehensive context was introduced in 1987 at the World Conference on Environment and Development. Such questions became so intense that already twenty years later, in 2002, at the conference in Johannesburg, which was later renamed "Rio 10+", a concept of sustainable development partnership was developed. In the next decade, the "green economy" was also targeted in the concept of sustainable development in the "Rio 20+" summit, when alternative energy resources will be used, greenhouse gas emissions will be reduced, and efficient eco-infrastructure services will operate. Finally, in 2015, the United Nations developed 17 sustainable development goals, which were adopted by 193 countries.

Regulations for sustainable business development ultimately formed the ideology of the "green economy" (Adams, C. A., Larrinaga, C. 2019). And the green economy cannot function efficiently without "green entrepreneurship". Perhaps, until now, there is no universal definition of the term "green economy", but international structures, when presenting

various interpretations in this direction, are guided not only by environmental but also by social, effective management, and reasonable resource use. approaches intending to secure the sustainable development of management (see Table 1.)

Table 1.

Definitions of "green economy" according to international authoritative structures

Organization	Definition
United Nations Environment Program (2011)	The "green economy" leads to improved human well-being and social equity by reducing environmental risks.
United Nations Conference on Trade and Development (2011)	"Green economy" is a component arising from the goals of sustainable development, which leads to the improvement of people's well-being and the reduction of inequalities, without transferring environmental risks and ecological scarcity problems to generations.
International Chamber of Commerce	In the "green economy", economic growth and environmental sustainability mutually cooperate, supporting progress and social development.
EEA (2013)	Environmental, economic and social policies and innovations in the "green economy" make it possible to effectively use resources, improving people's well-being, preserving natural systems.

In this sense, "Green Enterprise" basically focuses on investments, capital, infrastructure, employment level, and social and environmental positive results. It is defined as low-carbon, resource-efficient, and socially inclusive management, aimed at reducing environmental risks, handling limited resources, and sustainable development. It works with the structure of achieving employment and income growth, by attracting investments, through which the reduction of carbon emissions and pollution, the improvement of energy and resource use efficiency, and the preservation of biodiversity are realized (Liu, H., Yao, P., Latif, S., Aslam, S., & Iqbal, N. 2022).

Thus, "green entrepreneurship" cannot be aimed only at increasing profit through "green procedures". It should enable necessary structural changes in the composition of used resources, management methods, level and structure of consumption, export in the context of actions aimed at reducing emissions and losses, as well as climate change prevention.

Green entrepreneurship seeks to create more value year after year by introducing innovations in business while preserving natural systems and mitigating environmental damage with a special toolkit (see Figure 1.). In addition, the green entrepreneurship process can be applied in whole or partly, depending on the scale of the business.

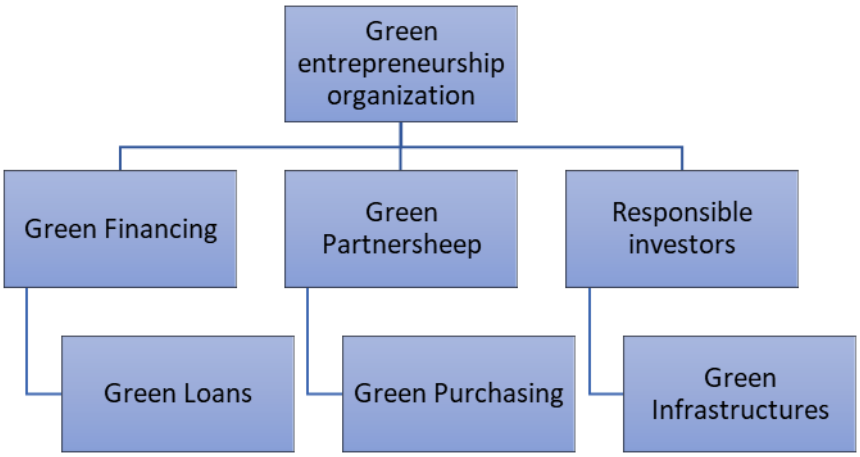

Figure 1. Green entrepreneurship toolkit[28]

Case study

George started his entrepreneurial activity by running a food stall and paying attention to environmental activities as well. In particular, he installed a mini solar panel on the roof of the booth and, along with the traditional one, also used alternative energy for lighting purposes. In addition, he regularly collected the paper cups thrown into the trash from the coffee drink vending machine and sent them for recycling as waste paper. Years later, George expanded his business, becoming a middle-class food store owner. His inclinations of a "green entrepreneur" deepened and

[28] Developed by authors.

he also organized promotions for the sale of juices in plastic bottles, using circular business approaches. When customers returned 20 empty used plastic bottles to the store, they received one bottle of juice in return. When buyers preferred paper bags instead of cheap polyethylene packages, certain discounts were applied for food purchases. As a result, George can get "green loans" from banks for business expansion, presenting the consequences of his environmental activities.

Eventually, George manages to issue "green securities", to form the necessary capital to start a supermarket and the most widely applicable green entrepreneurship tools. In particular, the system of green purchases is put into operation, when additional payments are made to the suppliers when delivering the goods to the supermarket with trucks, powered by electric motors. Customers are offered sales discounts if they present receipts for charging their electronic vehicles in the supermarket parking lot.

Continuing to expand his business, George also carried out "green securitization" by issuing bonds and providing financing for responsible investments, improving the area around the supermarket, and establishing an entertainment center, which was to be 90% green covering and have a social service orientation to vulnerable populations. In this context, along with the expansion of the business, the Georges supermarket entrepreneurship included a whole set of green financing, partnership, and responsible investment implementation tools (see Figure 1.).

Therefore, "Green Entrepreneurship" is a model focused on the harmonious coexistence of people and nature, with the main principles of its operations.

1. Principle of sustainability, based on which policies for environmental, social, and economic development are developed.

2. A principle of justice, that promotes equality in the distribution of natural resources between generations and between generations.

3. Principle of dignity. which respects the rights of employees and actively supports the development of new, "green jobs and careers". It contributes to the self-development of employees.

4. The principle of a healthy planet, by which entrepreneurship preserves the integrity of the environment, the wise use of natural resources is ensured.

5. Principle of inclusiveness, which ensures participatory decision-making in green entrepreneurship for all stakeholders.

6. The principle of effective management and accountability, when not only the sustainable progress of environmental, social, and economic measures is recorded, but also the beneficiaries are presented with a report on the fulfillment of obligations undertaken in the field of "green development".

7. Principle of flexibility, which promotes the harmonious and interconnected activities of different models of green entrepreneurship development, aimed at cultural, social, and environmental issues.

9. Principle of generations, by which investments in the "green economy" are made to ensure the well-being of current and future generations.

Case study

In practice and among theoreticians, green entrepreneurship is traditionally perceived as environmental protection, social justice, and resource efficiency, bypassing the financial aspect of this activity. However, in addition to ensuring sustainable development, green entrepreneurship can also be targeted at increasing the profit of organizations (Li, Dayuan, 2018).

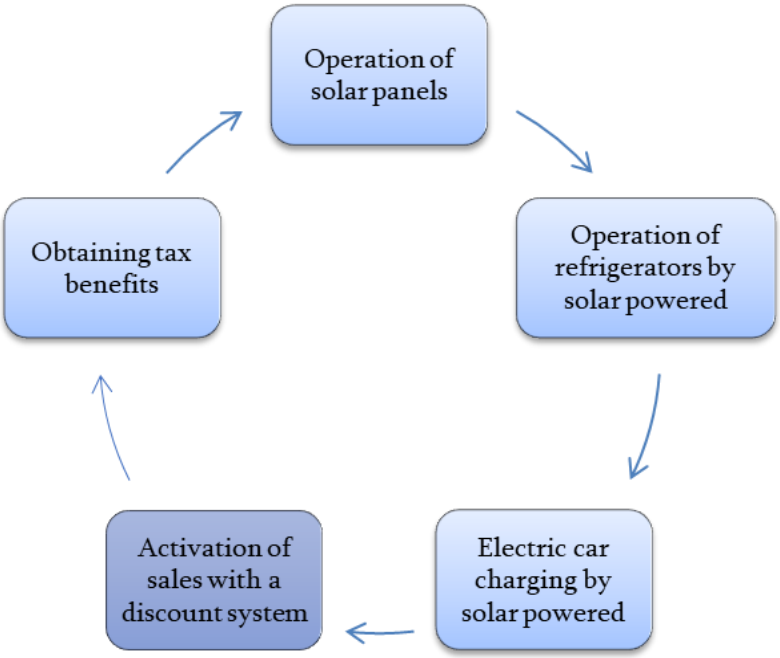

Figure .2 Demonstrations of business value formation around solar energy by a supermarket[29]

In this way, the shareholders of the "Miraculous" supermarket make a decision, in addition to traditional commercial activities, to organize a green enterprise, and not only to ensure a good reputation of the business among the public, but also to get additional profit from green activities. The motivation of this idea is the use of alternative energy, for which solar panels will be installed on the roof of the supermarket, around which a number of consequences of the internal value of the business will be formed (see diagram 1.3.2).

➢ solar energy will be used in the refrigerator of the supermarket, reducing the commercial costs of the business,

➢ With electric charging points installed in the supermarket parking lot, solar energy will be sold to shoppers shopping in the supermarket who have come shopping with their own electric cars.

[29] Developed by authors.

➢ In order to install solar panels, the supermarket will take advantage of green lending privileges.

➢ the supermarket will also benefit from property tax privileges for buildings using solar panels,

➢ the supermarket will also take advantage of the profit tax privileges provided by the state to organizations working with alternative energy.

➢ in order to promote the consumption of alternative energy among buyers, they will be given a certain discount in the case of purchases from the supermarket, if they present a receipt for recharging an electric car in the parking lot of the same area.

The owners of the supermarket claim to pay back the investment costs of the solar panels within a maximum of 4 years. Therefore, a decision will be made regarding the feasibility of installing solar panels on the roof of the supermarket building and the business feasibility of the green initiative, making calculations based on the information provided below.

1. For the installation of solar panels, the supermarket will receive a 5-year green loan for 150 million drams. The annual preferential interest rate of the loan is 9%, and it will be repaid in one go at the end of the 5th year.

2. The annual net profit of the supermarket, 200 million drams, will increase by 5% as a result of reducing the operating costs of refrigerators using solar energy.

3. The revenue from the annual charging services of electric mobiles in the parking lot of the supermarket is planned to be 12 million drams.

4. When shoppers charge their electric vehicles in the supermarket parking lot, they will receive a 7% discount by showing the charging receipt at checkout.

5. In the case of launching the discount system, the supermarket will have an additional sales turnover of 80 million per year, with an 11% sales profit.

6. The property tax of the supermarket building is 0.8% per year for the building's value of 400 million drams, which will decrease to 0.2% in the case of installing electronic panels on the roof.

Calculations of the economic feasibility of green entrepreneurship.

