CHAPTER 7

Information and digital technology trends in the green economy

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Abstract

Information and digital green tech encompass many technological practices, all geared towards safeguarding the environment. Green tech addresses a climate change by reducing greenhouse gas emissions and promoting a circular economy from harnessing renewable energy and eco-friendly transportation to revolutionizing agriculture.

The aim of the research paper is to highlight the role of information and digital technology trends in the green economy.

The digital transition towards a greener future prioritizes sustainability through resource optimization, waste reduction, and recycling. Digital green IT refers to adopting environmentally sustainable computing practices, striving to curtail energy usage, mitigating the technology sector's impact on global emissions, and combatting climate change.

Practical implications of the research are represented in green tech innovation clusters, digital technology trends in the green economy and a case study of digital technologies' effect on the energy efficiency in Ukraine during the Russian-Ukrainian war.

The paper has been developed through a systematic methodology, centered on a desk research, surveys, and empirical analysis while formulating hypotheses, testing them for visualizing research results to identify, short-list, and validate economy trends in green architecture and Sustainable Development Goals (SDGs) of Ukraine under conditions of instability due to the information and digital green tech of Ukraine under conditions of war.

Keywords

Technology, digital, information, green economy, trends, Sustainable Development Goals.

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7.1 Introduction

In recent decades, one of the main trends in the development of green economy has been the penetration of information and digital technologies into various spheres of human activity. Informatization has become an important factor in the increasing labor productivity and improving the quality of life that the changes are considered to be the beginning of a new era of green economic development which is characterized by the term "digital or information economy". The relevance of the paper is driven by two stable and large-scale trends as: the need of global economic transformation in accordance with the concept of sustainable development and green economy; the deployment of the fourth industrial revolution, the main target of which is information and digital technologies.

Europe is a leading player in green innovations, venture capital, deployment of net-zero digital technologies and sustainable products. According to the European Commission, it has a strong starting point – a green industry with a track record as a proven trend-setter and standard-setter, with growing levels of digitalization. Manufacturing high quality and green innovative products that are used across the world, the European Green Deal sets in stone green transition ambitions, including climate targets towards net-zero by 2050. The Fit for 55 package provides a concrete plan to put the European economy firmly on track, with the REPowerEU Plan accelerating the move away from fossil fuels. Alongside the Circular Economy Action Plan, this sets the framework for the transformation of the EU's industry for the net-zero age [1].

According to the European Commission, in the next few years, the economic shape of the net-zero age will be firmly set. New markets will have been created, breakthrough clean digital technologies will have been innovated, developed, and brought to market. The International Energy Agency estimates that the global market for key mass-manufactured clean energy technologies will be worth around 650 billion USD a year by 2030. The United States' Inflation Reduction Act will mobilize over 360 billion USD by 2032. Japan's green transformation plans aim to increase up to 20 trillion JPY (approximately 140 billion EUR) – through green transition bonds. India has put forward the Production Linked Incentive Scheme to enhance competitiveness in sectors like solar photovoltaics and batteries [2].

The UK, Canada and many others have also put forward their investment plans in clean tech technologies. Europe is committed working with all of those partners for the greater good. However, the trade and competition on net-zero industry must be fair. More fundamentally, China's subsidies have long been twice as high as those in the EU, relative to GDP. This has distorted the market and ensured that the manufacturing of a number of net-zero digital and green technologies is currently dominated by

China, which has made subsidizing clean tech innovation and manufacturing a priority of its Five-Year Plan. China's pipeline of announced investments in clean technologies exceeds 280 billion USD [3]. Europe needs a new Green Deal Industrial Plan that will form part of the European Green Deal, which set us on the path to climate neutrality, and will enable Europe to lead the way globally in the net-zero industrial age.

7.2 Literature review

Many studies and scientific papers of leading research institutes and scholars are dedicated to determining problems, prospects, and consequences from integrating digital transformation and opportunities for sustainable development and green economy.

Analysis of scientific publications of E. Barbier, R. Berger, H.-J. Chang, J. Davis, T. Edgar, J. Porter, J. Bernaden, M. Sarli shows that the green industry belongs to modern strategies for the digital development of an intellectual society, characteristic of technologically advanced countries with the high investment, innovation potential and close integration of digital transformation. According to the scholars, the main driver of progress green and digital transformations are technical and technological innovations that involve the transformation of material production assets, and thus significant investments and the involvement of highly qualified specialized labor for research and development [4, 5], the creation of pilot sites [6], the introduction of effective developments into mass production, and ultimately large-scale reengineering of business processes [7].

According to C. N. Ciocoiu, digital economy and green economy are the most important subjects on the environmental policy agenda. Both are paradigms that have become prominent in the separate worlds of ITC policy and sustainable development. The integration between them leads to new paradigms and creates opportunities for sustainable development, also for economic recovery in the context of recent crises [8]. The authors consider that now it is essential to provide evidence of how a greener economy can offer direct economic benefits of information and digital technology trends to national economies and the majority of their citizens.

A. Strzelecki, B. Kolny and M. Kucia consider that green living issues that arise as a result of smart home use in the context of sustainability consumption, at a time when smart homes are being built that can improve the management of electricity, water, gas consumption, and when their use offers the opportunity to raise awareness of caring for health and achieving wellbeing [9]. The scholars highlight that the significant positive influence of smart homes on sustainable consumption behaviors,

underscoring their potential in driving the digital economy towards sustainability goals lies in their contribution to the understanding of how digital technologies.

