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Impact of Digitalization on Global Sustainable Development Across Countries

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Abstract: This study develops an economic development index, a social development index, an environmental sustainability index, and an information and communication technology index to explore the comparison of 34 countries in global sustainable development (GSD) and its promoting indicators, and digitalization. The composite Z-score method is used to create the above-mentioned indexes between 2000 and 2021. The statistical values of these indexes are used to explicate the performance of these countries in all components of sustainable development and digitalization. The correlation coefficients among the mentioned indicators are also estimated to measure associations among them. The regression coefficients of explanatory variables with GSD and digitalization are also estimated using a log-linear regression model. There is reported a high diversity in digitalization, economic development (ED), social development (SD), environmental sustainability (ES), and GSD across countries. GSD is not possible without ED, SD, and ES. Digitalization has a positive impact on sustainable, social, and ED. Digital technology helps to increase GSD, while GSD seems favorable to increasing digitalization. Digitalization improves as ED, SD, and GSD increase, while digitalization has a negative impact on ES. Green innovation, green and appropriate technologies, green entrepreneurship, and technological advancement would be supportive to increase digitalization and GSD.

Keywords: digital technology, digitalization, economic development (ED), environmental sustainability (ES), global sustainable development (GSD), social development (SD), sustainable development goals (SDGs)

1. Introduction

Nowadays, global countries are giving important attention to achieving global sustainable development (GSD) through implementing appropriate policies in associated fields. GSD is not a new thought in academic literature. GSD can be defined as a process that meets the needs of social–economic development and increases the well-being of the present and future generations (Khan & Khan, 2012). It creates a platform to meet the need of future generations to achieve similar goods and services from the available resources in a sustainable way. GSD also assists in increasing the productivity and efficiency of all resources without diminishing their availability, especially ecosystem services (Misztal & Kowalska, 2020). GSD has the potential to resolve existing issues related to environmental and ecological degradation and climate change (Apostu & Gigauri, 2023). GSD, therefore, helps to increase inclusive economic, social, and environmental growth (Chandel, 2022). However, the definition of GSD varies in different sectors. For instance, GSD is necessary to increase economic profits and productivity of resources and create employment in the production sectors (Misztal & Kowalska, 2020). In the agricultural sector, GSD ensures the productivity and profits of farmers, reducing the adverse impact of this sector on natural resources. GSD also helps to increase the productivity of water and energy. In business sector, GSD helps to increase sustainability of business activities. GSD also enhances green entrepreneurship (GE) and sustainable entrepreneurship. GSD is also beneficial to increase green growth and green GDP. Hence, GSD develops a scientific way to increase the sustainability of all production sectors in multiple ways.

Sustainability is supportive for re-allocating the resources to achieve certain goals in the social, economic, and environmental sectors (Ozili, 2022). It also provides a scientific approach to making better decisions to increase the sustainability of human life and its allied sectors. Education, income equality, social justice, food security, and livelihood-related activities improve as GSD increases (Mensah, 2019). GSD, therefore, creates a suitable platform to meet the diverse needs of all people, promote well-being, increase social unity and inclusion, and provide equal opportunities for all. GSD is about finding better ways of doing something for the present and future generations. It means that future generation should also get all services that present generation is receiving from social, economic, environmental, business, and technological sectors. Moreover, the concepts and approaches of GSD bring multiple benefits for common people in all sectors. GSD also makes people better decision-makers for the utilization of available resources to produce goods and services to meet their needs. Accordingly, GSD is a necessary determinant to increase the social welfare and well-being of society (Misztal & Kowalska, 2020). Earlier studies found a

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uniform interlinkage between GSD and its key pillars (Chandel, 2022). Most researchers assessed the factors affecting GSD in different sectors (Belyaeva & Lopatkova, 2020).

Environmental sustainability (ES) is the most important pillar of GSD as compared to social development (SD) and economic development (ED) (Domańska et al., 2018). Twesige and Mbabazize (2013) proposed that sustainability in natural resources is highly effective in increasing sustainable development. Despite that, most countries are paying little attention toward ES, while ES is adversely affected due to high ED and human-driven activities. For instance, the process of ED is required more inputs from natural resources. Hence, ED is highly responsible to increase environmental degradation. Therefore, it seemed impossible for global countries to achieve GSD without ES. Accordingly, the scientific research community argues that green entrepreneurial practices in production sectors will be beneficial to increasing ES (Chandel, 2022). Green entrepreneurial practices also promote GE and GSD (Domańska et al., 2018; Galindo-Martín et al., 2020), while GE increases as sustainable entrepreneurship and sustainable development increase (Apostu & Gigauri, 2023). GE is also positive for reducing various environmental issues in the production sector (Chandel, 2022). GE also helps to increase the movement of global countries toward the green economies.

Most scholars proposed that digitalization brings widespread possibilities and alternatives to increase GSD and its supportive dimensions, i.e., social, economic, environmental, science, and technological fields (Belyaeva & Lopatkova, 2020; Mondejar et al., 2021; Rath & Hermawan, 2019). Digitalization creates a conducive ecosystem in which digital technologies, and information and communication technology (ICT) can be used by people in their daily lives (Mondejar et al., 2021). Digitalization is a process that increases the transformation of society to use digital technologies in different areas (Ionescu-Feleaga et al., 2023). ICT is beneficial to increase easy accessibility of markets for consumers and producers. ICT, therefore, is a key driver to increase new business opportunities for entrepreneurs (Galindo-Martín et al., 2023; Jiao & Sun, 2021). All economic agents can reduce transaction costs using digital technologies and ICT in production activities and market (Bon, 2021). A country can be a digital economy using digital technologies and ICT (Raeskyesa & Lukas, 2019). The digital economy contributes to increase green growth, green GDP (Chen et al., 2023), and sustainable economic growth (Jiao & Sun, 2021). Digitalization is also a determinant of green innovation (Luo et al., 2023). Further, digitalization helps to generate extensive jobs, new business opportunities, and green entrepreneurial activities (Galindo-Martín et al., 2023; Xu et al., 2022). Digitalization is helpful to create new markets, green innovation, green technology, and green environment (Galindo-Martín et al., 2023).

Information about government policies, scientific outcomes, and social–economic issues can be disseminated among a large community through digital infrastructure, i.e., social media and online platforms. Thus, digitalization is also supportive for increasing the skills and knowledge of people (Xu et al., 2022) and competition across countries (Aleksandrova et al., 2022; Galindo-Martín et al., 2023). Digitalization is also an important driver to increase transfer of technology across countries. Technology transfer is useful to discover innovation and scientific process to increase the growth of manufacturing sector. Furthermore, production units can reduce their dependency on natural resources using ICT and digital technologies (Xu et al., 2022). For example, the agricultural sector can mitigate the negative implications of climate change and reduce the use of irrigation and environmental degradation using digital and advanced technologies in it (Kumar et al., 2016; Mondejar et al., 2021). Digitalization is also useful for increasing transparency and the involvement of people in ongoing public policies (Xu et al., 2022). Further, digital technologies have a positive contribution for developing green products and green innovation (Ma & Zhu, 2022). Subsequently, digitalization is extremely effective in increasing inclusive growth, social equity, and ES (Xu et al., 2022). Also, the research community and students can use and derive desired scientific information through an online platform. Thus, digitalization is beneficial to nurture a conducive mechanism to increase technology transfer for the discovery of advanced technologies, ICT tools, green infrastructure, and environmental technologies (Soomro et al., 2022). Subsequently, digital technologies and ICT tools are helpful to stimulate ED, SD, ES, and GSD (Belyaeva & Lopatkova, 2020; Novikova et al., 2022; Pradhan et al., 2022).

Previous literature highlighted that digitalization helps to promote social–economic development, human development, environmental development, and ES (Rath & Hermawan, 2019; Xu et al., 2022). ICT is also supportive of achieving sustainable development goals (SDGs) (Mondejar et al., 2021; Vyas-Doorgapersad, 2022). Secundo et al. (2022) also reported that digital technologies are favorable to attaining sustainable development goals in the agri-food sector of Italy. Digitalization also provides protection for biodiversity and addresses the issue of climate change in most sectors (Mondejar et al., 2021; Xu et al., 2022). The process of digitalization is vital to promoting GSD (Ionescu-Feleaga et al., 2023; Novikova et al., 2022). Digitalization also depends on GSD-promoting indicators, ICT infrastructure, and technological development. It is, therefore, noticed that digitalization, GSD, and its supportive indicators have a positive association with each other, although previous studies included different indicators in the empirical analysis to observe the implication of digitalization on ED, SD, ES, and GSD. While digitalization, ED, SD, ES, and GSD cannot be measured efficiently due to their noteworthy and manifold association with development-related activities, existing researchers, therefore, could not be established a reliable empirical model to perceive the implications of digitalization on GSD and its pillars. Henceforth, this study achieves the following objectives:

- To assess the relative strengths of 34 countries in digitalization (ED, SD, ES, and GSD).
- To observe the existence of casualties between digitalization and GSD and its key components.
- To perceive the impact of digitalization on ED, SD, and ES.

The assessment of the economic development index (EDI), social development index (SDI), environmental sustainability index (ESI), and information and communication technology digitalization index (ICTDI) for selected 34 countries during 2000–2001 using the composite Z-score (CZS) method is a novelty of this article. Accordingly, it provides the relative positions of undertaken countries in the above-mentioned developmental-related indicators. It is also provided policy suggestions for the lowest-ranking countries to improve their positions in ED, SD, ES, GSD, and digitalization. The Karl Pearson correlation coefficient analysis is also used to check the internal and external validity of above-mentioned indexes. Thereupon, log-linear regression models are employed to assess the interconnection among the estimated indexes using country-wise panel data. The existence of causal associations between dependent and independent variables is also observed using the Granger co-integration test. The descriptive and empirical findings of this study recommend numerous policy suggestions to increase sustainable development, its supportive components, and digitalization. It also provides scope for further research in the area of digitalization and its allied sectors.

This article has nine broad sections. Section 1 explains the introduction relevant to the theme of this study. Section 2 introduces the theoretical and empirical review. The theoretical framework of the CZS technique is described in Section 3. Section 4 describes the research methodology that is applied to achieve the prescribed objectives of this article. The descriptive and empirical results are highlighted in Section 5. Section 6 discusses the results. The conclusion of this article is presented in Section 7. Policy implications are described in Section 8. Limitations and future research directions are clarified in Section 9.

2. Theoretical and Empirical Review

In the last decade, existing researchers investigated the role of digitalization, digital technologies, and ICT in social–economic development, human development, financial development, energy consumption, the labor market, labor productivity, and the entrepreneurship ecosystem (Khater & Allah, 2017; Galindo-Martín et al., 2023; Jyoti & Singh, 2023; Kim et al., 2022; Secundo et al., 2022; Tiutiunyk et al., 2021). Most studies reviewed the impact of digitalization on a specific component of sustainable development (Xu et al., 2022). Existing scholars also preferred different variables, e.g., fixed telephone subscribers, population using computers, and internet users, as representative variables for digitalization in assessing their empirical relationship with social–economic development-related indicators (Minges, 2015). ICT tools provide growth opportunities for industries, agriculture, business, engineering, and science and technology (Khater & Allah, 2017). Irtyshcheva et al. (2021) reported that ED could increase due to an increase in internet users in Ukraine. Afonasova et al. (2019) emphasized that the internet and digital devices are crucial determinants of economic growth. Solomon and van Klyton (2020) also noted a positive impact of ICT on economic growth.