- annual additional benefits from green business;

a/ annual increase in net profit as a result of reducing the operating costs of refrigerators using solar energy = 200*0.05 = 10 million drams

b/ the annual additional profit of the supermarket from sales promotion with discounts = 80*0.11 = 8.8 million drams

c/ annual revenue from electric car charging services in the parking lot = 12 million drams

d/ annual saving of building property tax = 400*(0.08-0.02) == 24 million drams

- annual supplementary expenses from green enterprise.

e/ loan interest = 150*0.09= 13.5 million drams

f/ Purchase discounts provided to owners of electric cars = 80*0.07= 5.6 million drams

- annual net benefit from green business = 10 + 8.8 + 12 + 24 – 13.5 – 5.6 = 35.7

- the years of the investment component of green entrepreneurship.

= 150 : 35.7 = 4.2 years

Since the 4.2 years of the investment term exceeds the 4-year requirement of the investment term presented by the supermarket owners, no decision will be made regarding the installation of solar panels under such conditions. Therefore, the purchase rebate system is being revised to ensure a 4-year investment payback period for green businesses.

Review of Green Entrepreneurship Organazing.

In calculating the payback period of investment costs, by designating the discount rate provided to buyers with the unnkoun Y, let's make an equation with one unknown, as follows:

Investment cost/annual net return on investment = 4 years

150 / (10 + 8.8 + 12 + 24 – 13.5 – 80*y) = 4

from where

Y = 0.04

In a bid to promote green entrepreneurship, the supermarket will offer electric vehicle owners a 4% discount on charging coupons instead of 7% to meet the owners' maximum 4-year payback requirement for the solar panel investment.

Thus, the 200 million annual profit of the supermarket with the structure of the traditional enterprise will increase the green enterprise by 38.1 million drams.

10 + 8.8 + 12 + 24 – 13.5 – 80*0.03 = 38.1

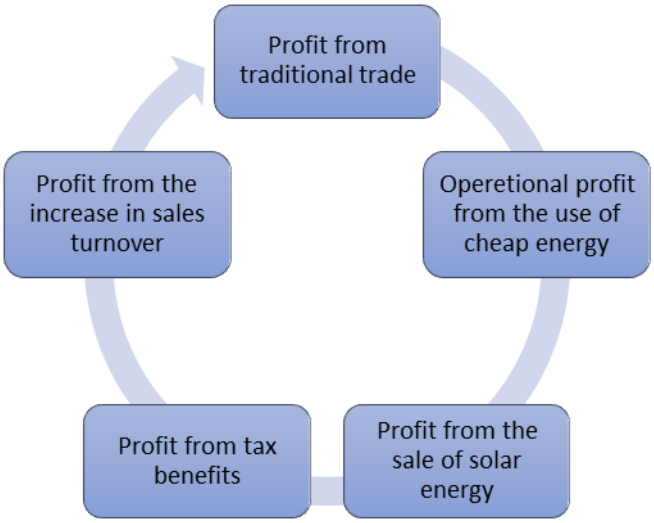

Figure 3 Cycle of additional profit generation from supermarket green entrepreneurship[30]

Conclusion

"Green entrepreneurship" implies long-term business planning, when resources used to create any value do not disturb the simple and natural rules of "coexistence" between man and nature. Therefore, the business organized according to such principles is able, while preserving nature, to be as human-centered as possible, to ensure well-being (higher quality health care and education, safe work, social equality), to promote the process aimed at reducing negative impacts on the environment, as well as curbing ecological risks. "Green entrepreneurship" provides an opportunity to create sustainable livelihoods by creating "green jobs", thereby increasing the availability of sustainable infrastructure and services

Green entrepreneurship has three main characteristics:

[30] Developed by authors.

1. Low level of negative impact of business on the environment. wise use of natural resources, growth with low emissions implies the development and application of such strategies that will contribute to the sustainable economic growth of the enterprise.

2. Resource efficiency, which contributes to increasing the efficiency of resource use, thereby extending their life and reducing the environmental impact associated with their entire life cycle.

3. Social inclusion, when creating opportunities for the vulnerable classes of society to participate in the development processes of the green economy and to have an impact on them.

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ԿԱՅՈՒՆՈՒԹՅԱՆ ԽՆԴԻՐՆԵՐԸ ԿԱՆԱՉ ԳՈՐԾԱՐԱՐՈՒԹՅԱՆ ՇՐՋԱՆԱԿՈՒՄ

Մարկո Սավաստանո
Հռոմի Սապիենսիայի համալսարան
Սոֆի Ճուղուրյան
Հայաստանի Ամերիկյան համալսարան

Ձեռնարկատիրությունն ավանդաբար համարվում է նյութական բարիքներ ստեղծելու, լրացուցիչ շահույթ ստանալու և մարդկանց բարեկեցությունը բարելավելու միջոց: Տնտեսական գործունեություն իրականացնելիս ձեռնարկատերերը միշտ հետապնդում են մասնավոր շահեր,

մի կողմից՝ շահույթ ստանալով մրցակցային շուկայում և նպատակ ունենալով մեծացնել իրենց ձեռնարկատիրական կապիտալը, մյուս կողմից՝ ստեղծելով նյութական բարիքներ, կամ կազմակերպելով ծառայություններ՝ նպաստելով մարդկանց աճող սոցիալ-տնտեսական կարիքների բավարարմանը: Սակայն ձեռնարկատիրական ծառայություններից օգտվելով՝ բնակչությունն արդեն հանրային պահանջ է ներկայացնում՝ պահպանել Երկիր մոլորակը, խնամել շրջակա միջավայրը, որը հաճախ անտեսվում է բիզնեսի ընթացքում, քանի որ այն գտնվում է շահույթի ձևավորման մրցավազքում և հաճախ անտեսվում է ձեռնարկություն: սեփականատերերի նպատակների շրջանակներում:

Հոդվածում ներկայացված են կանաչ բիզնեսի կառավարման բարելավման վերաբերյալ առաջարկություններ, ինչպես նաև կայուն զարգացման արդյունքների գնահատման նոր մոտեցումներ:

Հիմնաբառեր - կանաչ գործարարություն, կայունության կառավարում, ձեռներեցություն, կանաչ գործընկերություն, պատասխանատու ներդրումներ

GREEN ECONOMY IN THE UNITED STATES OF AMERICA AND ARMENIA
(comparative analysis)

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Abstract

A "green economy," according to the United Nations Environment Programme, is an economy that promotes human well-being and social equity while reducing environmental risks and resource depletion. The three main pillars of a green economy are low-carbon development, resource efficiency, and social inclusion. The United States and Armenia, countries of different sizes and economic capabilities, are both taking steps towards sustainable development and a green economy. The country is developing solar energy, electric vehicles, air quality control, and efficient waste management. Armenia, although smaller and resource-limited, is actively involved in the development of solar energy, attracting international support, and stabilizing agriculture. The Armenian Masrik-1 solar power plant is an important step towards energy independence. Both countries have air pollution problems that require strict control and an increase in green spaces to solve them. Effective waste management and the development of recycling systems are vital for both. Overall, both the United States and Armenia are making important progress towards a green economy and sustainable development, but many challenges still lie ahead.

GEL code: O2

Keywords: Green Economy , Sustainable Development, Renewable Energy ,Solar Energy, Air Pollution,Waste Management, Social Inclusion, Climate Change, Environment, Ecological Risks.

Introduction

According to United Nations Environment Programme (UNEP), green economy is "an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP). Green economy plays a major role in the well-being of a country's economic stability. Green economy is based on three pillars: low-carbon development, resource efficiency, and social inclusion (UNEP). Green economy also plays a big role in a country's sustainable development. The United Nation defined sustainable development as "how we must live today if we want a better tomorrow, by meeting present needs without compromising the chances of future generations to meet their needs" (United Nation). Key sectors of the green economy include renewable energy, sustainable agriculture, eco-friendly industry, green transportation, waste reduction, and natural resource conservation. By transitioning to green economic models, countries can promote long-term resilience and reduce dependence on finite natural resources. In the world today many countries have implemented green economy, two of these countries are the United States of America and Armenia. The United States of America and Armenia are two countries with different economic views but both countries have in some way incorporated green economy and sustainable development in their country model. The United States of America, a large, industrialized country with vast resources while Armenia, a smaller, developing nation with significant environmental challenges and opportunities, have committed to sustainable development through renewable energy, green innovation, and environmental governance.

Findings

The United States of America, one of the world's largest economies and contributors to global emissions, has a unique responsibility and opportunity to lead in green economic transformation. Over recent years, federal, state, and local governments have implemented a variety of

initiatives to transition toward cleaner and more sustainable practices. In August 2022, the U.S. Congress approved the Inflation Reduction Act (IRA) of 2022, combining the objectives of reducing domestic inflation ("Inflation Reduction Act of 2022 – Policies"). According to the article, "Inflation Reduction Act of 2022-Policies," the IRA includes a combination of grants, loans, tax provisions and other incentives to accelerate the deployment of clean energy, clean vehicles, clean buildings and clean manufacturing. Around $370 billion will be disbursed for measures dedicated to improving energy security and accelerating clean energy transitions ("Inflation Reduction Act of 2022 – Policies"). The United States of America uses and produces many different types and sources of energy, which are grouped into general categories such as primary, secondary, renewable, or fossil fuels (U.S. Energy Information Administration). Primary energy sources include fossil fuels, nuclear energy, and renewable sources of energy, and secondary energy source is electricity that is produced from primary energy sources (U.S. Energy Information Administration). According to the U.S. Energy Information Administration (EIA), renewable sources accounted for approximately 21% of total electricity generation in 2022, with wind and solar showing the most significant growth. One major way electricity is generation with solar is through solar panels. Solar panels capture the sun's energy and convert it into electricity to use in your home (Energy Saving Trust). As of February 2024 over 4,227,503 million US homes have solar panels attached on their roofs (Agopian). Another major issue in the United States of America is the air quality which is worsen by air pollution. Air pollution is the release of pollutants into the air, pollutants that are detrimental to human health and the planet as a whole (Mackenzie and Turrentine). Emissions of air pollutants continue to play a big role in a number of air quality issues (US EPA). According to the United States Environmental Protection Agency, "In 2023, about 66 million tons of pollution were emitted into the atmosphere in the United States." The Clean Air Act of 1970 has been a crucial tool to reducing air pollution. The Clean Air Act is a comprehensive federal law that gives the U.S. Environmental Protection Agency (EPA) authority to regulate air pollutants and polluting industries (Hu). The Clean Air Act requires the EPA to set national health-based standards for air

pollution. It also requires the government to review, update, and enforce these standards (Hu). The most effective way to control air pollution is to speed up our transition to cleaner fuels and industrial processes by switching over to renewable energy, maximizing fuel efficiency in our vehicles, and replacing our gasoline-powered cars with electric versions. According to the article, "U.S. share of electric and hybrid vehicle sales increased in the second quarter of 2024," by Monica Abboud, on the U.S.

