# Quantitative Frameworks for Investigating the Relationships Between Sustainability Factors and Lifelong Learning

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In an era characterized by rapid economic growth, globalization, and pressing environmental challenges, the role of education in advancing sustainability has become paramount. This paper's primary focus is on sustainability, aiming to provide meaningful insights into the function of educational attainment, specifically lifelong learning, in promoting sustainable development. The paper's novel approach lies in its data-driven perspective, utilizing international indices to quantify the relationship between educational metrics and the UN Sustainable Development Goals. This paper adopts a quantitative, index-based methodology to compare lifelong learning performance across four countries with similar economic circumstances, utilizing sustainability indicators from the SDG Index, Youth Progress Index, and Social Progress Index. The key findings reveal that while Estonia exhibited leading performance, Hungary's index value declined between 2016 and 2022. In contrast, Turkey demonstrated the most substantial improvement during this period, despite starting from the lowest point. The paper emphasizes the importance of carefully managing educational incentives and innovations to strengthen the alignment between sustainability and lifelong learning, particularly in addressing specific sustainability challenges through targeted ESG strategies.

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## 1 Introduction

The dramatic changes of modern times have brought a range of economic and environmental challenges that affect society and individuals. Rapid economic growth, population increase, and globalization have increased resource use, making environmental and social impacts central topics in academia and policy (Wuaten, 2022). Concerns about sustainability have expanded beyond environmental protection, now encompassing broader social and economic aspects. In this context, education, an institution with wide societal influence and direct involvement in socioeconomic structures, must adapt and respond to these evolving challenges (Aikowe, 2021). The education system performs eight crucial functions: melding individual character, transmitting culture, upholding or altering social structures, fostering economic development, legitimizing political frameworks, promoting social cohesion, offering direct services, and either enabling or impeding societal change, while simultaneously serving as a wellspring of personal fulfilment (Sujitjorn & Lertsuksombat, 2019). The complex interplay between education, society, and the economy has only intensified over time, evolving into a global preoccupation due to expansion and globalization. Since its inception, the demand for high-calibre knowledge and expertise has been consistently rising. In modern society, this tendency has further escalated with the growing recognition of human capital as a pivotal asset for both competitiveness and sustainability. However, knowledge attainment can no longer be solely confined to acquiring essential skills for task execution (Kim & Park, 2020). The processes and settings of teaching and learning have undergone substantial transformations, with methods and tools continuously evolving. The increasing availability of information, driven by digitalization and innovative pedagogical approaches, has made learning more accessible than ever (Srivastava, 2023). Consequently, knowledge development is expanding beyond traditional schooling and formal education, emphasizing non-traditional and informal learning environments. This shift underscores the emergence of lifelong learning (abbreviation: LLL) (Jackson, 2023; Kitagawa, 2021). The growing influence of artificial intelligence is transforming learning and lifelong education, presenting both challenges and opportunities for the education system. AI integration enhances personalized experiences, accessibility, and new knowledge acquisition methods to address societal and technological changes. LLL is essential for a sustainable future. In a "knowledge-based society," individuals must continuously update their knowledge and skills to contribute to environmental preservation (Kanwar et al.,

2019). This paper examines the LLL paradigm from a sustainability-focused viewpoint. It analyses key metrics pertaining to environmental, social, and governance aspects in nations with economic circumstances analogous to Hungary's. By employing a "green lens," the research aims to provide meaningful insights into the function of LLL in promoting sustainable development.

## 2 Theoretical Background

The extant literature underscores that the ongoing advancement of learning not only bolsters the development of individuals and their adaptability to the workforce, but is also a pivotal factor in fostering sustainable social, economic, and environmental systems (Aikowe, 2021). The UN's 2030 Agenda accentuates the role of education in realizing the Sustainable Development Goals (abbreviation: SDGs), particularly by cultivating mindsets and skills that support sustainability (Carney & Carty, 2024). Hence, learning serves not merely as a means for personal fulfilment but can catalyse social transformation that contributes to the long-term achievement of the SDGs. The connection between LLL and sustainability is underpinned by the acknowledgment that the knowledge required for sustainable development is dynamic, continuously evolving and being renewed (Ugwuoke et al., 2021). Educating people is key to helping them adapt to sustainability challenges. It raises environmental awareness, spreads knowledge about climate change, and encourages the use of new eco-friendly technologies. The diverse modalities of LLL - formal, non-formal, and informal - can all foster education for sustainability (Aikowe, 2021). Formal education can teach sustainable development. Non-formal and informal learning can help workers and communities update their sustainability knowledge. This is crucial for the environment, social and economic sustainability. Continuous learning can reduce inequalities and improve social cohesion (Battistella et al., 2021). Research shows that LLL helps achieve wider SDGs. Education can reduce poverty by giving people skills for financial independence. It also promotes gender equality by opening up educational and job opportunities for women (Piao & Managi, 2023). Continuous learning makes the workforce more flexible and innovative, which supports sustainable economic growth and good jobs (Khan et al., 2023). LLL is crucial for promoting sustainable development. It can cultivate attitudes supportive of sustainable lifestyles and help individuals and organizations understand and address sustainability challenges (Ugwuoke et al., 2021). Through continuous skill development, LLL enables sustainability at both individual and structural levels.

