CERTAIN ASPECTS OF THE POST-WAR RECOVERY OF UKRAINE'S DIGITAL INFRASTRUCTURE

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Abstract. *The policy in information and communication technologies serves as a basis for the digital transformation of the economy and society. It focuses on measures related to information technologies, communication networks, and services, including technological and security aspects of domestic digital infrastructure development. The policy is in the context of the development of trans-European infrastructure. The digital transition is a central point of the new strategy, which involves an international digital partnership to implement the EU4Digital Initiative in Ukraine. The strategy aims to focus on key areas of the digital economy and society in line with EU norms and practices. It also includes the expansion of network infrastructure, uniting research and educational communities, implementing the broadband strategy, strengthening cybersecurity, and increasing trust in the use of digital services. Digital transformation has the potential to drastically change the economy and society. It utilizes ICT technologies, such as cloud services, communication technologies, big data analytics, artificial intelligence (AI), cybersecurity, cloud, and quantum computing, to drive digital transformation. This approach requires transitioning to more digital and sustainable economic models based on digital infrastructure. However, the full-scale invasion of Russia into Ukraine has slowed down the implementation of these processes. Therefore, it's necessary to identify priority directions for the post-war restoration of the economic landscape. This includes restoring digital infrastructure and identifying the tools needed to achieve this restoration. The purpose of the study is to systematize, coordinate, and prioritize tasks required for developing a strategic plan. The plan aims to restore Ukraine's digital infrastructure amidst war and post-war situations. To achieve this, the study analyzes international experiences and specific measures implemented in EU countries. Based on this analysis, the study outlines practical recommendations for the post-war restoration of damaged and destroyed infrastructure. These recommendations are mutually agreed upon and supported by specific examples to ensure the reliability and stability of the digital infrastructure.*

Keywords: *big data, ecosystem, digital infrastructure cost estimation model, digital infrastructure, digital transformation of the economy.*

On the eve of the International Economic Forum [1], the World Bank published a report called *"Global Economic Prospects"* [2]. The report provides an analysis of the world economy's prospects for 2023-2024. It also proposes economic guidelines and conclusions for the short and medium term. These guidelines and conclusions can be used in the development of economic strategies. According to the report, the slowdown in growth due to the consequences of the war in Ukraine affects 95% of developed economies and almost 70% of markets. In order to form a strategic vision at the World Economic Forum, the *EDISON* Alliance was created, which primarily gives priority to the digital transformation of the economy and society. The World Economic Forum and the Organization for Digital Cooperation have launched a collaboration called the "Digital Foreign Direct Investment Initiative". The initiative aims to identify the biggest challenges of the digital economy. It also aims to help implement policies and measures that will create a "digital" investment climate.

According to the *Global Soft Power Index 2023*, Ukraine ranked 19th among the 20 most influential countries in the world in 2022. This indicates that Ukraine has the ability to influence through attraction and persuasion, including its digital transformation of the economy [3]. In addition, Ukraine was recognized as second in the Open Data Maturity ranking among 35 European countries, rising from sixth to second place among European countries [4]. However, the outbreak of war has drastically changed the situation.

As the war in Ukraine transitioned from a short-lived conflict on February 24, 2022, to a protracted war of attrition, the burden of combat operations increased. Additionally, targeted enemy attacks on the country's digital infrastructure have made it essential to ensure stability. To achieve this stability, the economic system and its participants must be adaptable in their ability to restore and maintain capacity under the influence of uncertain, complex, and difficult-to-predict risks. This includes the risk of physical destruction caused by the war.

However, one year after Russia's invasion of Ukraine, the geopolitical context is increasingly tense and volatile, with an uncertain economic outlook coupled with

rising inflation, supply chain disruptions, energy losses, damage to critical infrastructure, extreme weather events and geopolitical volatility.

According to a joint report by the United Nations, the World Bank and the European Commission, Ukraine's digital infrastructure suffered significant destruction and vulnerabilities due to the military conflict. Russian forces caused massive damage, including to civilian infrastructure. The losses in Ukraine's housing sector reached 50 billion USD after 400 days of full-scale Russian invasion, 4.4 billion USD for educational institutions and 2.5 billion USD for healthcare facilities. According to estimates, Ukraine will need 411 billion USD to rebuild its economy after the full-scale invasion.

Conceptualizing the tasks of restoring Ukraine from the consequences of the war in the form of a comprehensive strategic plan based on the principles of complementarity is an important stage in forming an effective digital strategy for Ukraine's recovery. Such plans may include goals and objectives for the resilience and optimal life cycle of critical infrastructure in a specific sector and require effective information-gathering systems to monitor their compliance and the adoption of a standardized asset management system.

The precondition for a strategic plan in Ukraine should be the creation of an international Register of Damages for documentary fixation of evidence and claims for damages, losses, or injuries for all interested physical and legal persons, as well as the state of Ukraine, caused by international unlawful actions of the Russian Federation in Ukraine or against Ukraine.