Energy Information Administration website the percentage of hybrid, electric, and plug-in hybrid cars have increased about 19% from 2014. In the United States of America another factor that is critical to a green economy transition is having control over waste management. Sustainable waste management includes reducing the amount of materials used in a product, reusing products whenever possible, and recycling products if they cannot be reused. When natural resources are continually extracted to produce goods that are used in the United States of America before they are thrown into landfills, incinerators or the natural environment, results in the waste of precious resources and pollution that threatens our health, environment and the global climate. Over 28% of all U.S. garbage is packaging, amounting to 82 million tons of material that is typically thrown out after a product is purchased or used (Environment America). Almost all of America's trash can be reused and recycled. According to an article on Environment America's website these are some of the steps that can be promoted through a variety of policies and programs at the local, state and national levels to better manage waste: set a goal to achieve zero waste, make recycling and composting mandatory, require that goods be built to last and easy to repair, reuse, recycle or compost, ban the sale of single-use items that are not easily recyclable or compostable, including packaging, plastic bags and food service ware, invest in repair, reuse, recycling and composting facilities to support a circular economy, require producers to use recycled and reused materials in new products, and encourage businesses and governments to set procurement standards for recycled materials. As of today in the United States there are different trash bins for different items and if more people separated their trash, we would have less items go to waste.

Armenia although smaller in scale and resources then the United States of America has shown a strong commitment to green economy principles, especially in renewable energy, climate adaptation, and sustainable agriculture. Armenia is aligning its economic development with global sustainability standards with international assistance and government policy shifts. One of the international assistances is from the World Bank's Board of Executive Directors. They approved a Development Policy Operation (DPO) in the amount of $116 million equivalent for Armenia to enable reforms aimed at promoting green, resilient and inclusive development (World Bank Group). DPO will help the Government of Armenia to build climate resilience and reduce vulnerabilities to future shocks. Another big international assistance is the Green Agenda project provided by the Stockholm Environment Institute and Sida, the Swedish International Development Cooperation Agency ("The Green Agenda Project: Armenia's Roadmap towards Sustainability"). According to the article, "The Green Agenda project: Armenia's roadmap towards sustainability," the Green Agenda is a decisive roadmap designed to cultivate a healthier environment for our citizens, administer our natural resources more effectively, and ultimately, lead us towards a more ecologically-friendly Armenia.

Armenia's energy system plays a vital role in its green economy development, offering both opportunities and challenges. The country's energy mix is heavily dependent on imported fossil fuels, with natural gas accounting for nearly 60% of primary energy consumption, most of which is imported from Russia and Iran (International Energy Agency). In contrast, electricity production is more diversified: nuclear power generates approximately 40% of electricity, while hydropower contributes around 25–30% ("Nuclear Power in Armenia - World Nuclear Association"). Natural gas is the main source of energy in Armenia ("ARMENIA ENERGY FACTSHEET 2022"). Solar energy is currently a small part of the grid but is rapidly expanding due to Armenia's favorable geographic conditions, boasting over 300 sunny days per year. On May 11, 2018 Armenia launched Masrik-1 the first large-scale solar power plant in the history of the country ("Time to Shine: Introducing Armenia's Solar Industry"). According to the World Bank, the Masrik-1 plant will improve long-term

energy security by promoting the development of solar resources and reducing the country's dependence on imported natural gas. Today we see more houses with solar panels on their roofs and hopefully as time goes on the numbers will increase. This will be the most efficient way to preserve energy in Armenia. One of the major issues we currently have in Armenia is air pollution. In Yerevan, atmospheric air pollution with dust and nitrogen dioxide often exceeds the permissible limit concentration (Ecolur). Another region of Armenia that is polluted is Ararat. The town of Ararat is home to 2 major industrial firms: the Ararat Cement factory founded in 1927, and the "Geopromining Gold" recovery plant operating since 1970. There is a major controversy over the pollution and the toxic waste. The Ararat Gold Recovery extraction process involves first pulverizing the raw material, and then filtering out the gold using a cyanide nitrate chemical process. The soupy byproduct of the cyanide nitrate chemical process is both toxic and radioactive and collects in a tailing dam. Industrial activities contribute to air and soil pollution. According to a research done by the experts of the Czech "Arnika" NGO, together with the Armenian "Center for Community Mobilization and Support" and "EcoLur" NGOs found lots of pollutions and Inga Zarafyan, President of "EcoLur" Informational NGO, said: "We have a lot of pollution in the areas where the mining industry is developed. We collect data so that we can demand decisions and laws that protect people from irresponsible businesses. The polluting organization must provide compensation for its pollution, but this principle does not apply to us." According to Yerevan Municipality, green areas in Yerevan have increased by 35 hectares during 2022-2023 (Ecolur). As stated in the article, "Sources of Atmospheric Air Pollution in Yerevan," in 2024, the tree replacement program was launched in Yerevan, perennial trees in the center of Yerevan were cut down and replaced by new ones, which, being small and lacking foliage, cannot perform a full dust-absorbing function. Armenia is also rich with forests located in Dilijan which help with reducing overall air pollution.

Conclusion

Armenia needs to improve on the ways of reducing greenhouse gas emissions. Waste management is also a big issue in Armenia. Material is not used probably and trash is not sorted accordingly. In Yerevan,

Nubarashen solid domestic waste landfill site is not originally designed and built according to any accepted standards, does not meet international or any technical, environmental and sanitary standards and is solely a place for garbage accumulation (Ecolur). Innovative Solutions for Sustainable Development of Communities (ISSD) is a non-profit, non-governmental organization whose main goal is to promote sustainable development through innovative projects in waste management, agriculture, education, circular economy, business, and women empowerment ("Recycle It! – Innovative Solutions for Sustainable Development of Communities"). Since November 2017, ISSD has been implementing a widespread initiative across Armenia, installing sorting bins for recyclable waste in both organizational settings (marked with green icons on the map) and public areas (identified by blue icons on the map). These bins are designated for plastic, paper, glass, and metal, making it easier for communities to participate in environmentally friendly practices ("Recycle It! – Innovative Solutions for Sustainable Development of Communities"). In conclusion, United States of America and Armenia have been taking steps toward sustainable development and a better green economy. In my opinion, Armenia should increase its' green areas with big tall trees that can absorb the dust and pay attention more to waste management. Armenia should carry out macroeconomic assessments and identify key sectors where opportunities exist. Armenia has opportunities for green growth, particularly in energy savings, renewable energy, agriculture, and manufacturing.

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ԿԱՆԱՉ ՏՆՏԵՍՈՒԹՅՈՒՆԸ ԱՄԵՐԻԿԱՅԻ ՄԻԱՑՅԱԼ ՆԱՀԱՆԳՆԵՐՈՒՄ ԵՎ Հ ԱՅԱՍՏԱՆՈՒՄ

(համեմատական վերլուծություն)

Նինո Աբեսաձե
Թբիլիսիի պետական համալսարան
Արմինե Սարդարյան
Արարատի պետական բժշկական քոլեջ
Մարուսյա Մեջլումյան
Արարատի պետական բժշկական քոլեջ

ԱՄՆ-ը և Հայաստանը, որպես տարբեր չափերի և տնտեսական հնարավորությունների երկրներ, քայլեր են ձեռնարկում կայուն զարգացման և կանաչ տնտեսության ուղղությամբ, զարգացնում են արևային էներգիայի արտադրությունը, էլեկտրական մեքենաների կիրառումը, օդի որակի վերահսկումը և թափոնների արդյունավետ կառավարումը: Հայաստանը, թեև ավելի փոքր և ռեսուրսներով սահմանափակ, այնուամենայնիվ ակտիվորեն ներգրավված է արևային էներգիայի զարգացման, միջազգային աջակցություն ներգրավելու և գյուղատնտեսության կայունացման գործում: Հայկական Մասրիկ-1 արևային էլեկտրակայանը կարևոր քայլ է էներգետիկ անկախության ճանապարհին: Երկու երկրներն էլ ունեն օդի աղտոտվածության խնդիրներ, որոնք պահանջում են խիստ վերահսկողություն և կանաչ տարածքների ավելացում՝ դրանք լուծելու համար: Թափոնների արդյունավետ կառավարումը և վերամշակման համակարգերի զարգացումը կենսական նշանակություն ունեն երկուսի համար:

Հոդվածում ներկայացվում են վերլուծություններ, նշելով, որ ընդհանուր առմամբ, և՛ Միացյալ Նահանգները, և՛ Հայաստանը կարևոր առաջընթաց են գրանցում դեպի կանաչ տնտեսություն և կայուն զարգացում,՝սակայն ունենալով բազում մարտահրավերներ:

Հիմնաբառեր - կայուն զարգացում, վերականգնվող էներգիա, արևային էներգիա, օդի աղտոտվածություն, թափոնների կառավարում, սոցիալական ներառում, կլիմայի փոփոխություն, շրջակա միջավայր, էկոլոգիական ռիսկեր:

FROM INTELLIGENCE TO IMPACT: REINFORCEMENT LEARNING AGENTS FOR SPATIAL ADAPTATION WITH 3D VISION-LANGUAGE MODELS IN SUSTAINABLE HOME ENVIRONMENTS

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Abstract

This paper proposes using reinforcement learning (RL) agents enhanced with 3D vision-language models (VLMs) to enable sustainable smart homes. These agents perceive the 3D layout and objects of a household environment and learn to autonomously adjust systems (e.g., HVAC, lighting, appliances) to optimize energy use and resource management. We identify specific energy-saving tasks (such as occupancy-driven thermostat control, efficient lighting and blind management) and resource-management tasks (like waste sorting assistance and water-use feedback) that such agents can perform. We review recent advances in RL and vision-language models, and outline a conceptual framework for embodied home agents. Through this synthesis, we demonstrate how RL-powered agents can significantly reduce domestic energy consumption and waste, thereby supporting eco-friendly lifestyles. We also discuss the potential environmental and economic benefits of these systems, as well as technical and social challenges to their adoption. The contribution of this work is in articulating "spatial adaptation" for sustainability: an RL-driven approach that transforms smart homes into proactive, learning environments for green living.

GEL code: O3

Keywords: reinforcement learning, spatial adaptation, 3D vision-language models, smart homes, sustainability, Green AI, intelligent agents

Introduction

Residential buildings are major energy consumers and emitters of greenhouse gases (IEA, 2024). For example, operations of buildings account for roughly one-third of global energy use (Markowitz & Drenkow, 2024), a large fraction of which is due to heating, ventilation, and air conditioning (HVAC) systems. In typical homes, HVAC and lighting systems often run inefficiently because current controllers lack real-time adaptation to occupancy and environmental changes. At the same time, household waste is growing rapidly worldwide. One report finds that global per-capita waste averages about 0.74 kg per day and can exceed 1.5 kg in high-income countries (Zhang et al., 2021). These trends — rising energy use and waste — pose a severe environmental burden. They highlight the urgent need for smarter automation that not only provides convenience but also actively reduces resource use and emissions.