Karaman Aksentijević et al. (2021) also noticed a positive impact of ICT on human development. Habibi and Zabardast (2020) perceived a positive impact of ICT on economic growth. The positive impact of ICT-related indicators on economic growth is also detected in ASEAN countries (Raeskyesa & Lukas, 2019). Economic growth in 74 SSA and Organization for Economic Co-operation and Development (OECD) countries also increased due to extension of broadband internet and mobile telecommunication (Myovella et al., 2020). ICT indicators and economic growth have a mutual interdependency in G20 countries (Pradhan et al., 2022). ICT promoting variables are also seemed useful for economic growth in BRICS and Asian countries (Nipo et al., 2022; Soomro et al., 2022). Earlier studies also used various indexes for digitalization to capture its implications on social–economic development (Aly, 2022; Bakry et al., 2023; Ionescu-Feleaga et al., 2023; Novikova et al., 2022; Özsoy et al., 2022; Rath & Hermawan, 2019). Belyaeva and Lopatkova (2020) investigated the impact of digitalization on social and environmental dimensions of GSD in small and medium enterprises (SMEs) of European countries. It is also noted that digitalization is useful in increasing the social–economic dimension of sustainable development in SMEs.

Secundo et al. (2022) ascertained the role of digital technologies in the sustainable development goals (SDGs) of the Italian food production sector. Digitalization is also useful to increase high-tech products across countries (Özsoy et al., 2022). Vyas-Doorgapersad (2022) applied a qualitative approach to observe the role of digitalization in various goals of the SDGs in South Africa. Galindo-Martín et al. (2023) reported that digitalization is conducive to stimulating entrepreneurial activities. Bakry et al. (2023) noticed that economic growth and energy consumption could improve due to the increase in the process of digitalization in 27 countries. Dovgal et al. (2021) identified the importance of digitalization in sustainable greening areas in OECD countries and Ukraine. Truong (2022) analyzed the impact of digitalization or digital transformation on ES. Luo et al. (2023) highlighted the significance of green innovation and the green economy in sustainable development in 278 cities of China. Ionescu-Feleaga et al. (2023) explained the association of digitalization with sustainable development in European countries. This study used the sustainable development goal index, and the digital economy and society index as dummy variables for sustainable development, and digitalization, respectively, in the empirical investigations. Apostu and Gigauri (2023) also detected the implication of entrepreneurship on sustainable development. The above-mentioned literature specifies that previous studies given crucial attention to determining the impact of digitalization, digital technologies, and ICT on labor productivity, energy consumption, high-tech products, employment, ED, and financial development. Despite that, limited studies could measure the implication of digitalization or digital technologies on GSD and its dimensions across countries.

3. Theoretical Framework of CZS Technique

The scientific research community and international organizations like UNDP, the World Bank, and the World Economic Forum applied principal component analysis (PCA), factor component analysis, CZS, and descriptive analysis to develop various indexes (Afonasova et al., 2019; Hussain et al., 2021; Luo et al., 2023). Verma et al. (2023) created an ICT diffusion index for 88 countries using the PCA method. Dovgal et al. (2021) applied simple descriptive analysis to develop a greening index for OECD countries. Most studies used the *CZS method* for developing different indexes due to its scientific viability in the research field. This method includes the normalization score of all variables across entities in index estimation. The researchers can make the relative comparison across entities for a specific variable easily. In this method, the weight for each individual variable is allocated according to its variance between the set of variables to create a desired index. The present study also creates an EDI, a SDI, an *ESI*, an *ICTDI*, and global sustainable development index (*GSDI*) to articulate the comparative presentation of included countries in ED, SD, ES, digitalization, and GSD, respectively. The method is based on the normalization value (*NV*) of individual variables. If a variable has a positive impact on a specific indicator, then the *NV* of this variable is valued as (Miola & Schiltz, 2019):

$$(NV)_{1,c,t} = \{(AVV)_{1,c,t} - (MinVV)_{1,c,t}\}/\{(MaxVV)_{1,c,t} - (MinVV)_{1,c,t})\} \quad (1)$$

If a variable is negatively associated with particular indicator, then the *NV* for this variable is computed as (Miola & Schiltz, 2019):

$$(NV)_{1,c,t} = \{(AVV)_{1,c,t} - (MaxVV)_{1,c,t})/(MinVV)_{1,c,t} - (MaxVV)_{1,c,t}) \quad (2)$$

Here, *NV* is the normalization value of variable 1; *AVV*; *MinVV* and *MaxVV* are the actual values; the minimum value and maximum value of this variable across countries, respectively, in the above equations. The numerical values of *NV* for all variables lie between 0 and 1. The NVs of all variables associated with *ICTDI*, *EDI*, *SDI*, *ESI,* and *GSDI* are estimated for each individual year using the above-mentioned equations. Consequently, the final index is the linear sum of the NVs of all variables that are also multiplied by their weightage in the specific category of indicator. The weight for the corresponding variable is assigned as:

$$wi = \frac{k}{\sqrt{Var(NV)}} \quad (3)$$

where w_i is the assigned weightage of i^{th} variable; *Var*(*NV*) is the statistical variance of normalization values of all variables; and Σw_i is 1 in above equation, while numerical value of *K* is measured as:

$$\text{Here,} \quad K = \frac{1}{\left\{\sum_{i=1}^{n}\left(\frac{1}{\sqrt{Var(NV)}}\right)\right\}} \quad (4)$$

4. Methodology

4.1. Study area

This study used the numerous reliable variables in the domains of digitalization, ED, SD, ES, and GSD to develop associated indexes, while related variables are finalized as per the existing literature (Tables 1, 2, 3, and 4). Since most countries do not have the statistics for the desired variables during 2000–2021, this study includes only 34 countries that have the data for related variables for the stated time period. These countries are listed below:

Table 1
Factors promoting digitalization

Variable's name	Unit
Education expenditure (% of GNI)	%
Communications, computer, etc. (% of service exports, BoP)	%
Communications, computer, etc. (% of service imports, BoP)	%
Compulsory education duration (years)	Years
Computer, communications, and other services (% of commercial service exports)	%
Computer, communications, and other services (% of commercial service imports)	%
Fixed broadband subscriptions (per 100 people)	Number
Fixed telephone subscriptions (per 100 people)	Number
ICT goods exports (% of total goods exports)	%
ICT goods imports (% total goods imports)	%
Individuals using the internet (% of population)	Number
Mobile cellular subscriptions (per 100 people)	Number
School enrollment secondary (% gross)	%

- **Asia and the Pacific, East Asia and Pacific, and South Asia:** Japan, China, and India.
- **Central, Northern, Western, and Northwestern Europe:** Austria, Hungary, Luxembourg, Poland, Spain, Estonia, Belgium, Denmark, France, Germany, the Netherlands, and the United Kingdom.
- **Central and Southeast, Central and Southeastern, Northern Europe, and the Pacific Oceans:** Croatia, Greece, Portugal, Australia, Finland, and Sweden.

Table 2
Factors influencing economic development (ED)

Variable's name	Unit
GDP per capita (constant 2015 US$)	US$
Gross capital formation (% of GDP)	%
Gross domestic savings (% of GDP)	%
Final consumption expenditure (% of GDP)	%
Foreign direct investment net inflows (% of GDP)	%
Employers total (% of total employment)	%
Employment to population ratio (15+, total) (%)	%
Labor force participation rate, total (% of total population ages 15–64)	%
Self-employed total (% of total employment)	%
Wage and salaried workers total (% of total employment)	%
Exports of goods and services (% of GDP)	%
Vulnerable employment total (% of total employment)	%
Inflation GDP deflator (annual %)	%

Table 3
Factors influencing SD

Variable's name	Unit
Age dependency ratio (% of working-age population)	%
Domestic general government health expenditure (% of GDP)	%
Employment to population ratio of female (15+ years) (%)	%
Energy use (kg of oil equivalent per capita)	Kg.
Food production index (2014–2016 = 100)	Number
Incidence of tuberculosis (per 100,000 people)	Number
Mortality rate infant (per 1000 live births)	Number
Life expectancy at birth total (years)	Years
People using at least basic drinking water services (% of population)	%
People using at least basic sanitation services (% of population)	%
Sex ratio at birth (male births per female births)	Number
Unemployment total (% of total labor force)	%
Women business and the law index score (scale 1–100)	Number

- **Latin America, Sub-Saharan Africa, and the Middle East and North Africa:** Argentina, Brazil, Mexico, South Africa, the United States, and Tunisia.
- **Europe, Central Asia, and North America:** Latvia, Lithuania, Norway, Romania, the Russian Federation, Switzerland, and Canada.

4.2. Source of data

Most data for selected variables related to *ICTDI*, *EDI*, *SDI,* and *ESI* are taken from the World Development Indicators (the World Bank) and the OECD. The statistics for few variables, such as electricity production from various sources, PM2.5 air pollution, mean annual exposure (micrograms per cubic meter), PM2.5 air pollution, population exposed to levels exceeding the WHO guideline value (% of total), fossil fuel energy consumption, research and development (R&D) expenditure, and researchers in

Table 4
Factors influencing ES

Variable's name	Unit
Agricultural land (% of land area)	%
Fertilizer consumption (kilograms/hectare of arable land)	Kg./Ha.
Annual freshwater withdrawals total (billion cubic meters)	Billion cubic meters
CO_2 emissions (kg per 2015 US$ of GDP)	US$
CO_2 emissions (metric tons/capita)	Metric tons/capita
CO_2 emissions from gaseous fuel consumption (% of total)	%
CO_2 emissions from manufacturing industries and construction (% of total fuel combustion)	%
CO_2 emissions from residential buildings and commercial and public services (% of total fuel combustion)	%
CO_2 emissions from transport (% of total fuel combustion)	%
CO_2 intensity (kg per kg of oil equivalent energy use)	Kg.
PM2.5 air pollution, mean annual exposure (micrograms/cubic meter)	Micrograms/cubic meter
PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	%
Combustible renewables and waste (% of total energy)	%
Environment-related technologies (% all technologies)	%
Electric power consumption (kWh/capita)	kWh/capita
Electricity production from coal sources (% of total)	%
Electricity production from hydroelectric sources (% of total)	%
Electricity production from natural gas sources (% of total)	%
Electricity production from oil sources (% of total)	%
Electricity production from oil, gas and coal sources (% of total)	%
Electricity production from renewable sources, excluding hydroelectric (% of total)	%
Access to clean fuels and technologies for cooking (% of population)	%
Access to electricity (% of population)	%
Energy intensity level of primary energy (MJ/$2017 PPP GDP)	MJ/$
Forest area (% of land area)	%
Fossil fuel energy consumption (% of total)	%
Population density (people per sq. km of land area)	Number
Population growth (annual %)	%
Urban population (% of total population)	%
Fertility rate total (births/woman)	Number
Production-based CO_2 productivity, GDP per unit of energy-related CO_2 emissions (US dollars/kilogram, 2015)	US$/Kg.
Renewable electricity output (% of total electricity output)	%
Renewable energy consumption (% of total final energy consumption)	%
Renewable internal freshwater resources per capita (cubic meters)	Cubic meters
Water productivity total (constant 2015 US$ GDP/cubic meter of total freshwater withdrawal)	US$ GDP/cubic meter

R&D, were not available during 2000–2021. Thus, interpolation and extrapolation techniques are employed to compute the missing values of these variables (Ma & Zhu, 2022).

