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The Role of the Digital Economy in Shaping Sustainable Development in Ukraine's Regions

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Abstract:
This article systematically synthesizes empirical evidence on the influence of the numerical economy on the economic, social, and conservational dimensions of supportable progress in Ukraine's regions. The paper aimed to integrate existing findings, identify key determinants of digital transformation effectiveness, and formulate practical policy recommendations at the regional level. The investigation was effectuated by using the PRISMA protocol systematic review, with searches performed in Scopus, Web of Science, SpringerLink, ScienceDirect, Google Scholar, and selected Ukrainian publications from 2019 to 2025. Clear inclusion and exclusion criteria, thematic mapping, and qualitative synthesis were applied, resulting in a final dataset of 25 studies.

The findings indicate that the digital economy generally enhances productivity, entrepreneurial activity, energy efficiency, and the adoption of green innovations, while also expanding social inclusion through digital public services and education. At the same time, persistent disparities remain in access and competencies, with institutional gaps in decentralization, uneven innovation capacities, and asymmetries in restoring critical infrastructure. The most significant determinants of impact include the quality of digital infrastructure and connectivity, population and SME digital literacy, agglomeration and sectoral renewal effects, efficiency of e-services, and the consistency of regulatory and budgetary support. The study proposes a policy package prioritizing broadband and smart networks in rural and war-affected communities, targeted skills programs, incentives for green technologies and R&D, strengthened digital public services, integration of social inclusion and mental health in digital strategies, and alignment of foreign investment with environmental standards.

Keywords: digital transformation; regional disparities; green innovation; social inclusion; post-war recovery.

JEL Classification: O33; Q01; R11; F63; I15; O18.

Introduction

Economic activity based on contemporary information and communication technology networks that generate, transmit, and employ data or information gathered as the main technical means is devoted to as the "digital economy." It encompasses digital infrastructure, e-commerce, digital platforms, data analytics, and ICT driven services. Digital economy has developed into an important agent for the pecuniary progress of many states, transforming how they live and work at an unprecedented pace and transition towards a digital and intelligent future (Wang et al., 2022; Zhang & Ran, 2023; Kobets et al., 2025). Other advantages include technical innovation encouragement, increased effectiveness of resource use, enhanced growth of environmentally and socially conscious companies, reshaped business models, and improve decision-making through accurate data (Kashchena et al., 2023; Omarova, et al., 2025). The digital economy can help attain a better equilibrium amid the economy, society, and milieu, thus advancing sustainable development goals globally (Xie & Zhang, 2024).

In the global economy, the concept of digitalization and digitization is a change agent which has become integrated into the dynamic inclinations of business and society in the extended and petite perspective According to Ojanperä et al. (2019), the uprising in the digital sphere is all-inclusive. It has permeated every segment of the economy, rising above mediocre systems that are traditional powers to transform informative revolution. However, an overall reduction in manufacture, a decrease in job supply, failing commercial circumstances, and declining organisation efficacy have been identified as major reasons for economic decline in several contexts (Smerichevskyi et al., 2021). Additionally, the global economic downturn has deepened inequalities in Ukraine, where external debt, weak innovation, conflict, and declining exports have created a poor investment climate compared to other EU nations. Addressing these challenges requires not just growth in scale but also qualitative improvements in technology adoption, diversification, and living standards to reduce disparities (Vdovichen & Vdovichena, 2020). This makes the transition toward digital technologies not merely optional but essential, as they provide innovative solutions to mitigate these structural weaknesses and create more resilient economies.

This development emphasizes how the move from traditional to digital systems represents a systemic economic shift rather than just a technical trend. Also, the rising interest and acceptance of digitalization is an aspect of the economy-introduced sectors committed to digitalization in the economy. The concept of digitalization and digitization are derivatives of fast-paced globalization, in which digitalization involves applying or adopting digital technologies while digitization entails converting information to digital form (OECD, 2020).

By incorporating digital technologies, creativity is created, economic output is improved, and modern avenue for attaining sustainable development enhanced. Its roles in economic, social, and environmental areas of any country cannot be over emphasized through supportive green technology usage and maximizing natural resources that donate to financial growth and sustainable development (Bernykov et al., 2025; Daud & Ahmad, 2023; Myovella et al., 2020). Furthermore, Zhang and Dong (2023) noted that a sensible distribution of resources is ensured by the development of the numerical budget, that as well increases labour provision competence, money provision efficacy, and entire issue output.

These developments enhance energy efficiency, lower carbon footprints, and aid in mitigation and adaptation plans for climate change. Additionally, digitization contributes to the gathering and analysis of environmental data, bolstering evidence-based policymaking. According to Liu et al. (2023) and Ding et al. (2022), the numerical economy has the potential to upgrade industrial structure and optimize quality in the manufacturing sector.

Digitalization has significantly contributed to economic development by increasing productivity and facilitating innovation across sectors (Tiurina et al., 2022; Nazarova et al., 2024; Elfaki & Ahmed, 2024). Bodrov et al. (2023) note that digitalization is a key factor in the development of the national smart economy.

Among other things, digital economy affects production, labour markets, wages, and inflation (Ahmed and Elfaki, 2023). This shift has become the driving force to the global economy, promoting transformative changes and creating new forms of economic and social progress (Li & Piachaud, 2019). Through digital economy, SMEs may now participate more actively in global markets for inclusive economic growth (Denicolai et al., 2021; Tazhibekova & Shametova (2025). In addition, digitalization enhances social inclusion through media like equal access to education and healthcare facilities, especially in rural regions, thereby reducing urban-rural disparities and empowering rural communities and recognizing local potentials (Sommer et al., 2025; Cherep & Sarbej, 2023).

The global pandemic enhanced numerical revolution globally and revealed vulnerabilities in human capital development. In the case of Ukraine, 59% of managers prioritized human capital investment, opposing the global trend of 67% focusing on technology, which emphasizes the significance of intellectual capital for enterprise resilience and economic security. In the Society 5.0 era, combining intellectual and human capital with information systems is crucial for economic sustainability (Mishchuk et al., 2022).

Furthermore, lowering inequality requires the political and socioeconomic inclusion of all citizens, regardless of their age, gender, race, background, conviction, income level, or any other status. Particularly in difficult-to-reach areas, digital technologies guarantee such participation regions such as islands, mountains, etc. (Deineko et al., 2022). Recently, as observed by Moris (2021), rustic numerical technologies and platforms are progressively being joined into many societal performs in rural life expectancy, counting distant working, online shop, and numerical health services. According to Tim et al. (2021), this shift has been reinforced by the emergence of the COVID-19 pandemic, contributing to compensation for (some) comparatively disadvantaged locations. Apart from the fact that it drives economic growth, it enables broader sustainability goals like social and environmentally sustainable development which makes it a crucial area of interest, particularly in regions like Ukraine, where sustainability goals meet with structural changes, decentralization, and technology advancements.

Over the past decade, Ukraine's digital evolution has accelerated due to regional gaps, increased technological adoption, and economic and political changes. As the Sustainable Development Goals for 2030 are announced, Ukraine and other European nations are adapting their policies (Deineko et al., 2022; Kozlovskyi et al., 2021). The COVID-19 pandemic has not only intensified this process but also highlighted spatial disparities and the need for sustainable development goals. Since Ukraine experiences serious wartime ecological destruction and harmonizes its environmental laws with EU laws, the digital economy offers the means to ensure the circulation of pollution, identify environmental offenses, conduct transnational investigations, and introduce ecological reporting in an open manner (Oderiy et al., 2024).

Digital technology innovation boosts productivity, reduces costs, and fosters global business models. Ukraine's IT sector contributed 2% of GDP from 2020-2021, rising to 4.5% in 2022. Despite war and infrastructure disruptions, IT sector's substantial foreign exchange earnings benefit Ukraine's economy (Kyiv Global Government Technology Center, 2025). The sector primarily sells facilities to corporations recorded in the USA ($2.4 billion in 2024), the United Kingdom ($0.6 billion) and Malta ($0.5 billion), Cyprus, Israel, Switzerland, and Germany. The IT industry contributes about UAH 20 billion ($0.5 billion) in taxes to the budget to each year from these revenues (Kyiv Global Government Technology Center, 2025).