Existing smart home systems tend to follow fixed schedules or simple rules (e.g., "turn off lights after 10 PM"), reacting only to explicit commands (Markowitz & Drenkow, 2024). This reactive approach misses opportunities for savings; for instance, a rule-based thermostat cannot anticipate when a room will become occupied or respond optimally to real-time price signals. In contrast, an intelligent agent with learning capabilities could continuously adapt to the household context. The goal of this research is to explore how such RL-driven agents, empowered by rich 3D visual and language understanding, can realize sustainable spatial adaptation in homes. Specifically, we ask:

1. **How can RL agents with 3D VLM capabilities adapt spatially to optimize sustainability in home environments?**
2. **What specific environmental and economic benefits can these systems bring to smart domestic ecosystems?**
3. **What technological, social, and infrastructural challenges must be overcome for widespread adoption?**

To address these questions, we undertake a qualitative, interdisciplinary study. We review state-of-the-art literature on reinforcement learning, vision-language models, and smart home technologies, with an emphasis on sustainability. We analyze case studies

and simulated platforms (e.g., AI2-THOR, Habitat, iGibson) where embodied agents perform household tasks. We compare intelligent RL-based strategies with conventional rule-based automation in terms of energy and waste reduction. Finally, we synthesize our findings into a conceptual framework and outline future research directions. In doing so, we identify promising tasks and system designs for "Green AI" in the home, and discuss how intelligent agents can become practical contributors to eco-friendly living.

Methodology

Our approach is qualitative and exploratory. We conducted a comprehensive literature survey of academic articles, technical reports, and industry white papers on topics including reinforcement learning algorithms, 3D vision-language models, and sustainable smart home systems. Special attention was given to recent work on AI for energy efficiency and resource management. In parallel, we examined existing embodied AI platforms and case studies. For example, we reviewed projects using AI2-THOR and Habitat simulators to train agents on navigation and object-interaction tasks in virtual homes. We also analyzed case studies where RL was applied to building control or home automation. Whenever possible, we compared these intelligent approaches to traditional rule-based systems, focusing on metrics such as energy usage, task success, and adaptability. Finally, we developed a conceptual framework for sustainable smart homes. This framework includes design considerations for RL agent architectures (see Figure 1) and outlines deployment strategies (e.g., training on simulators before real-world transfer) to maximize ecological impact. By triangulating these sources — literature, simulation case studies, and comparative analysis — we ensured a robust understanding of how RL and 3D VLMs can be leveraged for sustainability in home environments.

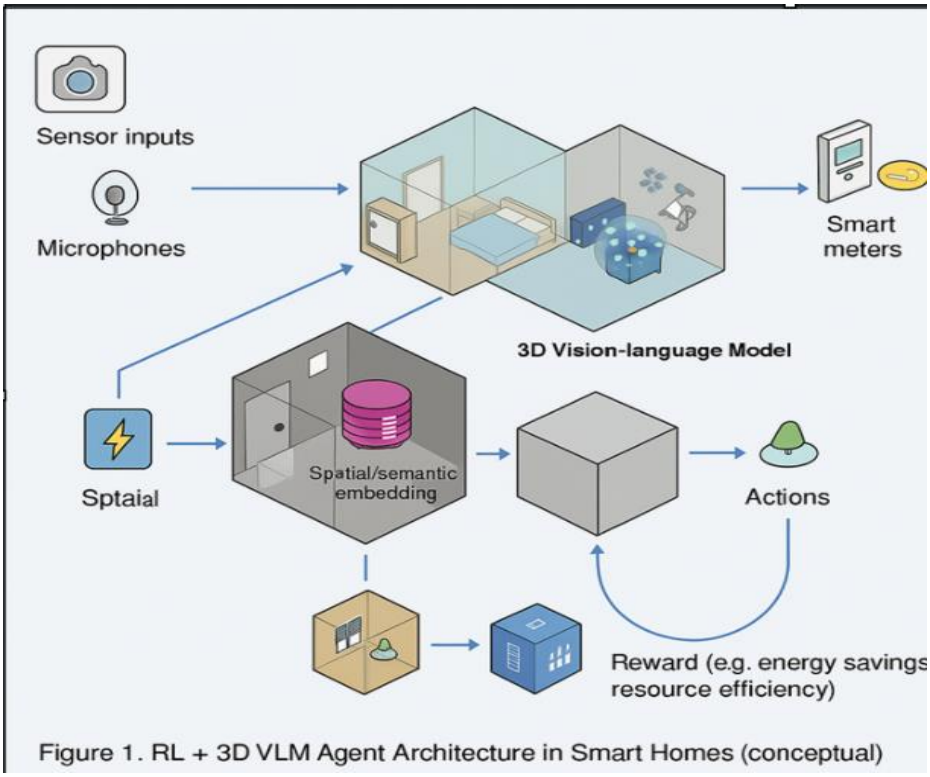


Figure 1. RL + 3D VLM Agent Architecture in Smart Homes (conceptual). The agent takes multimodal sensor inputs (e.g., RGB-D camera, microphones, smart meters), processes them through a 3D vision-language model to understand the environment, and feeds a spatial embedding into an RL policy network. The policy outputs actions (e.g., adjust thermostat, operate blinds, sort items), which are executed via home automation actuators. A feedback loop provides rewards based on energy savings or resource efficiency, enabling the agent to learn and improve its behavior over time.

Figure 2: Comparison of Rule-Based vs. RL + 3D VLM Smart Home Systems

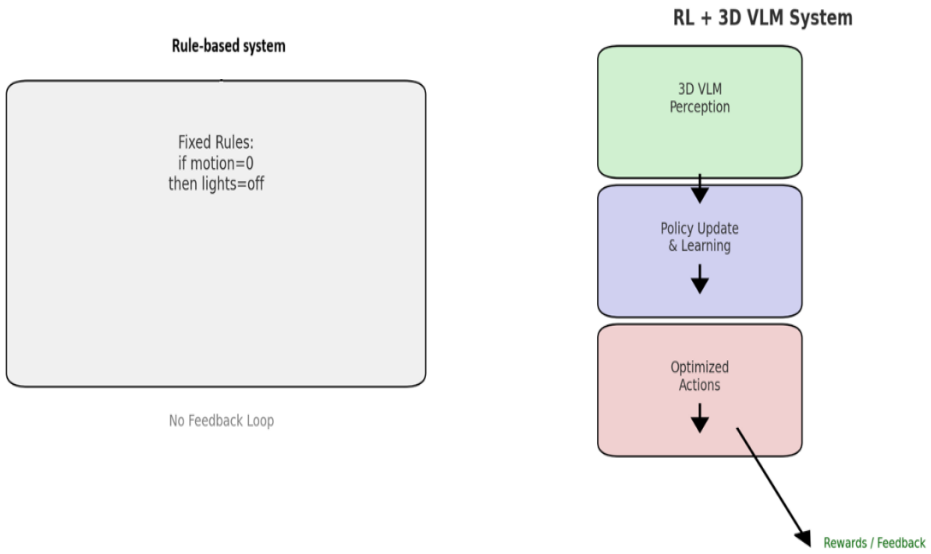


Figure 2 (conceptual) contrasts traditional rule-based home control with our RL-based approach. The rule-based system (left) follows fixed input-output mappings (e.g., "if motion=0 then lights=off"), lacking adaptability. The RL-based system (right) continuously learns from feedback: it perceives the environment with a 3D VLM, updates its policy via rewards, and gradually optimizes its actions. This learning loop and spatial language grounding enable it to handle novel situations that rule-based systems cannot.

Literature Review

Reinforcement Learning and Energy Management

Reinforcement learning (RL) is a paradigm where agents learn optimal policies through trial-and-error interactions with an environment. Classic successes include game-playing systems and robotic manipulation, demonstrating that RL can handle complex decision-making with sparse rewards. In residential applications, RL has shown promise for personalized energy management. Agents can learn when and how to operate HVAC,

lighting, and other systems to balance comfort and efficiency. For example, deep Q-learning and policy-gradient methods have been applied to building climate control: agents forecast occupancy patterns and external weather to adjust heating/cooling proactively, resulting in measurable energy savings without reducing comfort. One study demonstrated that an RL-based HVAC controller maintained temperature constraints while significantly reducing energy use compared to a standard controller (Schwartz et al., 2019). Hierarchical RL approaches, which decompose tasks into sub-goals, further improve learning speed and generalization across different home layouts. In summary, RL's core strength — learning from experience — is well-suited to dynamic home environments, enabling continuous adaptation to user behavior and external conditions.

3D Vision-Language Models and Spatial Perception

Recent advances in computer vision and language have led to 3D vision-language models (VLMs) that deeply integrate visual and linguistic information. These models process multimodal data — such as RGB images, depth maps, and semantic segmentations — along with natural language to produce rich scene embeddings. This allows an agent to not only *see* objects and geometry in 3D space but also *understand* references to them in language. For instance, models like CLIP, Flamingo, and BLIP-2 have demonstrated strong zero-shot recognition and instruction-following capabilities for household objects and commands. With a 3D VLM, an agent can interpret a command like "turn off the lamp in the living room" by recognizing the lamp object and its 3D position. In our context, 3D VLMs provide the RL agent with a semantically informed map of the home: they identify appliances, windows, humans, and even categories like recyclable waste. This enriched perception is crucial for sustainable tasks; e.g., the agent needs to *know* which items are on and who is present in which room. Several works have leveraged such perception modules for embodied AI. In simulated homes (e.g., Habitat, Gibson), VLMs have been used to ground language navigation and object manipulation, enabling generalization to unseen objects and layouts. We build on this trend by using VLMs to enhance the agent's spatial reasoning about energy and resource contexts.

Embodied AI Platforms and Language Grounding

The development of RL-driven home agents has been accelerated by realistic simulators. Platforms like Habitat (Savva et al., CVPR 2019)and AI2-THOR provide photorealistic 3D environments of houses and apartments, complete with interactive objects (lights, appliances, trash bins). In these virtual worlds, agents are trained to navigate, manipulate, and fulfill instructions. Benchmarks such as the Home Assistant Benchmark Suite (HABS) focus explicitly on household tasks (cleaning, fetching items, operating devices) using RGB-D input and language commands. Advances in language grounding have produced architectures where instructions (e.g., "find the recycling bin") are embedded and combined with visual perception to produce actions. For example, PIGLeT (Zellers et al., EMNLP 2021) and ELLA (Majumdar et al., NeurIPS 2022) demonstrate neural-symbolic models that translate language into sequences of robot-like actions in a 3D world. Open-vocabulary mobile manipulation research (Yu et al., 2023) shows agents can generalize to novel objects by leveraging pretrained models. Scene graph prediction (Khandelwal et al., ICCV 2023) and object-centric representations help agents build detailed semantic maps of the home. These developments mean that an RL agent can flexibly interpret high-level commands (e.g., "clean up recyclables") and recognize relevant objects without retraining. We leverage this body of work by assuming our home agent uses similar perception and grounding techniques.