4.3. Data analysis

4.3.1. Development of ICTDI

Digitalization is the process by which production sectors or common people use technologies in digital form for various purposes (Mondejar et al., 2021; Xu et al., 2022). It ensures the usability and practicality of digital technologies for the daily lives of everyone (Hussain et al., 2021). Digitalization, therefore, depends on the accessibility, usability, and skill ability of ICT tools. Accordingly, the progress of digitalization in a country may not be easily determined. Previous studies, therefore, created the ICT composite index, European index of digital entrepreneurship systems, ICT development index, digitalization transformation index, digital transformation index, ICT index, digital density index, and ICT diffusion index to explicate the relative or absolute development of digitalization across economies (Aly, 2022; Dahmani et al., 2022; Habibi & Zabardast, 2020; Rath & Hermawan, 2019; Tiutiunyk et al., 2021). For instance, Luo et al. (2023) used ICT-related indicators to determine the implications of digital transformation on ES. Previous studies also considered diverse variables to develop the above-mentioned indexes. The present study is also comprised 13 variables to create an *ICTDI* for 34 countries, as Table 1 shows (Bon, 2021; Ionescu-Feleaga et al., 2023; Jiao & Sun, 2021; Kumari & Singh, 2023; Nipo et al., 2022; Pradhan et al., 2022; Tiutiunyk et al., 2021). These 13 variables have a positive impact on digitalization. Here, *ICTDI* is defined as a composite index of those variables that help to increase digitalization. It shows the relative progress of these countries in digitalization.

4.3.2. Development of EDI

ED helps to increase the quality of life and social welfare in manifold aspects. ED ensures economic growth, social equity, income, and prosperity and well-being of people. It is significant to reduce poverty, income inequality, and the unemployment and illiteracy rate (Khan & Khan, 2012). Thus, ED depends on various variables that rectify the above-mentioned problems in society. Per capita GDP is a uniform measure of ED (Aly, 2022). Per capita GDP is the ratio of gross GDP to the total population. Therefore, per capita GDP does not show an appropriate performance of ED. Moreover, rising GDP cannot provide equal benefits to all people, and it may cause to increase income inequalities and an unequal distribution of resources. Therefore, considering per capita GDP as a key indicator of ED in an empirical investigation may be unreasonable and produce unreliable empirical results. The scientific research community, therefore, created the *EDI* to avoid the discrepancy of previous studies. This study, therefore, includes 13 different variables to create *EDI* as Table 2 shows (Aly, 2022; Bon, 2021; Jyoti & Singh, 2023; Koirala & Pradhan, 2020; Tampakoudis et al., 2014). These variables have positive and negative impacts on ED. Gross capital formation, savings, consumption expenditure, employers, self-employed, wage and salaried workers, and exports of goods and services have a positive impact on ED, while vulnerable employment and inflation have a negative impact on ED (Aly, 2022). In this study, *EDI* is a combined index of 13 different variables that explain the overall progress of ED across countries.

4.3.3. Development of SDI

SD depends on multiple variables related to gender equality, women's empowerment, health and medical facilities, education level, social justice, food security, basic sanitation, SD policies, and equal opportunities for all. Hence, measurement of SD is difficult. Previous studies, therefore, created the *SDI* as a composition of multiple variables related to SD. For instance, the infant mortality rate, unemployment rate, and incidence of tuberculosis have a negative impact on SD, while general government health expenditure, employment to population ratio of females, life expectancy rate, age dependency ratio, energy use, food production index (FPI), people using at least basic drinking water services, people using at least basic sanitation services, and women business and the law index (WBLI) score have a positive reflection on SD. FPI and WBLI are included to capture the impact of food security and women empowerment, respectively, on SD in this study. Incidence of tuberculosis, life expectancy, and infant mortality rate are included to identify the role of health facilities in SD, while sex ratio at birth is used to examine the contribution of gender equality in SD. Accordingly, this study creates *SDI* as a composition of the 13 variables listed in Table 3 (Tampakoudis et al., 2014). Here, *SDI* is defined as an integrated index of 13 variables that have a significant impact on SD. The *SDI* also demonstrates the relative performance of undertaken countries in SD.

4.3.4. Development of ESI

A country implements environmental policies to increase the protection of ecosystem services, and make green environmental to achieve ES (Galindo-Martín et al., 2020).

ES helps to resolve several issues like climate change, waste materials, air and water pollution, contamination of natural resources, and overutilization of ecosystem services (Xu et al., 2022). ES also helps to provide scientific methods to minimize the carbon and greenhouse gas (GHG) emissions from the production sectors. ES ensures human welfare and provides the protection of sources of raw materials (Luo et al., 2023). ES is beneficial to increase the productivity and fertility of available natural resources to ensure GSD (Luo et al., 2023). Henceforth, ES depends on social–economic development, trade, industrial development, agricultural development, demographical changes, human-driven activities, and national and global environmental policies. Hence, the progress of ES cannot be explained by a single activity. Existing researchers and international development organizations formed various indexes such as environmental quality index (Streimikiene, 2015), pro-environmental consumption index, ESI (Dash, 2011), environmental performance index (Duasa & Afroz, 2013; Gallego-Álvarez et al., 2014; Lee et al., 2017; Samimi et al., 2011), and environmental democracy index (Galli et al., 2018) to describe the improvement in ES (Mukherjee & Chakraborty, 2013).

This study includes 35 most reliable variables associated with ES to create *ESI* (Table 4). Air quality and pollution increase due to increases in CO_2 emissions from various sectors, GHG emissions, CO_2 intensity, PM2.5 air pollution, fossil fuel energy consumption, agricultural land, fertilizer consumption, and production-based CO_2 productivity (Luo et al., 2023). Thus, these variables have a negative impact on ES. ES also decreases due to increases in population density, annual population growth, urban population, fertility rate, and annual freshwater withdrawals, while environment-related technologies, electric power consumption, electricity production from different sources, energy intensity, forest area, renewable sources of energy, and water productivity have a positive impact on ES. These indicators help to increase green growth and ES (Dovgal et al., 2021). Therefore, this study also develops *ESI* as an integration of 33 different indicators that are listed in Table 4 (Dash, 2011; Dovgal et al., 2021; Galli et al., 2018; Karimi & Chashmi, 2019; Koirala & Pradhan, 2020; Luo et al., 2023; Menyah & Wolde-Rufael, 2010; Miola & Schiltz, 2019; Tampakoudis et al., 2014; Xu et al., 2022). *ESI* is defined as a composition of 35 indicators that have a significant reflection on ES in this study. Also, *ESI* signifies the relative performance of 34 countries in ES.

4.3.5. Development of GSDI

Different variables are used by the scientific research community to explain the performance of sustainable development at the micro- and macro-levels. For instance, adjusted net savings may be a good indicator to define sustainable development (Koirala & Pradhan, 2020). Social–economic development also plays a positive role in increasing sustainable development (Ullah et al., 2021). Armeanu et al. (2018) reported that economic, human, social, and technological development regulate sustainable development. Hence, sustainable development is not possible without social–economic development. Also, ES is a significant pillar of sustainable development. Misztal and Kowalska (2020) advised that economic, social, and environmental development are the dimensions of sustainable development. Rath and Hermawan (2019); Belyaeva and Lopatkova (2020); and Mondejar et al. (2021) also point out the above-mentioned components of sustainable development. Mensah (2019) also argued that sustainable development has a multifold association with social–economic, human, and environmental development. Hence, variables leading to social–economic and environmental development may be conducive to increasing GSD.

Existing studies used different variables to define sustainable development. Tampakoudis et al. (2014) used 11 different indicators in the domain of sustainable ED. Miola and Schiltz (2019) argued that measurement of sustainable development depends on methods and indicators that a researcher uses to estimate it. Consequently, it is difficult and controversial to estimate GSD. Many studies used various indexes, like the sustainable development goals index (Apostu & Gigauri, 2023; Guijarro & Poyatos, 2018; Ionescu-Feleaga et al., 2023; Miola & Schiltz, 2019), the greening index (Dovgal et al., 2021), and the GSDI to identify the motion of GSD. Furthermore, existing researchers have uniformly accepted that GSD is an integration of ED, SD, and ES (Armeanu et al., 2018; Chandel, 2022; Xu et al., 2022). GSD is also a combination of economic growth, human development, and environmental quality (Dhahri & Omri, 2018). In this study, thus, *GSDI* is computed as a linear average sum of *EDI*, *SDI,* and *ESI*. Here, *GSDI* provides the relative performance of 34 countries in GSD.

4.4. Empirical analysis

4.4.1. Regression analysis

Existing studies used different models to explain the interlinkages between estimated indexes and specify control variables (Apostu & Gigauri, 2023; Duasa & Afroz, 2013; Galindo-Martín et al., 2020; Gallego-Álvarez et al., 2014; Ionescu-Feleaga et al., 2023; Samimi et al., 2011; Soomro et al., 2022; Streimikiene, 2015). Lee et al. (2017) analyzed the association of the pro-environmental consumption index with social–economic indicators across countries using a linear regression model. Galindo-Martín et al. (2020) used the environmental performance index, human development index, and GDP per capita to determine their association with sustainable development, green innovation, and entrepreneurship. Hussain et al. (2021) assessed the impact of the ICT composite index on economic growth by employing the panel Vector Error Correction Model (VECM) model. Dynamic panel data regression analysis is used by Karaman Aksentijević et al. (2021) to explore the association between dependent and independent variables. Pradhan et al. (2022) applied the Autoregressive Distributed Lag (ARDL) Model to explore the interrelationship between ICT infrastructure and economic growth. Nipo et al. (2022) applied the standard endogenous growth model to explore the relationship between ICT and economic growth. The present study also applied Cobb–Douglas production function approach to determine the relationship between digitalization, GSD, and its drivers. For the stated empirical investigations, the following regression equations are executed:

$$\ln(ICTDI)_{ct} = \text{¥}_0 + {}_1 \ln(GSDI)_{ct} + \text{¥}_2 \ln(RRD)_{ct} + \text{¥}_3 \ln(RDE)_{ct} + \text{¥}_4 \ln(STJA)_{ct} + \text{¥}_5 \ln(MVA)_{ct} + \text{¥}_6 \ln(MT)_{ct} + \mu_{ct} \tag{5}$$

$$\ln(GSDI)_{ct} = \beta_{0+}\beta_1 \ln(ICTDI)_{ct} + \beta_2 \ln(RRD)_{ct} + \beta_3 \ln(RDE)_{ct} + \beta_4 \ln(STJA)_{ct} + \beta_5 \ln(MVA)_{ct} + \beta_6 \ln(MT)_{ct} + \varphi_{ct} \tag{6}$$

$$\ln(ICTDI)_{ct} = \theta_0 + \theta_1 \ln(EDI)_{ct} + \theta_2 \ln(SDI)_{ct} + \theta_3 \ln(ESI)_{ct} + \sigma_{ct} \tag{7}$$

$$\ln(EDI)_{ct} = \lambda_0 + \lambda_1 \ln(ICTDI)_{ct} + \lambda_2 \ln(SDI)_{ct} + \lambda_3 \ln(ESI)_{ct} + \lambda_4 \ln(RRD)_{ct} + \lambda_5 \ln(RDE)_{ct} + \text{€}_{ct} \tag{8}$$

$$\ln(SDI)_{ct} = \xi_0 + \xi_1 \ln(ICTDI)_{ct} + \xi_2 \ln(EDI)_{ct} + \xi_3 \ln(ESI)_{ct} + \xi_4 \ln(RRD)_{ct} + \xi_5 \ln(RDE)_{ct} + \tau_{ct} \tag{9}$$

$$\ln(ESI)_{ct} = \gamma_0 + \gamma_1 \ln(ICTDI)_{ct} + \gamma_2 \ln(EDI)_{ct} + \gamma_3 \ln(SDI)_{ct} + \gamma_4 \ln(RRD)_{ct} + \gamma_5 \ln(RDE)_{ct} + \eta_{ct} \tag{10}$$

Table 5
Summary of *DV*s and *IV*s

Variables	Unit	Code
Information and communication technology digitalization index	Number	*ICTDI*
Economic development index	Number	*EDI*
Social development index	Number	*SDI*
Environmental sustainability index	Number	*ESI*
Global sustainable development index	Number	*GSDI*
Researchers in research and development (R&D) (per million people)	Number	*RRD*
Scientific and technical journal articles	Number	*STJA*
Research and development (R&D) expenditure as percentage of gross domestic product	%	*RDE*
Manufacturing value added as percentage of gross domestic product	%	*MVA*
Merchandise trade as percentage of gross domestic product	%	*MT*

Here, *RRD* is the researchers in R&D; *RDE* is the R&D expenditure; *STJA* is the scientific and technical journal articles; *MVA* is the manufacturing value added; *MT* is the merchandise trade; *ln* is the natural logarithm of accompanying variables; ¥_0, β_0, θ_0, λ_0, ξ_0, and γ_0 are the constant coefficients; ¥_i, β_i, θ_i, λ_i, ξ_i, and γ_1 are the regression coefficient of independent variables; μ_{ct}, ϕ_{ct}, σ_{ct}, €_{ct}, $\tau_{ct,}$ and η_{ct} are the error terms in Equations (5), (6), (7), (8), (9), and (10), respectively. The explanations of all variables are emphasized in Table 5.