Furthermore, the All-Ukrainian Online School (2025), flung in 2020 as a temporary solution to COVID-19 institute closings, has changed into a lasting tactical resolution for Ukraine's instruction organisation. The integration of Information and Communication Technologies (ICT) is now essential for teaching and assessment, with e-learning significantly enhancing access to education and e-assessment proving crucial for evaluating student performance, especially in large classes (Shalatska et al., 2020). Similarly, in tertiary education, integration of AI can streamline assessment, personalize learning, and strengthen research processes, thereby fostering fairness, innovation, and improved outcomes (Kobets et al., 2025). The pandemic highlighted the necessity of these approaches, solidifying their role in maintaining educational continuity. During the Russian invasion in 2022, AOS became a vivacious fragment of state digital infrastructure, safeguarding endurance, fairness, and pliability in schooling. Formally permitted by the Ministry of Education, AOS has touched over 900,000 recorded users counting more than 50,000 new users in Q1 of 2025 alone (AOS, 2025; Vasina et al., 2024). The platform lasts to reveal solid appointment and constancy throughout war period, building faith both in Ukraine and amid the world-wide Ukrainian diaspora (Vasina et al., 2024).

Despite, regional differences still exist in Ukraine despite the significant role of digitalization. These divide results in unequal access to digital infrastructure, digital literacy, and differing capacities to achieve sustainable environment (Deineko et al., 2022). Although the digital economy is popularly known as a catalyst for sustainable development, existing research tends to examine its economic, social, or environmental impacts in isolation (Adamyk et al., 2025; Liutak & Baula, 2024). The systematic literature review is a systematic process that systematically map existing documents, identifying trends and gaps, and synthesizing these documents to produce findings (Tsekhmister, 2024). A systematic review is useful because of the study's intricate, multidisciplinary nature (monetary, public, and conservational extents of sustainability) across multiple geographic variety.

While several studies have examined the influence of the numerical economy on supportable advance in different regions globally, including some in Ukraine, these efforts are scanty. Initial exploration conducted on some selected databases indicate no current and comprehensive systematic review specifically focused on how digital transformation impacts the sustainable development of Ukraine’s region. Hence, the study. To attain the stated objective for this study, three questions were raised:

Q1: How does the digital economy contribute to the economic, social, and environmental sustainability of Ukraine’s regions?

Q2: What are the main issues manipulating the efficiency of numerical revolution in regional sustainable development?

Q3: What policy recommendations can be derived from existing research to improve the role of the numerical economy in regional sustainability?

Answering the above questions provide vital findings on influence of numerical transformation on a country’s maintainable growth across Ukraine's diverse regions. Additionally, the study's evidence-based findings are essential to making informed and strategic policies in this era of digital and economic transformation in Ukraine. The study highlights key areas where targeted policy interventions can best bring desirable results regarding infrastructure development, digital literacy equity, and environmental innovation.

For business leaders and investors, the study identifies the influence of numerical tools on both small and medium-sized enterprises (SMEs), which are important to the regional digital economies. The paper adds to the body of knowledge already available on the digital economy while extending the empirical data and theoretical foundation. The reviews fill the literature gap by providing a comprehensive analysis of the impact of digitalisation on the economic, social, and environmental aspects of sustainability in a transition economy and technological advancement in Ukraine.

1. Literature Review

1.1. Conceptual Review

Digital Economy

Digital economy covers economic actions and influences that are enabled by the use of numerical technology (Raihan, 2024). The approval experienced a distinguished increase in the 2010s; yet, its beginning can be drawing posterior to the arrival of the cyberspace and the spread of individual computers during the 1980s (Begazo et al., 2023). Corejova & Chinoracky (2021), in arrangement with Laitsou et al. (2020), discoursed that the numerical economy could be articulated as an instrument of economic development growth, a section of maintainable growth. The numerical economy has numerous qualities that is dissimilar from outmoded economies. The numerical economy displays a distinguished grade of linking and mutuality enabled by networks and digital platforms (Cha et al., 2023). The numerical economy has many benefits that can donate to the improvement of economic growing, revolution, and growth. When the digital economy is developed, there will be a transformation from the consummation of the resource economy to the creation of a resource economy (Skliarov & Prokopov, 2019). The thorough development of the digital economy within the region provides for the momentum of spatial growth, and it also contributes to growth in nearby regions to achieve overall regional growth and sustainable development (Jiao & Sun, 2021; Ushenko et al., 2023).

Sustainable Development

The term “development” is a wide range of tactics used to change the socioeconomic and environmental conditions from their current to their ideal levels (Raihan, 2024). Sustainability is a popular concept from far back because of the rise in consciousness and anxiety about climate shift, loss of biodiversity, and social disparity which are major environmental challenges (Raihan, 2023). Popularized by the United Nations 2030 Agenda for Sustainable Development, Breuer et al. (2023) state that, to achieve sustainable development agenda, strong emphasis on addressing three important areas: the environment, society, and economy is vital.

Sustainable development on the other hand, is an integrated approach where contribution of entities, clusters, governments, civic and governments at specific, local, regional, national and global levels, social media to attain maintainable aims (Balaswamy & Palvai, 2017; Sheikh & Serhan, 2022). Maintainable growth pursues to remove scarcity, inexperience, and backwardness and increase consciousness to human civil liberties, women and children's rights, democracy, social development, and the propensity for natural resources continuance. In count, it pursues to rise the persons’ living standard; increase their profits through work prospects; improve their instruction, health, and accommodation. According to Tian et al. (2024), sustainable development entails sustainable economic growth, environmental preservation, and effective resource utilization necessary to balance now and the future.

Regional Sustainability

Comprehensive community development on a specific territory is typically referred to as a region's development whether social, economic, or environmentally. Applying sustainable development principles at the subnational or regional level while incorporating social cohesiveness, economic competitiveness, environmental stewardship, and local system resilience is known as regional sustainability (Jovovic et al., 2017). It supports policies that strive to balance growth and innovation across regions while acknowledging spatial differences. This idea promotes localized solutions that are suited to the particular traits and difficulties of each region by highlighting the connections between the environmental, social, and economic systems within certain geographic locations.

Furthermore, maintainable regional development is on the connections between local and global sustainable equilibrium and economic development, the variations and transformations of the forces that drive regional sustainability at various scales, and the differences in regional development modes (Liu & Zhou, 2020). By addressing regional imbalances, increasing competitiveness, and promoting sustainable development, regional sustainability actually entails promoting economic growth, social integration, and environmental preservation.

Policymakers can more successfully handle problems like urban sprawl, poverty, and environmental concerns by taking a regional strategy. This will encourage social justice and economic competitiveness by coordinating efforts across locales (Liu et al., 2023).

The triple bottom line is a principle incorporating sustainable development, environmental integrity, economic prosperity, and social equity (Elkington, 1994, 1998, 2018). According to George et al. (2016), digitalization greatly affects organizations and a key player in promoting sustainability. Accordingly, companies cannot only concentrate on economic value but also consider the environmental and social value that they may contribute to or destroy (Elkington, 2004; Gao & Bansal, 2013) since they must implement the triple bottom line principles to meet sustainable development requirements (Bansal, 2005; Bansal & Song, 2017). Accordingly, "leaders must concurrently address widely disparate but interrelated considerations for the natural environment, social welfare, and economic prosperity" in order to achieve corporate sustainability (Hahn et al., 2014). It has been demonstrated that implementing sustainable business practices increases resilience and provides long-term benefits for companies (Amui et al., 2017; Ortiz-de-Mandojana & Bansal, 2016). Bansal (2005) expanded the concepts to sustainable corporate development at the firm level, including corporate managing the environment, corporate social responsibility, and economic growth through value creation**.** Through Triple Bottom Line principle, inclusive, resilient, and ecologically conscious regional system can be assessed.

1.2. Empirical Review

Zubchyk & Kireev (2019) assessed the prospective growth of the numerical economy using Ukraine as a study. Developing a numerical economy is perceived as a means of societal development, requiring academic and professional attention. The paper emphasized the impact of digital and communiqué technologies on production, information dissemination and domestic use. Also, it is established that macroeconomic factors determine the pace of development in a digital economy.

Ivanova (2024) evaluates Ukraine's preparedness for an interrelated economy by applying a digital economy to achieve SDGs. The findings reveal that Ukraine achieved remarkable progress as a result of digital transformation. It is concluded that despite Ukraine's progress in network economy integration, notable efforts are needed to surmount imminent barriers.