From the long-term perspective, the existence of such a strategic plan is a necessary condition for the fundamental transformation of Ukraine into a digital, green, and sustainable economy based on a reliable digital infrastructure, innovative technologies, unlocking data capacity, shaping the regulatory framework, and creating a safe digital environment.

The key to solving the issue of rebuilding and restoring Ukraine's economy in the medium and long term is the fundamental basis on which a dynamic, sustainable

and growing digital economy is built: reliable digital infrastructure, big data, innovation and a secure digital environment.

Digital infrastructure has become a key element of critical infrastructure, the development of all sectors of the economy, economic security, business environment and competitiveness depends on its digital capabilities. Digital infrastructure includes the physical structure; cable and network systems; software and large amounts of data.

As a complex of technologies, products and processes, digital infrastructures provide computing, telecommunication and network capabilities for electronic interaction, data exchange, signals, etc. and operate on a digital basis. Digital infrastructure includes the physical resources required to use data, computerized devices, methods, systems and processes and integrates and connects physical and virtual technologies such as computing, storage, networking, applications and IaaS, PaaS and SaaS platforms to form a digital basis.

The growing number of systems containing physical and digital connections creates space for an ecosystem of connected digital doubles and complex cyber-physical systems that make decisions or support decisions with the help of collected data. However, the information and communication technology (ICT) sector is characterized by rapid technological change and the convergence of technological platforms for telecommunications, information delivery, broadcasting and computing, which are key factors in the development of the digital economy. The development of ICT infrastructure, digital technologies and the convergence of broadcasting, telecommunications and informatics opens up significant opportunities for the introduction of relevant new technologies in Ukraine.

The World Telecommunication Development Conference (WTDC-17), held in Buenos Aires (Argentina), initiated the promotion of modern and secure ICT infrastructure and services, including the strengthening of trust and security in the use of ICT [6]. The Network Infrastructure and ICT Services Program, initiated by WTDC-17, promotes the use of new technologies for the development of information and communication infrastructures and services.

Today, ICT infrastructure has moved beyond simple connectivity and computing to form a digital ecosystem driven by artificial intelligence, data and green technologies, where gigabit broadband infrastructure will provide ubiquitous real-time computing power and is optimized for growth, cost, and robustness. Digital technologies enable basic business operations, which is becoming a strategic imperative and the new norm and expected standard.

The digital infrastructure consists of all electronic and non-electronic assets used to provide broadband services to users, and in the context of this publication includes durable physical assets that transport and store data. Data infrastructure is vital to the delivery of mission-critical services and is essential to the functioning of major sectors of the economy, including financial systems, utilities, industrial supply chains, media, and telecommunications. Data generation and consumption, an ever-increasing number of connected devices, the rise of cloud computing, and the deployment of 4G and IoT devices are accelerating the growth of both mobile and fixed devices. Internet traffic is expected to grow to 175 zettabytes worldwide by 2025.

Digital technologies of the new technological framework are the driver of significant structural changes not only in the systems and ways of meeting the needs of consumers but also in economic development models to encourage the development of a generally accepted class of sustainable infrastructure assets. However, according to the report of the Global Future Council on Infrastructure of the World Economic Forum (hereinafter – the Council), currently, infrastructure remains one of the sectors of the economy with the least number of digital transformations [7]. Taking into account the need to innovate and build a technologically structured digital infrastructure, taking into account economic, social, environmental and technological components, the Council developed six characteristics of a sustainable digital infrastructure (GFC-6) [8], namely: access and sharing of benefits, logical and climate sustainability, social acceptability, economic and institutional efficiency, perspective throughout the life cycle and critical mass potential due to reproducibility.

According to the recent report “Digital Economy Documentation – Asia Pacific”, it is noted that the digital economy of the first level of ICT infrastructure (*Digital First Economy, DFE*) contributes to inclusive, innovative, sustainable and ecological economic growth [8]. *DFE* indicators indicate a significant multiplier effect of GDP growth. Each US dollar of ICT investment generates $13 of GDP, and a one-point increase in DFE correlates with a 3% increase in GDP.

Investing in universal digital infrastructure is essential to the adoption of the Internet and is a key objective of 9 Industry, Innovation, and Infrastructure. Creation of sustainable infrastructure, promotion of inclusive and sustainable industrialization and innovation of the Sustainable Development Goals of the UN [9]. Achieving universal broadband requires investment in infrastructure [10]. The availability of Internet connectivity can provide new economic opportunities for unconnected communities and help facilitate larger structural shifts in the digital transformation of the economy and society [11].