Green AI and Edge Deployment

Concurrently, there is growing awareness of the environmental impact of AI itself. The concept of **Green AI** emphasizes designing AI systems that are energy-efficient and carbon-aware. Scholars like Schwartz *et al.* (2019) and Zhang *et al.* (2021) argue for minimizing the carbon footprint of training and inference, through techniques such as algorithmic efficiency, model compression, and renewable-powered computing. In our context, deploying RL agents in homes naturally leans toward Green AI: the agents run continuously to save energy, so their own energy use should be minimal. Thus, we envision using on-device (edge) inference on low-

power hardware rather than cloud servers. Edge deployment also improves privacy, since data (e.g., camera feeds) need not leave the home. In summary, our framework is aligned with sustainable AI principles: it uses AI to reduce energy/waste *and* follows best practices to reduce the AI's own energy cost.

Spatial Adaptation for Sustainable Home Environments

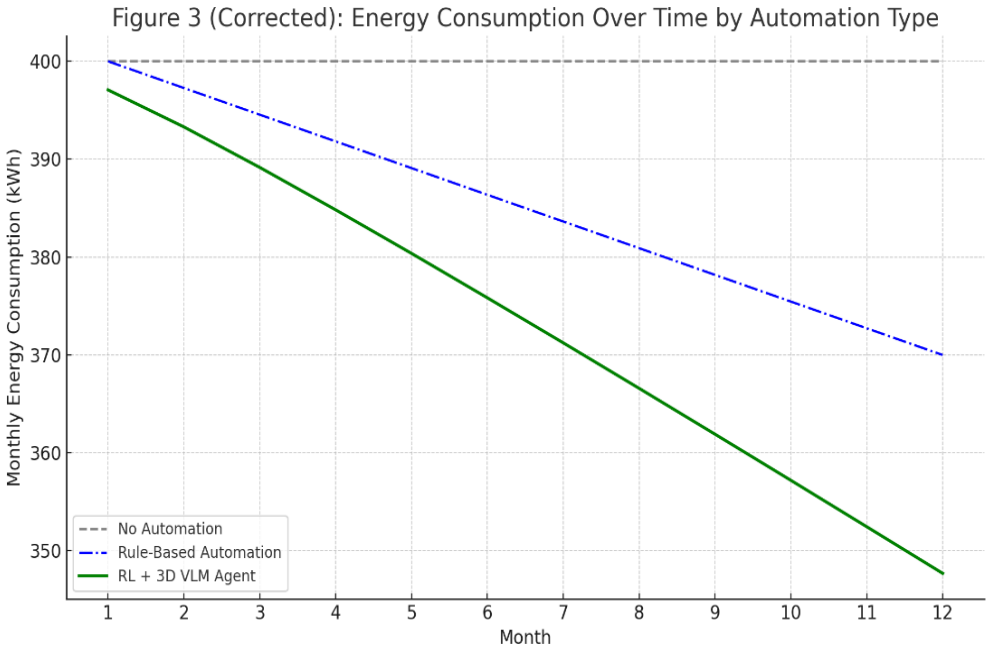
Spatial adaptation here means the RL agent's ability to autonomously adjust home systems and resource use based on a rich understanding of the 3D space. Our approach targets two key domains: energy-saving control and household resource management. Figure 1 depicts the overall system architecture (sensor → 3D VLM → RL policy → actuation → feedback loop). The agent continuously perceives the home (rooms, appliances, windows, people) and uses a learned policy to execute sustainability-oriented actions. Below we outline concrete tasks that illustrate spatial adaptation.

- **Thermostat Optimization:** The agent learns to adjust heating or cooling settings based on real-time occupancy (detected via the 3D camera) and forecasts. For example, if no one is in the bedroom, it lowers the thermostat setpoint; when occupants approach home from work, it pre-emptively raises it. The policy considers weather predictions and time-of-use energy prices to schedule heating cycles just in time. Over weeks of learning, the agent anticipates patterns (e.g., evening occupancy) and proactively optimizes settings to minimize HVAC energy while keeping occupants comfortable.
- **Appliance Management:** By monitoring room usage, the agent identifies idle devices and powers them down. For instance, it might turn off lights or plug strips for electronics in unoccupied rooms. It can learn routines (e.g., coffee maker schedule) and ensure devices do not waste power. When the 3D VLM detects a person leaving a room, the agent can autonomously cut power to that room's non-essential outlets, reducing phantom loads.
- **Window Blind Control:** Leveraging ambient light and weather data, the agent controls blinds or curtains to regulate solar heat gain. On sunny winter days, it opens blinds to let sunlight warm the room; on hot summer afternoons, it closes them to reduce cooling load. By doing

so, it maximizes use of natural light and heat, lowering the need for electric lighting and HVAC.

- **Water Conservation:** The agent can monitor and provide feedback on water usage patterns (e.g., shower length, faucet flow). Using connected flow sensors, it could suggest shorter showers or recommend efficient washing machine cycles. If the home has indoor plants or irrigation, the agent might optimize watering schedules based on recent rainfall data. In this way, the agent extends its environmental intelligence beyond electricity to water savings.
- **Waste Sorting Assistance:** With its 3D vision capability, the agent can learn to recognize recyclable and compostable items. It can guide users via voice or notifications on where to throw each type of waste. In the future, it could even manipulate objects (using a robot arm) to sort trash. By educating or physically assisting with recycling, the agent reduces landfill waste. For instance, it might detect a plastic bottle in the living room and prompt the user to place it in the recycling bin.
- **Sustainable Consumption Patterns:** By analyzing usage data (e.g., daily electricity consumption logs) and user behavior, the agent can suggest greener habits. It might notice that certain devices are used during peak-priced hours and recommend shifting their use to off-peak times. It could also identify older, energy-inefficient appliances in inventory and alert the homeowner to consider replacements. Over time, these recommendations help residents adopt more sustainable lifestyles.

Figure 3 conceptually illustrates the potential impact of these adaptations. In a hypothetical study, one would compare monthly energy consumption in three homes: (a) with no automation, (b) with simple rule-based automation, and (c) with our RL+VLM agent. *Figure 3 depicts the RL-equipped home's consumption dropping steadily as the agent learns, surpassing the incremental gains of the rule-based home.* This exemplifies how continual learning yields compounding savings.



Beyond immediate efficiency, the agent serves as an *eco-assistant* for the household. It not only automates actions but also educates and nudges occupants toward sustainability. For example, if the agent consistently restores the thermostat to an eco-friendly setpoint, residents may learn to value conservative heating. If it praises users for each correct recycling action (through a companion app), it reinforces positive habits. Over months, such feedback loops can instill eco-conscious behavior. In this way, intelligent spatial adaptation helps reduce each household's environmental footprint and contributes to broader climate goals.

Finally, our framework embraces **Green AI** principles. We aim to minimize the agent's own computational footprint. Techniques like model compression and knowledge distillation will be used to shrink the policy network without loss of performance. The 3D VLM and policy can be optimized for efficient edge inference (e.g., running on a Raspberry Pi or home AI hub). We also consider the energy cost of training: where possible, agents are pre-trained in simulation and only fine-tuned (with online learning) in the real home. These measures ensure that the sustainability gains of the agent are not offset by excessive energy use in training or operation.

Findings

While promising, the RL+VLM approach faces several challenges and opens many avenues for future work:

- **Complexity of Home Environments:** Homes are varied and cluttered. Agents must cope with diverse floor plans, objects, and user behaviors. Ensuring reliable perception (e.g., correctly identifying objects under occlusion) is non-trivial. Future work should explore robust vision models and transfer learning so agents can adapt to new homes with minimal retraining.
- **Safe and Reliable Interaction:** Any agent that controls physical devices must be fail-safe. Misadjusting a thermostat or operating a device unsafely could harm occupants or property. We must incorporate safety constraints into the RL framework (e.g., hard bounds on actions). Rigorous simulation and staged deployment are needed before real-world trials. Privacy and security are also critical: continuous camera monitoring raises concerns, so architectures must safeguard data (e.g., by on-device processing and secure firmware).
- **Ethical and User-Centric Design:** Automating home functions has social implications. Users may feel a loss of control if an AI overrides their preferences. It is essential to design the system for transparency and user override. For instance, the agent should explain its actions ("I turned off the AC because no one is home"). Incorporating user feedback into the learning loop can ensure the agent respects habits and comfort thresholds. Studies on human-AI interaction will be important to make these systems acceptable.
- **Computational Resources:** Training advanced RL agents with 3D vision models can be computationally intensive. Research must focus on lightweight algorithms and hardware acceleration. Approaches like federated learning, where multiple homes share anonymized models, could reduce individual training costs. Additionally, new benchmarks are needed to evaluate energy use of these AI systems themselves (i.e., measure the carbon footprint of training and inference).

Looking forward, several research avenues are promising:

- **Personalization:** Agents should adapt to individual user preferences. Future work could integrate methods from preference learning so that, for example, the agent learns how warm or cool a user likes their bedroom to be. Personalization will improve user comfort and acceptance.
- **Expanded Sustainability Tasks:** Beyond the examples above, agents could tackle broader goals. This includes managing home-grown food (e.g., minimizing kitchen waste), optimizing charging of electric vehicles during off-peak hours, or coordinating with smart grid signals. Investigating such extensions will amplify environmental impact.
- **Multi-Agent Coordination:** A single home may contain multiple agents (e.g., separate agents for heating, lighting, and appliances) or interact with external systems (energy grid, solar panels). Research into multi-agent RL could enable whole-home optimization. For example, agents could negotiate to shift loads between them or coordinate with neighbors' systems to balance local renewable generation.
- **Long-Term Field Studies:** Finally, it will be crucial to deploy prototypes in real households and measure outcomes over months or years. Questions to study include: How much do actual energy bills drop? Do occupants change their behavior? Are there rebound effects (e.g., saving on heating but using more appliances)? Longitudinal field trials will validate the theoretical benefits.

In summary, RL-powered spatial adaptation presents a transformative vision for smart homes, but realizing it requires interdisciplinary advances in AI, human-computer interaction, and sustainability science.

Conclusion

Reinforcement learning agents integrated with 3D vision-language perception offer a powerful new paradigm for smart home automation. Unlike static rule-based controllers, these agents can *learn* from experience how to adjust household systems proactively to save energy and resources. By continuously interpreting occupancy, weather, and user routines, an RL+VLM agent can optimize thermostat settings, lighting, device usage, waste sorting, and more. The net effect is a smarter, greener home: energy consumption declines, waste is diverted from landfills, and residents

receive gentle nudges toward eco-friendly habits. This approach embodies the principles of **Green AI** by using artificial intelligence to reduce ecological impact without imposing excessive computational costs.

The potential benefits are significant. One analysis suggests that if an autonomous agent reduces HVAC energy use by even 10–20%, the resulting savings could translate to billions of kWh and millions of tons of CO_2 worldwide. Moreover, the same technology can improve comfort and convenience, accelerating user adoption. However, deploying these systems safely and ethically remains a challenge. Issues of privacy, trust, and equitable access must be addressed.