The results of P. Tamasiga, H. Onyeaka and E. H. Ouassou illustrate an increasing trend in the research attention towards the green FinTech concept and its relationship with the green economic growth, climate change, and greening rules and standards. A deep inspection indicates that future research trajectories are oriented into five different mainstreams: technology and instruments in digital finance; regulation, policies, and green FinTech; climate risk mitigation through Fintech; Fintech and environmental quality; green finance and climate change mitigation. Based on these research directions, an integrated framework was conceptualized that aims to deliver green economic growth using Fintech as a vehicle of transition especially for African countries [10]. The authors fully support the idea that the emergence of new transformational technology, known as the fourth industrial revolution, has crucially opened a new window to green economic growth. The transition to low carbon, green economy, and green sustainability has gained momentum simultaneously in developed and developing countries.

T. Altenburg, A. Pegels, M. B. Gutierrez, C. Brandi, H. Fuhrmann-Riebel, F. J. Fung, D. Malerba, B. Never, A. Stamm, R. Strohmaier and U. Volz sustain that a development policy should promote inclusive green finance (IGF) through market-shaping policies, such as an enabling regulatory framework for the development of digital IGF services and customer protection in digital payment services. It should also build policymakers' capacity in developing IGF policies and regulation. Support in the area of sustainable, circular consumption should focus on eco-design, and repair and reuse systems. This will need new collaborations with actors shaping systems of consumption and production, for instance with supermarkets or the regulators of eco-design guidelines [11]. The authors suppose that governments should support a green industrial policy and enlarge a policy space in trade rules by promoting technology foresight agencies, coordinating platforms for industry upgrading, and policy think tanks, and working towards reforms of the trading system.

Svitlana Bila underlies that one of the most essential tasks for current economics and researchers of systems and processes of organization future maintenance of world production is to determine the main strategic priorities of social production digitalization. Digital technologies radically change all spheres of a social life, including business and managerial processes at all levels. 21st century witnessed establishing digital economy, smart economy, circular economy, green economy and other various arrangements of social production which are based on digital technologies [12]. The authors consider that green economy consequences of radical structural reformation of all spheres in national and world economy in the 21st century, undoubtedly, will be stipulated with the processes of green production digitalization.

It will require further systemic and fundamental scientific studies on this complicated and multi hierarchical process.

L. Qin, G. Aziz, M. Wasim Hussan, A. Qadee and S. Sarwar examine the influence of Fintech innovations on environment, by using multiple angles. However, they formulate the advanced green environmental index by utilizing the environmental, economic, resources and financial indicators. In recent years, the progress in Fintech has emerged a significant source to decline the energy which turns to enhance the environmental quality. Fintech has confirmed the significant and positive relationship with green environmental index [13]. Scholars consider that three subcategories of Fintech, financial breadth, financial depth, and financial digitalization, have positive influence to promote the green environmental index.

At the same time, M. Sadiq, C. Paramaiah, R. Joseph, Z. Dong, A. M. Nawaz and N. Khajimuratov revealed that green finance as a mediator enhances while natural resource volatility as a mediator deteriorates climate sustainability. Furthermore, industrial structure and environmental regulations also shed inverse impacts on environmental quality. Government interventions play a crucial role in the betterment of climate quality. It is also observed that Fintech-associated carbon emission intensity varies with higher-order quartiles [14].

The conceptual study of Y. Li, R. Sun and Y. Rao provides a framework for digital technologies that can significantly improve green total factor productivity. Their results of the analysis show that there is heterogeneity in the driving effect of digital technology development on green total factor productivity, but this heterogeneity is mainly in the magnitude of the impact. At the subregional level, digital technology development has a greater impact on green total factor productivity in coastal or southern regions.

At the external environment level, digital technology development has a greater impact on green total factor productivity in regions with smaller economies, less external economic dependence, and less government fiscal intervention. According to Y. Li, R. Sun and Y. Rao the capital accumulation has moderating effect in the process of digital technology affecting green total factor productivity which will inhibit the improvement of digital technology development on green total factor productivity [15]. In authors' opinion, it is necessary to encourage the development of this technology by local conditions, formulate differentiated development policies by regional development levels, drive industrialization with digital industrialization, and drive the digitalization of industries in surrounding areas promoting green economic trends.

The paper has been developed through a systematic methodology, centered on desk research, surveys, and empirical analysis, graphical methods while formulating hypotheses, testing them for visualizing research results to identify, short-list, and validate digital green economy trends. This methodology consists of three main steps as:

scan, analyze, and recommend. The success and reliability of any trends report hinge upon developing and implementing a well-defined and thorough methodology, which ensures accuracy, credibility, and actionable insights for informed decision-making.

The following methods are used in the study as monographic, while studying the literature and analyzing previous studies. It should be noted that the paper includes scientific works of Ukrainian and foreign researchers; systemic, while clarifying the categorical apparatus and analyzing the concept of green economy trends in order to identify the key aspects and characteristics in the context of information and digital technologies; induction and deduction for a better understanding of the research results.

In the "scan" step the authors perform a research by identifying and reviewing the relevant data sources, including policy reports of the European Commission, technology and economic trend reports, research articles, relevant think tank publications, databases and thought leadership from recognized multilateral bodies, to identify an exhaustive list of digital green economy trends. The scholars subsequently conduct surveys with international subject-matter experts and global digital economy leaders to substantiate the secondary research findings.

In the "analyze" step the authors perform a qualitative evaluation framework, formulated with the support of leading global experts, to short-list the identified digital green economy trends, employing four criteria: impact, risk, disruption, and scalability. The result list of trends is validated through several figures. In the "recommend" step the authors synthesizes insights gained from the "analyze" step and provide actionable suggestions and guidance, in respect to the green IT trends shortlisted. These include insights on critical challenges, enablers, implications, and recommendations for relevant stakeholders across the digital green economy.