Zhumabekova & Mukanov (2025) analyses how the implementation of the smart governance and sustainable financing mechanism affects the sustainable development of Kazakhstan. The results reveal that appealing to retain investment in green infrastructure with the help of financial tools is due to intelligent governance.

Moussa et al. (2024) examined the numerical economy's influence on maintainable growth throughout global economic calamities, pandemics and war. The dataset from 1990 through 2022 was assessed for 25 developing and 28 developed countries to establish a nexus between environmental indicators and the numerical economy. The outcomes show that the numerical economy contributes significantly to maintainable growth. An et al. (2024) investigated the interplay of sustainable development level, digital economy and green innovation using data from 268 cities in China from 2011 through 2020. Findings expose that the numerical economy has a noteworthy influence on maintainable growth.

Ma et al. (2024) empirically studied how the digital economy influences sustainable development in China. Cobb-Douglas functions to explore the relationship between the digital economy, clustering of industries and sustainable development. Data collected from 30 Chinese districts between 2015 and 2021 was analysed. Findings reveal a notable positive influence of the digital economy on maintainable growth.

According to earlier research, technological advancement is one of the most important elements in promoting entrepreneurship (Afawubo & Noglo, 2021), since digitalization is essential for the creation of business concepts. Digital technology gives entrepreneurs the chance to introduce new businesses and inspire creative entrepreneurial endeavours (Del Giudice & Straub, 2011; Afawubo & Noglo, 2021). Definitely, digital technologies enable entrepreneurs to gain timely and valuable market insights, enhance their ability to adapt to environmental changes (Luo et al., 2012; Tymoshenko et al., 2023), lower transaction and communication costs [36], expand their

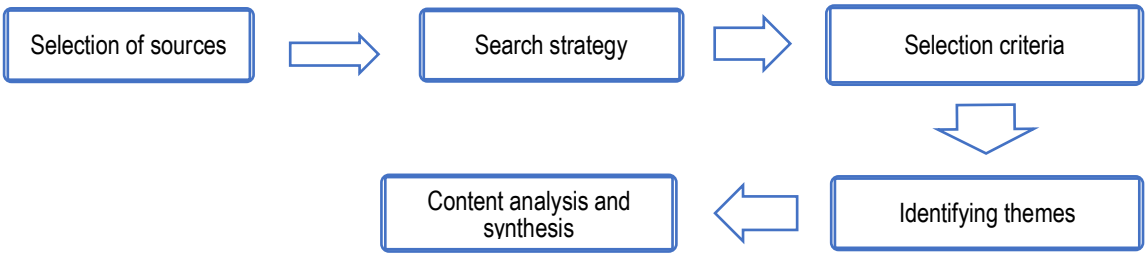
market reach, foster global exchanges (Niebel, 2018), and lower institutional, organizational, and cultural barriers (Davidsson et al., 2020). Davidsson et al. (2020) highlight those technological advancements like artificial intelligence influence entrepreneurial activity, encourage ecosystem operations, and facilitate virtual meetings and socialization during the COVID-19 pandemic (Ferraris et al., 2020; Bouncken & Kraus, 2022).

2. Research Methodology

To investigate and compile pertinent information that addresses the research topic in this paper, a systematic review was used. Finding, evaluating, and synthesizing pertinent evidence linked to the intended paper topic in order to produce responses that are substantiated by evidence is the goal of a systematic review (Higgins et al., 2022). Considering a variety of information sources, including the difficulties presented by digital transformation, this approach was selected because it strikes a balance between offering a thorough examination of the rapport amid numerical technologies, social, economic, and environmental sustainability, as well as identifying and analysing patterns and trends (Snyder, 2019).

The main process consists of five different stages: selection of sources, search strategy, selection criteria, identifying themes, and content analysis and synthesis. The process is shown in Figure 1.

Figure 1. The process of the systematic review



Source: author's development

Getting a complete grasp of the acquaintances amid numerical transformation and social, economic, and environmental sustainability was the aim of the literature search. A full exploration was led on some reliable theoretical records, counting Google Scholar, Elsevier's Scopus, Web of Science, SpringerLink, and ScienceDirect, because of their wide assemblages of peer-reviewed periodical papers, conference documents, and reports. Also, relevant article of interest was search in local academic publications from Ukraine. This method guaranteed a comprehensive and reliable corpus of works concerning both theoretical and business viewpoints.

Terms or key words from appropriate source material were used to create an exploration approach that considers all applicable periodicals from 2021-2025 (Goel et al., 2024). All of the databases that were chosen were thoroughly searched utilising a grouping of key words and Boolean operators (Ugwu & Opah, 2023). Keywords like “digital innovation,” OR “digital technology” OR “technology integration”, AND “digital economy” OR “economic growth” OR “economic impact” OR “economic sustainability” AND “social impact” OR “socioeconomic sustainability” AND “environmental impact” OR “environmental sustainability” OR “Sustainable development”, AND “regional development”, OR “digital divide” AND “Ukraine” OR “Ukraine’s region”. This iterative process made it possible to thoroughly review the literature and capture the variety of articles.

The titles and abstracts of every article that was found after the first search were evaluated for relevance to the study's objective. The topic of an article was eliminated if it deviated considerably from the study's main issues, which were sustainability, social, economic, and environmental implications, or digital innovation. Articles that met the qualifying and disqualifying criteria were selected for evaluation, as Table 1 and Table 2 show us. The quality of the chosen material was carefully evaluated as shown in Figure 2. Following thorough search, 25 scientific publications were chosen using the most recent PRISMA procedure (refer to Figure 3).

Table 1. Inclusion criteria

Criteria	Include
Publication Years	Studies published between 2019 and 2025
Geographical Focus	Studies done all across the world, specifically in Central Asia, Europe, Ukraine, and similar settings
Language	Articles published in English
Study Type	Empirical studies (quantitative, qualitative, or mixed methods)
Availability	Full-text articles are available and accessible online
Focus Area	Studies addressing one or more aspects of economic, social, or environmental sustainability in the context of the digital economy

Source: author's development

Table 2. Exclusion criteria

Criteria	Exclude
Publication Years	Studies published before year 2019
Geographical Focus	Studies with no geographical location
Language	Articles not published in English
Study Type	Studies with a purely theoretical or conceptual focus
Availability	Full-text articles are available and accessible online
Focus Area	Studies not related to digital economy, digital innovation, digital transformation or sustainability

Source: author's development

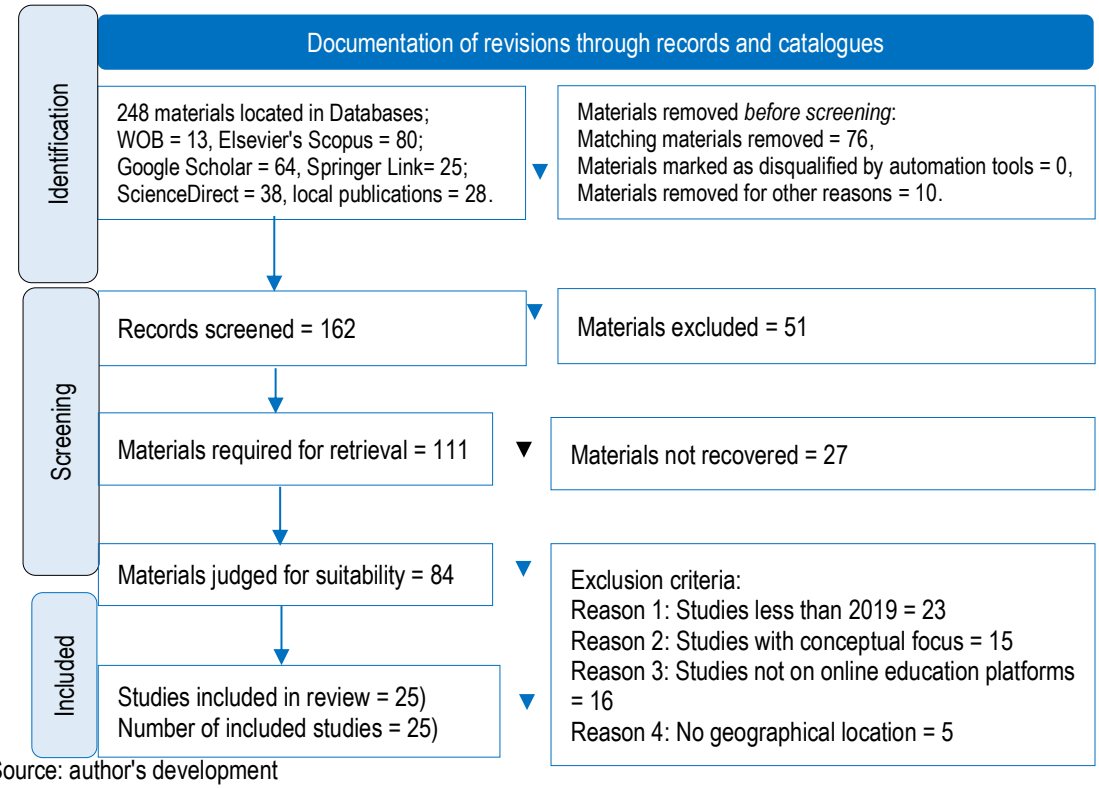
Figure 2. Criteria for documents selection

Source: author's development

Figure 3 illustrates the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart applied in the present study to ensure transparency and methodological rigor in the selection of relevant literature. The process begins with the identification stage, during which potentially relevant studies were retrieved through systematic searches of academic databases, records, and catalogues.