Our paper has laid out the *concept* of spatial adaptation for sustainability: a conceptual framework describing how RL and 3D VLMs can transform home living. We have identified key tasks, highlighted enabling technologies, and discussed important challenges and research directions. The next step is to build working prototypes and field-test them. With continued advances in embodied AI and a focus on efficiency, RL-powered smart homes could become a cornerstone of a larger green transition. In the future, every household might host an intelligent agent acting as an *eco-assistant*, quietly optimizing our living spaces for the planet's health.

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ԲԱՆԱԿԱՆՈՒԹՅՈՒՆԻՑ ՄԻՆՉԵՎ ԱԶԴԵՑՈՒԹՅՈՒՆ. ՏՆԱՅԻՆ ԿԱՅՈՒՆ ՄԻՋԱՎԱՅՐԵՐՈՒՄ 3D VISION-LANGUAGE ՄՈԴԵԼՆԵՐՈՎ ՏԱՐԱԾԱԿԱՆ ՀԱՐՄԱՐՎՈՂԱԿԱՆՈՒԹՅՈՒՆԸ ՀԶՈՐԱՑՆՈՂ ՈՒՍՈՒՄՆԱԿԱՆ ԳՈՐԾԱԿԱԼՆԵՐ

Վանգ ԳԱՈՆԳ

Չժեցզյան համալսարան, Չինաստան

Արեն ՄԽԻԹԱՐՅԱՆ

Չժեցզյան համալսարան

Հոդվածում առաջարկում է օգտագործել զորակցող ուսուցման (RL) գործակալներ, որոնք ուժեղացված են 3D տեսողության լեզվի մոդելներով (VLM)՝ կայուն խելացի տներում օգտագործման հնարավորություն համար: Այս գործակալները ընկալում են կենցաղային միջավայրի 3D դասավորությունը և առարկաները և սովորում են ինքնուրույն կարգավորել համակարգերը (օրինակ՝ HVAC, լուսավորություն, տեխնիկա) էներգիայի օգտագործումը և ռեսուրսների կառավարումը օպտիմալացնելու համար: Սահմանվել են էներգախնայողության հատուկ առաջադրանքներ (օրինակ՝ զբաղվածության վրա հիմնված թերմոստատի կառավարում, արդյունավետ լուսավորություն, կույր կառավարում) և ռեսուրսների կառավարման առաջադրանքներ (օրինակ՝ թափոնների տեսակավորմանը նպաստում, ջրի օգտագործման գծով հետադարձ կապի ապահովում), որոնք կարող են կատարել այդպիսի գործակալները: Մեկնաբանվել են RL-ի և տեսողության լեզվի մոդելների վերջին ձեռքբերումները՝ուրվագծելով տնային գործակալների հայեցակարգային շրջանակը: Ներկայացվել է, թե ինչպես RL-ով աշխատող գործակալները կարող են զգալիորեն նվազեցնել կենցաղային էներգիայի սպառումը և թափոնները՝ դրանով իսկ աջակցելով էկոլոգիապես մաքուր ապրելակերպին: Կատարվել են առաջարկություններ «տարածական հարմարվողականության» համատեքստում կայուն զարգացման գծով, նպատակ ունենալով խելացի տները վերածելու է կանաչ ապրելու միջավայրի:

Հիմնաբառեր - ամրապնդող ուսուցում, տարածական հարմարվողականություն, 3D տեսլականի մոդելներ, խելացի տներ, կայունություն, կանաչ AI, խելացի գործակալներ

FEATURES OF GREEN EDUCATION MANAGEMENT

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Abstract

The implementation of the green education requirement is currently facing challenges. On the one hand, it seems that sufficient green education is being implemented in schools and universities and there are no concerns in this direction, but on the other hand, green education is not systematic in nature and is not subject to systematic management, which, by the way, is a UNESCO requirement. The article comments on the features of green education management and, based on this, makes recommendations for the implementation of effective management decisions in this direction.

Keywords: green education, transdisciplinary education, long life learning, management of green activity, green behavioral settings, green education regulation framework.

GEL code: Q5

Introduction

Issues of educational management have been repeatedly discussed in professional literature, both from the perspective of quality assurance and the effectiveness of financing educational services. However, these studies have mainly targeted individual levels of education (elementary, general education, secondary and higher vocational). When the international requirement for mandatory implementation of green education was set at all levels of education, the management of environmental education faced challenges. Currently, there is a need to implement systematic management

functions so that the final results of green education are not only not repeated at different levels of education, but also continuously complement each other (Busch, K. C., Ardoin, N., Gruehn, D., and Stevenson, K., 2019). In addition, currently, it is important to ensure the inclusiveness of green education so that internal and external stakeholders of education ensure their active participation in the implementation of environmental education programs. Therefore, taking all this into account, an international standard was defined for green education, which set its requirements for the management functions serving environmental services. Currently, the organization and management of green education throughout life, which is carried out in both formal and non-formal and informal educational environments, is considered key (Grewal, R.K., Field, E. and Berger, P., 2022). Therefore, managing green education requires new methodological approaches throughout the individual's life.

Findings

There are many definitions of management, which stem from the goals of business activity, ensuring the stability of socio-economic progress, or behavioral regulations of groups of people. But now our goal is not to search for a “golden definition” of management, but simply to understand why it is necessary to manage. Indeed, if we observe the behavior of animals, we note that especially those living in groups apply clear principles of management and demonstrate more organized behavior. This is especially evident in bees and ants, which use no less management tools than humans. implement a division of labor, apply safety systems, and organize control operations, and not a priori, but in an organized way.

Thus, if hardworking bees do not bring nectar, then the soldier bees standing at the entrance to the hive do not let them in and send them back to harvest. Inside the hive, each bee knows its job, working in the areas of nectar collection, feeding the queen bee, and protection from predators. And these functions are carried out in a coordinated manner, complementing each other, and seem to be guided by the unwritten rules of the bee colony, that is, they have an instinctive regulated nature.

An excellent example of behavioral guidance is also the anthill, the community of which also consists of worker ants, soldier ants, from the

mother ant, which provides generations. Here too, everyone knows their functions and performs them with instinctive, regulated approaches, without any written laws or imposed behavioral norms.

This raises a question: Can't people imitate the natural behavior of these insects and act and create freely, not subject to laws or rules of conduct, not guided by anyone and not having any regulatory influence from the outside? Incidentally, the anarchist movement, which began three centuries ago, was based on the idea of individual or public freedom, proposing an autonomous society based on voluntary cooperation.

Here, the emphasis was on both the freedom of personal action and the independence of community groups, which should not be subject to regulatory influence from the outside. However, history has shown that people were unable to act in an anarchic environment and were always under the systematic regulatory influence of various by the rulers of the lower levels, they had not chaotic, but controlled behavior. Moreover, this behavior can be implemented not only through the influence of rulers, but also through self-government. However, the latter is also indirectly subject to external governmental influence. Even the primitive caveman understood that life becomes easier when people live in groups and are governed by the chieftain, albeit authoritarian, but with regulated approaches. Behavioral anarchy would lead to the fact that the distribution of prey among the members of the community would become uncontrollable, a disorganized distribution of labor would be carried out and, ultimately, a chaotic situation would be created and people would be subjected to hunger and helplessness. So, even the caveman realized that his goals could not be achieved by a priori actions, they had to be directed in some way so that they would ultimately provide the desired result for survival. And that direction required special skills and abilities, the entirety of which can now be formulated as the art of management (Mkhitaryan A., Khachatryan N., Khalafyan N., 2020).

Management is an integral part of society and individual activity today. Nothing is unmanageable, and if actions go beyond the influence of management, they carry the risk of failure. Thus, management ensures a natural process and stability in achieving the set goals, by exercising

regulatory influence on the managed objects by the subjects (Benavot, A., and M. McKenzie., 2021).

If management is not implemented, that is, regulatory influence on activities, then it will not be clearly established what goals there are, how they can be achieved, who will regulate the process of implementing the set goals, who will monitor how they are implemented and, ultimately, who will make decisions, which will be indispensable in implementing the goals. It is these "who" who act as managers in our lives.

Let us also add that management (French: ménagement "the art of leading, directing", from Latin: "to direct by hand"), in a broader sense, means a means of achieving the goals included in various types of socio-economic systems and models, which in our days has turned into an applied science.

Individuals or human groups in today's "Sardinian" of socio-economic development and information saturation will simply get entangled in their behavioral actions and will find themselves in a chaotic environment if they do not have the ability to achieve goals, especially if they are not subject to the regulatory influence of achieving these goals. Moreover, this regulatory influence can be formed in the individual as a means of self-government or self-organization, in the collective as a means of corporate governance, or in the upper class as a means of executive management. However, in all cases, management will not take place if it does not operate within the framework of a predetermined system. Green education management is not only related to the direction of the activities of individuals or human groups, but includes a wider range of regulations, conditioned by the educational system. with a number of special features of the process (Andersson, E. and Öhman, J., 2016).

First: being considered a continuous process throughout an individual’s life, green education management sets itself the task of harmonizing the methodology of learning for individuals in different age groups. There is a need to regularly monitor the methodology of different levels of green education, on the one hand, eliminating repetitions, and on the other hand, gaps in the provision of key skills. Therefore, the process of organizing green education is comprehensive in nature, taking into account

learning throughout an individual's life (Tshughuryan A., Grigoryan L., Martirosyan T. 2025).

Second: traditional forms of remuneration are not applied to individuals included in the green education system. If a student studying the basics of environmental protection at school or a student studying environmental economics at a university is motivated by performance evaluations, then in a non-academic environment, the motivation of students in green education is based primarily on self-awareness and personal self-discovery, the management of which from the outside becomes extremely difficult.

Third: the effectiveness of green education significantly depends on the experience of the individual, which goes beyond the academic framework and is formed by observations and critical analysis. Therefore, it is necessary to make efforts to make not only the academic, but also the extra-academic environment of the educational process manageable, applying the principles of transdisciplinarity.

Fourth: transdisciplinarity also plays a major role in increasing the effectiveness of green education. Transdisciplinary curricula are mainly used in master's education, the teaching of which requires not only the application of interdisciplinary knowledge, but also the use of crowdsourcing tools. Here, the tools of participatory research are used, the possibilities of generating and transferring interdisciplinary knowledge to the management field, as well as the use of public inclusiveness in the process of managerial decisions. In the process of forming a curriculum, the dominance of knowledge transfer with an interdisciplinary approach over individual sectoral knowledge is also emphasized. When creating a curriculum with a transdisciplinary approach to green education, gaps in the necessary skills are revealed that students had not previously mastered. Thus, the distinctive features of green education management in relation to traditional education are presented in a number of directions (see Figure 1.)