7.3 Digital technologies and green tech innovation clusters

A climate change and environmental degradation are an existential threat to the entire world. This requires global measures to both prevent it and adapt to changes where their consequences are unavoidable. The Green Deal is a response to these challenges that is considered inseparable from the simultaneous digital transition.

According to the European Commission, the starting point for the Green Deal Industrial Plan is the need to massively increase the digital technological development, manufacturing production and installation of net-zero products and energy supply in the next decade, and the value added of an EU-wide approach to meet this challenge together [2]. This is made more difficult by the global competition for raw materials and skilled personnel.

The Plan aims to address this dichotomy by focusing on the areas where Europe can make the biggest difference. It also seeks to avert the risk of replacing its reliance on Russian fossil fuels with other strategic dependencies that could impede our access to key technologies and inputs for the green transition, through a mix of diversification and own development and production. The Plan will complement ongoing efforts to transform industry under the European Green Deal and the EU Industrial strategy, in particular the Circular Economy Action Plan. Modernizing and decarbonizing energy-intensive industries also remains a top priority, as does ensuring job transitions and quality job creation through training and education [2].

As part of the Green Deal Industrial Plan, the Commission proposes to put forward a Net-Zero Industry Act to underpin industrial manufacturing of key digital technologies in the EU. The act would provide a simplified regulatory framework for production capacity of products that are key to meet our climate neutrality goals, such as: batteries, windmills, heat pumps, solar, electrolysers, carbon capture and storage technologies.

Taking technology neutrality as a starting point, the Act would build on an assessment of strategic importance and identified needs of manufacturing investment in different types of net-zero digital products. Those technologies may go beyond the strategic net-zero technologies that will be eligible for the specific type of support available under the State aid Temporary Crisis and Transition Framework.

European standards can help to promote the roll-out of clean and digital technologies. In particular for new industrial value chains, anticipating and developing high-quality European standards could provide EU industries an important competitive advantage – including at global level. They could demonstrate "marketability" and attract investment in firms that adhere to them. European standards would allow EU industries to scale up green technologies across the single market – that is very important for start-ups and SMEs.

V. Vishnevsky, O. Harkushenko, M. Zanizdra and S. Kniaziev suppose that at the global level, the introduction of state-of-the-art digital technologies has a generally positive relationship with the state of environment: the higher the level of digitalization, the more environment friendly national economies, and other things being equal. The scholars have found that the environmental performance of digitalization depends on the level of manufacturing technologies and the overall economic development. In the clusters of less developed countries, including Ukraine that has significant problems in industry and innovation, the spread of digital technologies has less positive impact on the environment than in the clusters of more advanced economies. Therefore, the long-term positive effects of digitalization for Ukraine are not obvious, while the negative ones may have serious negative consequences [16].

To minimize the environmental risks of digitalization processes in Ukraine, it is necessary to develop a national academic program for comprehensive assessment of effects of various aspects (abiotic, biotic, anthropogenic) of digital technologies on environment, as well as to harmonize economic digitalization programs with the overall strategy for innovation-driven national manufacture.

As for digital technologies' effect on energy efficiency in Ukraine, it is possible to include the following applications as: smart transport, and virtual goods, followed by smart buildings, smart energy, smart production and virtual mobility (**Table 7.1**). Other less frequently assessed domains are smart agriculture, smart water, or waste management.

Table 7.1 Digital technologies' effect on energy efficiency in Ukraine

Application	Use cases
Smart transport	Route optimization, traffic flow management
Smart production	Automation of production processes
Smart energy	Smart metering, demand side management, distributed power generation
Smart buildings	Smart heating, smart lighting
Virtual goods	E-books, online newspapers, music and video streaming
Virtual mobility	Video conferencing, e-commerce, e-health, distance learning, remote maintenance

Source: compiled by the authors [17]

In our opinion, Ukraine's implementation of the Green Deal is an important component of European integration. The European Commission determines that Ukraine's reconstruction should be in line with the green and digital agenda. The National Economic Strategy of Ukraine until 2030 envisages synchronization with the Green Deal. Existing environmental problems have become even more acute due to the war (over 200 billion USD in environmental damage). At the same time, the ICT sector needs its own green transformation. Its carbon footprint in the EU is estimated at about 4 %, with a tendency to grow to 8–10 %. Achieving climate neutrality and circularity of ICTs involves, among other things, more energy-efficient data centers and electronic communication networks, fully circular eco-design of ICT equipment, enhanced environmental measures during network deployment, and transparency of the sector's environmental impact.

Driven by the rising awareness of climate change, advancements in enabling technologies, and stricter regulatory mandates by governments, investments in

Green Tech have surged, propelling rapid growth in the green tech market. In our opinion, green tech innovations should include four main clusters (**Fig. 7.1**), such as:

1) green mobility;
2) green information technology;
3) green architecture;
4) carbon capture and storage technologies.

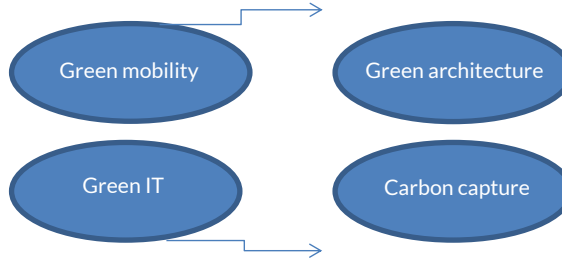

Fig. 7.1 Green tech innovation clusters
Source: compiled by the authors [18]

A green mobility involves utilizing transportation technologies like electric vehicles, hybrids, and vehicles running on alternative fuels, all designed to minimize their environmental impact. As battery and charging technology progresses, electric vehicles are becoming increasingly affordable and convenient for daily use. Conversely, electric vehicles are the incubator for battery technologies.