4.4.2. Estimation of regression coefficients and usage of statistical software

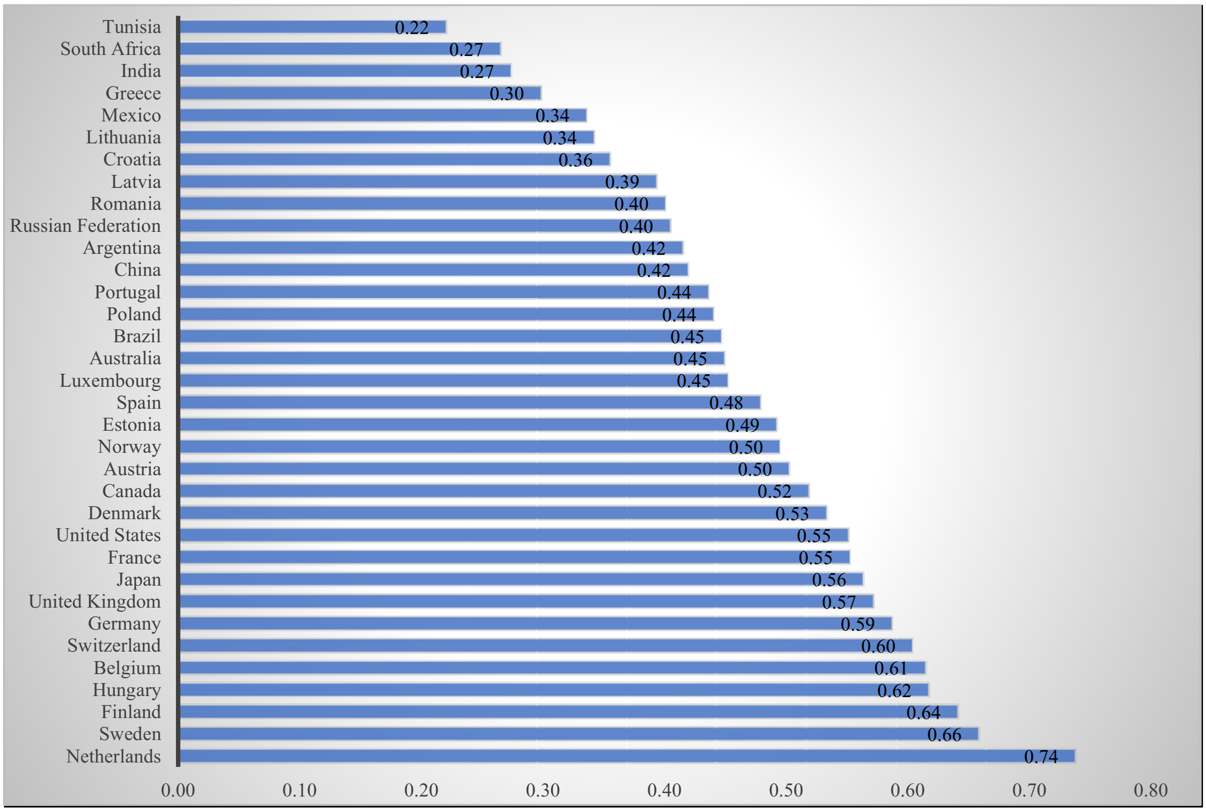
This study comprised *DV*s and *IV*s with certain control variables in panel data from 34 countries between 2000 and 2021. These 34 countries have a significant diversity in ED, SD, ES, and digitalization-associated variables. Therefore, it is expected that panel data have autocorrelation, serial correlation, and heteroskedasticity. Hence, the panel-corrected standard errors estimation model is applied to observe the regression coefficients of *DV*s with *IV*s in the proposed regression equations (Jyoti & Singh, 2023). The descriptive and regression analyses of the data are completed using MS Excel, SPSS, and STATA software.

5. Descriptive and Empirical Results

5.1. Cross-Comparison of across countries in *ICTDI* and *EDI*, *SDI*, *ESI,* and *GSDI*

The cross-comparison of 34 countries in digitalization, ED, SD, ES, and GSD is given in Figures 1, 2, 3, 4, and 5, respectively. The ranking of these countries is assigned as per the estimated mean values of *ICTDI*, *EDI*, *SDI*, *ESI*, and *GSDI* during 2000–2021 (Table 6). There is also reported a high inequality in the stated indicators in the 34 countries. The numerical values of *ICDTI*, *EDI*, *SDI*, *ESI,* and *GSDI* lie between 0.22 and 0.74, 0.33 and 0.64, 0.28 and 0.81, 0.35 and 0.61, and 0.32 – 0.66, respectively, across countries. There is a high degree of dissimilarity in digitalization, ED, SD, ES, and GSD within a country and across countries.

Figure 1
Relative position of selected countries in ICTDI

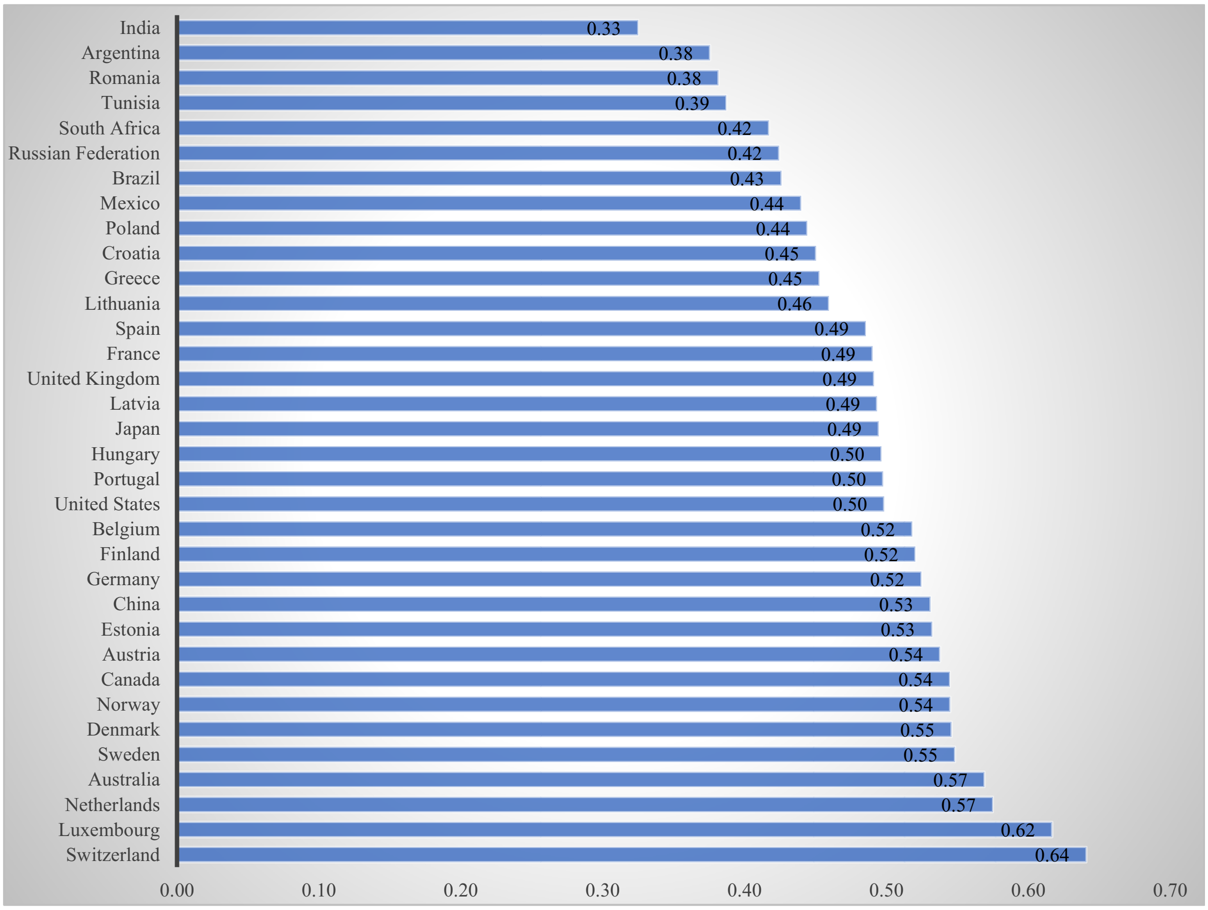


The highest value of *ICTDI* for the Netherlands indicates that this country is in the best position in digitalization. Netherland has highest values of most variables that are used to estimate *ICTDI*. Hence, this country could maintain their best position in digitalization. Sweden, Finland, Hungary, Belgium, Switzerland, Germany, the United Kingdom, Japan, France, the United States, Denmark, Canada, Austria, and Norway are in better positions in digitalization. These countries provided fixed telephone subscription, fixed broadband subscription, and automated teller machine to their people. These countries have low population growth with effective human skills, and better education and technical literacy. Moreover, these countries could increase the trust of people in digitalization as providing secure sources of internet, and digital infrastructure in terms of computers and ICT tools. Also, the group of countries are applying effective measures to control cybercrime to increase the faith of people in digital activities. Therefore, mentioned group of countries have better positions in digitalization. In contrary, Estonia, Spain, Luxembourg, Australia, Brazil, Poland, Portugal, China, Argentina, the Russian Federation, and Romania could not increase their positions in digitalization due to their lower performance in most indicators that are essential to create digital infrastructure. Latvia, Croatia, Lithuania, Mexico, Greece, India, South Africa, and Tunisia have poor performance in digitalization. This group of countries have high illiteracy and low confidence of people in digital activities. These countries also have low numbers of telephone and fixed broadband subscribers. Also, the government have low provision to provide cybersecurity to the people in these countries. Furthermore, the people in these countries are unable to use digital technologies due to low infrastructure in terms of computers, and ICT goods and services. The performance of these countries, therefore, in digitalization is reported average among the 34 countries, while the performance of Tunisia in digitalization is observed to be very poor among the 34 countries.