In the screening stage, duplicate records were removed, and the remaining studies were screened based on titles and abstracts to assess their relevance to the research objectives. Studies that did not meet the predefined inclusion criteria were excluded at this stage. The eligibility stage involved a full-text assessment of the remaining articles to determine their suitability for inclusion. At this step, studies were excluded due to reasons such as lack of relevance to the research scope, insufficient methodological quality, or incomplete data. Finally, the included stage presents the studies that met all inclusion criteria and were retained for qualitative and/or quantitative synthesis. This structured approach enhances the reliability and reproducibility of the review process by clearly documenting each phase of study selection.

Figure 3. Studies PRISMA flowchart



Source: author's development

The name of author of the article, year, study design, and findings were among the details the study independently collected as part of the data extraction process. A thematic study was laboured to synthesize the information.

Digital economy refers to the digital preparedness to utilize and incorporate digital tools. There are three dimensions of the digital economy index (DEI) that are (1) digital infrastructure and connectivity (e.g. internet rate and subscription, investment in ICT etc.), (2) digital skills and human capital (e.g. digital literacy, digital competence workforce), (3) digital application and use (industry 4.0 adoption etc.). In addition, the research defined sustainability index through 3 major indicators Economic sustainability (infrastructure development, economic recovery etc), Social sustainability (social inclusion indicators etc), and Environmental sustainability (green innovation, resource efficiency, circular economy etc). The Principal Component Analysis (PCA) method was applied to shrink a group of correlated indicators to a smaller group of unobserved components which captures most of the variance. Moreover, the study took a fixed effect panel model that allowed it to adjust the regional heterogeneity and time-specific effects. A fixed model structure is a straightforward demonstration of the direct impact of the use of digital economy on the sustainability outcomes.

In order to measure the impact of the digital economy on the economic, environmental, and social sustainability outcomes, a scoring framework based on pillars was created. A normalized score (0-1) of the three pillars of sustainability based on empirical evidence of the connection between digitization and (i) Total Factor Productivity and entrepreneurial activity, (ii) energy/resource efficiency and de-materialization and (iii) inequality, labour market skills, and access to digital public services were assigned to each study. The panel regression models for the study were designed as;

$$ESI_{it} = \beta_0 + \beta_1(DIC_{it}) + \beta_2(DSHC_{it}) + \beta_3\,(DAU_{it}) + \alpha_i + \gamma_t + \varepsilon_{it} \quad (1)$$

$$SSI_{it} = \beta_0 + \beta_1(DIC_{it}) + \beta_2(DSHC_{it}) + \beta_3\,(DAU_{it}) + \alpha_i + \gamma_t + \varepsilon_{it} \quad (2)$$

$$EVSI_{it} = \beta_0 + \beta_1(DIC_{it}) + \beta_2(DSHC_{it}) + \beta_3\,(DAU_{it}) + \alpha_i + \gamma_t + \varepsilon_{it} \quad (3)$$

where: ESI = Economic sustainability index, SSI = social sustainability index, EVSI = Environmental sustainability index, DEI = Digital economy index, SI= Sustainability index, DIC = Digital infrastructure and connectivity, DSHC = Digital skills and human capital, DAU = Digital application and use, β = Beta weight, i = Region, t = Year, αi = Region-specific fixed effect, controlling for time, γt = Time-specific fixed effect, controlling for year, εit = Error.

3. Results and Discussion

Table 3 presents the characteristics and key findings of the studies included after the PRISMA screening and eligibility assessment. The table summarizes essential information for each included study, namely the authors, geographical context, methodological design, and principal results, thereby supporting transparency and reproducibility of the systematic review process.

The included studies cover a wide geographical distribution, encompassing EU Member States, China, Ukraine, Southeast Asia, and other global regions, which reflects the global scope of the evidence base identified through the systematic search. In line with PRISMA reporting standards, the table highlights the heterogeneity of methodologies, including panel data analyses, surveys, mixed-method designs, scenario analyses, bibliometric reviews, and qualitative case studies.

The synthesis of findings indicates that digitalization and the digital economy are predominantly associated with positive outcomes in economic growth, productivity, sustainability, and regional development, although effect sizes and directions vary across contexts. Several studies identify mediating and moderating factors, such as human capital, institutional quality, innovation capacity, and governance structures, while others report persistent challenges related to digital divides, regional inequalities, and uneven access to digital infrastructure. Overall, Table 3 supports the qualitative synthesis by systematically mapping the scope, methodological diversity, and thematic convergence of the included studies, providing the empirical foundation for the discussion of patterns, inconsistencies, and research gaps identified in this PRISMA-based systematic review.

Table 3. An overview of studies selected for systematic review

S/N	Author(s)	Location	Methodology	Key Findings
1	Dabbous et al., 2024	Global	Panel Data Analysis, (34 countries 2015-2018)	Digitalization has a good effect on sustainable competitiveness and entrepreneurial activity. Digital skills and public services are less important drivers of sustainable competitiveness than connectivity, Internet use, and digital integration. promotes laws that support digital infrastructure and new business ventures.
2	Yang et al., 2024	China	Dealing outcome type and facilitating effect model using survey information as of 2,825 grain farmers	Involvement in the numerical economy meaningfully indorses farmers' approval of ecological agricultural technologies (EATs). Numerical manufacture, numerical auctions, and numerical investment all positively influence adoption. Mechanisms include augmented request for agrarian equipment, better info accessibility, and

S/N	Author(s)	Location	Methodology	Key Findings
			(2020 China Rural Revitalization Survey)	enhanced sustenance security alertness. Effects are stronger amongst agriculturalists with advanced numerical literateness and greater property scale.
3	Barbara et al., 2021	Austria	Multi-method empirical study: media analysis + two experimental studies	Perceptions of the relationship between digitalization and sustainability vary by dimension: ecological and economic sustainability perceptions are influenced by digitalization extent, but social sustainability is less affected. Findings highlight the need to consider social sustainability separately. The way actors perceive these links influences their responses and decisions, with practical implications for managers and policymakers.
4	Ma et al., 2023	China	Panel data analysis of 30 provinces (2015–2021), using Cobb-Douglas production function, time-fixed effects model, mediation effect model, Shapley Additive Explanations	The numerical economy meaningfully indorses maintainable growth in China. Industrial agglomeration mediates this effect with an upturned U-shaped association amid numerical economy and agglomeration. The positive impact is stronger in eastern and western regions than in north-eastern and central regions. Specialized agglomeration enhances sustainable development more than diversified agglomeration.
5	Hnatkovych et al., 2023	Ukraine	Normative-legal analysis, statistical data assessment, comparative analysis with European decentralization experience	The Ukrainian decentralization model is imperfect with management shortcomings at the regional level. The study identifies key regional development problems and proposes management improvements drawing on European experience. Strategic planning plays a vital role. Recommendations focus on authorised, official, structural, and technical reforms for regional development management in Ukraine.
6	Lauer e al., 2025	Global	Scenario analysis using neo-Gramscian and functionalist frameworks, combined with sustainability modelling	Developed six Fast Sustainability Transitions (FST) scenarios outlining diverse pathways for rapid societal transitions toward sustainability, emphasizing structural politico-economic changes alongside technological shifts. Scenarios reveal opportunities and obstacles for timely sustainability transformations, highlighting the need to bridge policy and quantitative modelling. Critiques the feasibility of 'green growth' and explores alternatives like post-growth and ecocentric economies.
7	Toșa et al., 2024	Norway	mixed-method approach	Digital transformation and pro-environmental behaviour are crucial for circular economy practices, with progress in energy and food sectors. The Circularity Readiness Index aids in sustainability benchmarking.
8	Al Amin et al., 2025	Bangladesh	The study uses ISM and MICMAC analysis	Industry 5.0 and GSCM integration can boost sustainability and resilience in Bangladesh's garment industry by combining human-centered innovation with environmental goals, guided by nine key factors for effective green supply chain transformation.
9	Raihan, 2024	Malaysia	Systematic literature review	The digital economy offers sustainable opportunities like renewable energy integration, big data use, and circular