In Ukraine the rising adoption of these technologies especially after the war has the potential to decrease greenhouse gas emissions, encourage sustainable energy consumption, enhance air quality, and reduce reliance on fossil fuels. According to the IEA, 2023, electric vehicle sales globally surged from approximately 1 Mn to exceeding 10 Mn from 2017 to 2022, showcasing exponential growth [19].

According to the DCO, green IT refers to adopting environmentally sustainable computing practices, striving to curtail energy usage, mitigating the technology sector's impact on global emissions, and combatting climate change. Green IT involves various measures, such as: energy-efficient hardware, data centers, server virtualization, IoT-powered monitoring systems, and e-waste disposal. For instance, Meta's Lulea, Sweden, data center utilizes freezing external air to naturally cool down the digital infrastructure while the server generated hot air is circulated. Axial fan walls are employed to maintain consistent temperatures [18].

Green architecture integrates eco-friendly and resource-efficient practices, prioritizing building design, construction, operation, and maintenance to minimize

environmental impact. With a focus on environmental responsibility and resource efficiency, green architecture also considers the life cycle of a building, from planning and design to construction, operation, maintenance, renovation, and demolition. Renewable energy sources include solar panels, efficient insulation, passive heating and cooling techniques. For instance, Apple's corporate headquarters, "Apple Park" in Cupertino, California, spans 175 acres and operates entirely on renewable energy, primarily sourced from an on-site low-carbon central plant. The site also boasts extensive solar installations, with a significant portion of the solar roof dedicated to electricity generation [20].

According to the DCO, carbon capture and storage (CCS) involves capturing carbon dioxide emissions from industrial activities or burning fossil fuels in power generation. This technique prevents the release of carbon dioxide into the atmosphere, curbing its contribution to global warming. Different technologies are used for CCS, including direct air capture and mobile air capture, where carbon dioxide is either recycled or securely stored where it cannot escape, offering a significant method for cutting emissions and addressing the challenge of global warming [21]. For instance, ExxonMobil's Shute Creek Gas Processing Plant in Wyoming, USA, operates as a CCS facility. It captures around 365 Mn cubic feet of carbon dioxide daily, utilized in oil recovery efforts across multiple oil fields [22]. To sum up, digital technology trends in the green economy are as follows (**Fig. 7.2**).

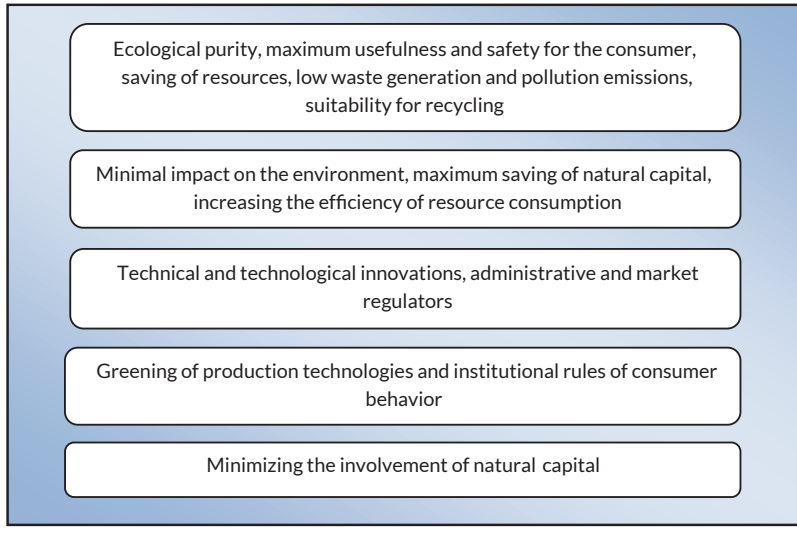

Fig. 7.2 Digital technology trends in the green economy

Green technologies offer a number of benefits, including: reducing greenhouse gas emissions, which are a major cause of climate change. They can help to improve energy efficiency, which can save the energy and reduce air, water and soil pollution.

7.4 Green architecture and sustainable development goals of Ukraine under conditions of instability

The large-scale war has exposed the challenges and issues of Ukraine's development that are in the focus of the UN's 2030 Agenda for Sustainable Development: demographic decline, poverty, various forms of violence, mental and psychological disorders of civilians and military personnel, the growth of refugees, ineffective justice, loss of biodiversity, and environmental damage.

Being a part of the 2030 Agenda for Sustainable Development, it is important for Ukraine to comply with all 17 SDGs, but some of them should be the basis of green policies and initiatives, namely 7 "Affordable and clean energy" in combination with 15 "Protection and restoration of terrestrial ecosystems", 11 "Sustainable development of cities and communities", in particular through 13 "Action on climate change", and 14 "Conservation of marine resources" [23].

The energy and industry are sectors most responsible for GHG emissions due to the high carbon intensity of energy resources and fossil fuels. Implementing Goal 7 through the large-scale deployment of renewable energy generation and energy efficiency is currently the most effective tool to ensure a relatively rapid and safe reduction of emissions. The war between Ukraine and the Russian Federation has demonstrated that no energy in a country means any life. The consequences that Ukraine has experienced from its long-term energy import dependence on Russia, including the first blackout in the country's history, make building energy independence and self-sufficiency based on the renewable energy a critical component of national security [24].