The highest value of *EDI* for Switzerland shows its best position in ED. Switzerland is a highly industrialized country and it has high per capita income. Consequently, it has significant positions in most variables such as labor force participation rate, total employers, self-employed person, foreign direct investment, consumption expenditure, capital formation, and employment to population ratio. Therefore, Switzerland has a best position in ED. Luxembourg, the Netherlands, Australia, Sweden, Denmark, Norway, Canada, Austria, Estonia, China, Germany, Finland, Belgium, the United States, Portugal, and Hungary have a better position in ED. Most countries in this group have greater values of underlined indicators. Therefore, it is obvious that these countries also have better positions in ED. Japan, Latvia, the United Kingdom, France, Spain, Lithuania, Greece, Croatia, Poland, Mexico, Brazil, the Russian Federation, and South Africa have average positions in ED. Per capita income, employment rate, foreign direct investment, capital formation, and consumption expenditure are the valuable indicators of ED, while Tunisia, Romania, Argentina, and India could not increase per capita income, foreign direct investment, capital formation, and consumption expenditure. Hence, Tunisia, Romania, Argentina, and India have poor positions in ED among the 34 countries.

The *SDI* is the composition of 13 different variables that are significantly linked with SD. As undertaken 34 countries have diversity in 13 variables, thus, it is expected that there seems

Figure 2
Relative position of selected countries in estimated EDI

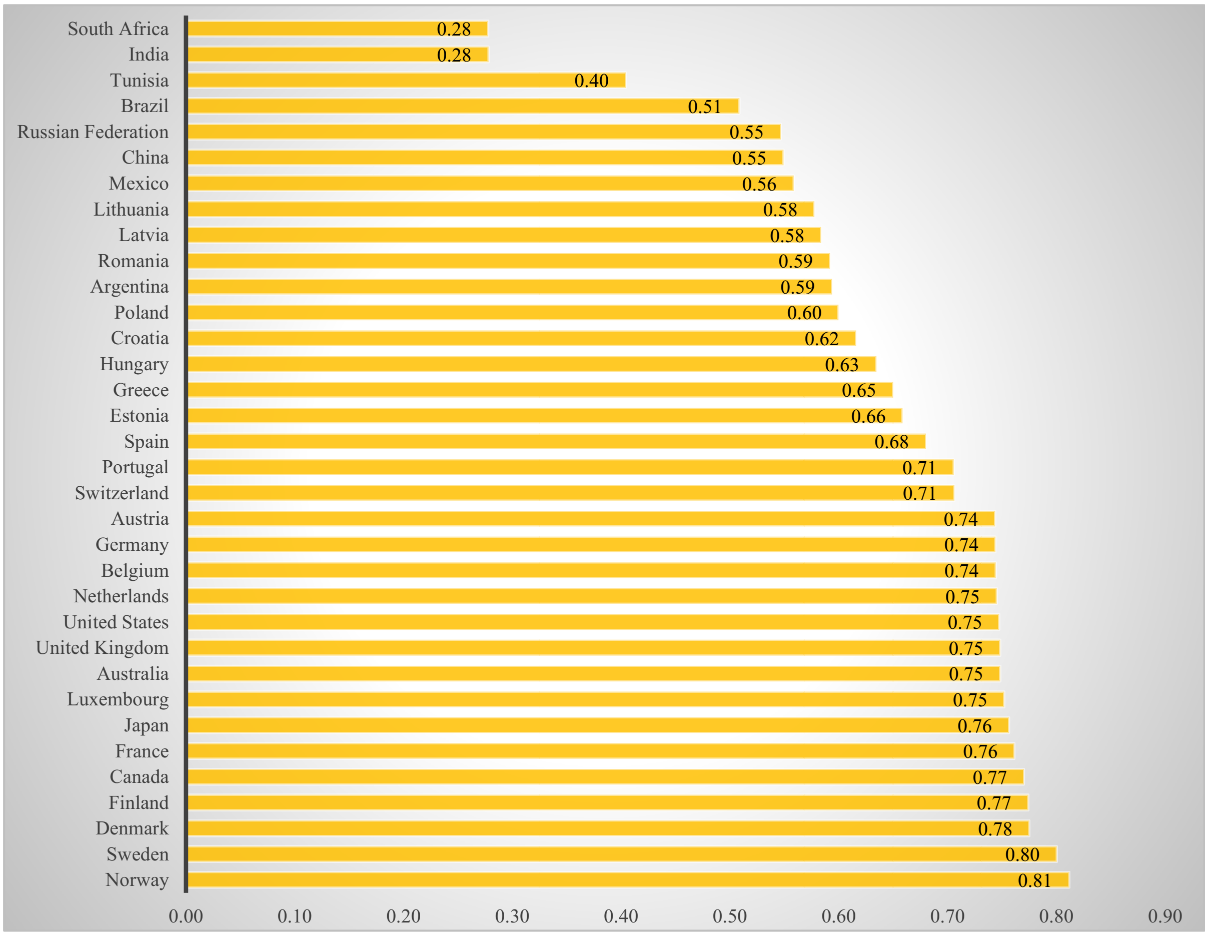


variation in the statistical values of *SDI* across countries. Most countries (except, India, Tunisia, and South Africa) are in a better position in SD due to their good performance in health and education expenditure, per capita energy use, basic sanitation facilities, and women empowerment. These countries could also reduce incidence of tuberculosis and infant mortality rate as providing better medical and health facilities to their people. Food security is also a vital determinant of SD. At present, most countries are also giving proper attention to achieve various goals of SDGs. Hence, most countries created an effective infrastructure to increase SD. The positions of India, Tunisia, and South Africa in SD are found poor due to food insecurity, low per capita income, high inequality, high incidence of tuberculosis, high infant mortality rate, and low sanitation accessibility of large community. These countries could also not reduce high unemployment rate and vulnerable employment. Moreover, India, Tunisia and South Africa could not reduce gender inequalities and develop proper social ecosystem for women. This group of countries also could not increase their position in global food security. Subsequently, India, Tunisia, and South Africa are seemed unable to create an effective ecosystem for SD.

It is universally accepted that extensive ED is caused to reduce environmental development. High ED, therefore, may reduce ES. Therefore, those countries (except a few) having better positions in ED have poor performance in ES. Australia, Denmark, Luxembourg, Argentina, Hungary, Switzerland, the Netherlands, and Belgium have better performance in ED. Accordingly, these countries could not increase their positions in ES. These countries are exploiting extensive quantity of natural resources to maintain the pace in ED. These countries are also fully urbanized and do not have further scope to increase the water, forest, and energy sustainability. Accordingly, these countries are unable to control carbon emissions from various production sectors, while Norway, Finland, Canada, Sweden, Portugal, Estonia, and Austria could maintain their better positions in ED and ES. The group of countries have significant positions in *ES* due to low population growth, low dependency of their population on agricultural sector, and high dependency on renewable sources of energy. These countries are also implementing their policies to be green economy through digitalization and technological advancement. These countries could also provide electricity and basic sanitation facilities to all sectors. Therefore, the above-mentioned countries are having best ecosystem of ES. Accordingly, Norway and Finland have the highest values of *ESI*. Thus, both countries are in the best position in the ES.

Canada, Sweden, Portugal, Estonia, Austria, Croatia, Latvia, Greece, Brazil, Spain, the Russian Federation, Japan, Lithuania, Australia, and Denmark have a better position in ES. Poland, the United States, Germany, Romania, Mexico, Luxembourg, Argentina, Hungary, France, Switzerland, South Africa, the United Kingdom, Tunisia, the Netherlands, Belgium, and China have average performance in ES. The group of countries have

Figure 3
Relative position of selected countries in estimated SDI

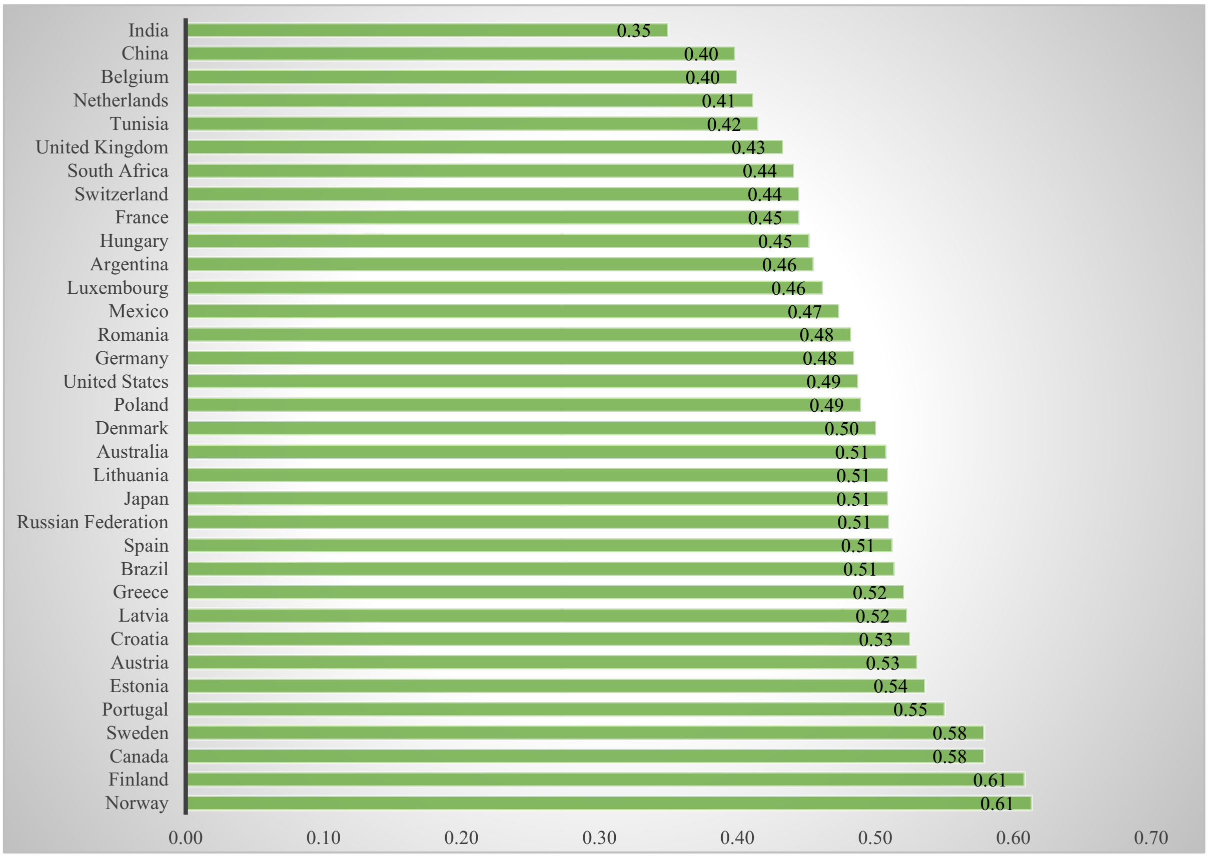


average positions in ES due to their low performance in most variables (i.e., industrialization, urbanization, agricultural growth, fertility rate, etc.) that have significant impact on ES. India is observed as a highly environmentally unsustainable country among the 34 countries. India is unable to increase ES due to high population growth, high dependency of people on agricultural sector, high fertility rate, and low opportunity of renewable sources of energy. India could also not implement appropriate technology in cultivation to increase sustainability in agricultural sector. The agricultural sector is also unable to apply organic farming that has least impact on environment. Thus, India is found most vulnerable country in ES among the 34 countries.