In order to attract funds for digital infrastructure, the IMF has developed a new model for estimating the costs of digital infrastructure (*Digital Infrastructure Costing Estimator, DICE*) taking into account the demographic forecast trends of each country, population, density, and future economic characteristics. The DICE model estimates the cost of investing in digital infrastructure to deliver affordable universal broadband by 2030 using harmonized global datasets to assess broadband infrastructure needs [12].

Consistent tracking of digital progress and evaluation of the results of the EU, as a whole, and individual EU member states, as well as their comparison with the indicators of leading countries that are not part of the EU, is carried out annually by the European Commission with the help of Digital Economy and Society Index reports and SocietyIndex, DESI) and international DESI index (I-DESI) [13]. DESI illustrates the evolution of digital transformation in Europe and consists of five components covering societal and economic aspects, namely measurement:

- deployment of broadband communication infrastructure;
- skills necessary for use in the digital society;

- online activities of citizens and use of Internet services;
- integration of digital technologies;
- digitalization of public services.

The DESI/I-DESI component “Integration of digital technologies” measures the availability and adoption of technologies by enterprises and the development of e-commerce. This is facilitated in accordance with the initiative of the European Commission and the formation of the European digital passport of an ecological product (Sustainable Products Initiative). This initiative provides the opportunity to mark, track, localize and exchange data related to the creation of value chains down to the level of individual components and materials. In order to create conditions for the inclusion of Ukraine in the EU Digital Economy and Society Index and the implementation of EU approaches, it is planned to introduce data collection and measurement of indicators of the digital economy and comparison with indicators of digital economies of European countries by the government of Ukraine already in 2023.

The *DICE* model, taking into account the *DESI* indicators, allows for the assessment of investments in digital infrastructure and the achievement of universal broadband connection. The model involves investment in infrastructure to support mostly terrestrial 4G deployments, while also involving investment in satellite connectivity in areas that require remote coverage in very hard-to-reach locations. The motivation for using cellular wireless is that it is one of the cheapest ways to affordably provide wide-range broadband services, as broadband consists of the first mile (where and how the connection enters the country), the middle mile (how data packets are transported over long distances between different regions) and the last mile (how data packets are distributed locally among end users).

A sensitivity analysis of key model parameters demonstrates that future broadband policy evaluation should clearly indicate the amount of data that each user can consume. To ensure universal broadband, according to the basic assumptions of the IMF, the need for necessary investments is estimated at 418 billion US dollars or approximately 0.45 percent of the world GDP. This estimate is based on the

assumption of providing universal 4G cellular broadband to users with approximately 40-50 GB of data per month with 95 percent reliability [14]. According to the IMF's estimates, the total needs in emerging market economies amount to $305 billion (73 percent). Demand is assessed to obtain the required amount of traffic to be served, network sizing and cost estimation metrics. Each of the three main modules will be presented as demand, network sizes and costs.

Before quantifying the cost of building the necessary infrastructure, the model begins by estimating future demand data. For the calculation of digital infrastructure assets, the key elements of investment programs and economic development models are:

- determination of infrastructure needs, including the inventory of existing infrastructure assets;

- definition of goals and expected results in combination with a predetermined set of sustainability factors relevant to the system;

- a creation of a template for analyzing the costs and benefits of including conditions and characteristics of sustainability in the necessary infrastructure;

- inclusion of sustainability goals, especially in the early stages of the strategy and design of infrastructure assets.

In addition, when creating or using a model of economic development, the main areas of application should be (Fig. 1.5):

- economic — cost/benefit analysis, asset life cycle analysis, costs, optimization, bankruptcy, etc.;

- environmental — mitigating the consequences of natural disasters and climate change, resilience to climate change, ensuring efficient use of energy during construction and operation, optimizing the use of natural resources, optimizing land use, minimizing waste;

- social – participation of the community/beneficiaries, availability of infrastructure for the population, health, and safety;

- technical – site research, design and alternative options, an interdisciplinary approach of complex design, starting with technical and economic justification,

meeting functional and aesthetic requirements, integrating design with the stages of construction and operation,

- regulatory requirements related to sustainable infrastructure;

- design/project management – involvement of contractors, suppliers at the design stage, design, control taking into account the interests of the community;

- the choice of materials — low energy/water consumption, technologically innovative, strong and durable materials and the use of locally produced materials.