Despite the fact that before Russia's large-scale invasion of Ukraine, the country has already made some progress in the development of renewable energy (according to the NEURC, as of December 31, 2021, the installed capacity of the sector reached 8450.8 MW, excluding small distributed generation, which amounted to only about 14,3 % of the total capacity of Ukraine's energy system), the national energy system was still a post-Soviet legacy, with baseload power provided by low-carbon nuclear power plants and carbon-intensive thermal power plants that are deteriorating.

The damaged thermal power plants across Ukraine, the destroyed "Kakhovka" HPP, and the nuclear blackmail of the country have created an opportunity for the government to make a real transition to a green, energy-efficient, innovative,

smart, environmentally and human-friendly, and distributed energy system based on renewable energy. Given that green recovery involves, Goal 7 "Affordable and clean energy" was strategically justified, and would become economically viable with low financing rates after the end of Russia's military aggression (**Fig. 7.3**).

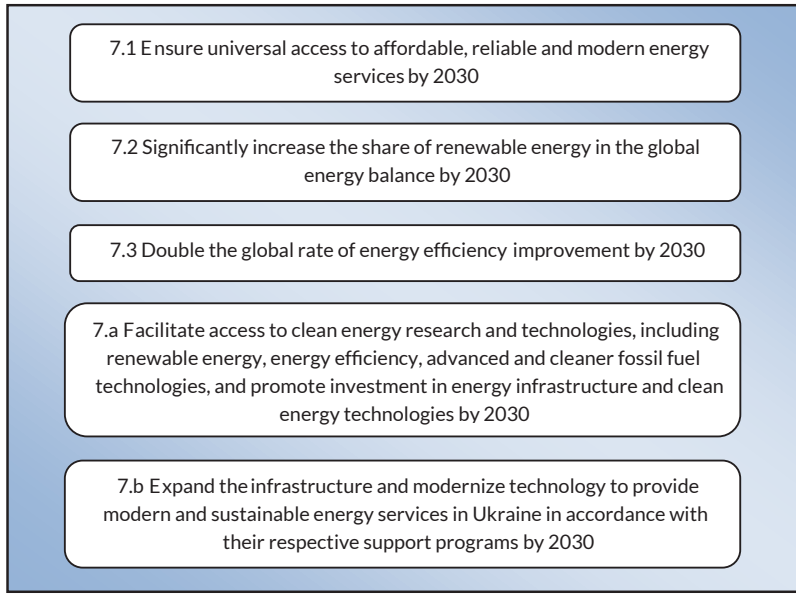

Fig. 7.3 Targets and indicators of SDG 7 "Affordable and clean energy" in Ukraine
Source: compiled by the authors based on [24]

Among the program measures aimed at solving the problems of the innovation sphere in Ukraine, the Strategy for the Development of the Innovation Sphere calls for a review of the priority directions of science and technology development in order to bring them closer to the directions defined in developed countries based on current global technological trends.

The Strategy for Innovative Activity Development until 2030 does not highlight low-carbon sectors and technologies as one of the priority directions, but refers to the Low Emission Development Strategy until 2050 as one of the approximately 40 strategic sectoral documents related to innovation development in various fields [25]. At the same time, attention should be paid to the status of this document, which is supported and approved by the protocol decision of the Cabinet of

Ministers of Ukraine on July 18, 2018 [26], but it is not available in the databases of the official documents of Ukrainian government bodies. There is also a resolution of the Verkhovna Rada (Parliament) dated November 5, 2021, No. 1870-IX, which, inter alia, instructs the Cabinet of Ministers of Ukraine to develop and submit to the Verkhovna Rada of Ukraine a draft Law of Ukraine on the Low Emission Development Strategy of Ukraine until 2050 [27].

SDG 11 "Sustainable development of cities and communities" is aimed at improving approaches to urban planning, management and development of cities and communities, taking into account the principles of inclusiveness, safety and sustainability, as well as preventing possible risks of deterioration in the quality of life of the population [28].

On February 28, 2024, more than 140 representatives of local governments of Ukraine, military administrations, and civil society organizations took part in a meeting of the professional network on municipal infrastructure restoration. The purpose of the meeting was to analyze and clarify current issues and opportunities for the restoration of municipal infrastructure after the war. The event brought together specialists in the field of recovery, including heads and deputy heads of villages, towns, and cities, heads of structural units of executive bodies of local councils, and representatives of NGOs in Ukraine.

In our opinion, achieving Goal 11 in business is possible after the war in Ukraine through: implementing a policy of resource efficiency and risk reduction at the company's operational level; an active participation in the processes of developing city or community development strategies with a special focus on opportunities for innovative and sustainable solutions; investing in the sustainable infrastructure of the local community (low-carbon transport, energy efficient buildings); cooperation with local governments to jointly develop and implement solutions aimed at minimizing the negative environmental impact associated with the company's operations (**Fig. 7.4**).

A climate change is a very real crisis of our time, which leads to various kinds of natural disasters or catastrophes, such as: floods, droughts, hurricanes, tornadoes, dust storms, uncontrolled forest and peatland fires, earthquakes, etc. The key cause of such crises is the gradual increase in the earth's temperature caused by high levels of GHG emissions due to human activity [29]. Given that climate change is global in nature, and Ukraine is interested in overcoming its consequences and maintaining a safe temperature for health, the alignment of investment decisions with SDG 3 (**Fig. 7.5**). On May 30, 2024 the Cabinet of Ministers of Ukraine approved the Strategy for the Formation and Implementation of the State Policy in the Field of Climate Change in Ukraine up to 2035 and the Operational Action Plan in Ukraine for its Implementation during 2024–2026 [30].