The *GSDI* is the integration of *EDI*, *SDI,* and *ESI*. Hence, those countries having a better position in ED, SD, and ES have significant positions in GSD. Accordingly, Norway has the highest value of *GSDI* and the best position in GSD. Sweden, Finland, Canada, Luxembourg, Australia, Denmark, Austria, Switzerland, Japan, Portugal, Germany, the United States, Netherlands, Estonia, France, Spain, the United Kingdom, Belgium, Greece, Latvia, Croatia, Hungary, Lithuania, and Poland have also better positions in ED, SD, and ES. Accordingly, these countries could achieve better positions in GSD. Russian Federation, China, Mexico, Romania, Brazil, Argentina, and Tunisia have average performance in GSD due to high population growth, high industrialization, and urbanization. Therefore, these countries are using extensive quantity of natural resources to meet the need of rising population, industrialization, and urbanization. Consequently, the performance of the Russian Federation, China, Mexico, Romania, Brazil, Argentina, and Tunisia is reported average in GSD. South Africa and India could not improve their positions in ED, SD, and ES. The positions of South Africa and India in GSD are reported to be poor among the 34 countries. Both countries have poor positions in GSD due to their low performance in most indicators like per capita GDP, low literacy rate, high inflation, gender discrimination, high unemployment rate, vulnerable employment, inappropriate medical facilities, and high mortality rate. Furthermore, the estimates also reveal that there is a high variation in the progress of digitalization, ED, SD, ES, and GSD within an individual country and across countries. For instance, Norway has 15th, 7th, 1st, and 1st positions in *ICTDI*, *EDI*, *SDI*, *ESI*, and *GSDI*, respectively (Table 6).

Sweden has 2nd, 2nd, and 2nd positions in *ICTDI*, *SDI,* and *GSDI*, respectively. Finland has 3rd, 4th, 2nd, and 3rd positions in *ICTDI*, *SDI*, *ESI,* and *GSDI*, respectively. Canada has 5th, 3rd, and 4th positions in *SDI*, *ESI,* and *GSDI*, respectively. Luxembourg has 2nd and 5th positions in *EDI* and *GSDI*, respectively, while most low-ranking countries have the lowest positions in *ICTDI*, *EDI*, *SDI,* and *ESI.* India has 32nd, 34th, 33rd, 34th, and 34th positions in *ICTDI*, *EDI*, *SDI*, *ESI,* and *GSDI*, respectively. India is unable to increase its positions in digitalization, ED, SD, ES, and GSD due to several

Figure 4
Relative position of selected countries in estimated ESI



reasons like low per capita income, low technological development, low technology transfer, low entrepreneurial opportunities, low skills of people, low facilities for people to use digital infrastructure in rural area, low medical facilities, etc. South Africa has 33rd, 30th, 34th, 28th, and 33rd positions in *ICTDI*, *EDI*, *SDI*, *ESI,* and *GSDI*, respectively. Tunisia has 34th, 31st, 32nd, 30th, and 32nd positions in *ICTDI*, *EDI*, *SDI*, *ESI,* and *GSDI*, respectively.

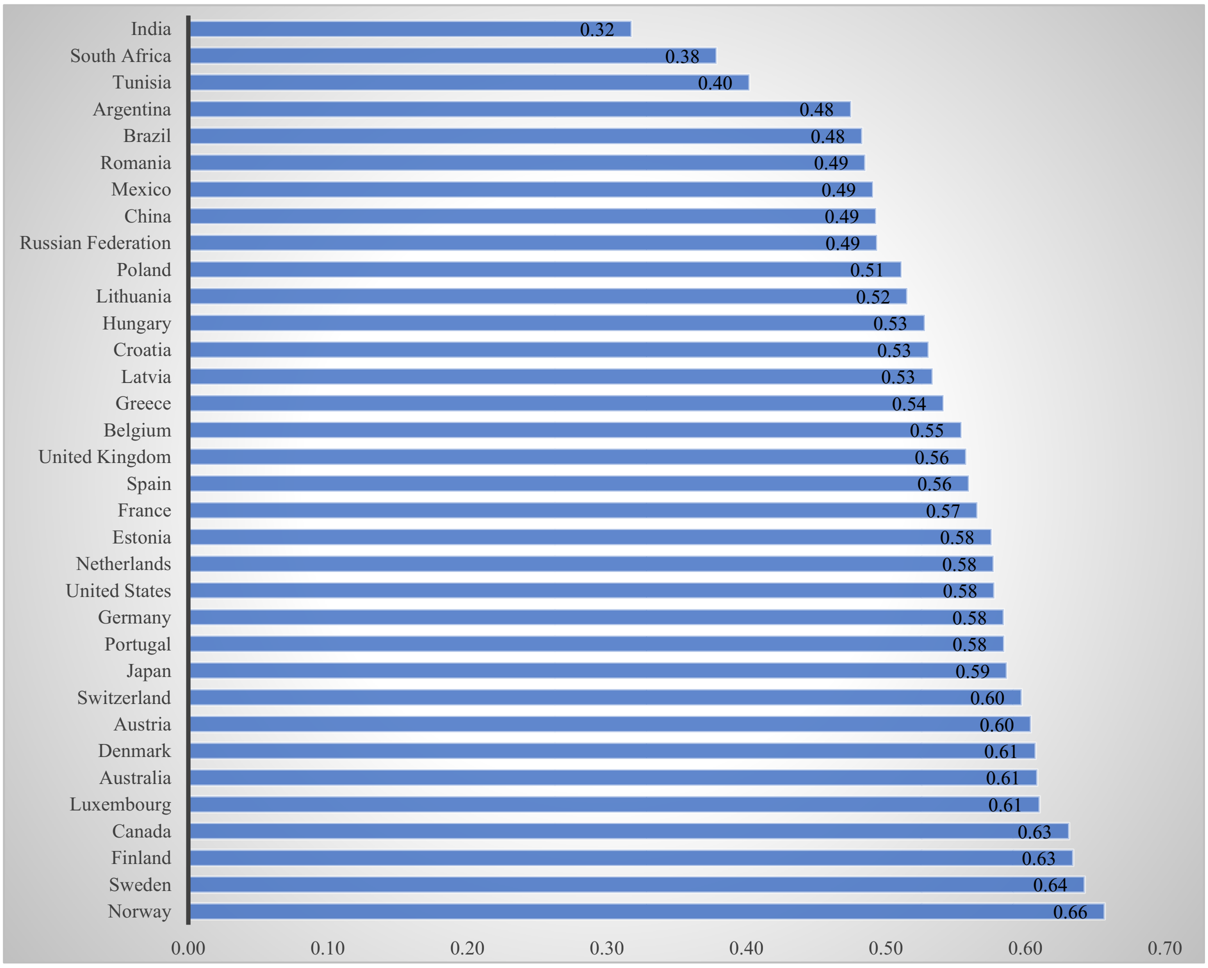
5.2. Statistical properties of dependent and independent variables

Table 7 presents the statistical summary of variables. The estimates indicate that 34 countries have diversity in all variables and estimated indexes, including R&D expenditure, S&T-enhancing variables, and manufacturing value added. The statistical values of the standard deviation (SD) for *ICTDI*, *EDI*, *SDI*, *ESI*, *GSDI,* and *RDE* are found to be less than 1. Also, the statistical values of skewness and kurtosis for most variables indicate that they are in their normal form, while *RRD*, *STJA*, *MVA,* and *MT* are not in a normal form.

5.3. Correlation coefficients of estimated indexes with explanatory variables

The correlation coefficient measures linear dependency or independence among two random variables as per their covariance. Accordingly, the correlation coefficient explains positive or negative association between two variables. The correlation coefficient of *ICTDI* with *EDI*, *SDI*, *ESI*, *GSDI*, *RRD*, *STJA*, *RDE,* and MT is found positive and statistically significant (Table 8). Thus, digitalization is positively correlated with ED, SD, ES, GSD, researchers in R&D, scientific and technical journal articles, R&D expenditure, and merchandise trade. The estimates also infer that digitalization has a significant interconnection with the above-mentioned activities. The correlation coefficient of *EDI* with *ICTDI*, *SDI*, *ESI*, *GSDI*, *RRD*, *RDE,* and *MT* also appeared positive and statistically significant. ED, therefore, is positively associated with digitalization, SD, ES, GSD, and science and technological development (S&TD)-related variables. Further, SD is also positively correlated with digitalization, ED, ES, GSD, and S&TD-related variables. SD, therefore, is expected to be improved as ED, ES, GSD, and S&TD increase. ES is also positively correlated with digitalization, ED, SD, GSD, and S&TD-associated variables, while S&TD-related variables are negatively correlated with ES. It may be due to that S&TD meets the technological needs of manufacturing sector and growth of this sector helps to increase industrial development and ED, while industrial development and ED produce negative impact on ES. Finally, GSD is also positively associated with digitalization, ED, SD, ES, and S&TD-related variables. The global countries should focus to increase ED, SD, ES, and applied green technologies to achieve GSD.

Figure 5
Relative position of selected countries in estimated GSDI



5.4. Regression results

The interdependency of digitalization with GSD and its components (i.e., ED, SD, and ES) is measured in terms of their respective regression coefficients (Table 9). Digitalization is helpful to improve ED, SD, and ES. Therefore, the positive coefficients of *ICTDI* with *GSDI* and vice versa show a positive relationship between digitalization and GSD. Further, it clear that GSD is beneficial to increase digitalization. Most countries, therefore, are taking several initiatives and policy actions to increase GSD and its supportive indicators through digitalization. Accordingly, these countries are promoting the extensive usages of digital technologies, ICT, S&T development, and innovation in production activities. Therefore, it is reasonable that GSD to be conducive to increasing digitalization, social–economic development, and ES, while people use digital technologies and ICT as their economic capacity increases. Also, SD is expected to improve as per capita income increases. Hence, ED and SD show a positive impact on digitalization.

S&TD are essential to creating and discovering digital technologies and ICT that mature a suitable platform for digitalization. Researchers in R&D, R&D expenditure, and scientific and technical journal articles help to enhance S&TD and innovation. These are crucial variables to increase the movement of a country to be digitalized. S&TD-associated variables, therefore, exhibited a positive impact on digitalization. Moreover, the manufacturing sector has a greater dependency on technological advancement and innovation. Thus, manufacturing value added and merchandise trade also increase as S&TD increases. Likewise, the process of digitalization improves as merchandise trade and manufacturing value added increase. The negative coefficient of *ICTDI* and *ESI* infers that digitalization has a negative impact on ES. There are many digital technologies that contribute to GHG emissions in the atmosphere. Hence, digital technologies may be caused to increase environmental degradation. Accordingly, digitalization may show a negative impact on ES. Hence, the scientific research community should develop and invent environmentally friendly technologies for manufacturing sector to increase ES.