## 3 Methodology

This paper aims to examine and compare the participation in lifelong learning activities across countries that have economic conditions similar to Hungary. By analysing the rates and patterns of lifelong learning engagement in these peer countries, the paper seeks to provide insights into the relationship between economic development and lifelong learning opportunities.

### 3.1 Countries Included in the analysis

The countries were selected based on a multi-pronged approach. The primary criterion was economic similarity, as measured by per capita purchasing power parity. This was necessary to ensure comparability. The categorization was based on a preliminary clustering using the Youth Progress Index, which allowed for the identification of countries with similar economic development levels. The specific countries were randomly chosen from the relevant sample. This selection considered the need to represent different geographical regions, providing an opportunity to analyse region-specific traits. Estonia, a Baltic state and EU digital education leader, Greece, representing Southern Europe, and Turkey, an emerging Eurasian economy, were included. This selection strategy ensured economic similarity while also offering insights into diverse geographical and cultural contexts, enabling an examination of varied lifelong learning participation trajectories.

### 3.2 Selected Indicators and Indices

Considering data availability, the years 2016 and 2022 were chosen as the reference years for analysis. The selection was influenced by two factors: methodological changes at both national and international levels were consolidated by 2016, making prior LLL-related data incomparable, and the most recent data available across all indices were from 2022. The indices selected for comparison were chosen to ensure the inclusion of key educational and social indicators. The research utilized three key international indices to assess lifelong learning participation. These included:

- The Sustainable Development Goals index (abbreviation: SDG index), which measures progress towards the UN's Sustainable Development Goals and incorporates indicators related to the quality and accessibility of education.

- The Youth Progress Index (abbreviation: YPI), which evaluates a country's capacity to provide young people with opportunities for self-actualization, including education and adult learning, based on a range of metrics.
- The Social Progress Index (abbreviation: SPI), an assessment of social progress that examines countries' provision of basic human needs, well-being, and developmental opportunities.

### 3.3 Standardisation and Analytical Methods

To begin, the baseline data with diverse units and dimensions is standardized into a common metric scale, following established methodologies (Macher et al., 2023; Macher & Szigeti, 2024). Next, a benchmark is defined by comparing the values of EU-27 Member States to the maximum value in the sample. This is followed by calculating the Euclidean distance, which quantifies how far the indicators are from a specific reference point. Finally, an integrated index with consistent dimensions is computed to enable a three-dimensional matrix analysis. Results should be interpreted with caution, as a small sample may not represent the broader population.

## 4 Results

In line with our research objectives, we conducted an index-based data analysis for the period 2016–2022 across four selected countries with similar economic conditions. Following data collection and standardization, we determined the Euclidean distance measure and the adaptive development index for ecosystem services. The average index value for the analysed countries was 75.75 in 2016, increasing to 77.36 in 2022 (Figure 1.) The results indicate that in 2016, Turkey had the lowest index value (0.1636), followed by Greece (0.8100). Estonia led in lifelong learning participation. By 2022, Hungary's performance declined to an index value of 0.7400, reflecting a -5.89% decrease. Turkey remained the lowest-ranking country but showed the most significant improvement (+21.57%) from 2016 levels. Greece exhibited a slight decrease (-0.9%), indicating stagnation.