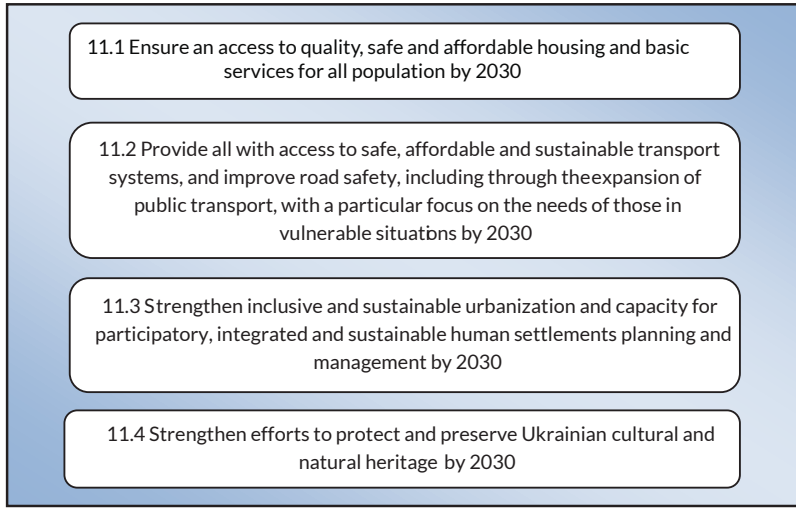

Fig. 7.4 Targets and indicators of SDG 11 "Sustainable development of cities and communities" in Ukraine
Source: compiled by the authors based [28]

Fig. 7.5 Targets and indicators of SDG 13 "Action on climate change" in Ukraine
Source: compiled by the authors based on [29]

On October 8, 2024, the Verkhovna Rada of Ukraine adopted the Law of Ukraine "On the Basic Principles of the State Climate Policy" in the second reading and as a whole by a majority of 284 votes of the people's deputies of Ukraine [31]. This Law was aimed at defining the legal and organizational framework of the state climate policy aimed at ensuring low-carbon and sustainable development of Ukraine, achieving climate neutrality, mitigating the effects of climate change and adapting to it, fulfilling Ukraine's international commitments in the field of climate change, improving the national system of inventory of anthropogenic greenhouse gas emissions by sources and removals by sinks, ensuring the functioning of the national monitoring system, and evaluation of achieving the goals of the state climate policy and forecasting in the field of climate change.

In order to encourage Ukraine to restore and preserve the ecosystem, separate Goals 14 "Protecting and Restoring Underwater Ecosystems" and 15 "Protecting and Restoring Terrestrial Ecosystems" were used, which directly addressed the conservation of "all living things" on land and in water. Sustainable forest management, combating desertification, halting and preventing soil degradation and biodiversity loss were all subject to the above goals and a prerequisite for sustainable recovery [32]. Healthy ecosystems and biodiversity were a source of food, water, medicine, shelter, and other material goods. In addition to the fact that human activity has already significantly altered most ecosystems on land, war crimes committed by Russia on the territory of Ukraine against flora and fauna led to ecocide in the country. Therefore, in the context of Ukraine's green recovery, these Goals have a broader goal: both to protect the national ecosystem from the potential effects of climate change and human activity and to recover from the direct and indirect damage that the ecosystem of all of Ukraine, including the Crimean Peninsula [33].

In January 2023, the Ministry of Environmental Protection and Natural Resources of Ukraine estimated the damage caused by the war to the environment at 46 billion USD. On June 6, 2023, with the Russian army's blowing up of the dam at Ukraine's largest hydroelectric power plant "Kakhovka", which became a large-scale ecocide of all living things both on land and in water, and large-scale pollution of water resources, these losses increased significantly [34]. In view of this, Ukraine's the green recovery should take into account the sustainable use of terrestrial and inland freshwater ecosystems, including forests, wetlands, and mountains. It should not lead to deforestation, but rather promote the restoration of degraded forests and reforestation. It should promote the creation of nature conservation eco-parks for animals, provide the reasonable management of fisheries and water bodies, and introduce water purification systems (**Fig. 7.6**).

The environmental restoration, like decarbonization, is a global necessity and will be possible with international loans in Ukraine. Therefore, the coherence of

investment decisions with SDG 15 is another important condition that Ukraine should take into account [35]. Despite the fact that, according to the Voluntary National Review of Ukraine's implementation of the SDGs for 2020 before the war, Ukraine was still gradually making progress in achieving 15 of the 17 Sustainable Development Goals, with the greatest success declared in poverty reduction, goals such as 13 "Climate Change Measures" and 15 "Protection and Restoration of Terrestrial Ecosystems" were out of the government's attention and showed a negative development trend [35]. It is worth noting that this assessment would be different, given the adoption of the Strategy for Environmental Security and Climate Change Adaptation after the war (**Fig. 7.7**).

According to the World Wildlife Fund, at least 812 protected areas of Ukraine covering 0.9 million hectares were affected by the full-scale Russian invasion of Ukraine. 2.9 million hectares of the Emerald Network were under threat of destruction. There were 17 wetlands of international importance with unique biodiversity at risk. 514 nature reserve sites covering 0.8 million hectares remained occupied [36].