S/N	Author(s)	Location	Methodology	Key Findings
				economy promotion, but challenges like electronic waste and digital divides must be addressed.
10	Smolińska-Bryza et al., 2025	Poland	Quantitative analysis using 12 socio-economic indicators; TOPSIS method for ranking regional development levels	Assessed socio-economic development across Polish regions in two periods (2010–2012 and 2020–2022). Found spatial and structural differences in development. Results help guide improved regional planning and targeted policy responses to disparities.
11	Farida et al., 2023	Indonesia	Survey	Access to ICT and gross fixed capital income positively influenced sustainable development both short- and long-term. Increased ICT usage and foreign direct investment (FDI) negatively impacted sustainable development over both timeframes. Policies should ensure equitable ICT access and productive ICT utilization. Foreign capital inflow strategies must be matched with strong sectoral and environmental regulation to mitigate negative externalities.
12	Cigu, 2025	EU countries	Theoretical review and panel data analysis	The findings confirm that the digital economy positively influences economic growth and environmental outcomes, demonstrating its key role in advancing sustainability.
13	Koundouri et al., 2023	EU countries	Descriptive analysis	Digitalization enhances sustainable development by improving resource and energy efficiency, improving access to clean water and sanitation, facilitating collaboration, and enabling real-time monitoring and predictive analytics.
14	Awli & Lau, 2023	Malaysia	bibliometric analysis and systematic literature review	The sharing economy is largely driven by the digital economy and dependent on its digital infrastructure. The role of digitalization in promoting sustainability shows mixed results, highlighting both opportunities and challenges in its impact on sustainable development.
15	Verbivska et al., 2023	Ukraine	Mixed-method design	Ukraine currently lacks sufficient digital resources compared to other European countries but is actively developing its information infrastructure. Digitalization is crucial for Ukraine's economic growth and overall development, especially in the context of ongoing war conditions. The study emphasizes the importance of information and communication technologies for economic development and well-being.
16	Song et al., 2024	China	principal component analysis and panel data analysis	The digital economy is crucial for sustainable urban development, driving green growth through industrial upgrading and technological innovation. Additionally, factors like marketization and environmental regulations enhance its impact. Government policies should prioritize promoting this economy, considering regional variations and marketization.
17	An et al., 2024	China	Panel data analysis	The results advocate that the numerical economy meaningfully inspires maintainable growth, and green novelty aids as an arbitrating intermediate and controlling result in easing this association.

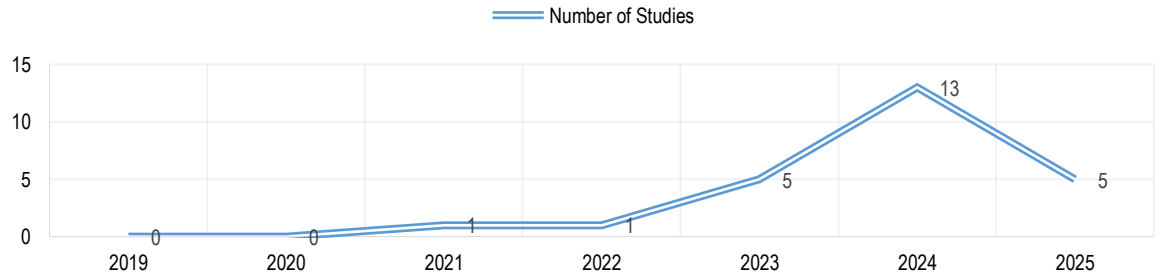
S/N	Author(s)	Location	Methodology	Key Findings
18	Deineko et al., 2022	Ukraine	Quantitative design	The regional digital divide in Ukraine has narrowed in terms of general Internet usage (variation coefficient dropped from 36.4% in 2010 to 10.2%. However, disparities remain in specific digital activities such as interacting with public authorities, online reading, and emailing. Industrial development level strongly influences regional digital adoption, although other unmeasured factors also contribute
19	He et al., 2024	China	Panel data analysis	digital economy promotes sustainable development by enhancing growth, employment, energy efficiency, and reducing emissions. It drives innovation through increased R&D and output. However, a digital divide exists, with developed regions gaining more in employment benefits than underdeveloped ones.
20	Skvarciany et al., 2024	EU countries	Data Envelopment Analysis (DEA) and Tobit regression	Bulgaria, Italy, and Romania demonstrated the highest efficiency in human capital. Connectivity was most efficient in Belgium, Bulgaria, Cyprus, Croatia, Estonia, Finland, Greece, Lithuania, Poland, and Portugal. Bulgaria, Hungary, and Romania led in the integration of digital technology, while Romania ranked highest in digital public service efficiency.
21	Rakhymzhan et al., 2024	Kazakhstan	Quantitative survey	Sustainable tech innovation, infrastructure investment, and natural resource management significantly influence the adoption of environmentally responsible practices. Corporate social responsibility enhances the impact of these factors on green economy development. The government sector plays a key role in shaping effective sustainability policies. Emphasis is placed on integrating technology and sustainability through institutional and policy-level efforts.
22	Sheikh & Serhan, 2022	Jordan	Qualitative analysis	Digital media is a vital tool for promoting sustainable development by raising awareness and facilitating communication between governments, organizations, and the public. Despite advancements, Jordan still face significant obstacles such as poverty, illiteracy, backwardness, and environmental challenges.
23	Machado et al., 2025	Brazil	Mixed-method approach:	Identified 32 key indicators (barriers and enablers) affecting this integration, with varying influences based on company size. Stressed the importance of treating Micro and Small Enterprises (MSEs) differently from Medium Enterprises (MEs) due to size-related differences in challenges and enablers.
24	Stender et al., 2024	Ukraine	nonconcrete perceptive, the Pareto principle, ABC analysis, and linear scaling	The results expose nuanced influences crossways diverse segments: Public service distribution notches a diffident 0.32, representative the necessity for crucial improvement. Business motion establishes reasonable flexibility with a score of 0.43. Organisation rebuilding lags at 0.28, tightfitting serious susceptibilities. Psychological

S/N	Author(s)	Location	Methodology	Key Findings
				health regaining (0.56) and societal unity (0.51) replicate more strong numerical incorporation.
25	Vasina et al., 2024	Ukraine	Qualitative case study	Under martial law, Ukraine's infrastructure faced significant challenges, including an energy crisis, social infrastructure destruction, reduced transport, and weak communication systems. A coordinated governance approach was proposed for recovery.