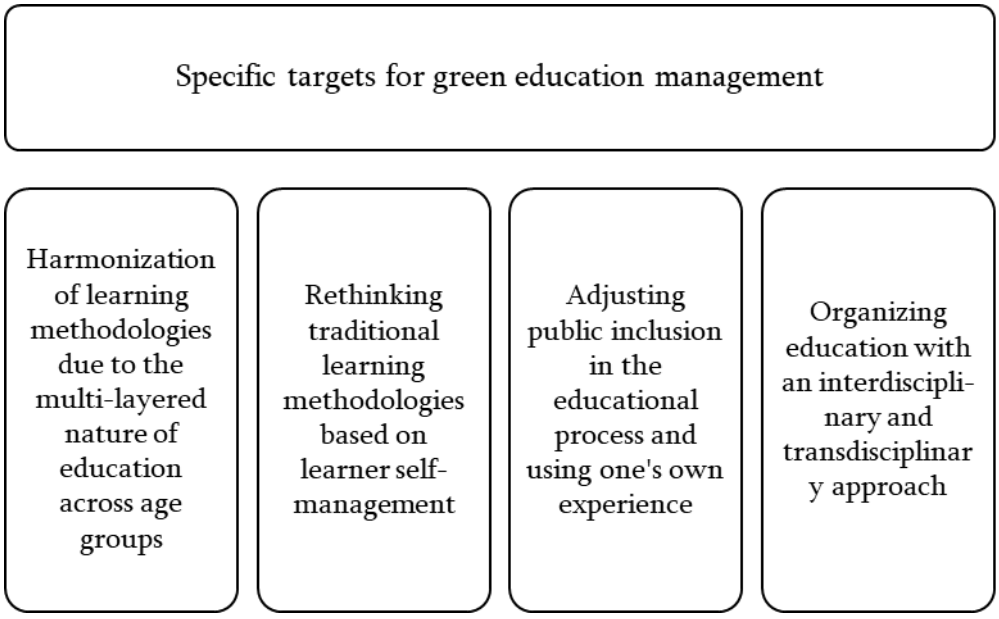

Figure 1 Distinctive features of green education management[31]

Conclusion

Green education management is presented with a number of methodological features. In addition to a localized approach, it is also implemented in a comprehensive way, including all levels of education, as well as non-formal and informal education. Green education management also tries to organize interdisciplinary educational services, since the environmental process is related to a number of subjects. Nevertheless , when implementing green education, there is a need for large-scale involvement of community representatives in educational programs in order to take into account the needs of external and internal stakeholders in environmental protection.

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ԿԱՆԱՉ ԿՐԹՈՒԹՅԱՆ ԿԱՌԱՎԱՐՄԱՆ ԱՌԱՆՁՆԱՀԱՏԿՈՒԹՅՈՒՆՆԵՐԸ

Արմեն Ճուղուրյան
Հյուսիսային համալսարան, տնտեսագիտության դոկտոր
Ատոմ Մխիթարյան
Հայաստանի գիտությունների ազգային ակադեմիա, ֆիզ. մաթ. գիտ. թեկնածու
Ռիմանտաս Ժելվիս
Վիլնյուսի համալսարանի պրոֆեսոր

Կանաչ կրթության կառավարումը ներկայանում է մեթոդաբանական մի շարք առանձնահատկություններով: Այն լոկալացված մոտեցումից բացի, իրականացվում է նաև համապարփակ կտրվածով, իր մեջ ներառելով կրթական բոլոր աստիճանները, ինչպես նաև ոչ ֆորմալ և ինֆորմալ կրթությունը: Կանաչ կրթության կառավարումը փորձում է նաև կազմակերպել միջգիտակարգային կրթական ծառայություններ, քանի որ բնապահպանական գործընթացը առնչվում է մի շարք առարկաների հետ:

Կանաչ կրթության պահանջի իրականացումը ներկայումս կանգնած է մարտահրավերների առաջ: Մի կողմից թվում է, թե դպրոցներում և բուհերում pat\a0 կանաչ կրթություն է իրականացվում, և այս ուղղությամբ մտահոգություններ չկան, բայց մյուս կողմից՝ կանաչ կրթությունն իր բնույթով համակարգված չէ և ենթակա չէ համակարգված կառավարման, ինչը, ի դեպ, ՅՈՒՆԵՍԿՕ-ի պահանջն է: Հոդվածում մեկնաբանվում են կանաչ կրթության կառավարման առանձնահատկությունները և դրա հիման վրա առաջարկություններ են արվում այս ուղղությամբ արդյունավետ կառավարման որոշումների իրականացման համար:

Հիմնաբառեր - կանաչ կրթություն, միջդիսցիպլինար կրթություն, ցկյանս ուսուցում, կանաչ գործունեության կառավարում, կանաչ վարքագծի կարգավորումներ, կանաչ կրթության կարգաբերման շրջանակ

GREEN ECONOMY CHALLENGES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: POLICY RESEARCH AND RECOMMENDATIONS FOR ARMENIA

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Abstract

This paper explores the concept of the green economy as a vehicle for sustainable development by integrating environmental protection, social equity, and economic growth. The global imperative to address climate change, resource depletion, and ecological degradation has brought renewed attention to the role of media, policy, and local practices in transitioning toward a green economy. The study investigates global policy challenges, environmental and economic dimensions of green economy practices, case studies of successful and failed transitions, and an in-depth analysis of Oklahoma's experience across energy, agriculture, and infrastructure sectors. Lessons are drawn for Armenia's policy future based on both global and subnational models. The paper concludes by emphasizing adaptive policy design, stakeholder engagement, and international support as cornerstones of successful green economy strategies.

Keywords: green economy, sustainable development, emissions, renewable energy, climate-smart agriculture, green infrastructure, Armenia, Oklahoma

GEL code: Q5

Introduction

The concept of a green economy has gained prominence as a framework to align economic development with environmental sustainability and social equity. It addresses the urgent need to reduce greenhouse gas emissions, conserve biodiversity, and ensure inclusive growth. Anchored in the Sustainable Development Goals (SDGs) and the Paris Agreement, the green

economy model promotes low-carbon, resource-efficient, and socially inclusive pathways. This paper presents a comprehensive analysis of green economy challenges and opportunities, focusing on policy design, environmental protection, and economic transformation. Special emphasis is placed on the state of Oklahoma and its evolving practices, as well as the application of global lessons to Armenia.

Findings

Green Economy and Sustainable Development: Concepts and Context

A green economy is defined as one that improves human well-being and social equity while significantly reducing environmental risks and ecological scarcities (UNEP, 2011). It decouples economic growth from environmental degradation through investments in sustainable infrastructure, renewable energy, and circular economic practices (BioMed Central, n.d.). The concept gained momentum post-2008 financial crisis and was institutionalized through SDGs, particularly goals 7, 8, and 13 (UN, 2015).

However, implementation remains fraught with challenges. Nations must balance growth with decarbonization, coordinate global policies, secure financing, stimulate innovation, and ensure policy coherence (IEA, 2023; IWMI, 2022). Moreover, equity concerns persist, as seen in France's fuel tax protests and Sri Lanka's fertilizer ban, where poorly sequenced policies caused social backlash (IWMI, 2022).

Environmental Dimensions of the Green Economy

Climate change remains the central environmental challenge. As of 2019, global emissions totaled 59 GtCO2e, necessitating halving by 2030 to meet the 1.5°C target (IPCC, 2021; WRI, 2023). Successful examples, like Denmark and Sweden, show that GDP growth can be decoupled from emissions through renewable energy and efficiency measures (Nordic Energy Research, 2012; CPLC, 2021).

The transition to a circular economy addresses unsustainable resource extraction by emphasizing reuse, recycling, and efficiency (REN21, 2023). Pollution control and biodiversity conservation are integral, with Costa

Rica’s payment for ecosystem services model reversing deforestation and increasing renewable energy use (Calma, 2024).

Economic Dimensions of the Green Economy

Economically, the green transition offers opportunities for innovation, job creation, and long-term cost savings. Global employment in renewables reached 16.2 million in 2023 (IRENA, 2023). Carbon pricing mechanisms, like Sweden's $120/ton tax, have shown efficacy in reducing emissions without compromising competitiveness (CPLC, 2017).

Green innovations, such as electric vehicles, biodegradable products, and renewable energy markets, drive new industries (IRENA, 2023). The economic cost of inaction is steep, with climate change threatening infrastructure and financial stability. Consequently, institutions like the World Bank and IMF endorse green economic policies.

Global Case Studies

Denmark has established itself as a global leader in renewable energy, particularly in wind power. As of 2022, over 50% of Denmark’s electricity was generated from wind, with some years reaching even higher levels (IEA, 2022). This achievement is the result of long-term strategic investments in wind technology, early adoption of feed-in tariffs, and strong public-private collaboration. Denmark’s energy transition was further supported by comprehensive energy efficiency policies and public awareness campaigns. Despite a high share of renewables, the country maintained robust economic growth, with an 80% GDP increase over three decades, showing that decarbonization and prosperity can go hand in hand (Nordic Energy Research, 2012).

Sweden is renowned for its pioneering carbon taxation policy introduced in 1991. The tax, which exceeds $120 per ton of CO_2, applies primarily to fossil fuel use in heating and transportation sectors (CPLC, 2017). Despite concerns that such a policy might hurt economic performance, Sweden has seen its GDP grow by 78% while reducing greenhouse gas emissions by 26% between 1990 and 2017. The tax revenue has been used to offset labor and income taxes, making the policy politically sustainable. Sweden’s success illustrates how fiscal instruments can align economic and environmental objectives when well-designed and socially inclusive.

Costa Rica presents a compelling example of integrated green development. Since the 1990s, the country implemented a payments for ecosystem services (PES) program that reversed deforestation and incentivized landowners to conserve forests (Calma, 2024). As a result, forest cover more than doubled, and biodiversity loss was curtailed. Costa Rica also generates more than 98% of its electricity from renewable sources, mainly hydro, wind, and geothermal. Furthermore, the country has invested in ecotourism and launched plans for carbon neutrality. Its holistic approach—combining environmental protection, renewable energy, and sustainable tourism—offers a model for balancing development and conservation.

Germany's Energiewende, or "energy transition," represents a large-scale effort to phase out nuclear energy and fossil fuels while boosting renewables. The policy involved generous feed-in tariffs, support for citizen energy cooperatives, and a target-driven roadmap for climate neutrality (Federal Ministry for Economic Affairs and Climate Action, 2021). By 2020, renewables accounted for around 45% of Germany's electricity generation. However, the nuclear phaseout resulted in a temporary increase in coal use, and challenges emerged in maintaining affordability and grid stability. Germany's experience demonstrates that ambitious green transitions require ongoing policy adjustments and strong infrastructure planning to ensure effectiveness and public support.

In contrast, Sri Lanka's decision to ban all chemical fertilizers and pesticides in 2021—aiming to transition to organic farming—serves as a cautionary tale. The sudden policy shift, implemented without adequate preparation or alternatives, caused widespread crop failures. Rice production fell by 32%, and tea exports declined by 18%, triggering a food crisis and economic losses (IWMI, 2023). Public backlash led to the reversal of the policy within seven months. This case highlights the importance of gradual implementation, stakeholder engagement, and technical readiness in green economy reforms.