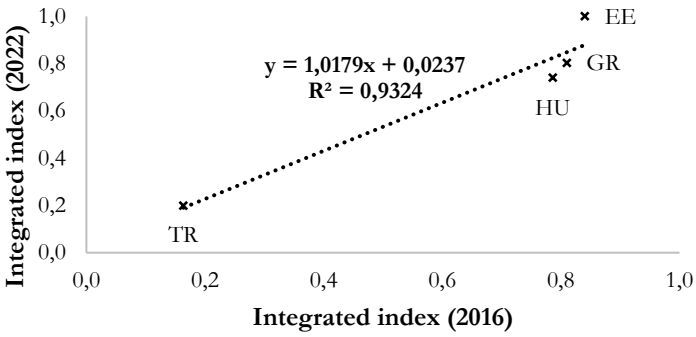


**Figure 1: Comparative analysis of calculated integral indices**

Comparing our findings with EUROSTAT data, we observe that Estonia is the only country that surpassed its pre-pandemic (2019) performance. The results suggest that the examined countries can be categorized into two groups, with Estonia significantly outperforming the other three in lifelong learning engagement (Figure 2.).

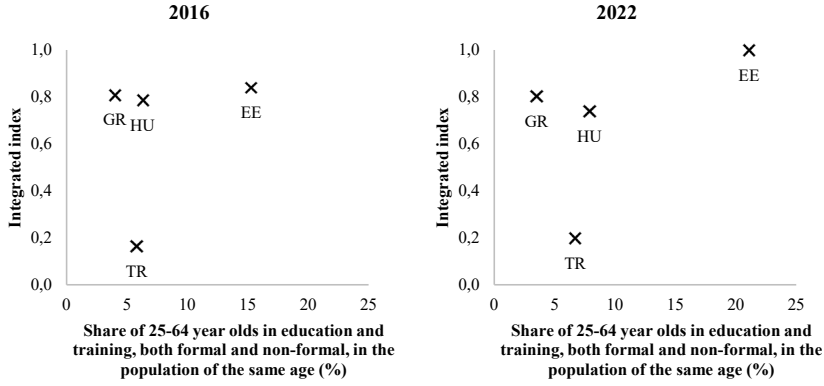


**Figure 2: Comparative analysis of LLL and standardised indices**

## 5 Discussion

This research aligns with prior work examining the relationship between sustainability and lifelong learning, building upon existing frameworks through a novel index-based methodology. Previous studies have underscored education's role

in cultivating sustainability by shaping attitudes and conduct (Michel, 2020). The current findings expand upon this foundation by incorporating quantitative metrics to evaluate the impact of lifelong learning on sustainable development. Prior research has often focused on the qualitative aspects of sustainability education, such as curriculum development and instructional approaches. In contrast, this paper leverages international indices to offer a more data-driven perspective, illuminating the relationships between educational metrics and sustainability goals (Peters et al., 2024). For instance, work by organizations like UNESCO has emphasized the need for a comprehensive approach to sustainability education, which this analysis complements by providing empirical insights derived from index-based assessment (Redman & Wiek, 2021). This paper offers a novel methodological approach that departs from conventional research focused primarily on policy implications. This interdisciplinary framework can be applied across diverse educational settings. Importantly, our research underscores how lifelong learning shapes sustainable practices at both the individual and societal levels. The findings corroborate the argument regarding the need to align educational initiatives with the United Nations' SDGs (Filho et al., 2023). By analysing SDG-related indicators, our paper offers additional empirical support for the notion that tailored educational strategies can foster sustainable outcomes (Filho et al., 2023). While prior research has primarily examined the role of higher education in sustainability, this work expands this focus to encompass lifelong learning, including adult education and continuous professional development.

## 6 Conclusions

This investigation has elucidated the pivotal nexus between sustainability and lifelong learning, underscoring how education can function as a catalyst driving sustainable development. By adopting an index-based methodology, we have furnished empirical evidence that lifelong learning occupies a fundamental role in cultivating sustainable practices, exerting influence on both individuals and societal frameworks. The results of this paper highlight the imperative of embedding sustainability principles within lifelong learning frameworks, ensuring that educational initiatives at all levels advance global sustainability objectives. Moreover, the findings demonstrate that interdisciplinary methodologies, particularly those leveraging quantitative data, can generate valuable insights into the relationship between education and sustainability. Although our research offers valuable insights,

it also has certain limitations, such as the scope of the indices employed and the geographical constraints of the data. To build upon these findings, future studies should incorporate a wider range of datasets and delve deeper into regional disparities. Furthermore, additional investigations into the direct impact of policy implementation on sustainability outcomes would provide valuable insights. Ultimately, lifelong learning must be continually supported and advanced to address the challenges of sustainability. By cultivating knowledge acquisition, skill improvement, and behavioural modification, education can serve as a driving force in realizing sustainable development, not merely as an end goal, but as a fundamental component of a more sustainable future.

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