Source: author's development

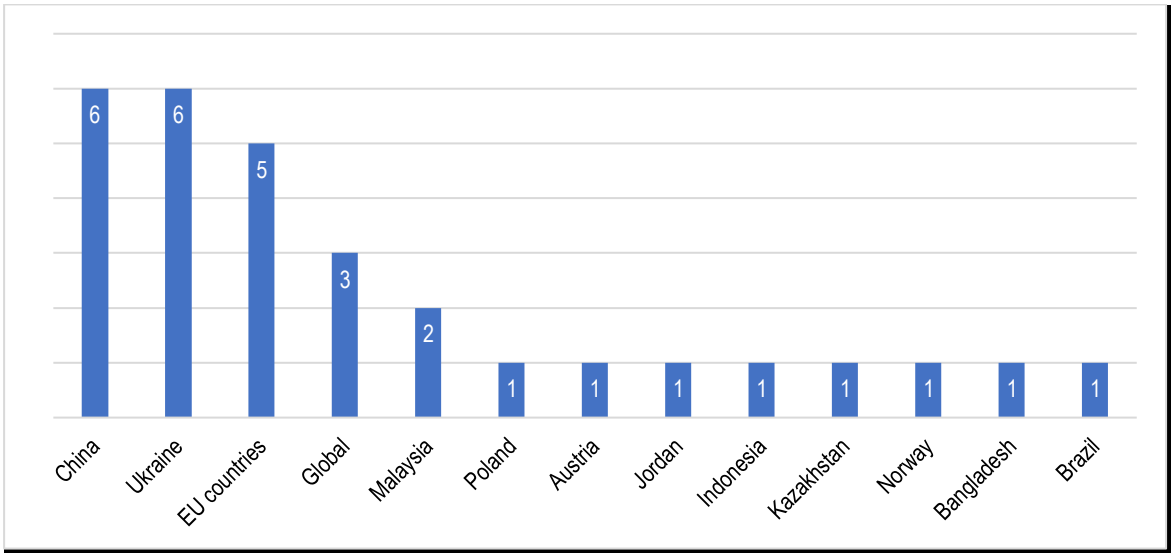
The reviewed studies display some variations, reflecting different years, diverse locations, methodologies and findings as presented in Table 3. The documents span multiple countries around the world, which represent a broad representation of different digital economic contexts on economic, social, and environmental sustainability. Documents published in year 2024 had the highest frequency while there so no selected publication for year 2019 and 2020 (see Figure 4). Also, the frequency of selected studies by geographical location is shown in Figure 5.

Figure 4. Number of revisions founded on year of publication



Source: author's development

Figure 5. Number of studies based on geographical location



Source: author's development

Research Questions

RQ1: How does the digital economy contribute to the economic, social, and environmental sustainability of Ukraine's regions?

The reviewed documents highlight several impacts of digital economy on sustainability. The global findings of the economic, social, and environmental impacts of digital economy are displayed in a format based on themes, as indicated in Table 4.

Table 4. Impacts of digital economy on global economic, social, and environmental sustainability

Theme	Description	Author(s)
Economic Sustainability	Entrepreneurship, competitiveness, economic growth, innovation, and employment are all enhanced by the digital economy. There are regional differences; infrastructure and fair access require policies.	Dabbous et al. (2023), Ma et al. (2023), He et al. (2024), Verbivska et al. (2023), Stender et al. (2024), Farida et al. (2023), Song et al. (2024), An et al. (2024), Skvarciany et al. (2024)
Environmental Sustainability	Digital economy enables adoption of ecological/agricultural technologies, green innovation, resource efficiency, circular economy, and environmental monitoring.	Yang et al. (2024), Toșa et al. (2024), Raihan (2024), Koundouri et al. (2023), An et al. (2024), Gani et al. (2024), Al Amin et al. (2025)
Social Sustainability	Digital economy influences social cohesion, mental health recovery, social infrastructure, and public communication; digital divides and uneven access limit benefits. Social sustainability needs separate consideration from economic/ecological.	Barbara et al. (2021), Stender et al. (2024), Vasina et al. (2024), Sheikh & Serhan (2022), Deineko et al. (2022)

Source: Author's development

According to o Table 4, Dabbous et al. (2023), Ma et al. (2023), He et al. (2024), Verbivska et al. (2023), and colleagues show that the digital economy positively impacts economic growth, innovation, and employment. Findings from Yang et al. (2024), Toșa et al. (2024), Raihan (2024), and colleagues shows improving natural resource efficiency and environmental monitoring. It also improves mental health and public communication (Barbara et al., 2021; Stender et al., 2024). The study also highlights the digital divide and regional disparities in Ukraine's regions. Furthermore, from the global findings, specific themes on impacts of digital economy on economic, social, and environmental sustainability in the context of Ukraine's regions is presented in Table 5.

Table 5. Impacts of digital economy on economic, social, and environmental sustainability of Ukraine's region

Global Theme	Ukraine Specific Themes	Description	Relevant Ukrainian Studies
Economic Sustainability	Infrastructure Development and Economic Recovery	developing ICT infrastructure, encouraging entrepreneurship, and reviving the economy	Dabbous et al. (2023), Verbivska et al. (2023), Stender et al. (2024)
Environmental Sustainability	Green Innovation and Climate Adaptation	Energy crisis, need for greener infrastructure, climate adaptation	Gani et al. (2024), Vasina et al. (2024)
Social Sustainability	Post-Conflict Recovery and Social Resilience	Social cohesion after war, mental health, infrastructure for public services	Stender et al. (2024), Sheikh & Serhan (2022)

Source: author's development

As shown in Table 5, the global themes are broad sustainability categories drawn from international studies, whereas the Ukraine-specific themes are developed based on Ukraine's particular post-conflict context and development needs, involving both local and international authors who concentrate on the country's region.

To identify the immediate impact of applying digital economy on the sustainability outcomes, the 25 studies that were reviewed were transformed into a replicable and transparent semi-quantitative scoring table, where pillar-level indices were generated on sustainability indicators, including economic sustainability (e.g., TFP, entrepreneurial activity), environmental sustainability (energy/resource efficiency, dematerialization) and social Sustainability (inequality, skills, access to digital public services). The scoring per study and per pillar is 0 5, after normalization of scores (normalized score) the summed pillar scores (index values 0 1) were presented in Tables 6 and 7 respectively.

Table 6. Study-by-study Scores (scores 0–5 and normalized 0–1)

ID	Study (author, year)	Economic score (0–5)	Economic normalized	Environmental score (0–5)	Environmental normalized	Social score (0–5)	Social normalized
1	Dabbous et al. (2024)	4	0.80	2	0.40	3	0.60
2	Yang et al. (2024)	3	0.60	4	0.80	4	0.80
3	Barbara et al. (2021)	3	0.60	3	0.60	2	0.40
4	Ma et al. (2023)	4	0.80	3	0.60	2	0.40
5	Hnatkovych et al. (2023)	2	0.40	1	0.20	2	0.40
6	Lauer et al. (2025)	3	0.60	3	0.60	3	0.60
7	Toșa et al. (2024)	2	0.40	4	0.80	2	0.40
8	Al Amin et al. (2025)	3	0.60	4	0.80	2	0.40
9	Raihan (2024)	3	0.60	3	0.60	2	0.40
10	Smolińska-Bryza et al. (2025)	3	0.60	2	0.40	3	0.60
11	Farida et al. (2023)	2	0.40	1	0.20	2	0.40
12	Cigu (2025)	4	0.80	4	0.80	3	0.60
13	Koundouri et al. (2023)	3	0.60	4	0.80	3	0.60
14	Awli & Lau (2023)	2	0.40	2	0.40	2	0.40
15	Verbivska et al. (2023)	3	0.60	2	0.40	4	0.80
16	Song et al. (2024)	4	0.80	4	0.80	3	0.60
17	An et al. (2024)	4	0.80	4	0.80	2	0.40
18	Deineko et al. (2022)	2	0.40	2	0.40	3	0.60
19	He et al. (2024)	4	0.80	4	0.80	3	0.60
20	Skvarciany et al. (2024)	3	0.60	2	0.40	4	0.80
21	Rakhymzhan et al. (2024)	3	0.60	3	0.60	3	0.60
22	Sheikh & Serhan (2022)	2	0.40	2	0.40	4	0.80
23	Machado et al. (2025)	3	0.60	3	0.60	3	0.60
24	Stender et al. (2024)	3	0.60	2	0.40	5	1.00

ID	Study (author, year)	Economic score (0–5)	Economic normalized	Environmental score (0–5)	Environmental normalized	Social score (0–5)	Social normalized
25	Vasina et al. (2024)	1	0.20	1	0.20	2	0.40
Mean Index			0.58		0.55		0.56

Note: (All normalized scores = raw score ÷ 5.) *Source: author's development*

Table 7. Pillar Indices and Composite scores of sustainability in reviewed studies