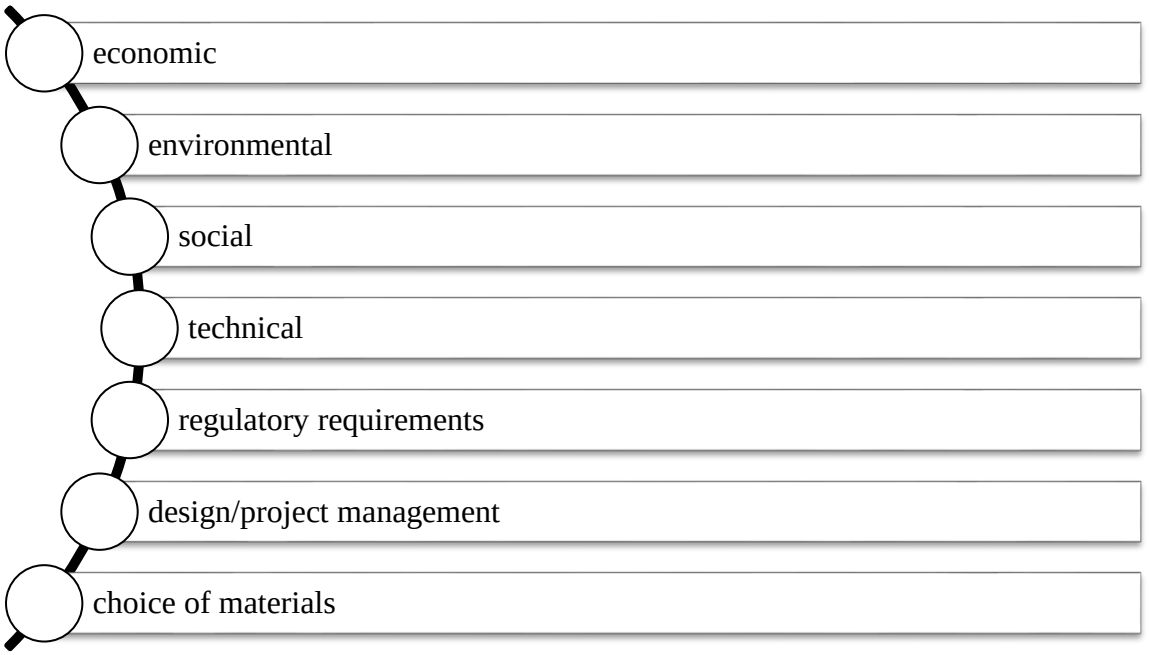

Figure 1.5. The main areas of application of the model of economic development

Sourse: developed by authors

More and more countries are realizing the importance of taking advantage of the digital economy for innovation, growth and social prosperity. This awareness comes as the cost of data collection, storage, and processing increasingly migrates to the Internet. Technology, smart applications and other innovations in the digital economy can improve services and help solve a wide range of issues, including health, agriculture, governance, taxation, transport, education and more. ICTs contribute not only to innovations in products, but also to innovations in processes and organizational mechanisms.

As the consumption of digital data grows, so does the importance of access to a high-performance digital infrastructure to connect, transport and store this data based

on international standards. Currently, about 80% of big data standards are developed by *ISO/IEC* technical committee *JTC 1/SC 42 – Artificial Intelligence.* In addition, big data terminology is defined in ISO/IEC 20546, while the big data reference architecture is covered by *ISO/IEC 20547-3*, and *ISO/IEC TR 20547-2* and *ISO/IEC TR 20547-5* describe the roadmap of existing and future standards in this field 15. The development of big data analytics regarding the life cycle of data science, which is developed by ISO/AWI TR 23347 [16], is timely and relevant.

A tool for measuring countries' performance against key factors of mobile Internet adoption is the *Global System for Mobile Communications* (*GSMA*) Mobile Connectivity Index, which outlines global connectivity trends in mobile Internet connectivity and accelerating digital engagement (infrastructure, affordability, consumer readiness, services). According to the report "The State of Mobile Internet Connection in 2022" in Ukraine, the *GSMA* index, in comparison with previous years, has increased by 1.6% and is 72.6% [17]. The key indicators of the index are infrastructure coverage – 65.6%, availability – 64.7%, consumer readiness – 89.5%, and services – 73.2%.

The placement of digital infrastructure at the centre of economic policy programs can unlock economic opportunities, create jobs, promote growth, and improve quality of life. In addition, the provision and implementation of digital services that use broadband communication can allow workers affected by technological economic transformation to retrain, while also providing access to essential services such as financial services, healthcare, education, and more. Furthermore, a higher level of digitization can help expand the tax base and increase revenue collection, as well as transform the management of public finances by modernizing relevant systems, improving the provision of public services, enabling digital payments, and promoting transparency.

An example of the construction of the government's digital policy for the near future, taking into account the above-mentioned postulates, can be the *Digital Strategy of Great Britain*, which focuses on 6 key areas [18]:

- *digital basis:* update of the Plan for digital regulation of the digital economy (digital infrastructure, data, regulation, digital markets, security);

- *ideas and intellectual property:* consolidation to support the innovation ecosystem, with a special emphasis on digital technologies;

- *digital skills and talent:* reforming and improving skills and talents for the digital economy;

- *financing digital development:* improving the technological ecosystem with access to financing through the British Business Bank and British Patient Capital, introducing the technological revolution into the economy through Fintech;

- *increasing the level of use of digital technologies to support the achievement of key strategic priorities:* increasing productivity through the introduction of technology, improving public services, improving the level and net-zero;

- *use of strategic advantages* in digital and technological spheres and establishment of global standards of digital products and services.