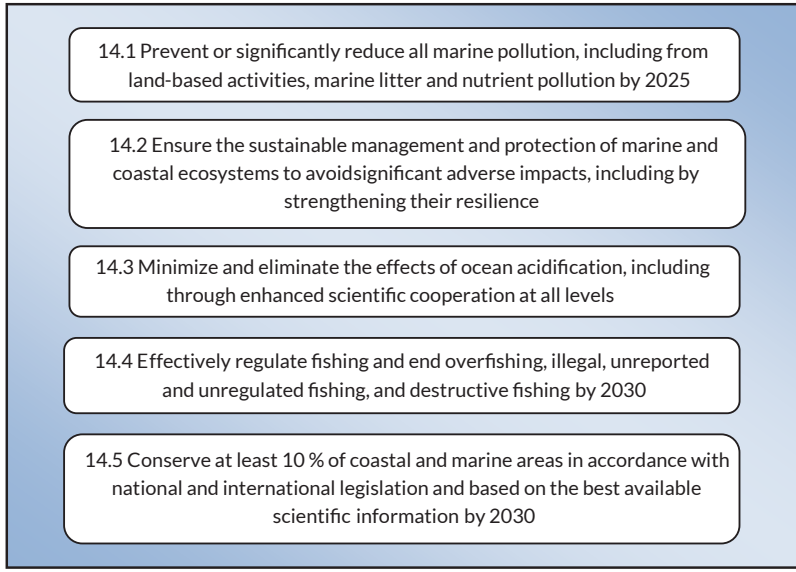

Fig. 7.6 Targets and indicators of SDG 14 "Protection and restoration of terrestrial ecosystems" in Ukraine
Source: compiled by the authors based on [34]

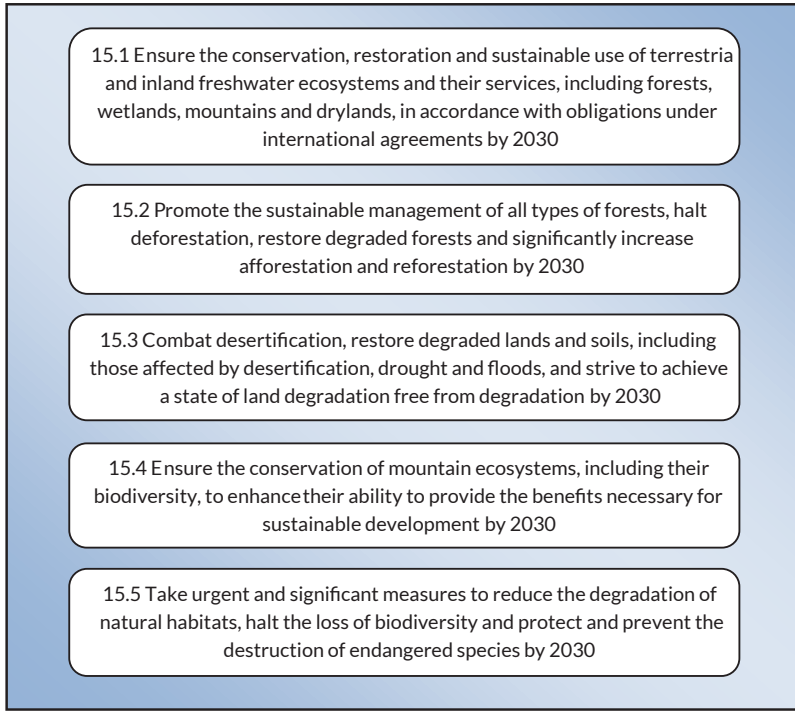

Fig. 7.7 Targets and indicators of SDG 15 "Conservation of marine resources" in Ukraine
Source: compiled by the authors based on [32]

In authors' opinion, to restore forestry, Ukraine needs to plant large artificial forests. However, due to the challenges posed by climate change, foresters must implement technologies that increase forest adaptation and help preserve continuous forest cover. The Forestry Strategy of Ukraine, which is designed for the period up to 2035, should provide for natural resource management in the context of climate change.

In order to integrate into the EU, Ukraine committed itself to create a water management plan. This document should include steps that Ukraine plans to take to solve the problem individually for each river basin or reservoir. Researchers believe that nature-based solutions can become a necessary innovative tool for preserving Ukraine's water resources. Nature-based solutions aim to protect, effectively manage and restore natural ecosystems, respond effectively and flexibly

to societal challenges, and create benefits for people and biodiversity. Farming in restored marshes is a promising natural solution for Ukraine which can contribute to ecological balance.

Due to Russia's large-scale war against Ukraine, the government was given the opportunity to build a new, green and sustainable economy, with a focus on social inclusion and environmentally friendly policies. The roadmap for rebuilding should be based on the synergy of the social and environmental dimensions of the UN SDGs. The alignment of Ukraine's recovery after the war with the SDGs is a condition for the allocation or mobilization of funds for this recovery by a financial institution of any type and scale. The government of Ukraine should place particular emphasis on ensuring that its recovery policy is aligned with the SDGs, and domestic businesses seeking international financial support should consider incorporating SDG principles into their corporate governance policies and follow relevant guidelines when planning and designing projects [37].

7.5 Information and digital green tech of Ukraine under conditions of war

The full-scale war, which has been going on for almost three years, caused enormous damage to Ukraine's economy and a huge humanitarian crisis. It would be worse if Ukraine did not digitize despite all the difficulties and obstacles. The whole world was watching and adopting Ukrainian experience in digitalization and Green Tech innovation clusters' development. The war showed that e-governance and digital services remained not only relevant but also an effective tool of public and green administration. Digitalization was the best example of the resilience and capacity of the Ukrainian state.

The Diia Business online platform received many prestigious international awards and honors during the war. It provided roving one's identity, applying for assistance, sharing a car registration certificate, paying taxes, and obtaining necessary certificates were just a small part of the services available, which were already used by more than 20 million Ukrainians. Diia portal offered 100+ government services, and the mobile application offers 14 documents and 30+ services [38].