Furthermore, S&TD help to develop advanced technologies for industrial and manufacturing sectors. Advanced technologies are also useful to increase production, productivity, and technical efficiency of the manufacturing sector. Accordingly, the manufacturing sector produces innovative goods and services for consumers and increases their production scale in sustainable way. Therefore, S&TD is positive for increasing the industrial development and ED that contribute to GHG emissions in the atmosphere. Hence, S&TD has a negative impact on ES. Therefore, S&TD may not be effective in increasing GSD. The negative coefficients of *GSDI* with *RRD*, *RDE*, *STJA*, *MVA,* and

Table 6
Ranking of countries in estimated indexes

Indicators	*ICTDI*		*EDI*		*SDI*		*ESI*		*GSDI*	
Value/Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Norway	0.50	15	0.54	7	0.81	1	0.61	1	0.66	1
Sweden	0.66	2	0.55	5	0.80	2	0.58	4	0.64	2
Finland	0.64	3	0.52	13	0.77	4	0.61	2	0.63	3
Canada	0.52	13	0.54	8	0.77	5	0.58	3	0.63	4
Luxembourg	0.45	18	0.62	2	0.75	8	0.46	23	0.61	5
Australia	0.45	19	0.57	4	0.75	9	0.51	16	0.61	6
Denmark	0.53	12	0.55	6	0.78	3	0.50	17	0.61	7
Austria	0.50	14	0.54	9	0.74	15	0.53	7	0.60	8
Switzerland	0.60	6	0.64	1	0.71	16	0.44	27	0.60	9
Japan	0.56	9	0.49	18	0.76	7	0.51	14	0.59	10
Portugal	0.44	22	0.50	16	0.71	17	0.55	5	0.58	11
Germany	0.59	7	0.52	12	0.74	14	0.48	20	0.58	12
United States	0.55	11	0.50	15	0.75	11	0.49	19	0.58	13
Netherlands	0.74	1	0.57	3	0.75	12	0.41	31	0.58	14
Estonia	0.49	16	0.53	10	0.66	19	0.54	6	0.58	15
France	0.55	10	0.49	21	0.76	6	0.45	26	0.57	16
Spain	0.48	17	0.49	22	0.68	18	0.51	12	0.56	17
United Kingdom	0.57	8	0.49	20	0.75	10	0.43	29	0.56	18
Belgium	0.61	5	0.52	14	0.74	13	0.40	32	0.55	19
Greece	0.30	31	0.45	24	0.65	20	0.52	10	0.54	20
Latvia	0.39	27	0.49	19	0.58	26	0.52	9	0.53	21
Croatia	0.36	28	0.45	25	0.62	22	0.53	8	0.53	22
Hungary	0.62	4	0.50	17	0.63	21	0.45	25	0.53	23
Lithuania	0.34	29	0.46	23	0.58	27	0.51	15	0.52	24
Poland	0.44	21	0.44	26	0.60	23	0.49	18	0.51	25
Russian Federation	0.40	25	0.42	29	0.55	30	0.51	13	0.49	26
China	0.42	23	0.53	11	0.55	29	0.40	33	0.49	27
Mexico	0.34	30	0.44	27	0.56	28	0.47	22	0.49	28
Romania	0.40	26	0.38	32	0.59	25	0.48	21	0.49	29
Brazil	0.45	20	0.43	28	0.51	31	0.51	11	0.48	30
Argentina	0.42	24	0.38	33	0.59	24	0.46	24	0.48	31
Tunisia	0.22	34	0.39	31	0.40	32	0.42	30	0.40	32
South Africa	0.27	33	0.42	30	0.28	34	0.44	28	0.38	33
India	0.27	32	0.33	34	0.28	33	0.35	34	0.32	34

Table 7
The descriptive statistics of the variables

Variables	Minimum	Maximum	Mean	Std. deviation	Skewness	Kurtosis
ICTDI	0.120	0.810	0.473	0.131	−0.249	−0.371
EDI	0.310	0.700	0.491	0.073	−0.170	−0.055
SDI	0.240	0.850	0.652	0.138	−1.202	0.999
ESI	0.330	0.650	0.490	0.061	−0.004	−0.153
GSDI	0.310	0.680	0.544	0.076	−1.010	0.957
RRD	94.640	8173.950	3129.612	1874.386	0.280	−0.582
STJA	53.720	669744.300	44994.296	86626.161	3.799	15.722
RDE	0.310	3.870	1.605	0.921	0.538	−0.882
MVA	4.550	32.450	14.442	4.757	0.777	1.657
MT	17.200	181.340	64.942	35.887	1.235	1.098

MT indicate that GSD is negatively associated with S&TD-related variables. The estimates, therefore, emphasized that the scientific research community should develop and discover environmentally friendly technologies, appropriate technologies, and green technologies to avoid the adverse impact of S&TD on GSD.

The interdependency of digitalization with explanatory variables is also estimated through their regression coefficients (Table 10). The coefficients of *ICTDI* with *EDI* and *SDI* are appeared positive and statistically significant. It is true that digitalization is effective to increase productivity and efficiency of resources in the production units. Accordingly, digitalization is

Table 8
Correlation coefficients of estimated indexes with control variables

Factors	*ICTDI*	*EDI*	*SDI*	*ESI*	*GSDI*	*RRD*	*STJA*	*RDE*	*MT*
ICTDI	1	0.618^B	0.731^B	0.139^B	0.677^B	0.643^B	0.143^B	0.700^B	0.262^B
EDI	0.618^B	1	0.700^B	0.231^B	0.807^B	0.650^B	0.063^A	0.613^B	0.259^B
SDI	0.731^B	0.700^B	1	0.451^B	0.950^B	0.771^B	0.089^B	0.652^B	0.114^B
ESI	0.139^B	0.231^B	0.450^B	1	0.614^B	0.448^B	−0.196^B	0.223^B	−0.154^B
GSDI	0.677^B	0.807^B	0.950^B	0.614^B	1	0.794^B	0.020	0.650^B	0.112^B
RRD	0.643^B	0.650^B	0.771^B	0.448^B	0.794^B	1	0.026	0.814^B	0.091^B
STJA	0.143^B	0.063^A	0.089^B	−0.196^B	0.020	0.026	1	0.300^B	−0.342^B
RDE	0.700^B	0.613^B	0.652^B	0.223^B	0.650^B	0.814^B	0.300^B	1	−0.024
MT	0.262^B	0.259^B	0.114^B	−0.154^B	0.112^B	00.091^B	−0.342^B	−0.024	1

Note: ^{A} and ^{B} indicate that correlation coefficients are statistically significant at 5% and 1% significance level, respectively.

Table 9
Interdependency of digitalization with GSD and its key components

DVs	*ln*(*ICTDI*)		*ln*(*GSDI*)		*ln*(*ICTDI*)	
Number of obs.	748		748		748	
Number of groups	34		34		34	
R^2	0.6703		0.7752		0.6764	
Wald Chi^2	1181.5*		3721.34*		888.8*	
Prob > Chi^2	0.000		0.000		0.000	
IVs	*Reg. Coef.*	*Std. Err.*	*Reg. Coef.*	*Std. Err.*	*Reg. Coef.*	*Std. Err.*
ln(*ICTDI*)	–	–	0.2031*	0.0148	–	–
ln(*GSDI*)	1.2666*	0.0979	–	–	–	–
ln(*EDI*)	–	–	–	–	0.1136	0.0768
ln(*SDI*)	–	–	–	–	0.7835*	0.0509
ln(*ESI*)	–	–	–	–	−0.3508*	0.038
ln(*RRD*)	0.0109	0.0079	−0.1012*	0.0028		
ln(*RDE*)	0.2145*	0.0201	−0.0590*	0.0171		
ln(*STJA*)	0.0928*	0.0051	−0.0196*	0.0014	–	–
ln(*MVA*)	0.0183	0.0122	−0.0232*	0.0059	–	–
ln(*MT*)	0.1844*	0.0151	−0.0411*	0.0038	–	–
Cons. Coef.	−1.7743*	0.077	−0.8294*	0.0481	−0.2115	0.1742

Table 10
Interdependency of digitalization and with components of GSD

DVs	*ln*(*EDI*)		*ln*(*SDI*)		*ln*(*ESI*)	
Number of obs.	748		748		748	
Number of groups	34		34		34	
R^2	0.5945		0.7918		0.3194	
Wald Chi^2	4473.54		4056.03		3963.96	
Prob > Chi^2	0.000		0.000		0.000	
IVs	*Reg. Coef.*	*Std. Err.*	*Reg. Coef.*	*Std. Err.*	*Reg. Coef.*	*Std. Err.*
ln(*ICTDI*)	0.0336	0.0222	0.3439*	0.0313	−0.1178*	0.0132
ln(*EDI*)	–	–	0.3319*	0.0368	−0.0495**	0.0266
ln(*SDI*)	0.2238*	0.0234	–	–	0.2484*	0.0217
ln(*ESI*)	−0.0437***	0.0235	0.3247*	0.0273	–	–
ln(*RRD*)	0.0213*	0.0051	0.1427*	0.0079	−0.0528*	0.0049
ln(*RDE*)	0.0759*	0.0076	0.0888*	0.0159	−0.0290*	0.0061
Cons. Coef.	−0.8130*	0.0428	−0.7913*	0.0815	−1.1381*	0.0503

Note: *, **, and *** infer that regression coefficients are statistically significant at 1%, 5%, and 10% significance level, respectively, in Tables 9 and 10.

Table 11
Causal association of *DVs* with explanatory variables

IVs	*W*-bar	*Z*-bar	*Z*-bar tilde	*Conclusion*
DV = Information and communication digitalization index (*ICTDI*)				
EDI	0.8639	−0.5610	−0.8683	Rejected H_1
SDI	1.8515	3.5107*	2.4162	Rejected H_1
ESI	1.1549	0.6387	0.0995	Rejected H_1
GSDI	2.3337	5.4989*	4.0200*	Rejected H_0
RRD	3.6392	10.8815*	8.3619*	Rejected H_0
STJA	3.5342	10.4490*	8.0130*	Rejected H_0
MVA	2.1245	4.6364*	3.3242*	Rejected H_0
MT	2.2429	5.1246*	3.7181*	Rejected H_0
DV = Global sustainable development index (*GSDI)*				
ICTDI	2.2779	5.2691*	3.8346*	Rejected H_0
RRD	1.9619	3.9662*	2.7836*	Rejected H_0
STJA	2.8701	7.7104*	5.8039*	Rejected H_0
MVA	2.1989	4.9431*	3.5716*	Rejected H_0
MT	2.5250	6.2878*	4.6563*	Rejected H_0
DV = Economic development index (*EDI)*				
IVs	*W*-bar	*Z*-bar	*Z*-bar tilde	*Conclusion*
ICTDI	3.8133	11.5997*	8.9412*	Rejected H_0
SDI	2.2529	5.1659*	3.7514*	Rejected H_0
ESI	1.4606	1.8992	1.1163	Rejected H_1
RRD	2.7259	7.1160*	5.3244*	Rejected H_0
RDE	3.3578	9.7214*	7.4260*	Rejected H_0
DV = Social development index (*SDI)*				
ICTDI	2.3726	5.6594*	4.1494*	Rejected H_0
EDI	1.7987	3.2933*	2.2408**	Rejected H_0
ESI	1.1448	0.5971	0.0659	Rejected H_1
RRD	1.8934	3.6835*	2.5556***	Rejected H_0
RDE	2.6291	6.7170*	5.0025*	Rejected H_0
DV = Environmental sustainability index (*ESI)*				
ICTDI	2.2927	5.3299*	3.8836*	Rejected H_0
SDI	2.1884	4.8998*	3.5367*	Rejected H_0
EDI	1.4306	1.7755	1.0165	Rejected H_1
RRD	1.5658	2.3327	1.4659	Rejected H_1
RDE	1.5235	2.1585	1.3254	Rejected H_1

Note: * and *** indicate that the regression coefficients are statistically significant at the 1% and 5% level, respectively

productive to increase ED. Also, social communication among the people increases due to increase in digitalization across regions and countries. The empirical results also specify that ED and SD improve as digitalization increases. Further, digitalization and ED have a positive casualty, while the impact of *ICTDI* and *EDI* on *ESI* is reported negative and statistically significant. Hence, ES declines due to increase in digitalization and ED.

Digital technologies and digitalization are helpful to increase social communication, the quality of education, social information, and social justice. Therefore, digitalization is favorable to increasing SD. The positive coefficient of *ICTDI* with *SDI* also infers that SD increases as digitalization increases, while digitalization also increases due to increase in SD. ED and SD also have a bi-directional and positive association with each other. SD and ES also have a bi-directional and positive casualty. Researchers in R&D and R&D expenditure showed a positive impact on ED and SD, while these variables have a negative impact on ES.