National digital security strategies play a key role in strengthening trust in digital technologies by creating the conditions for all stakeholders to manage digital security risks in the economy and public activities. Governments of many countries are increasingly aware of the need to develop the digital economy strategically in order to expand their advantages and respond to the key challenges of today. Modern national digital strategies cover a variety of business creation and productivity growth challenges for public administration, employment and education, health and livelihoods, environmental protection, and economic development.

Most OECD countries have adopted or are close to adopting national strategies related to the digital economy. Germany's digital agenda emphasizes “increasing the use of the potential of innovation to achieve further growth and jobs” as a key goal (in addition to strengthening high-speed networks and trust). Germany's smart grid initiative aims to strengthen basic infrastructure, develop cooperation between infrastructure sectors, improve basic conditions and increase early-stage stakeholder participation with the ambition to expand and deepen the integration of applications and smart grids. Another program under the Digital Agenda aims to help small and

medium-sized enterprises understand the importance of using software for business processes and support these companies to digitize.

Mexico's National Digital Strategy plans to make Mexico a “leading digitization country in Latin America” with a focus on promoting innovation and entrepreneurship in the digital economy, among other priorities. Mexico's *Creative Digital City* initiative aims to create an urban “ecosystem” that concentrates on creative industries (film and television studios, mobile applications, interactive media, etc.) to harness the creative potential and talent of people in Guadalajara, along with the use of technology to drive innovation to maximize economic, environmental and social benefits.

In *Brazil*, the Strategic Information Technology Software and Services Program (TI Major) aims to improve Brazil's performance in the ICT sector and focuses on innovation, entrepreneurship, and competitiveness.

Colombia's Vive Digital plan includes the Digital Talent Initiative, Apps.co for digital entrepreneurship and the Digital Content Initiative.

In recent years, policymakers have increasingly focused on promoting the open, distributed, and interconnected nature of the Internet, while protecting the privacy and managing digital security risks to build trust in the digital economy.

Japan's National Parliament has amended the Personal Information Protection Act to introduce new definitions of confidential and anonymous personal information, as well as new rules for cross-border transfers. A key element of the updated Japanese privacy legislation is the creation in 2016 of the independent agency of the Commission for the Protection of Personal Information and the exercise of control over the protection of the rights and interests of citizens in this area.

To bridge the digital divide, *China* has launched a national broadband strategy that aims to connect 98% of Chinese villages to 2Mbps fixed broadband by 2020. China Telecom is also partnering with Alibaba Group to promote low-cost smartphones in rural areas.

To successfully use the potential of innovation and growth of the digital economy, high-quality access to communication infrastructure at a competitive price is necessary. This, in turn, requires sufficient trust in the reliability and security of digital networks, respect for privacy and consumer rights.

High-speed networks and services are essential for future economic growth, job creation and competitiveness. Public policy is aimed at promoting strong competition in the provision of high-speed broadband Internet access services and encouraging investment in these networks to achieve the greatest geographic coverage. There is now a need to close the digital divide, which acts as an obstacle to the deployment of the Internet of Things in areas such as healthcare, transport, and energy to improve competitiveness, the environment, and well-being.

Strong privacy protections are critical to ensuring that the social and economic potential of the digital economy is harnessed. Privacy can be protected based on globally recognized principles, such as the OECD Privacy Guidelines, under which governments work to achieve global compatibility by expanding mutual recognition of privacy frameworks that achieve the same goals.

Особливо важливе значення в цьому контексті приділяється розвитку більш стійкої до потенційних загроз критичної інфраструктури, інноваційних технологій і ланцюгів постачання.

Critical infrastructure is considered as an asset, object, equipment, network, or system or a part of an asset, object, equipment, network, or system that is necessary for the provision of basic services and significantly affects the social and economic well-being of the country's population [19]. Classic examples of assets are data centers, fibre optics, last-mile broadband, and cell towers. Most of the revenues from digital infrastructure assets in international practice are now indexed by the passively managed byte (BYTE) investment fund (Exchange Traded Fund, ETF), which trades on the stock exchange. BYTE index includes such main verticals of digital infrastructure as data centers; mobile infrastructure (towers, cellular communication, etc.); infrastructure of broadband access to a fixed line (optical fiber, cable).

From a security perspective, critical infrastructure (cyber and physical) is the fundamental basis for the functioning of every aspect of society. Adverse impacts on critical infrastructure include events or incidents that threaten public safety and trust, threaten economic and national security, harm international competitiveness, and impede industrial development and their ability to deliver essential services.

The growing interdependence between infrastructure and sectors is the result of an increasingly cross-border and interdependent service delivery network using key infrastructure in energy, transport, banking, drinking water, wastewater, food manufacturing, processing and distribution, healthcare, space, infrastructure financial market and digital infrastructure, as well as in certain aspects of the public administration sector.