On the Internet, Ukrainians could find many useful opportunities to develop their own business in information and digital green tech. Ukrainians who were engaged in green entrepreneurship or were just planning to start their own business could find it useful to know: how to prepare for starting green business, where to study [39], to get an advice, and financial support for business from the state or international programs, how to find investors and partners, more about programs for women's

green entrepreneurship, bank support programs for different types of business and how to use government online services for green tech innovation clusters of Ukraine during the war.

"Kyiv Digital" was another platform of how information technology and innovation helped to ensure sustainability and move forward, providing significant benefits and value to users. Started as a public transport fare app at the very beginning, it grew into a super-powerful platform in three years, offering almost everything people needed to live in the capital: air raid and power outage notifications, utility, fare and parking payments, traffic, registration at the ASC, petitions and polls. Despite the war, Ukraine did not only manage to maintain its digital services but also expanded them significantly. The country adapted to new challenges with innovative solutions that were being actively studied by even the most digitally advanced EU countries, such as Estonia, Denmark, and Sweden.

O. Lytvyn, A. Onyshchenko and O. Ostapenko found that the challenges of implementing new technologies into business include the absence of a unified regulatory framework, high costs associated with transitioning to digital platforms, and resistance from traditional players. These challenges can be addressed by creating clear regulations, providing financial support to companies transitioning to digital technologies, and fostering partnerships between innovative startups and large financial institutions for collaborative development and implementation of technological solutions [40].

I. Maksymenko, A. Akimov and S. Markova suppose that in the context of Russia's full-scale invasion of Ukraine, digital transformations in Ukraine 2023 were aimed at expanding digital opportunities to achieve the resilience of the national economy. In particular, this included Ukraine's integration into the EU's Digital Single Market, building digital infrastructure, attracting investment, creating a register of damage caused by Russia's aggression against Ukraine, etc. In Ukraine, significant attention was paid to digitalization not only at the national but also at the regional level. Thus, digital projects relevant to martial law were implemented in a number of regions using various sources of funding [41].

The full-scale war confirmed that Ukraine's future lied in green tech innovations. Ukraine had the potential to become the country with the largest number of green startups per one million people. Stimulating the development of the startup ecosystem in 2022, the Ministry of Digital Transformation of Ukraine supported existing green tech projects and implemented new ones. It launched the American venture fund Blue&Yellow Heritage Fund together with the company ff Venture Capital. It was focused on Ukrainian enterprises and startups. The fund managed to raise 50 million USD. Plug&Play Tech Center was one of the first investors in the international payment system PayPal.

An important role was also played by the Innovation Development Fund, which was transferred to the Ministry of Digital Transformation. Due to its work, the state became the largest investor in the country. The Fund invested more than 6 million USD in more than 250 startups in Ukraine and Eastern Europe. And the winners of the pitching rose more than 40 million USD in investments on their own. The Fund was going to change its focus to developing military-tech projects to strengthen Ukraine's defense capabilities [42].

Ukraine had to encourage green tech innovation clusters to stay at the forefront of the technological progress. Supporting research and development in the field of the latest technologies, including military and digital, was the key to maintaining a competitive advantage. In the world of digital technologies, where everything was changing at an incredible speed, this was the only way to stay on top. Ukraine needed an innovative ecosystem and investments in key technology sectors, such as: artificial intelligence, cybersecurity, military and green technologies. Supporting at all levels and the creating of a favorable environment for green startups and technology companies would be crucial for the development of innovation and entrepreneurship, attracting investment, economic growth and increasing the global competitiveness of Ukraine.

O. Lytvyn, V. Kudin, A. Onyshchenko, M. Nikolaiev and N. Chaplynska suggest that being a part of sustainable development, post-war companies should increase their activities in the field of renewable energy and ecology, as well as support environmental projects in any way possible, thus contributing to the achievement of the 6, 7 and 13 Global Goals for Sustainable Development, which the United Nations has set for 2015 [43]. Ukrainian companies should be aware of their environmental impact and strive to reduce it by developing their sustainability orientation, including sustainable business and sustainable management. According to the scholars, this once again proves that the path of sustainable development is inevitable for Ukraine. It is possible to believe that the concept of social responsibility should reflect rationality in the, as a rule, conflicting expectations of the entire set of interested parties, be based on the principles of continuous and long-term development of business entities, with the aim of obtaining competitive advantages [44].

The development of green tech innovation clusters was not only about improving Ukraine's position in global innovation rankings, which could help to increase international investments, but also about creating new jobs and engaging women more actively. This would be of great importance in overcoming the demographic crisis caused by the war. In addition, supporting startups and businesses would ensure a diverse and inclusive green economic recovery.

7.6 Conclusions

In conclusion, green IT involves various measures, such as: energy-efficient hardware, data centers, server virtualization, IoT-powered monitoring systems, and e-waste disposal. At the same time, digital technologies also ensure a nature positive transition to the green economy that includes climate resilience and the protection of biodiversity. Adopting green technologies is essential to improve well-being and health, offering benefits like clean air, water, soil, energy-efficient buildings, affordable and healthy food, and creating future-proof jobs for a resilient green industry transition. As a candidate country for EU membership, Ukraine must adopt a number of norms, standards and commitments, as well as pursue a Green Policy, which will focus on the sustainable use of resources. Ukraine needs to develop a collective vision of the harmonious coexistence of humans and nature that are based on the use of ecosystems to combat climate change, preserve biodiversity and promote community development after the war.

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