Biofuel policies in the United States and European Union during the 2000s were initially lauded as steps toward cleaner energy. However, the large-scale diversion of food crops like corn and palm oil for biofuel production contributed to spikes in global food prices and deforestation, especially in tropical countries such as Indonesia and Brazil (CGD, 2022; The

Breakthrough Institute, 2021). These unintended consequences prompted a policy re-evaluation, with the EU and U.S. scaling back support for first-generation biofuels. The lesson is that environmental solutions must consider cross-sectoral and global impacts.

European diesel promotion policies, aimed at reducing CO_2 emissions from vehicles, also produced harmful outcomes. Diesel cars emit lower CO_2 per kilometer than gasoline vehicles, prompting tax incentives across Europe. However, they also produce higher levels of nitrogen oxides (NO_x), contributing to urban air pollution and respiratory diseases. The Dieselgate scandal in 2015 revealed that major car manufacturers had manipulated emissions data, further damaging public trust. An estimated 38,000 premature deaths were attributed to excess diesel emissions in Europe (Carrington, 2017). This case underscores the necessity of multi-dimensional policy assessments that include climate, health, and ethical considerations.

Australia's carbon pricing scheme, introduced in 2012, was a brief but instructive episode in climate policy. The system successfully reduced emissions and stimulated renewable energy investment. However, political opposition led to its repeal in 2014, causing a reversal in progress and policy uncertainty (IWMI, 2023). The case illustrates the vulnerability of climate policies to political cycles and the importance of building broad-based support for long-term sustainability reforms

Green Economy in Oklahoma

Oklahoma presents a mixed picture in its pursuit of a green economy, characterized by significant progress in renewable energy and climate-smart agriculture, alongside persistent structural and policy-related challenges.

Energy: Oklahoma's most notable success lies in its rapid expansion of wind power. By 2023, wind energy accounted for 42% of the state's electricity generation, up from near-zero levels two decades prior (EIA, 2024). This transition was primarily market-driven, supported by federal production tax credits and state-level incentives. Wind energy development brought rural economic benefits, including lease payments to landowners and job creation in wind farm construction and operations. However, the

state continues to rely heavily on fossil fuels, especially natural gas and oil, which still dominate production and employment. Additionally, Oklahoma lacks a binding statewide climate policy or emissions reduction targets, which limits coordinated progress toward decarbonization. While green hydrogen and carbon capture have been discussed as future avenues, these remain in early-stage planning and face technological and economic uncertainties.

Agriculture: Oklahoma has made strides in promoting climate-smart agricultural practices. Programs encouraging no-till farming, cover cropping, rotational grazing, and carbon sequestration have gained traction, particularly through the Oklahoma Carbon Initiative and extension services (Oklahoma State University Extension, 2023). These efforts contribute to soil health, drought resilience, and emissions mitigation. However, implementation is uneven across the state. Many farmers still use conventional practices, and adoption of carbon markets or regenerative techniques remains limited due to skepticism, lack of technical support, and market infrastructure. The agriculture sector also remains a significant source of methane and nitrous oxide emissions, and challenges like fertilizer runoff and groundwater depletion persist, particularly in the Panhandle region. While voluntary programs have spurred innovation, the absence of regulatory frameworks and targeted financial incentives hinders widespread transition.

Infrastructure: In urban infrastructure, Oklahoma has taken modest steps toward sustainability. Investments in electric vehicle (EV) charging networks, smart grids, and public transit pilots in cities like Oklahoma City and Tulsa signal early-stage momentum. The launch of downtown streetcars and incremental expansion of bike lanes and pedestrian access reflect shifting priorities. Additionally, select buildings have achieved LEED certification, and landfill methane capture programs offer environmental co-benefits. Nevertheless, major gaps remain. The state's building stock is largely inefficient, urban planning continues to favor low-density sprawl, and solar energy—despite abundant sunlight—accounts for less than 1% of electricity generation. Public transit remains underfunded, and EV adoption rates are low compared to national averages. Without comprehensive policy incentives or building codes that prioritize energy

efficiency, Oklahoma's infrastructure transition remains slow and fragmented.

In sum, Oklahoma's green economy development shows strong sectoral highlights—particularly in wind energy and conservation agriculture—while also revealing significant policy and implementation challenges. Progress has been largely driven by market forces and federal support rather than coordinated state planning. To realize its full potential, Oklahoma would benefit from adopting a more strategic, inclusive green economy framework that expands renewable diversity, scales sustainable agriculture, and accelerates investments in climate-resilient infrastructure.

Lessons for Armenia

Drawing from international and Oklahoma examples, Armenia can shape its green economy trajectory through the following interconnected strategies:

Craft a long-term green economy strategy aligned with EU and global commitments: As seen in countries like Denmark and Sweden, and reinforced by Oklahoma's sector-specific progress, long-term policy vision is crucial for sustained green transition. Armenia can build a roadmap that incorporates its Nationally Determined Contributions (NDCs) under the Paris Agreement, synchronizing with the EU Green Deal and leveraging regional frameworks like EU4Environment (SEI, 2021). Such a strategy should include sectoral targets, a climate finance plan, and mechanisms for monitoring and accountability to guide cross-sectoral development.

Scale solar and wind energy to reduce fossil dependency: Inspired by Oklahoma's success in wind energy development and Costa Rica's use of renewables for nearly all electricity, Armenia can exploit its high solar irradiation and moderate wind potential to diversify its energy mix. While Armenia currently imports a large share of its energy, especially natural gas, scaling community solar and utility-scale renewables would strengthen energy independence and resilience. Policies modeled after Oklahoma's tax incentives or Denmark's feed-in tariffs could mobilize private investment (World Bank, 2021).

Use carbon pricing to fund climate investments: Sweden's experience with carbon taxation illustrates that it is possible to reduce emissions while

maintaining economic growth. Armenia could adopt a modest carbon pricing mechanism or emissions trading system to create predictable funding for low-carbon infrastructure, green public transport, and rural electrification. As in Sweden, revenues could be recycled into social programs or clean technology subsidies to ensure public support (CPLC, 2021).

Promote climate-smart agriculture in semi-arid regions: Oklahoma's voluntary conservation practices, such as no-till farming and cover cropping, provide a strong model for Armenia's dry and erosion-prone agricultural zones. These methods increase drought resilience and carbon storage while preserving productivity. Armenia's rural development strategy can integrate carbon markets, technical support, and extension services to accelerate the transition, ensuring that smallholders are included (Oklahoma State University Extension, 2023).

Expand clean transport and urban green infrastructure: The fragmented but growing efforts in Oklahoma City and Tulsa to improve transit and pedestrian systems offer lessons for Yerevan and other Armenian cities. Armenia can prioritize investments in electric buses, cycling infrastructure, and EV charging corridors. Upgrading inefficient buildings and incorporating green infrastructure (e.g., permeable pavements, tree planting) will also increase urban resilience to climate impacts (U.S. Department of Transportation, 2023).

Prioritize stakeholder engagement and just transition frameworks: Failed or reversed policies in Sri Lanka and Australia show that even well-intended reforms can falter without social backing. Armenia should ensure inclusive decision-making by engaging farmers, workers, municipalities, and civil society early in the policy process. Mechanisms such as retraining programs, social protection for displaced workers, and awareness campaigns will help maintain trust and legitimacy during transitions (IWMI, 2022).

Together, these steps offer Armenia a practical and locally adaptable path toward building a resilient, low-carbon economy that balances environmental, social, and economic priorities.

Conclusion

The transition to a green economy is no longer an aspirational ideal but a pressing necessity in the face of accelerating climate change, resource depletion, and growing social inequities. This paper has shown that while the pathways to sustainability vary by context, successful strategies share core traits: long-term policy commitment, inclusive planning, adaptive governance, and alignment of environmental goals with economic opportunity. From Denmark's wind revolution to Oklahoma's wind-powered pragmatism, and from Costa Rica's forest restoration to Sweden's effective carbon tax, the lessons are clear—green growth is both possible and profitable when paired with sound policy and public engagement.

For Armenia, these global and subnational insights illuminate a path forward. By setting clear goals, leveraging renewable resources, promoting climate-resilient agriculture, investing in clean infrastructure, and fostering social consensus, Armenia can build a green economy tailored to its unique geography and development stage. The green transition is complex and will require trade-offs, but with smart policy design and strong stakeholder collaboration, Armenia has the opportunity to become a regional model of sustainable development. Now is the moment to act decisively and strategically for a cleaner, fairer, and more resilient future.

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ԿԱՆԱՉ ՏՆՏԵՍՈՒԹՅԱՆ ՄԱՐՏԱՀՐԱՎԵՐՆԵՐԸ ԿԱՅՈՒՆ ԶԱՐԳԱՑՄԱՆ ՀԱՄԱՏԵՔՍՏՈՒՄ. ՔԱՂԱՔԱԿԱՆՈՒԹՅԱՆ ՀԵՏԱԶՈՏՈՒԹՅՈՒՆՆԵՐ և ԱՌԱՋԱՐԿՈՒԹՅՈՒՆՆԵՐ ՀԱՅԱՍՏԱՆԻ ՀԱՄԱՐ

Արինե Մխիթարյան

Միջազգային ուսումնասիրությունների քոլեջ, Օկլահոմայի համալսարան, ԱՄՆ

Ուսումնասիրվել է կանաչ տնտեսության հայեցակարգը որպես կայուն զարգացման միջոց՝ ինտեգրելով շրջակա միջավայրի պաշտպանությունը, սոցիալական արդարությունը և տնտեսական աճը: Կլիմայի փոփոխության, ռեսուրսների սպառման և էկոլոգիական քայքայման հարցերը լուծելու գլոբալ հրամայականը ուշադրություն է

հրավիրել լրատվամիջոցների, քաղաքականության և տեղական գործելակերպերի դերի վրա՝ կանաչ տնտեսության անցման գործում: Հետազոտվել են գլոբալ քաղաքականության մարտահրավերները, կանաչ տնտեսության գործելակերպի բնապահպանական և տնտեսական կողմերը, հաջող և ձախողված անցումների ուսումնասիրությունները և Օկլահոմայի փորձի խորը վերլուծությունը էներգետիկայի, գյուղատնտեսության և ենթակառուցվածքների ոլորտներում: Դասեր են քաղվել Հայաստանի քաղաքականության ապագայի համար՝ հիմնվելով ինչպես գլոբալ, այնպես էլ ենթաազգային մոդելների վրա: Հոդվածն ավարտվում է՝ շեշտը դնելով հարմարվողական քաղաքականության մշակման, շահագրգիռ կողմերի ներգրավման և միջազգային աջակցության վրա՝ որպես կանաչ տնտեսության հաջող ռազմավարությունների անկյունաքարեր:

Հիմնաբառեր - կանաչ տնտեսություն, կայուն զարգացում, արտանետումներ, վերականգնվող էներգիա, կլիմայական առումով խելացի գյուղատնտեսություն, կանաչ ենթակառուցվածքներ, Հայաստան, Օկլահոմա

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