The EU's Critical Facilities Resilience Directive, adopted in January 2023, aims to strengthen resilience against a range of threats, including terrorist attacks, natural hazards, internal threats or sabotage, and emergencies under new rules that require the adoption of a national strategy and carrying out regular risk assessments to identify entities that are considered critical or vital for society and the economy [20].

The space sector is subject to this Directive in relation to the provision of certain services that depend on ground infrastructure owned, managed and operated by countries. The new European Space Strategy for Security and Defense is focused on protecting space assets, deterring hostile activities in space, and strengthening strategic position and autonomy [21].

The recently established NATO-EU Task Force on Critical Infrastructure Resilience covers critical sectors of the economy, including new and revolutionary technologies for the impact of climate change on security [22].

The stability of critical infrastructure and critical objects is vital in maintaining economic activity and social functions in the domestic market in the conditions of increasing interdependence of the economy of Ukraine with partner countries due to disruption or destruction of infrastructure due to dynamic hybrid and terrorist threats of the russian federation, as well as growing interdependence between infrastructure and sectors, which will have a significant cross-border impact.

Digital infrastructure in Ukraine in the energy, transport, industrial, and water sectors plays a decisive role in accordance with international commitments regarding the Paris Agreement on climate change and the Sustainable Development Goals (SDGs). Ukraine's rating of infrastructure indicators in the World Bank's *Logistics Performance Index* (LPI) shows that over the last decade, the quality of infrastructure has deteriorated both in absolute terms and in comparison with other countries. In 2007, Ukraine ranked 74th in the world with an average infrastructure index (2.35), and in 2018 – 119th with a score of (2.22) [23]. However, in the World Economic Forum's Competitiveness Index for 2019, the quality of Ukraine's infrastructure is assessed positively. Its indicator (70.3) is significantly higher than the average indicator for countries with a lower average income level (60) [24].

The creation of a platform for operational monitoring of the state of the energy industry and accounting of assistance *"Energy Aid"* is a top priority in establishing supply chains and coordination mechanisms between the customer, companies in the energy sector affected by russian armed aggression against Ukraine, and international donors and suppliers for emergency equipment repair. This includes creating a "single window" tool to address issues related to emergency repairs and find the necessary equipment for Ukraine's digital energy infrastructure, as well as interconnecting parties [25].

According to the OECD database, before the beginning of the Russian invasion, more than 77 infrastructure projects with a total cost of 37.0 billion US dollars were implemented in Ukraine. The largest share in terms of value was allocated to projects in the transport (55%, USD 20.3 billion) and energy (40%, USD 15.6 billion) sectors. Inadequate quality of infrastructure systems of Ukraine and the need for post-war reconstruction is defined as a key structural bottleneck, which prevents the formation of innovative digital infrastructure and bringing it into line with international norms and rules. Standardization in the field of ICT infrastructure covers areas such as planning and installation of networks (ISO/ IEC 14763-2 and ISO/IECTR 14763-2-1), enterprise telecommunications networks (ISO/IEC 17343), urban networks (ISO/IEC/IEEE 8802-A), private integrated telecommunications networks (ISO/

IECTR 14475) and wireless networks, networks of the next generation (ISO/IEC TR 26905). In addition, ISO implements standards for so-called future networks, which are intended to provide futuristic capabilities and services beyond the limitations of current networks, including the Internet.

A prolonged and widespread power outage, caused by the full-scale aggression of russia against Ukraine, has led to a massive impact on water supply and sanitation, which in turn affects public health. It has resulted in reduced service delivery, disconnection of banking, financial, and retail sectors, as well as instability in food supply and disruptions in transportation and telecommunications networks.

The roadmap for the development of digital infrastructure and asset recovery for Ukraine in the post-war period should prioritize energy resilience and security, overcoming market instability and geopolitical tensions to enable the implementation of next-generation mobile technologies, including 4G and 5G, which offer new technical possibilities, including virtual reality (VR) and augmented reality (AR) in education, healthcare, transportation, and more. Ukraine's participation in the EU program “Digital Europe”, the development of the resource base, the improvement of the unified interoperable system of public e-registries, the introduction of the electronic presidency, digitization of subsoil use, and waste management are key tasks in the near future [26].