5.5. Causal association between dependent variables with independent variables

The presence of causal association among the *DV*s and *IV*s is observed using the Granger casualty test (Pradhan et al., 2022). The estimates imply that GSD, researchers in R&D, scientific and technical journal articles, manufacturing values added, and merchandise trade have a causal association with digitalization (Table 11). Hence, these variables are supportive of increasing digitalization in the future. Accordingly, the stated indicators can be used to predict the position of digitalization for the future. While digitalization and underlined variables have a causal association with GSD, moreover, digitalization, SD, researchers in R&D, and R&D expenditure have a causal association with ED. Hence, the above-mentioned variables are beneficial for the prediction of ED in future. Digitalization, ED, researchers in R&D, and R&D expenditure have a causal relationship with SD, while digitalization and SD have a causal relationship with ES. Hence, this study has found a complex association among the estimated indexes across 34 countries.

6. Discussion

The 34 countries had high diversity in digitalization, ED, SD, ES, and GSD during 2000–2010. The diversity in underlined indicators exists due to variations in various variables that are used to create *ICTDI*, *EDI*, *SDI*, *ESI,* and *GSDI,* while ED is causing environmental degradation (Menyah & Wolde-Rufael, 2010).

Hence, global countries should implement their policies to reduce environmental degradation. Subsequently, ES provides a positive return in the economic, environmental, and social sectors. GSD may be positive due to an increase in ES. The global countries should apply green practices in production sectors to increase economic and SD, and ES in the long term. Digitalization is the fruit of various digital and information technologies used by production sector. Hence, most countries that have a high dependency on digital technologies could maintain their better positions in digitalization.

Digitalization helps to create several possibilities to increase social–economic development (Belyaeva & Lopatkova, 2020; Novikova et al., 2022). For instance, Jyoti and Singh (2023) noticed a positive association between ED and digitalization. Hence, digitalization is positively associated with economic and SD. Vyas-Doorgapersad (2022) also suggested that technological advancement and social–economic development are necessary to achieve various goals of the SDGs. However, high ED may be accountable for increasing environmental degradation. Mukherjee and Chakraborty (2013) also claimed that ES decreases as per capita income increases. Digitalization is also favorable to increasing sustainability in environmental resources. Subsequently, digitalization may be an effective tool for increasing GSD. Novikova et al. (2022) also argued that digitalization prepares a foundation for GSD. For instance, farmers can reduce the negative impact of climate change in the agricultural sector using digital instruments and ICT (Mondejar et al., 2021). Digital technologies are also effective in disseminating climate change-related information among farmers on time. Industries can reduce their dependency on natural resources and ecosystem services using digital technologies.

Producers and consumers can also reduce their physical presence in the market using digital platforms. Hence, digital platform may be beneficial for business community. Accordingly, ES is projected to be increased as digitalization increases. However, it is also perceived that all digital technologies do not have a positive impact on environmental resources. Also, extensive use of digital technologies in the production sector may be harmful for ES. It may be due to the existence of the law of diminishing returns in the production sector. For instance, a specific input provides a positive return up to a certain extent in a production unit. Digitalization is highly effective in creating an online platform for technology and knowledge transfer among a large group of economic agents. Hence, digitalization assists in increasing S&TD and innovation, while S&TD is an appropriate determinant of digitalization. Thereupon, innovation creates a positive atmosphere to increase digitalization (Afonasova et al., 2019). Moreover, the production and growth of the manufacturing sector and merchandise trade depend on technological advancement, innovation, and digitalization. Hence, S&TD has a greater contribution in industrial development, while it is also responsible for environmental degradation (Chen et al., 2023).

7. Conclusion

The descriptive results showed that the selected 34 countries have a diversity in digitalization, ED, SD, ES, and GSD. Further, there exists a high variation in the above-mentioned indicators within a country and across countries. The variation in digitalization, ED, SD, ES, and GSD is due to variability in various factors that are applied to create *ICTDI*, *EDI*, *SDI*, *ESI,* and *GSDI*. Also, the results based on correlation coefficients indicate that digitalization is positively associated with ED, SD, ES, GSD, and S&TD. ED is also positively correlated with digitalization and the mentioned variables. SD and GSD are also positively associated with the stated variables, while ES is positively correlated with ED, SD, GSD, and digitalization. The estimates indicate that digitalization helps to increase GSD and its key components. The empirical findings perceived a multifaceted interconnection between digitalization, ED, SD, ES, and GSD. Digitalization and GSD have a positive causation. Thus, the results infer that digitalization helps to increase GSD, while GSD is found positive for increasing digitalization. Digitalization showed a positive impact on SD and ED, while ED and SD seem supportive of increasing digitalization. SD and digitalization also have positive consequences on ED. There has also been a negative causality between digitalization and ES in 34 countries. Moreover, ED produces a negative impact on ES, and the impact of ES on ED is also observed to be negative. Henceforth, ED and ES have a negative casualty with each other. Digitalization, ED, and SD are expected to be improved as S&TD increases, while extensive industrial development and ED are accountable for increasing environmental degradation (Chen et al., 2023). The scientific research community should invent and discover green, appropriate, and environmentally friendly digital technologies to increase ES and GSD (Ashraf & Singh, 2022).

8. Policy Implications

The following suggestions can be implemented in low-ranking countries to improve their position in respective indicators: GSD is not possible without enlightening its key drivers (i.e., ED, SD, and ES). Therefore, global countries should implement integrated policies to increase all indicators of GSD. Digitalization seems to be useful to increase ED, SD, and GSD while ES is negatively affected due to increase in digitalization. The significances of ED and SD are also perceived as positive in digitalization. Thus, low-positioned countries (e.g., Latvia, Croatia, Lithuania, Mexico, Greece, India, South Africa, and Tunisia) in digitalization must create ICT infrastructure and increase digital literacy (Mondejar et al., 2021). Digital literacy and adequate infrastructure for ICT will promote digitalization (Nipo et al., 2022). Accordingly, this group of countries can increase ED and SD. The low-ranking countries should create ICT infrastructure by increasing internet facilities, internet security, high internet speed, digital devices, and online security. R&D investment and S&TD also nurture digital technologies and favorable platforms for digitalization. Hence, global countries should increase extensive investment in ICT infrastructure to cultivate a platform of digitalization (Rath & Hermawan, 2019). Low-ranking countries in digitalization should also organize regular training for people to increase their usability of digital technologies (Raeskyesa & Lukas, 2019).

ED is indispensable to increasing SD, GSD, and digitalization. Low-positioned countries (i.e., Tunisia, Romania, and India) in ED should adopt demand-driven policies. Demand-driven components will regulate the balance between demand- and supply-side components. Accordingly, it helps to increase consumption, saving, investment, and employment. Further, it would also be positive to increase money supply in the financial market, infrastructural development, foreign direct investment, capital formation, and foreign trade. Demand-driven components would be beneficial to increase the participation of people in social–economic activities. The global countries should also adopt precautionary monetary and fiscal policies to reduce high inflation and unemployment. Extensive job opportunities and green entrepreneurial practices will be positive for ED and ES. SD is also reported as a crucial determinant of digitalization, along with

ED and ES. SD also has a high dependency on digitalization. Accordingly, low-ranking countries in SD should take thoughtful steps to improve their position in it. Equal opportunities for males and females, free education, better health facilities, better livelihood security, equality in financial resources, social justice, inclusive economic growth, women's empowerment, and participation of women in economic sector help increase SD.

The empirical results found a negative impact of digitalization, ED, and S&TD on ES. While ES is a crucial indicator of GSD, it also fosterages numerous possibilities for a sustainable future for society. Therefore, global and national policymakers should give more priority to increasing ES. Highly populated countries (e.g., India and China) should control population growth, urbanization, fertility rate, population density, and diversity in infrastructural development to increase ES. Highly industrialized countries (e.g., USA, China) should apply green technologies in industrial and other sectors to abate GHGs and CO_2 emissions. These countries should also implement conducive policies to protect natural resource for further improvement of ES. Green entrepreneurial activities appear to be supportive of promoting ES (Apostu & Gigauri, 2023; Chen et al., 2023). The global countries should also give more priority to increasing GE and green economies to accomplish ES and GSD (Alwakid et al., 2021; Chandel, 2022; Chen et al., 2023). Largely agriculturally intensive countries (e.g., India, China, and Brazil) should use green fertilizer, green technologies, and appropriate technologies in cultivation to increase ES (Ashraf & Singh, 2022). Usages of appropriate technology in production sector will enhance sustainability of resources and ES. Agriculturally intensive counties should also apply those technologies that minimize the use of ecosystem services in agricultural production activities. Agricultural development agencies should provide regular training to the farmers to increase their awareness toward ES. Providing electricity, clean fuels, and green sources of income to all may be a solution to increasing ES in global countries. Protection of forest areas, renewable electricity, renewable energy, and renewable freshwater resources also promote ES. Furthermore, reducing waste materials from production sectors will increase ES. The government and financial organization should also provide green fund to the business community to increase ES.

9. Limitations of This Study and Scope for Further Research

This study creates *ICTDI*, *EDI*, *SDI,* and *ESI* that are the integration of 13, 13, 13, and 35 variables, respectively, for selected 34 countries during 2000–2021, while *GSDI* is the combination of *EDI*, *SDI,* and *ESI*. Accordingly, it provides several policy suggestions to increase the progress of these countries in the above-mentioned development-related indicators. However, the estimated values of underlined indexes for a specific country are varied due to the inclusion of other variables or dropping any variable in their estimation. Also, the ranking of these countries may be differed as the inclusion of any country in index estimation. Moreover, the values of estimated indexes also depend on a particular method. Thereupon, it used a different set of simultaneous regression equations to examine the inter-casualty among the mentioned indexes and significant control variables. However, it could not include more macro-level variables, which may be effective for reaching a conclusive policy decision. Therefore, the descriptive and empirical findings of this study cannot be generalized worldwide. Thus, the above-mentioned points are considered limitations of this research and helpful for existing researchers to considered more research to check the validity of this research.

The findings of this research perceive a negative impact of digitalization and ED on ES. The impact of S&TD on GSD and ES is reported negative. Therefore, existing researchers can segregate those digital technologies and ICT that have at least adverse impact on ES and GSD. Furthermore, at present, the dependency of most production sectors on digitalization and S&TD has increased. Therefore, the production sector should adopt green technologies and green digital technologies to increase their contribution toward the green economy and GE. Agricultural scientists and researchers can also assess the impact of digital technologies on sustainable agricultural development in further study. Further research can also identify the role of agri-entrepreneurial opportunities in the agricultural sector using digitalization, digital technologies, and ICT. It is difficult to measure the progress of ED, SD, ES, GSD, and digitalization appropriately. Therefore, this study develops an EDI, a SDI, an ESI, a GSDI, and an *ICTDI* to explain the relative performance of 34 countries in the stated indicators. The statistical values of related indexes are considered to explicate the relative progress of these countries in the mentioned indicators. The correlation coefficients among the mentioned indicators are also estimated using Karl Pearson correlation coefficient analysis. The descriptive results highlighted that these countries have a high diversity in digitalization (ED, SD, ES, and GSD). Accordingly, this study attracts the attention of national policymakers in the respective countries to implement effective policies to improve their positions in the above-mentioned indicators. Further scope of research in the area of digitalization and its affecting sectors is also highlighted in this study.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

The data that support the findings of this study are openly available in World Intellectual Property Organization at https://www.wipo.int/portal/en/index.html, in The World Bank at https://databank.worldbank.org/source/world-development-indicators, and in The Organisation for Economic Co-operation and Development at https://data.oecd.org/

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