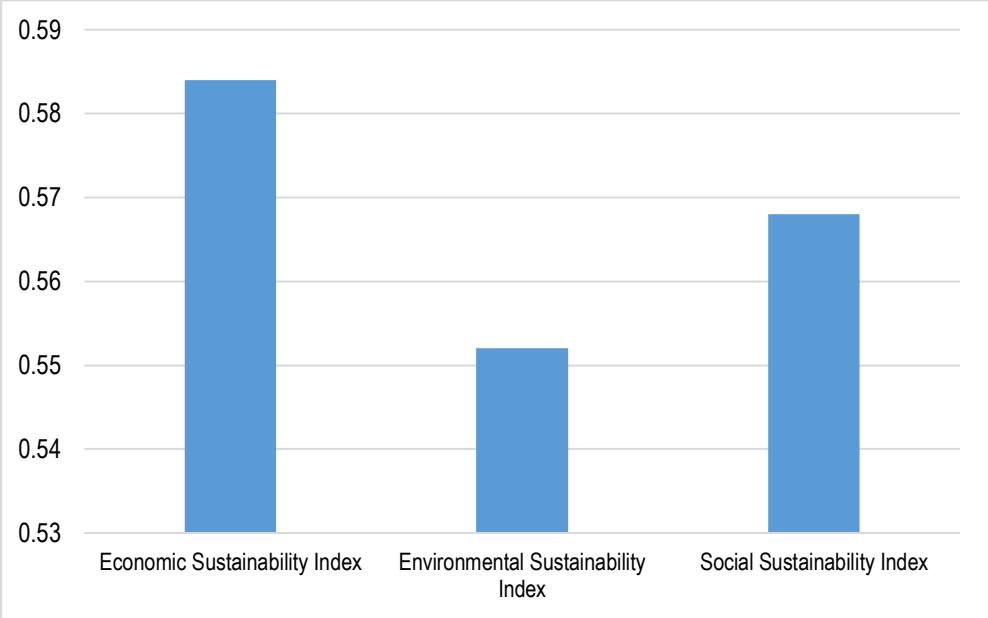
ID	Study	Economic Sustainability Index	Environmental Sustainability Index	Social Sustainability Index	Composite Sustainability Index	weighted contributions (%)
1	Dabbous et al. (2024)	0.8	0.4	0.6	0.6	0.62
2	Yang et al. (2024)	0.6	0.8	0.8	0.73	0.72
3	Barbara et al. (2021)	0.6	0.6	0.4	0.53	0.54
4	Ma et al. (2023)	0.8	0.6	0.4	0.6	0.62
5	Hnatkovych et al. (2023)	0.4	0.2	0.4	0.33	0.34
6	Lauer et al. (2025)	0.6	0.6	0.6	0.6	0.6
7	Toșa et al. (2024)	0.4	0.8	0.4	0.53	0.52
8	Al Amin et al. (2025)	0.6	0.8	0.4	0.6	0.6
9	Raihan (2024)	0.6	0.6	0.4	0.53	0.54
10	Smolińska-Bryza et al. (2025)	0.6	0.4	0.6	0.53	0.54
11	Farida et al. (2023)	0.4	0.2	0.4	0.33	0.34
12	Cigu (2025)	0.8	0.8	0.6	0.73	0.74
13	Koundouri et al. (2023)	0.6	0.8	0.6	0.66	0.66
14	Awli & Lau (2023)	0.4	0.4	0.4	0.4	0.4
15	Verbivska et al. (2023)	0.6	0.4	0.8	0.6	0.6
16	Song et al. (2024)	0.8	0.8	0.6	0.73	0.74
17	An et al. (2024)	0.8	0.8	0.4	0.66	0.68
18	Deineko et al. (2022)	0.4	0.4	0.6	0.46	0.46
19	He et al. (2024)	0.8	0.8	0.6	0.73	0.74
20	Skvarciany et al. (2024)	0.6	0.4	0.8	0.6	0.6
21	Rakhymzhan et al. (2024)	0.6	0.6	0.6	0.6	0.6
22	Sheikh & Serhan (2022)	0.4	0.4	0.8	0.53	0.52
23	Machado et al. (2025)	0.6	0.6	0.6	0.6	0.6
24	Stender et al. (2024)	0.6	0.4	1	0.66	0.66
25	Vasina et al. (2024)	0.2	0.2	0.4	0.26	0.26
Mean Index		0.584	0.552	0.568	0.568	0.5696

Source: author's development

Results from Table 7 shows the economic sustainability index depicts a strong positive relationship between digitalization and economic performance with the mean being 0.584. The similar results are reflected in the environmental sustainability index which averages 0.552 in terms of energy efficiency and resource optimization.

The social sustainability index, at 0.568 on the mean, indicates the impact of the digital economy on the service accessibility and the social bond, in particular, in the post-conflict regions. These metrics are summed to create the composite index, which averages 0.568, which is used to evaluate the overall effect of the digital economy on sustainability as visualized in Figure 6.

Figure 6. Means Sustainability Index across the three pillars



RQ2: What are the key factors influencing the effectiveness of digital transformation in regional sustainable development?

Table 8. Key factors influencing the effectiveness of digital transformation

Theme	Key Factor	Supporting Studies
Digital Infrastructure & Technology	Connectivity, digital integration, and internet usage	Dabbous et al. (2023), Skvarciany et al. (2024), He et al. (2024)
	Rate of Internet Usage	Deineko et al. (2022)
	Internet Technology	Koundouri et al. (2023)
	Digital Public Service Efficiency	Skvarciany et al. (2024), Stender et al. (2024)
	ICT Access and Gross Fixed Capital Income	Farida et al. (2023)
Human Capital & Skills	Digital Literacy	Yang et al. (2024), Verbivska et al. (2023)
	Human Capital	Dabbous et al. (2023), Skvarciany et al. (2024)
Innovation & Industrial Development	Innovation, Green Designing, Smart Manufacturing	Gani et al. (2024), An et al. (2024), Toșa et al. (2024)
	Industrial Agglomeration	Ma et al. (2023)
	Industrial Upgrading and Technological Innovation	Song et al. (2024)
	Industry 5.0 & GSCM Integration	Al Amin et al. (2025)
	Industrial Development Level	Deineko et al. (2022)
Economic Factors	Employment Opportunities	He et al. (2024), Dabbous et al. (2023)
	Entrepreneurial Activity	Dabbous et al. (2023), Stender et al. (2024)
	Government Expenditure	Dabbous et al. (2023)
	Foreign Direct Investment	Farida et al. (2023)
	Trade	Dabbous et al. (2023)

Theme	Key Factor	Supporting Studies
	Gross Fixed Capital Income	Farida et al. (2023)
Policy & Governance	Decentralization	Hnatkovych et al. (2023)
	Marketization and Environmental Regulations	Song et al. (2024)
	Digital Transformation Policies	Vasina et al. (2024), Gani et al. (2024)
Social Factors	Digital Media	Sheikh & Serhan (2022)
	Education	Dabbous et al. (2023)
	Population Growth	Dabbous et al. (2023)
	Social Inclusion (e.g., Interacting with Authorities)	Deineko et al. (2022)
Digital Applications	Digital Sales, Finance, Production	Yang et al. (2024)
	Improving Information Availability	Yang et al. (2024), Koundouri et al. (2023)
	Pro-environmental Behaviour	Toșa et al. (2024)

Source: author's development

Several key factors were identified from the literature review according to Table 8. These factors underscore the complex and interrelationship of the economic factors, social factors, environmental factors, technological factors, and governmental factors which are vital aspects of sustainable development. Furthermore, the moderating effect of regional factors on the relationship between digitalisation and sustainability is presented in Table 9.