According to the International Energy Agency, in order to achieve the goals of the Paris Agreement, it is necessary to increase the supply of critical minerals by 2040 — 7 times rare earth elements and 42 times lithium [27]. Securing the supply of these minerals is a priority for all OECD governments. The concentration of mineral reserves, critical for the green transition, is of significant importance for Ukraine as well. In 2021, Ukraine was among the top 10 countries in the production of titanium, iron ore, kaolin, manganese, zirconium, and graphite. Among the 120 types of minerals consumed in the world, 117 were discovered in the bowels of Ukraine, concentrated deposits of 22 of 30 minerals that are included in the list of critical for the EU. Among them are lithium, beryllium, rare earth elements, nickel and cobalt. Several minerals will underpin the transition to low-carbon energy. These include

cobalt, nickel, and lithium contained in electric vehicle batteries; rare earth elements, which are critical for the production of wind turbines; and copper, necessary for all clean technologies (eg photovoltaic systems, bioenergy, wind turbines or electric cars), which will be important for Ukraine's participation in the EU's Digital Europe program and the construction of modern digital infrastructure.

Creating conditions for the influx of technological companies into Ukraine and the cooperation of foreign customers with domestic enterprises through the regulatory regulation of the functioning of digital innovation hubs (*Digital Innovation Hub*) and business innovation centers is a priority task of their integration into the European network, proactively attracting investments from international companies to form a modern digital infrastructure with an extensive network

The implementation of specific measures for the restoration and development of digital infrastructure in the conditions of war in Ukraine requires a transition to practical productive actions in all areas of digital transformation, the development of a pool of strategic documents agreed among themselves and supported by thorough analysis, in particular regarding:

- implementation of a set of measures for the restoration and development of the system of research infrastructures and the development of a mechanism for consolidating the efforts of executive authorities, science and international organizations that provide international technical assistance for the restoration and development of the system of e-infrastructures that were critically affected by hostilities during martial law. To do this, develop a state program aimed at ensuring inventory and systematization of research infrastructures and assessment of their compatibility with European research infrastructures;

- establishment of integration and interaction of digital infrastructures using IT technologies for conducting joint research and providing remote access and the possibility of uniting geographically distant scientific centers that suffered as a result of the Russian military invasion of Ukraine in the format of joint research infrastructures using joint scientific equipment and activation mobilization of resources for their development;

- creation of a single online portal for posting information about unique e-research infrastructures at the national level that go through a full life cycle (design, construction, use and provision of services, development and renewal or liquidation) for the provision of services for the maintenance and development of the scientific and innovative sphere in the conditions of the war and the post-war period in order to increase their competitiveness;

- introduction of new-generation Internet platforms to stimulate the process of digital transformation and facilitate collaboration and knowledge exchange (intelligent global search engine, customizable design, integrated content management, multilingual interface, etc.). Implementation of appropriate digital accounting tools for project management, recruitment, payroll, customer relations (CRM), content management system (CMS) software;

- introduction of legal regulation and functioning of digital platforms as business tools of the digital economy of public (financial, tax) and private (civil, economic, labor) law and regulation of relations in the field of personal data processing, taking into account the collection and processing of information using big data technologies through EU4Digital correspondent networks, which serve as platforms for the exchange of best practices and experiences from the EU and reflect the main directions of digital development on the way to the EU Digital Single Market (ICT innovation, telecommunications, e-health system, e-commerce, e-skills , security, etc.);

- harmonization of the use of digital data of remote, terrestrial observations shared with the world community, development of a methodology for evaluating modeling results in the post-war period for solving applied problems of environmental security, energy, climate change, biodiversity, food security, forest, water, and agricultural resources within the framework of creation Global Earth Observation System (GEOSS);

- increasing the availability of space data and signals to address various types of natural, technological and societal threats and vulnerabilities caused by war and their early warning. In the current state of war, this process consists of determining the

coverage level of complementary, overlapping satellite systems and the availability of data for dual-purpose systems that play an important role in aviation, as well as in precision agriculture, maritime and land transportation, and mapping [1]. Satellite signals and images of the aggressive war of the russian federation against Ukraine now have the ability to support unprecedented coverage of events in almost real-time;

- improvement of effective and responsible access and data exchange in accordance with agreed international principles [1] to increase the credibility of the data ecosystem. This approach involves promoting inclusive representation of stakeholders in the data ecosystem; increasing the transparency of access to data and the mechanisms of their joint use; data sharing competition, including public-private partnerships, as well as the empowerment of individuals, social groups and organizations.

References:

1. World Economic Forum Annual Meeting. URL: https://www.weforum.org/events/world-economic-forum-annual-meeting-2023.
2. Sharp Slowdown in Growth Could be Widespread, Increasing Risks to Global Economy | World Bank Expert Answers.URL: https://www.worldbank.org/en/publication/global-economic-prospects.
3. Ukraine entered the TOP-20 most influential countries in the world according to the "soft power" rating. URL: https://www.unian.ua/world/ukrajina-uviyshla-u-top-20-nayvplivovishih-krajin-svitu-za-reytingom-m-yakoji-sili-12164916.html.
4. Open data during the war: what they provide for understanding the present and the future. URL: https://www.radiosvoboda.org/a/vidkryti-dani-pid-chas-viyny-vplyv-vykorystannya/32323255.html.
5. Damage to the civil infrastructure of Ukraine during the year of the war. URL: https://www.ukrinform.ua/rubric-ato/3689778-zbitki-civilnoi-infrastrukturi-ukraini-za-rik-vijni.html.
6. Annual Meeting of the Global Future Councils. URL: https://www.weforum.org/events/annual-meeting-of-the-global-future-councils-2019.
7. Global Future Council on Infrastructure Six Qualities of Sustainable Infrastructure. URL: https://www3.weforum.org/docs/WEF_GFC_6_Sustainble_Infrastructure_2020.pdf.
8. Digital First Economy Whitepaper — Asia PacificICT infrastructure and policy empower inclusive, innovative, resilient and green economic growth. URL: https://www.huawei.com/en/huaweitech/industry-trends/digital-first-economy-whitepaper.
9. Industry, Innovation and Infrastructure. Build resilient infrastructure, promote sustainable industrialization and foster innovation. URL: https://ukraine.un.org/uk/sdgs/9.
10. Estimating Digital Infrastructure Investment Needs to Achieve Universal Broadband Edward Oughton, David Amaglobeli, and Mariano Moszoro WP/23/27.
11. Jung, J.; López-Bazo, E. On the regional impact of broadband on productivity: The case of Brazil. Telecommunications Policy, 44 (1), 101826.

12. Estimating Digital Infrastructure Investment Needs to Achieve Universal Broadband. URL: https://www.elibrary.imf.org/view/journals/001/2023/027/article-A001-en.xml?rskey=0Lw75R&result=12.
13. Digital Economy and Society Index 2021: overall progress in digital transition but need for new EU-wide efforts. URL: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_5481
14. Estimating Digital Infrastructure Investment Needs to Achieve Universal Broadband, WP/23/27, February 2023.
15. ISO/IEC JTC 1/SC 42 Artificial intelligence. URL: https://www.iso.org/committee/6794475.html.
16. ISO/AWI TR 23347 Statistics - BigDataAnalytics - DataScienceLifeCycle. URL: https://www.iso.org/standard/75289.html.
17. GSMA Mobile Connectivity Index. URL: https://www.mobileconnectivityindex.com/#year=2021&zoneIsocode=UKR.
18. UK DigitalStrategy Policy Paper. URL: https://www.gov.uk/government/publications/uks-digital-strategy/uk-digital-strategy.
19. Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities and repealing Council Directive 2008/114/EC (Text with EEA relevance). URL: https://eur-lex.europa.eu/eli/dir/2022/2557/oj.
20. EU Space Strategy for Security and Defense. URL: https://www.geospatialworld.net/prime/special-features/eu-space-strategy-for-security-and-defense/
21. Launch of the EU-NATO Task Force: strengthening our resilience and protection of critical infrastructure. URL: https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_23_1705.
22. Ukraine - Logistics Performance Index: Ease Of Arranging Competitively Priced Shipments (1=low To 5=high). URL: https://tradingeconomics.com/ukraine/logistics-performance-index-ease-of-arranging-competitively-priced-shipments-1-low-to-5-high-wb-data.html.
23. Davos-2019: main messages of the World Economic Forum. URL: https://www.epravda.com.ua/publications/2019/01/27/644694.
24. PLAN of priority actions of the Government for 2023: order of the Cabinet of Ministers of Ukraine of March 14, 2023 No. 221 URL: https://www.kmu.gov.ua/npas/pro-zatverdzhennia-planu-priorytetnykh-dii-uriadu-na-2023-rik-221r-140323.
25. PLAN OF PRIORITY ACTIONS OF THE GOVERNMENT FOR 2023. URL: https://www.kmu.gov.ua/storage/app/sites/1/18%20-%20Department/18%20-%20photo/2023/03.2023/14.03.2023/prezentatsiya planu2023edit1403-1.pdf.
26. World Energy Outlook 2021. URL: https://www.iea.org/reports/world-energy-outlook-2021
27. Recommendation of the Council on Enhancing Access to and Sharing of Data. URL: https://legal instruments.oecd.org/en/instruments/OECD-LEGAL-0463.
28. Gupta, S. K., Gupta, R., Srivastava, V., & Gopal, R. The Digitalisation of The Monetary system in India: Challenges and Significance for Economic Development. *Journal of Emerging Technologies and Innovative Research*, March, 2109, 01-04.
29. Arefieva, O., Polous, O., Arefiev, V., Kopcha, Yu., Gupta, S.K. (2020). Intellectualization of Human Capital Development in Digital Economics. *International Journal of Advanced Science and Technology*. Issue 8S. Volume. 29. PP. 2297-2303.
30. Renu Sharma, Mamta Mohan and Sandeep Kumar Gupta (2022). The effect of mall ambiance, layout, and utility on consumers' escapism and repurchase intention. *Innovative Marketing*, *18*(4), 161-173. doi:10.21511/im.18(4).2022.14.