Table 9. Moderating Effect of Regional Factors on the Relationship Between Digitalisation and Sustainability

Regional Characteristics	Moderating Factor	Strength	Supporting Studies
Economic Structure	Industrial diversification, innovation capacity, entrepreneurial activity, Foreign Direct Investment	▪ Greater digital adoption of diversified/industrial regions. ▪ Increased economic, social and environmental sustainability	Gani et al. (2024); Ma et al. (2023); Al Amin et al. (2025); Dabbous et al. (2023); Farida et al. (2023); Song et al. (2024)
Urban–Rural Differences	Access to ICT, digital literacy, infrastructure, human capital	▪ Urban areas are more advantageous because of more connectivity, skills. ▪ Fast economic recovery, social service provision and environmental management which may be slow in rural region.	Dabbous et al. (2023); Koundouri et al. (2023); Yang et al. (2024); Verbivska et al. (2023); Deineko et al. (2022)
Proximity to Conflict Areas	Infrastructure damage, social disruption, environmental vulnerability	▪ Digitalisation has the potential to support post-conflict recovery, social cohesion, and climate adaptation, but it will have availed success when ICT and specific policies are rebuilt.	Dabbous et al. (2023); Stender et al. (2024); Sheikh & Serhan (2022); Gani et al. (2024); Vasina et al. (2024); Hnatkovych et al. (2023)

Source: author's development

The economic structure is a key factor in determining the way digitalisation can lead to the results of sustainability. Areas with a diversified economy, industrial base and high innovation (as shown in Table 6 under Innovation and Industrial Development) are in a better position to use digital infrastructure to gain economically and environmentally (Gani et al., 2024; Ma et al., 2023). In addition, a stronger level of technological development can embrace smart manufacturing and Industry 5.0, which leads to better resource utilization, productivity, and green innovation (Al Amin et al., 2025; Song et al., 2024). The stronger the economy, the greater the foreign investment

and entrepreneurial activity are, the faster the digital solutions will be adopted, which accelerates the effect of the digital change on the economic sustainability, such as employment and infrastructure development (Dabbous et al., 2023; Farida et al., 2023). According to Dabbous et al. (2023) and Koundouri et al., (2023), urban experienced better digital equipment and internet connection unlike the rural region (Deineko et al., 2022). This will foster fast adoption of digitalization which influence their level of sustainability. Digital literacy and skilled labour force may be more effective in urban areas to boost the efficacy of urban digital technologies to enhance economic efficiency, social services, and environmental monitoring (Yang et al., 2024; Verbivska et al., 2023). War zones tend to have damaged infrastructure, fewer investments and supply chains.

On the one hand, the digital transformation can be key to the economic recovery, but its efficiency requires the restoration of the ICT and transport infrastructure (Dabbous et al., 2023; Stender et al., 2024). The use of digital data and planning devices to reduce environmental vulnerability is another example of green innovation and climate adaptation activities that are in place in war-affected regions (Gani et al., 2024; Vasina et al., 2024). Digital tools may facilitate post-conflict recovery through enhancing social service access and mental health care and community integration (Sheikh & Serhan, 2022). The use of digital data and planning devices to reduce environmental vulnerability is another example of green innovation and climate adaptation activities that are in place in war-affected regions (Gani et al., 2024; Vasina et al., 2024).

RQ 3: What policy recommendations can be derived from existing research to enhance the role of the digital economy in regional sustainability?

Based on the reviewed studies, seven themes emerged based on policy recommendations enhance the role of the digital economy in regional sustainability. The themes are discussed as follows:

Theme 1: Infrastructure & Connectivity Development Policy: This policy calls for investments in digital infrastructure, such as smart grids, mobile networks, and connectivity, to promote inclusive access, particularly in rural and underdeveloped areas (Dabbous et al., 2023; Verbivska et al., 2023; Deineko et al., 2022).

Theme 2: Capacity Building and Digital Literacy Policy: Policy for Promoting digital skills training for individuals and SMEs to improve their ability to use digital tools for sustainable practices (Yang et al., 2024; Machado et al., 2025).

Theme 3: Strategic Regional Planning: Enhance strategic regional planning by adopting decentralization models and learning from EU policy frameworks (Hnatkovych et al., 2023; Stender et al., 2024).

Theme 4: Sustainable Innovation and Green Technologies: R&D and green innovation policies to mediate the positive impact of the digital economy on sustainability (An et al., 2024; He et al., 2024).

Theme 5: Policy for Mental Health Support and Social Inclusion

Theme 6: Financial and Regulatory Instruments: To reduce adverse externalities, foreign capital inflow plans must be combined with strict sectoral and environmental regulations.

4. Discussion of Findings

Findings from literature reviewed showed that digital economy affect sustainability dimensions, the economic, social, and environment through diverse mechanisms. The panel analysis of the 25 empirical studies also confirms that digital economy plays a significant role in enhancing the sustainability of a region, although the extent of influences is not the same in the economic, environmental, and social pillars. Furthermore, in terms of Ukraine's region, impacts of numerical economy on financial, societal, and conservational is also applicable. For instance, From the global perspective, digital economy boosts entrepreneurship, specifically in China, digital economy boosts ecological practices via digital finance and literacy (Yang et al., 2024), therefore, Ukraine can replicate such targeted digital training for farmers to promote green agriculture in rural areas. Similarly, in Russia digital maturity was found to be positively correlated with economic, social, and environmental sustainability that

indicates how digital platforms and e-governance enhance the results of transparency, efficiency, and sustainability (Sanina et al., 2025; Mirolubova et al.,2023). Also, Austria shows digitalization improves economic/eco-sustainability but not social sustainability which can be a special focus for Ukraine particularly with the era of after war regional development (Barbara et al., 2021). Despite these effectiveness, infrastructure and regional gaps still exist (Deineko et al., 2022; Vdovichen & Vdovichena, 2020) and similar trends are seen in Romania and Bulgaria. The findings are also similar to the other countries like Indonesia and Bangladesh but is far below European Union average. For Ukraine's regions, the success in social cohesion and mental health using digital tools is moderate less than those global best practices. The implication of these findings is that those other countries success or challenges can inform Ukrainian implementation and policies especially in their regional contexts to promote economically, socially and environmentally sustainable development.

Furthermore, the efficiency of digital transformation in regional maintainable growth depends on a complex interplay of technological, economic, social, and environmental factors. The results of this research are consistent with the overall evidence about the fact that technological, economic, social, and policy-related aspects are combined and influence the success of digital transformation in fostering sustainable regional development (Lu et al., 2024). Important driver includes a population that is digitally literate or fast in technology, entrepreneurship and innovation, robust digital infrastructure, and informed policy frameworks (Mirolubova et al., 2023). Additionally, social inclusion issues and the local industrial environment influence results but combining digital tactics with environmental sustainability programs increases overall resilience. Adoption rates and investments are important, but they must be balanced with policies to reduce potential negative externalities and inequality.

Lastly, the findings of Farida et al. (2023) support the policy recommendations' transformative potential for advancing sustainable regional development through the digital economy. However, long-term investment, context-sensitive planning, robust institutional support, and inclusive design are essential for successful implementation. These policies have the potential to promote sustainable development in social progress, environmental preservation, and equitable growth if they are implemented well.

Despite the rigorous review and findings, the study acknowledges some limitations. The review primarily draws from peer-reviewed literature published in English, which may unintentionally exclude valuable studies in grey literature sources which are often times localized authors with first-hand experience regarding regional disparities and digital inclusion, especially those originating from underrepresented or developing regions. The study also used varying methodology which includes panel data analyses, mixed-method studies, and qualitative studies. although it makes the study outcome robust but also complicates comparable metric standards. Differences in variables and evaluation criteria limit the generalizability of insights across contexts.

Conclusion

This study measures the impact of the digital economy on economic, environmental, and social sustainability in regions of Ukraine by applying a methodology of the creation of a pillar-based index. The review of 25 empirical studies indicates that digitalization has a positive impact on the economic sustainability level, a moderate effect on the environmental results, and an ambiguous influence on the social sustainability. The composite index average shows the net positive but disproportionate effects of digitalization in the regions and dimensions of sustainability. Economic gains are the most eloquent, but the social and environmental gains are more situational and, therefore, need to be integrated and unified digital strategies. Policy recommendation include training about 30,000 citizens per year in lagging parts of the region would improve the economic and social indices, promoting entrepreneurship and increased use of government services. More so, increasing the Environmental Sustainability Index by approximately 0.1 points in regions with a low current uptake of smart meters, energy-saving ICT, and digital environmental monitoring can be done.

The use of infrastructure, skills acquisition and environmental rules will make sure that economic development linked to digitalization does not widen social inequalities and environmental expenses. Therefore, evidence-based strategy, digital interventions that are well coordinated can deliver maximum benefit of the digital economy to sustainable development in the regions of Ukraine. Future studies should look into empirical and quantitative aspect of research comparing global studies and vital sustainable development metrics to making important policy decisions.

Credit Authorship Contribution Statement

Zrybnieva, I. contributed to the conceptualization of the study, methodology design, data curation, formal analysis, and the preparation of the original draft. Martynenko, M. was responsible for the literature review, validation of results, supervision of the research process, and critical review and editing of the manuscript. Nazarov, N. contributed through data visualization, software development, and statistical analysis. Hustera, O. provided resources, conducted the investigation, and managed project administration. Kravets, R. was responsible for funding acquisition, formal verification of the research outputs, and English language proofreading. The corresponding author confirms that all listed authors have made substantial contributions to the research and have approved the final version of the manuscript.

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Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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